Contents

EB GROUP MEMBERS

LECTURERS

PhD Students EB GROUP MEMBERS

Master Students

EB GROUP MEMBERS

Biorefinery Complex

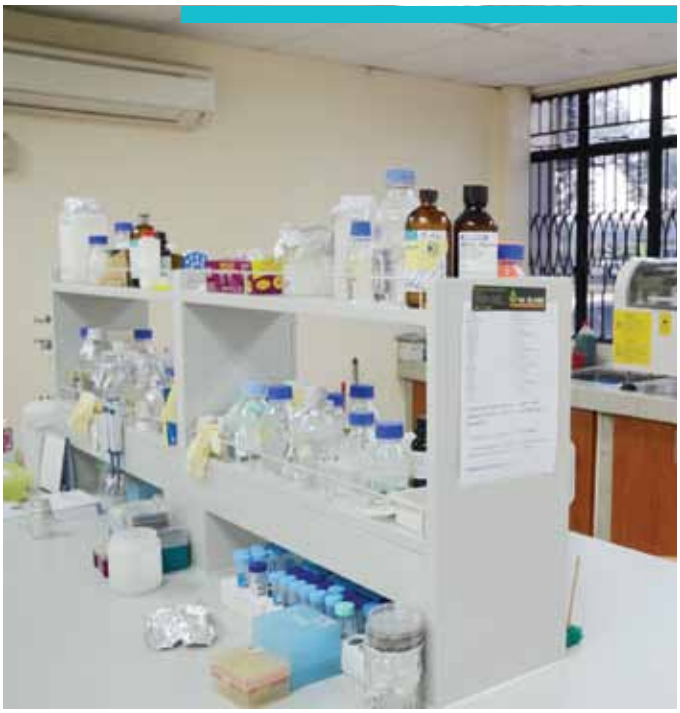
Biorefinery Complex of Environmental Biotechnology Research Group (EB) is the first pilot processing in UPM that incorporate a holistic approach in exploiting solid biomass into value added products through green technology. Biochar, biocompost, biodiesel and biogas pilot plants are developed based on our extensive research for 20 years in environmental biotechnology. Pilot plants are majorly equipped with solid biomass processing machines and instrument for generation of lignocellulosic based products. The pilot plants consist of biocompost machinery including biocompost reactor, mechanical compost turner, grinder, wood chipper as well as other machines such as steam blasting and biodiesel reactor. Serdang Biomass Town launched in January 2012 was a breakthrough project for EB group in collaboration with MPSJ, MARDI, KyuTech (Japan), FELDA, AIST (Japan) and KPKT. Through this project, we promoted zero discharge concept for Serdang community by converting selected biomass into valuable biomaterials.

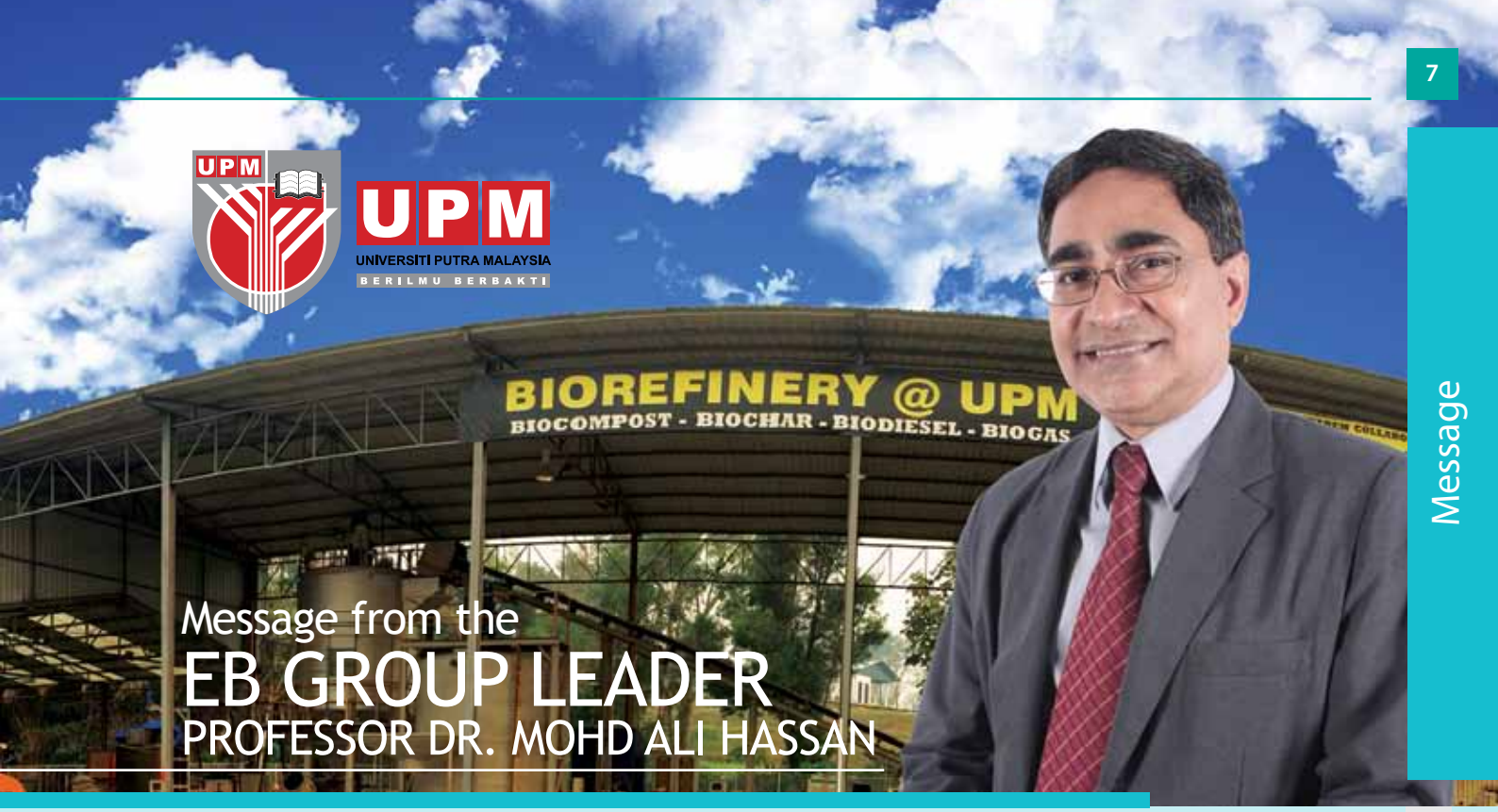
Biorefinery Complex also includes Biomass Technology Centre (BTC) for analytical purposes to attain research and development requirement. This year, EB Group is proudly marks the first anniversary of BTC. BTC located near to the University Agricultural Park (TPU) and UPM golf course, was operated last year starting from January 2014. The whole area of BTC covers 1075 m2 features laboratories, postgraduate students' room which accommodates 30 students, researcher rooms, meeting room and seminar room. The seminar room can accommodate a maximum of 100 people at a time for meetings and presentations. The laboratory of this centre comprises of a chemical room, a culture room, a bioreactor room, an analysis room and a cold room. These rooms are fully equipped with instruments for environmental biotechnology research such as biomass pretreatment, fermentation process, bioalcohol detection and wastewater characterization.

EB Lab at BioTech 3

Environmental Biotechnology Research Group (EB) comprises of two laboratories at BioTech 3: Environmental Biotechnology (General and Molecular) Laboratories. There are 15 postgraduate students currently working in both laboratories. Environmental Biotechnology (General) Laboratory mainly focusing on research related to biopolymers, biomaterials and biochemicals. The laboratory is equipped with instruments such as stirred tank bioreactors (2L & 7L), incubator shaker, freeze-dryer, glass tube oven for pyrolysis, gas-chromatography with flame ionization detector (GC-FID), gel permeation chromatography (GPC) with UV and RI detectors, high performance liquid chromatography with UV and RI detectors, phase-contrast microscope and UV-VIS spectrophotometer.

Environmental Biotechnology (Molecular) Laboratory on the other hand is a laboratory dedicated for molecular work focusing on environmental samples. The laboratory is equipped with instruments for molecular analyses such as PCR, RT-PCR, denaturing gradient gel electrophoresis (DGGE), NanoDrop, gel documentation and flow cytometer system.





UPM
UNIVERSITI PUTRA MALAYSIA
BERILMU BERBAKTI

Message from the EB GROUP LEADER
PROFESSOR DR. MOHD ALI HASSAN

In The Name of ALLAH, Most Gracious, Most Merciful

AlhamduLillah, praise to ALLAH for His generous favours and blessings on us. I am very happy that over the years, our Environmental Biotechnology Research Group (EB) at Universiti Putra Malaysia has gone from strength to strength. I am glad to share with you our research report for 2014. We now have two sub-groups comprising of EB1- Biomass and Biorefinery, and EB2 – Bioenergy and Biobased Chemicals. We have 9 academic staff members, 1 post-doctorate researcher and 15 associate researchers. Our current student enrolment are 19 PhD, 18 MS and 23 undergraduate students. In addition we also have 4 students on the PhD Double-Degree and 5 students on the Split-PhD program with Kyushu Institute of Technology, Japan. We continue to operate the Biorefinery@UPM Complex, comprising of the Biomass Technology Centre and the Pilot Plants for Biocompost, Biochar, Biodiesel and Biogas under the Serdang Biomass Town project, in collaboration with The Ministry of Housing and Local Government (KPKT, Malaysia), The Ministry of Agriculture, Forestry and Fisheries (MAFF, Japan), Malaysia Agricultural Research and Development Institute (MARDI) and The Subang Jaya Municipal Council (MPSJ). We managed to secure the JICA-JST SATREPS International Grant for the period 2013-2017, with a matching grant from The Ministry of Education Malaysia, to set up an integrated zero-emission showcase pilot plant at Keningau Palm Oil Mill in Sabah. Under the JICA-JST SATREPS project, we continue to strengthen the academic and research collaboration with Professor Yoshihito Shirai and co-workers from Kyushu Institute of Technology, Dr. Satoshi Hirata and co-workers from Advanced Institute of Science and Technology (AIST) Japan, Professor Dr. Kenji Sakai and co-workers from Kyushu University and Professor Dr. Charles Vairappan and co-workers from Universiti Malaysia Sabah. We also conducted collaborative research projects with the industry, namely Indah Water Konsortium (IWK) on composting of sewage sludge, and with CES Company, Korea on biochar from oil palm biomass. In total, we have RM 3,934,726 in R&D grants in 2014. In terms of output, we successfully published 28 research papers in 2014, with 12 in Quartile 1 (Q1) and 9 in Quartile 2 (Q2), with a total of 66.298 Impact Factors. We also filed 1 Patent in 2014 and won 3 medals in 'Pameran Rekacipta, Penyelidikan dan Inovasi 2014' and Malaysia Technology Expo 2014.

I appreciate the hard work from all EB members in maintaining our high-performance culture. May ALLAH give us the strength to continue the good work and contribute to the university, the ummah and the nation.

Thank you. Wassalam.

Professor Dr. Mohd Ali Hassan
alihas@upm.edu.my

EB GROUP

OIL PALM BIOMASS

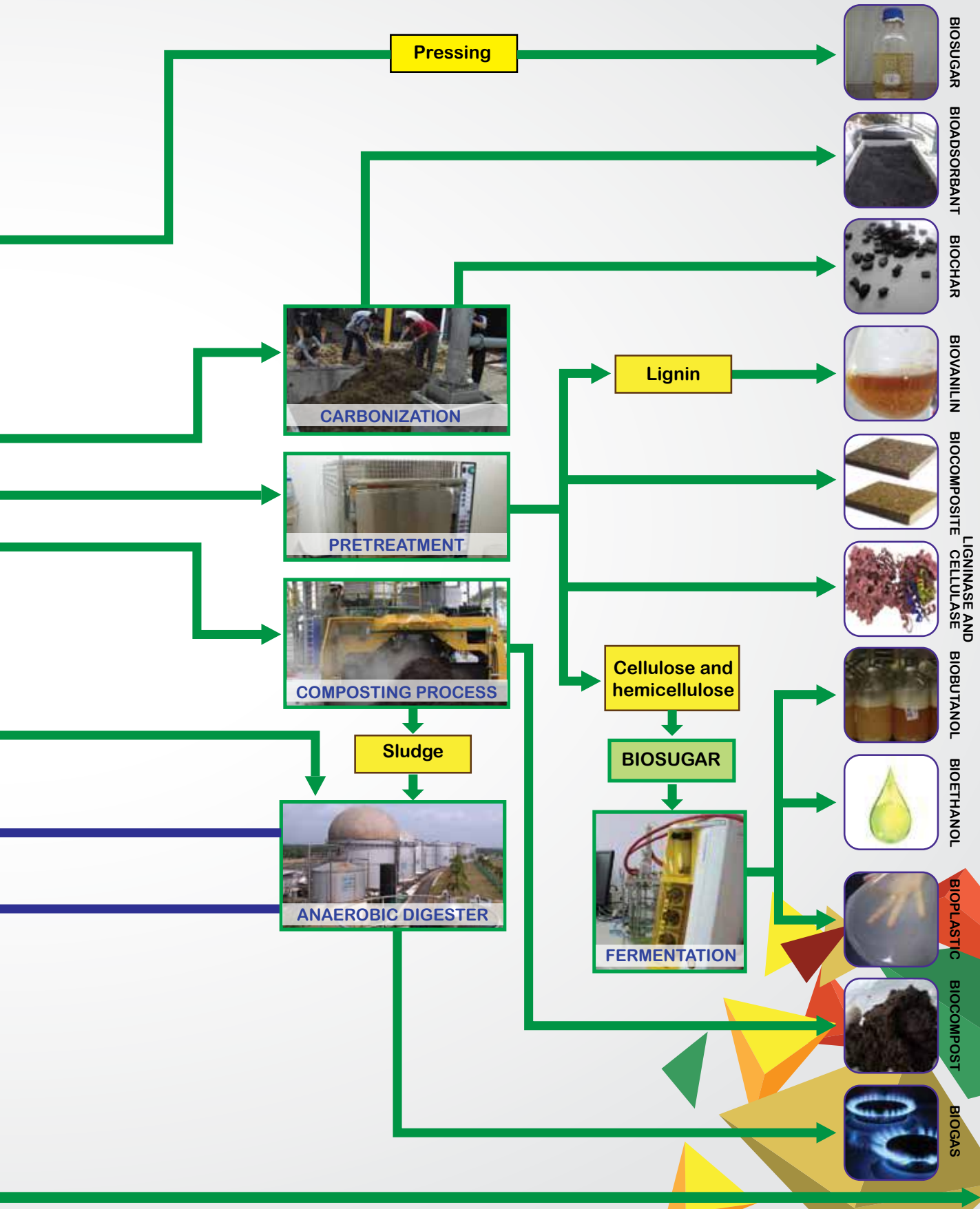
MAIN PRODUCTS

Methane for electricity generation

POME final discharge treated with bioadsorbent

TRADITIONAL TECHNOLOGY

BIG PICTURE



EMERGING TECHNOLOGY

SERDANG BIOMASS

BIOCOMPOST

Composting Process

Biodiesel Production

BIODIESEL

BIOREFINERY COMPLEX AT UNIVERSITI PUTRA MALAYSIA

- Landscaping Waste
- Livestock Manure
- Sewage Sludge
- Municipal Solid Waste
- Used Cooking Oil

UPM UNIVERSITI PUTRA MALAYSIA BERILMU BERBAKTI
Kyutech Kyushu Institute of Technology

TOWN BIG PICTURE

BIOCHAR

Carbonization Process

Sludge

Biogas Production

Segregation

FOOD WASTE

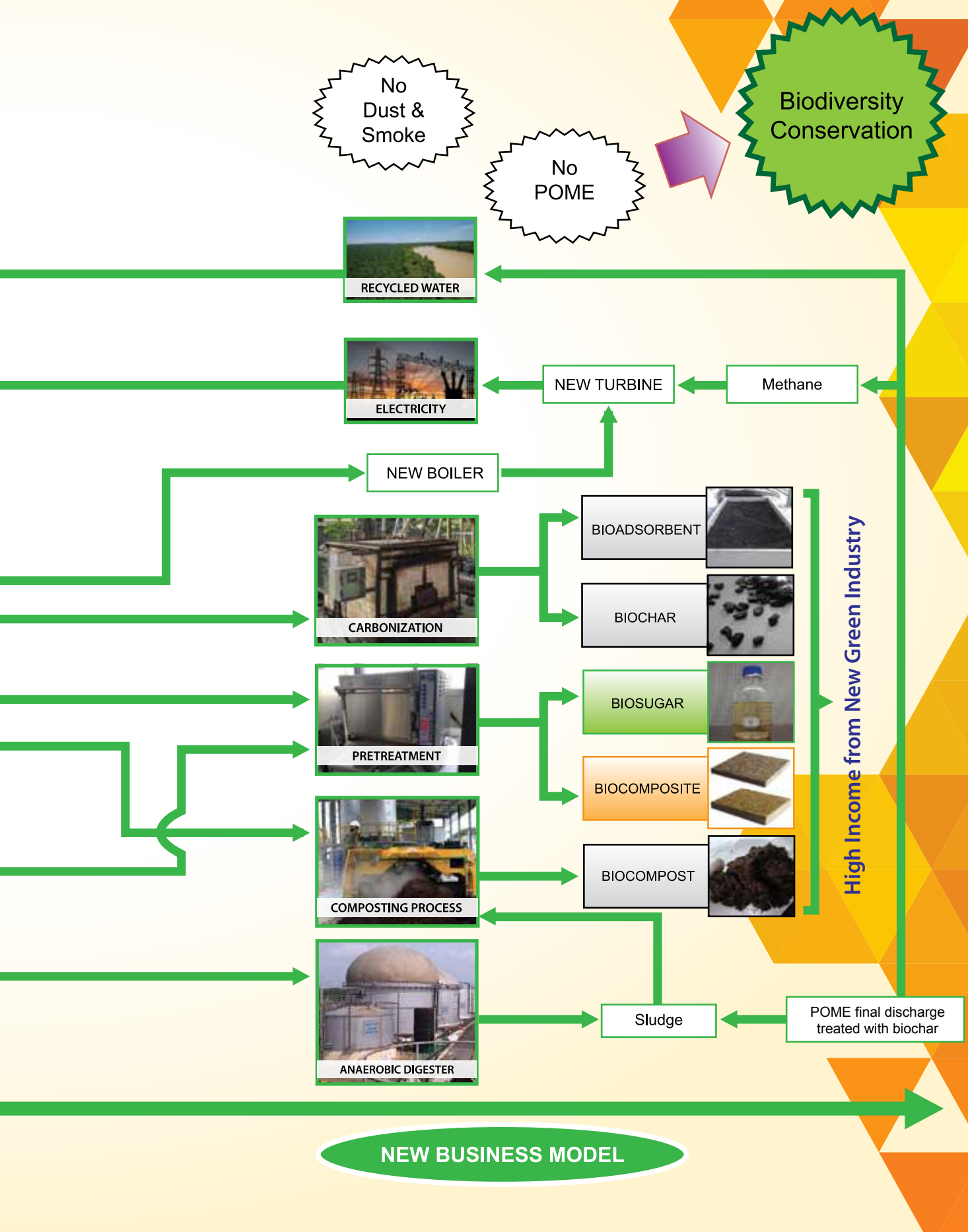
RECYCLEABLE MATERIALS

BIOGAS

SATREPS


TRADITIONAL PRODUCTS
RAW MATERIALS
OIL PALM TREE
FRESH FRUIT BUNCH
CRUDE PALM OIL
KERNEL
RIVER WATER
PALM OIL MILL
Crisis in Biodiversity
ELECTRICITY + STEAM
Chemical Treatment
HOLDING POND
TURBINE
Air Pollution
Dust and Smoke
BOILER
SHELL
MESOCARP FIBRE
Mulching and dumping
EMPTY FRUIT BUNCH
Heat
EXCESS STEAM
Water Pollution
POME final discharge
BOD 50ppm
COD 600ppm
Methane
ANAEROBIC TREATMENT
POME
AEROBIC TREATMENT
BUSINESS AS USUAL

BIG PICTURE


No Dust & Smoke
No POME
Biodiversity Conservation
RECYCLED WATER
ELECTRICITY
NEW TURBINE
Methane
NEW BOILER
CARBONIZATION
BIOADSORBENT
BIOCHAR
PRETREATMENT
BIOSUGAR
BIOCOMPOSITE
COMPOSTING PROCESS
BIOCOMPOST
High Income from New Green Industry
ANAEROBIC DIGESTER
Sludge
POME final discharge treated with biochar
NEW BUSINESS MODEL

EB GROUP Researcher

Professor Dr. Mohd Ali Hassan

Specialization:
Bioprocess Engineering and Environmental Biotechnology

Current research interest:
Treatment and utilization of biomass for the production of bio-based products, bioremediation and reduction of greenhouse gases

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Academic Qualification:

(a) PhD (Environmental Biotechnology), University of Okayama, Japan (1997)

(b) M. Phil. (Chemical Engineering), University of Birmingham, U.K. (1990)

(c) M.Sc. (Food Engineering), University of Leeds, U.K. (1982)

(d) B.Sc. (Honours)(Chemical Engineering), University of Leeds, U.K. (1980)

(e) 'A' Levels (Math., Chem., Physics), Oxford College Further Edu., U.K. (1977)

(f) Post-graduate Diploma (Islamic Studies), University Kebangsaan Malaysia (1985)

Selected Publications:

Mohd Ridzuan Othman, Mohd Ali Hassan, Azhari Samsu Baharuddin, Yoshihito Shirai, Ahmad Amiruddin Mohd Ali and Juferi Idris. 2014. Treatment of palm oil mill effluent final discharge wastewater to achieve river water quality for use as recycled water in zero emission system. Journal of Cleaner Production. 67, 58-61.

Mohd Huzairi Mohd Zainudin, Mohd Ali Hassan, Norhani Abdullah, Mitsunori Tokura, Hisashi Yasueda, Yoshihito Shirai and Azhari Samsu Baharuddin. 2014. Bacterial community and biochemical changes associated with composting of lignocellulose oil palm empty fruit bunch. BioResources. 9(1), 316-335.

Mior Ahmad Khushairi Mohd Zahari, Sharifah Soplah Syed Abdullah, Ahmad Muhaimin Roslan, Hidayah Ariffin, Yoshihito Shirai and Mohd Ali Hassan. 2014. Efficient utilization of oil palm frond for bio-based products and biorefinery. Journal of Cleaner Production. 65, 252-260.

Mohd Rafein Zakaria, Satoshi Hirata and Mohd Ali Hassan. 2014. Combined pretreatment using alkaline hydrothermal and ball milling to enhance enzymatic hydrolysis of oil palm mesocarp fiber. Bioresource Technology. 169, 236-243.

Tatsuya Yoshizaki, Yoshihito Shirai, Mohd Ali Hassan, Azhari Samsu Baharuddin, Nik Mustapha Raja Abdullah, Alawi Sulaiman and Zainuri Busu. 2013. Improved economic viability of integrated biogas and compost production for sustainable palm oil mill management. Journal of Cleaner Production. 44, 1-7.

Mohd Ali Hassan, Yee Lian-Ngit, Phang Lai Yee, Hidayah Ariffin, Raha Abdul Rahim, Yoshihito Shirai and Kumar Sudesh. 2013. Sustainable production of polyhydroxyalkanoates from renewable oil palm biomass. Biomass and Bioenergy. 50, 1-9.

Mohd Huzairi Mohd Zainudin, Mohd Ali Hassan, Mitsunori Tokura and Yoshihito Shirai. 2013. Indigenous cellulolytic and hemicellulolytic bacteria enhanced rapid composting of lignocellulose oil palm empty fruit bunch with palm oil mill effluent anaerobic sludge. Bioresource Technology. 147, 632-635.

Mior Ahmad Khushairi Mohd Zahari, Mohd Rafein Zakaria, Hidayah Ariffin, Mohd Noriznan Mokhtar, Jailani Salihon, Yoshihito Shirai and Mohd Ali Hassan. 2012. Renewable sugars from oil palm frond juice as an alternative novel feedstock for value added products. Bioresource Technology. 110, 566-571.

Mitra Mohammadi, Mohd Ali Hassan, Phang Lai Yee, Hidayah Ariffin, Yoshihito Shirai and Yoshito Ando. 2012. Recovery and purification of intracellular polyhydroxyalkanoates from recombinant *Cupriavidus necator* using water and ethanol. Biotechnology Letters, 34 (2), 253-259.

Saleha Shamsudin, Umi Kalsom Md Shah, Huzairi Zainudin, Suraini Abd-Aziz, Siti Mazlina Mustapa Kamal, Yoshihito Shirai and Mohd Ali Hassan. 2012. Effect of steam pretreatment on oil palm empty fruit bunch for the production of sugars. Biomass and Bioenergy, 36, 280-288.

Researcher EB GROUP

Professor Dr. Suraini Abd-Aziz

Specialization:
Biochemical Engineering and Enzyme Technology

Current research interest:
Utilization of lignocellulosic biomass for bioenergy and biobased chemicals

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Academic Qualification:

(a) PhD (Biochemical Engineering), University of Wales, Swansea, United Kingdom (1997)

(b) M.Sc. (Biochemical Engineering), University of Wales, Swansea, United Kingdom (1994)

(c) B.Sc. (Hons) (Clinical Biochemistry), Universiti Kebangsaan Malaysia (1992)

Selected Publications:

Mohd Azwan Jenol, Mohamad Faizal Ibrahim, Phang Lai Yee, Madihah Md Salleh and Suraini Abd-Aziz. 2014. Sago biomass as a sustainable source for biohydrogen production by *Clostridium butyricum* A1. BioResources. 9(1), 1007-1026.

Zuraidah Zanirun, Ezyana Kamal Bahrin, Phang Lai-Yee, Mohd Ali Hassan and Suraini Abd-Aziz. 2014. Effect of physical and chemical properties of lignocellulosic biomass on cellulases production by *Trichoderma asperellum* UPM1 and *Aspergillus fumigatus* UPM2. Applied Biochemistry and Biotechnology. 172, 423-435.

Nur Ain Zamzuri, Suraini Abd-Aziz, Raha Abd Rahim, Lai Yee Phang, Noorjahan Banu Alitheen and Toshinari Maeda. 2014. Rapid colorimetric screening method for vanillin and vanillic acid-producing strains. Journal of Applied Microbiology. 116(4), 903-910.

Shankar Ramanathan, Madihah Md. Salleh, Shaza Eva Mohammed, Nur Aswati Kader Olee, Suraini Abd-Aziz and Kamarulzaman Kamaruddin. 2014. Application of different feeding strategies in fed batch culture for pullulanase production using sago starch. Carbohydrate Polymers. 102, 962-969.

Nurul Atika Mohamad Remli, Umi Kalsom Md Shah, Rosfarizan Mohamad and Suraini Abd-Aziz. 2014. Effects of chemical and thermal pretreatments on the enzymatic saccharification of rice straw for sugars production. BioResources. 9(1), 510-522.

Fairouz Mohd Aanifah, Phang Lai-Yee, Helmi Wasoh and Suraini Abd-Aziz. 2014. Effect of different alkaline treatment strategies on the release of ferulic acid from oil palm empty fruit bunch fibres. Journal of Oil Palm Research. 26(4), 321-331.

Lam, Han Yuen, Khatijah Yusoff, Swee Keong Yeap, Tamilselvan Subramani, Suraini Abd-Aziz, Abdul Rahman Omar and Noorjahan Banu Alitheen. 2014. Immunomodulatory effects of Newcastle Disease virus AF2240 strain on human peripheral blood mononuclear cells. International Journal of Medical Sciences. 11, 1240-1247.

Nur Amelia Azreen Adnan, Sheril Norliana Suhaimi, Suraini Abd-Aziz, Mohd Ali Hassan and Lai-Yee Phang. 2014. Optimization of bioethanol production from glycerol by *Escherichia coli* SS1. Renewable Energy. 66, 625-633.

Seminars Presented 2014:

Chairman for the Asian Federation of Biotechnology Regional Symposium. Kuala Lumpur, Malaysia. February 9-11, 2014.

Invited Speaker: The 8th Korea-ASEAN Joint Symposium on Biomass Utilization and Renewable Energy: Integration of Agriculture and Biotechnology. Seoul, Korea. 18-22 August, 2014.

Invited Speaker: AFOB Bioenergy & Biorefinery Divison Annual Meeting and Bioenergy & Biorefinery Summit. Jinan, China. 24-27 August, 2014.

Invited Speaker: AFOB International Symposium 2014 and AFOB Delegate Meeting. Changwon & Songdo, Korea. 6-8 October, 2014

EB GROUP Researcher

Dr. Hidayah Ariffin

Specialization:
Bioprocess Engineering, Environmental Biotechnology and Biomaterials.

Current research interest:
Utilization of oil palm biomass for the production of bio-based chemicals, biopolymers and biocomposites; chemical recycling of biopolymers.

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Academic Qualification:

(a) PhD (Environmental Engineering) Kyushu Institute of Technology, Japan (2009)

(b) M.Sc. (Bioprocess Engineering) Universiti Putra Malaysia (2006)

(c) Bachelor of Engineering (Process and Food) Universiti Putra Malaysia (2004)

researcher

Selected Publications:

Mohd Rahimi Zakaria Mamat, Hidayah Ariffin, Mohd Ali Hassan and Mior Ahmad Khushairi Mohd Zahari. 2014. Bio-based production of crotonic acid by pyrolysis of poly(3-hydroxybutyrate) inclusions. Journal of Cleaner Production. 83, 463-472.

Che Mohd Hakiman Che Maail, Hidayah Ariffin, Mohd Ali Hassan, Umi Kalsom Md Shah and Yoshihito Shirai. 2014. Oil palm frond juice as future fermentation substrate: a feasibility study. BioMed Research International. 2014, Article ID 465270.

Mior Ahmad Khushairi Mohd Zahari, Sharifah Soplah Syed Abdullah, Ahmad Muhaimin Roslan, Hidayah Ariffin, Yoshihito Shirai and Mohd Ali Hassan. 2014. Efficient utilization of oil palm frond for bio-based products and biorefinery. Journal of Cleaner Production. 65, 252-260.

Noor Farisha Abd. Rahim, Kohtaro Watanabe, Hidayah Ariffin, Yoshito Andou, Mohd Ali Hassan and Yoshihito Shirai. 2014. Design of bio-based monomers from oleic and linoleic acids for greener polyester. Chemistry Letters. 43 (9), 1517-1519.

Yoon Yee Then, Nor Azowa Ibrahim, Norhazlin Zainuddin, Hidayah Ariffin, Wan Md Zin Wan Yunus and Buong Woei Chieng. 2014. The influence of green surface modification of oil palm mesocarp fiber by superheated steam on the mechanical properties and dimensional stability of oil palm mesocarp fiber/poly (butylene succinate) biocomposite. International Journal of Molecular Sciences. 15 (9), 15344-15357.

Chern Chiet Eng, Nor Azowa Ibrahim, Norhazlin Zainuddin, Hidayah Ariffin and Wan Md Zin Wan Yunus. 2014. Impact strength and flexural properties enhancement of methacrylate silane treated oil palm mesocarp fiber reinforced biodegradable hybrid composites. The Scientific World Journal. 2014 (2014), Article ID 213180.

Book Chapter:

Haruo Nishida, Hidayah Ariffin, Yoshihito Shirai and Mohd Ali Hassan. 2010. Precise Depolymerization of Poly(W-hydroxybutyrate) by Pyrolysis. In: Biopolymers. Ed. Magdy M. Elnashar. 369-386 pp. Sciyo: Rijeka.

Patents:

Hidayah Ariffin, Nur Falia Shazana Manja Farid, Mohd Rahimi Zakaria @ Mamat and Mohd Ali Hassan. 2014. Bio-based crotonic acid Production. PI2014702609. Filing date: 12th September 2014. Filed.

Mohd Ali Hassan, Hidayah Ariffin, Mior Ahmad Khushairi Mohd Zahari, Mohd Rafein Zakaria, Jailani Salihon, Mohd Noriznan Mokhtar and Yoshihito Shirai. 2012. Renewable sugars from oil palm waste. PCT/MY2012/000218. Filed

Haruo Nishida, Yoshito Ando, Subbian Karuppuchamy, Yoshihito Shirai, Noor Ida Amalina, Hidayah Ariffin and Mohd Ali Hassan. Biomass powder derived from oil palm and production method therefor, and biomass-composite molded body and production method therefor. 2012. Japanese Patent. PCT/JP2012/007427. Filed.

Mohd Ali Hassan, Mitra Mohammadi, Phang Lai Yee, Hidayah Ariffin, Yee Lian Ngit and Yoshihito Shirai. 2012. Polyhydroxyalkanoate recovery. PI 2012700848. Filed.

Researcher EB GROUP

Dr. Mohd Rafein Zakaria

Specialization:
Environmental Biotechnology and Bioprocess Engineering

Current research interest:
Biomass valorization in biorefinery concept

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Academic Qualification:
(a) PhD (Environmental Biotechnology), Universiti Putra Malaysia (2012)

(b) M.Sc. (Environmental Biotechnology), Universiti Putra Malaysia (2008)

(c) B.Sc. (Hons) Biotechnology, Universiti Putra Malaysia (2003)

Selected Publications:

Faiqah Abd-Rahim, Helmi Wasoh, Mohd Rafein Zakaria, Arbakariya Ariff, Rizal Kapri, Nazaruddin Ramli and Liew Siew-Ling. 2014. Production of high yield sugars from *Kappaphycus alvarezii* using combined methods of chemical and enzymatic hydrolysis. Food Hydrocolloids. 42, 309-315.

Mohd Rafein Zakaria, Satoshi Hirata and Mohd Ali Hassan. 2014. Combined pretreatment using alkaline hydrothermal and ball milling to enhance enzymatic hydrolysis of oil palm mesocarp fiber. Bioresource Technology. 169, 236-243.

Mohd Rafein Zakaria, Shinji Fujimoto, Satoshi Hirata and Mohd Ali Hassan. 2014. Ball milling pretreatment of oil palm biomass for enhancing enzymatic hydrolysis. Applied Biochemistry and Biotechnology. 173: 7.

Mohd Rafein Zakaria, Hidayah Ariffin, Suraini Abd-Aziz, Mohd Ali Hassan and Yoshihito Shirai. 2013. Improved properties of poly(3-hydroxybutyrate-co-3-hydroxyvalerate) produced by *Comamonas* sp. EB172 utilizing volatile fatty acids by regulating the nitrogen source. BioMed Research International., 2013, 1-8.

Nordiyana Nordin, Mohd Rafein Zakaria, Mohd Izuan Effendi Halmi, Arbakariya B. Ariff, Ruzniza Mohd Zawawi and Helmi Wasoh. 2013. Isolation and screening of high efficiency biosurfactant-producing bacteria *Pseudomonas* sp. Journal of Biochemistry, Microbiology and Biotechnology. 1, 25-31.

Nur Haziqah Aniyah Salihan, Arbakariya Ariff, Mohd Rafein Zakaria, Suraini Abd_ Aziz, Md Noor Abd Wahab and Helmi Wasoh. 2013. Performance of B-glucosidase produced by *Ganoderma lucidum* using waste substrate as carbon source. Journal of Biochemistry, Microbiology and Biotechnology. 1, 17-24.

Mior Ahmad Khushairi Mohd Zahari, Mohd Rafein Zakaria, Hidayah Ariffin, Mohd Nooriznan Mokhtar, Jailani Salihon, Yoshihito Shirai and Mohd Ali Hassan. 2012. Renewable sugars from oil palm frond juice as an alternative novel fermentation feedstock for value-added products. Bioresource Technology. 110, 566-571.

Noor Azman Mohd Johar, Mohd Ali Hassan, Mohd Rafein Zakaria, Phang Lai Yee and Yoshihito Shirai. 2012. Evaluation of factors affecting polyhydroxyalkanoates production by *Comamonas* sp. EB172 using central composite design. Malaysian Journal of Microbiology, 8, 184-190.

Yee Lian Ngit , Tabassum Mumtaz, Mitra Mohammadi, Phang Lai Yee, Yoshito Ando, Raha Abdul Rahim, Sudesh Kumar, Mohd Ali Hassan, Hidayah Ariffin and Mohd Rafein Zakaria. 2012. Polyhydroxyalkanoate synthesis by recombinant *Escherichia coli* JM109 expressing PHA biosynthesis genes from *Comamonas* sp. EB172. Journal of Microbial and Biochemical Technology. 4, 103-110.

EB GROUP Researcher

Dr. Norhayati Ramli

Specialization:
Microbial Biotechnology and Environmental Biotechnology

Current research interest:
Molecular analysis of environmental microbial community; Strain improvement and utilization of biomass for the production of enzymes, bioproducts, bioethanol

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Academic Qualification:
(a) PhD (Microbial Biotechnology), Universiti Putra Malaysia (2012)

(b) B.Sc. (Biotechnology), Universiti Putra Malaysia (2008)

researcher

Selected Publications:

Norhayati Ramli, Suraini Abd-Aziz, Noorjahan Banu Alitheen, Mohd Ali Hassan and Toshinari Maeda. 2013. Improvement of cyclodextrin glycosyltransferase gene expression in *Escherichia coli* by insertion of regulatory sequences involved in the promotion of RNA transcription. Molecular Biotechnology. 54, 961-968.

Norhayati Ramli, Suraini Abd-Aziz, Mohd Ali Hassan, Noorjahan Banu Alitheen, Kamarulzaman Kamaruddin and Zoolhilmi Ibrahim. 2011. Molecular cloning and extracellular expression of cyclodextrin glycosyltransferase gene from *Bacillus* sp. NR5 UPM. African Journal of Microbiology Research. 5, 3475-3482.

Norhayati Ramli, Suraini Abd-Aziz, Mohd Ali Hassan, Noorjahan Banu Alitheen and Kamarulzaman Kamaruddin. 2010. Potential cyclodextrin glycosyltransferase producer from locally isolated bacteria. African Journal of Biotechnology. 9(43), 7317-7321.

Seminars Presented:

Speaker. Changes in the bacterial community structure in the palm oil mill effluent treatment in Malaysia. 2nd International Symposium on Applied Engineering and Sciences, Kyutech, Japan. December 20-21, 2014.

Participant. AFOB Regional Symposium 2014 (ARS2014), Kuala Lumpur, Malaysia. February 9-11, 2014.

Speaker. Development of a local bacterial isolate expressing cyclodextrin glycosyltransferase through molecular cloning approaches. International Symposium on Applied Engineering and Sciences, UPM. September 30-October 1, 2013.

Researcher EB GROUP

Dr. Mohamad Faizal Ibrahim

Specialization:
Enzyme Technology, Microbial Biotechnology, Industrial Biotechnology

Current research interest:
Biomass utilisation and conversion into biofuels and bio-based chemicals through biotechnology approaches

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Academic Qualification:
(a) PhD (Environmental Biotechnology), Universiti Putra Malaysia (2013)

(b) B.Sc. (Biotechnology), Universiti Putra Malaysia (2009)

(c) Diploma in Science, Universiti Teknologi MARA (2006)

Selected Publications:

Mohd Azwan Jenol, Mohamad Faizal Ibrahim, Phang Lai Yee, Madihah Md Salleh and Suraini Abd-Aziz. 2014. Sago biomass as a sustainable source for biohydrogen production by *Clostridium butyricum* A1. BioResources. 9 (1), 1007-1026.

Mohamad Faizal Ibrahim, Mohamad Nafis Abdul Razak, Phang Lai–Yee, Mohd Ali Hassan and Suraini Abd-Aziz. 2013. Crude cellulase from oil palm empty fruit bunch by *Trichoderma asperellum* UPM1 and *Aspergillus fumigatus* UPM2 for fermentable sugars production. Applied Biochemistry and Biotechnology. 170, 1320-1335.

Mohamad Nafis Abdul Razak, Mohamad Faizal Ibrahim, Phang Lai Yee, Mohd Ali Hassan and Suarini Abd-Aziz. 2013. Statistical optimization of biobutanol production from oil palm decanter cake hydrolysate by *Clostridium acetobutylicum* ATCC 824. BioResources. 8(2), 1758-1770.

Mohamad Faizal Ibrahim, Suraini Abd-Aziz, Mohamad Nafis Abdul Razak, Lai Yee Phang and Mohd Ali Hassan. 2012. Oil palm empty fruit bunch as alternative substrate for acetone–butanol–ethanol production by *Clostridium butyricum* EB6. Applied Biochemistry and Biotechnology. 166 (7), 1615-1625.

Ezyana Kamal Bahrin, Azhari Samsu Baharuddin, Mohamad Faizal Ibrahim, Mohamad Nafis Abdul Razak, Alawi Sulaiman, Suraini Abd-Aziz, Mohd Ali Hassan, Yoshihito Shirai and Haruo Nishida. 2012. Physicochemical property changes and enzymatic hydrolysis of oil palm empty fruit bunches treated with superheated steam. BioResources. 7(2), 1784-1801.

Mohamad Nafis Abdul Razak, Mohamad Faizal Ibrahim, Suraini Abd-Aziz, Phang Lai Yee and Mohd Ali Hassan. 2012. Utilization of oil palm decanter cake for cellulase and polyoses production. Biotechnology and Bioprocess Engineering. 17: 547-555.

Ezyana Kamal Bahrin, Mohamad Faizal Ibrahim, Mohamad Nafis Abd Razak, Madihah Md Salleh , Umi Kalsom Md. Shah, Noorjahan Banu Alitheen and Suraini Abd-Aziz. 2012. Improved cellulase production by *Botryosphaeria rhodina* from OPEFB at low level of moisture condition through statistical optimization. Preparative Biochemistry and Biotechnology. 42 (2), 155 –170.

Seminars Presented in 2014:

Participant. AFOB Regional Symposium 2014 (ARS2014), Kuala Lumpur, Malaysia. February 9-11, 2014.

Speaker. Biofuels production through simultaneous acetone-butanol-ethanol fermentation using oil palm empty fruit bunch as substrate. AFOB Bioenergy and Biorefinery Division Annual Meeting and Bioenergy and Biorefinery Summit 2014, Jinan, China. August 24-27, 2014.

Speaker. Co-production of biobutanol and biohydrogen from pretreated oil palm empty fruit bunch through simultaneous saccharification and fermentation. 2nd International Symposium on Applied Engineering and Sciences 2014 (SAES2014), Kitakyushu, Japan. December 20-21, 2014.

EB GROUP Researcher

Dr. Mohd Zulkhairi Mohd Yusoff

Specialization:
Environmental Biotechnology and Molecular Biotechnology

Current research interest:
Biomass utilization for biohydrogen production, bioenergy, biocomposting, microbial fuel cells, molecular biotechnology applications

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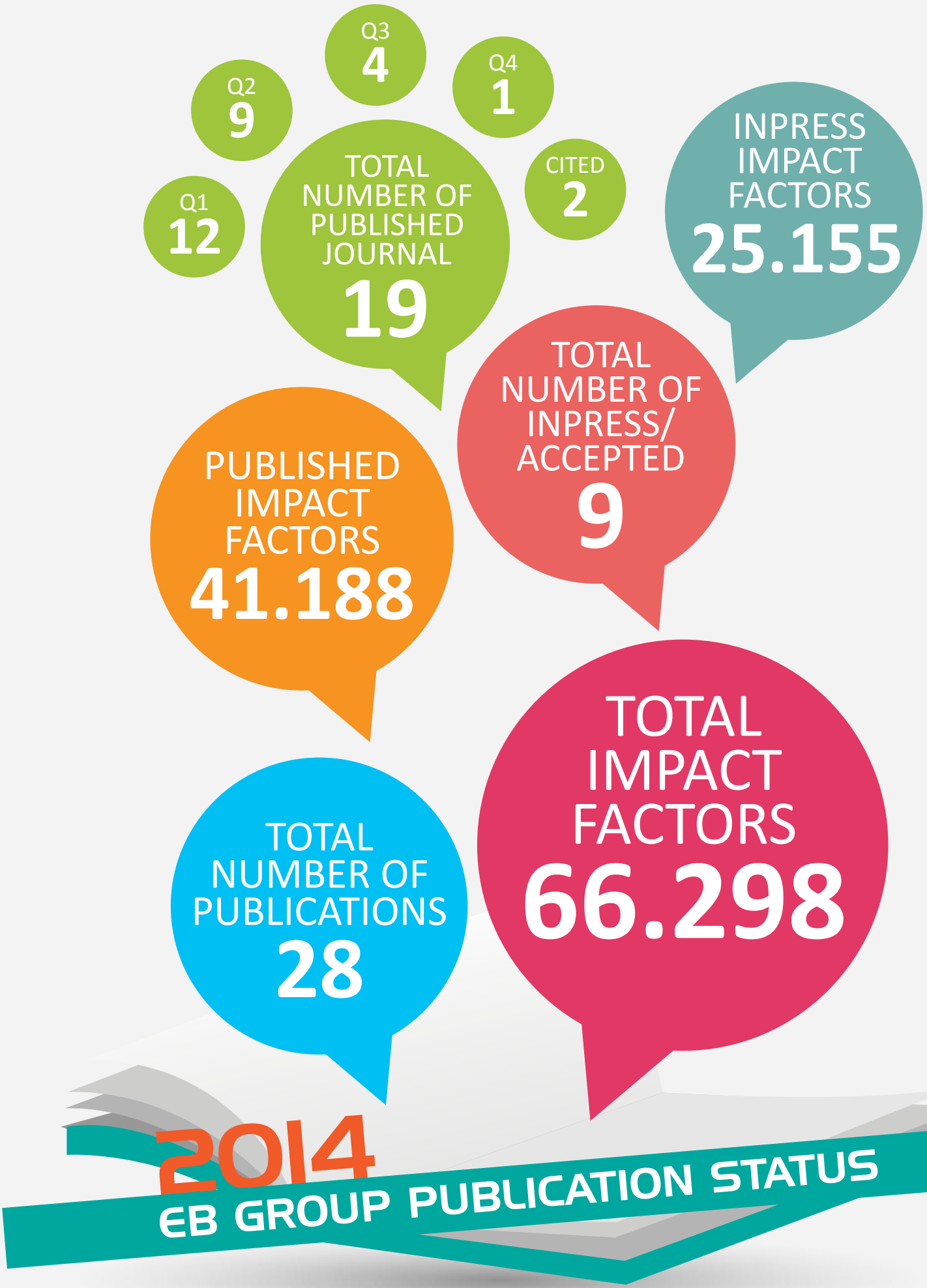
Q3
4
Q4
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Q2
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Q1
12
TOTAL NUMBER OF PUBLISHED JOURNAL
19
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9
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Q1
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Bioresource Technology

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Combined pretreatment using alkaline hydrothermal and ball milling to enhance enzymatic hydrolysis of oil palm mesocarp fiber

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HIGHLIGHTS

- Oil palm mesocarp fiber suitable lignocellulosic biomass for biosugar production.
- Hydrothermal treatment improved hemicellulose removal and lignin migration.
- Alkaline hydrothermal treatment improved ester bond cleavage and delignification.
- Mechanochemical treatment reduced particle size and crystallinity of cellulose.
- The highest xylose and glucose obtained were 63.2% and 97.3%.

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Oil palm mesocarp fiber
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ABSTRACT

Hydrothermal pretreatment of oil palm mesocarp fiber was conducted in tube reactor at treatment severity ranges of log Ro = 3.66–4.83 and partial removal of hemicellulose with migration of lignin was obtained. Concerning maximal recovery of glucose and xylose, 1.5% NaOH was impregnated in the system and subsequent ball milling treatment was employed to improve the conversion yield. The effects of combined hydrothermal and ball milling pretreatments were evaluated by chemical composition changes by using FT-IR, WAXD and morphological alterations by SEM. The successful of pretreatments were assessed by the degree of enzymatic digestibility of treated samples. The highest xylose and glucose yields obtained were 63.2% and 97.3% respectively at cellulase loadings of 10 FPU/g-substrate which is the highest conversion from OPMF ever reported.

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Carbohydrate Polymers 102 (2014) 962–969

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Application of different feeding strategies in fed batch culture for pullulanase production using sago starch

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Pullulanase
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ABSTRACT

The production of pullulanase by *Bacillus flavothermus* KWF-1 in batch and fed batch culture were compared using 2 L bioreactor. In batch culture, 0.0803 U/mL of pullulanase activity with specific activity of 0.0213 U/mg was produced by controlling the agitation speed and temperature at 200 rpm and 50 °C, respectively. Fed batch production was studied by feeding the culture with different sago starch concentrations in various feeding modes for enhanced pullulanase production. Exponential feeding mode at dilution rate of 0.01/h was the preeminent strategy for enhanced pullulanase production of 0.1710 U/mL with specific activity of 0.066 U/mg. It had shown an increment of pullulanase production and specific activity by 2.1 and 3.1-fold, respectively when compared to batch culture. Increment of pullulanase activity in exponential feeding mode improved hydrolyzation of sago starch into maltotriose and panose by 4.5 and 2.5-fold respectively compared to batch system.

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Bio-based production of crotonic acid by pyrolysis of poly(3-hydroxybutyrate) inclusions

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Crotonic acid
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ABSTRACT

Bio-based material development has become a new focus globally due to limited supply, increasing price of fossil fuel, and demands for environment sustainability. Current industrial production of crotonic acid through petrochemical route has several drawbacks: i) non-renewable, as it is derived from petroleum resource, ii) involves numerous complicated steps, and iii) produces low yield. Therefore, this paper proposes a method for production of bio-based crotonic acid by direct pyrolysis of bacterial poly(3-hydroxybutyrate) inclusion as an alternative to the petrochemical route. Thermogravimetric profile of poly(3-hydroxybutyrate) inclusions showed poly(3-hydroxybutyrate) degradation occurred at a temperature range of 270 °C–350 °C with maximum degradation rate at 310 °C. Analysis of products from isothermal pyrolysis of poly(3-hydroxybutyrate) at 310 °C revealed that pyrolysis of poly(3-hydroxybutyrate) inclusions yielded approximately 63% of crotonic acid. This is 30% higher than the conventional crotonic acid production via petrochemical method. The proposed method also offers other benefits such as renewable and simpler in processing. Besides, by-products of fermentation and pyrolysis are easy to treat, thus minimizing threat to the environment. Moreover, demands for bio-based products are expected to rise in the near future because of social, environmental and economical issues related to fossil resources which make bio-based production method more appealing and favourable. Therefore, pyrolysis of bacterial poly(3-hydroxybutyrate) inclusions provides new insight of renewable and green chemistry of the crotonic acid production.

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Efficient utilization of oil palm frond for bio-based products and biorefinery

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Oil palm frond petiole
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ABSTRACT

The prospect of oil palm frond (OPF) juice as fermentation feedstock was investigated by taking two bioproducts, i.e. poly(3-hydroxybutyrate), P(3HB) and bioethanol as example. P(3HB) was successfully produced by *Cupriavidus necator* NCIMB 11599 from OPF juice through fed-batch fermentation with cell dry mass and PHB content of 40 g/l and 75 wt.%, respectively. On the other hand, bioethanol fermentation from OPF juice was conducted by using Baker's yeast, with and without nitrogen source supplementation. Ethanol yield of 0.49 g/g sugars was recorded when OPF juice was supplemented with nitrogen source. Furthermore, OPF pressed fiber obtainable after pressing the OPF juice was saccharified in order to obtain more fermentable sugars from OPF petiole. Hydrolysis of OPF fiber holocellulose into sugars was very high at 95%, contributed by the low lignin content in OPF and pre-treatment by wet disc-mill. Apart from fermentation, OPF pressed fiber is also useful for bio-based plastics, ruminant feed, reinforce material for biocomposites and bio-briquettes. Efficient utilization of OPF petiole proposed herewith can be an alternative pathway to the contribution of green and sustainable biorefinery.

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Treatment of effluents from palm oil mill process to achieve river water quality for reuse as recycled water in a zero emission system

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ABSTRACT

A major problem facing the palm oil industry is the need to use fresh river water for processing which leads to the discharge of treated palm oil mill effluent (POME) to the river daily. In this paper, we propose a practical solution using activated carbon and selected coagulants for the zero emission of POME final discharge, using river water quality as the benchmark. The target was on the reduction of chemical oxygen demand (COD) and suspended solids (SS) to meet river water quality for recycling and reuse of the POME final discharge as boiler feed water to fulfil the zero emission concept. Our results showed that a new two-step process, based on adsorption of organic pollutants on activated carbon (AC), with a ratio of 10 g AC per 1 L of wastewater (POME), followed by coagulation using a ratio of 0.6 g of polyaluminium chloride per 1 L of treated POME, was the best treatment. By using this new proposed treatment the final COD and SS of resulted residual water from palm oil mill process were 10 mg L^{-1} and 2 mg L^{-1}, respectively, which is better than river water quality. Therefore the objective of zero emission of POME final discharge can be achieved.

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1.549

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Bacterial Community Structure and Biochemical Changes Associated With Composting of Lignocellulosic Oil Palm Empty Fruit Bunch

Mohd Huzairi Mohd Zainudin,[a] Mohd Ali Hassan,[a,*] Umi Kalsom Md Shah,[a] Norhani Abdullah,[b,c] Mitsunori Tokura,[d] Hisashi Yasueda,[d] Yoshihito Shirai,[e] Kenji Sakai,[f] and Azhari Samsu Baharuddin [g]

Bacterial community structure and biochemical changes during the composting of lignocellulosic oil palm empty bunch (EFB) and palm oil mill effluent (POME) anaerobic sludge were studied by examining the succession of the bacterial community and its association with changes in lignocellulosic components by denaturing gradient gel electrophoresis (DGGE) and the 16S rRNA gene clone library. During composting, a major reduction in cellulose after 10 days from 50% to 19% and the carbon content from 44% to 27% towards the end of the 40-day composting period were observed. The C/N ratio also decreased. A drastic change in the bacterial community structure and diversity throughout the composting process was clearly observed using PCR-DGGE banding patterns. The bacterial community drastically shifted between the thermophilic and maturing stages. 16s rRNA clones belonging to the genera *Bacillus*, *Exiguobacterium*, *Desemzia*, and *Planococcus* were the dominant groups throughout composting. The species closely related to *Solibacillus silvestris* were found to be major contributors to changes in the lignocellulosic component. Clones identified as *Thermobacillus xylanilyticus*, *Brachybacterium faecium*, *Cellulosimicrobium cellulans*, *Cellulomonas* sp., and *Thermobifida fusca*, which are known to be lignocellulosic-degrading bacteria, were also detected and are believed to support the lignocellulose degradation.

Keywords: Composting; Lignocellulose degradation; Denaturing gradient gel electrophoresis; 16S rRNA gene clone library

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Compositional and Morphological Changes of Chemical Modified Oil Palm Mesocarp Fiber by Alkaline Bleaching and Silane Coupling Agents

Chern Chiet Eng,[a] Nor Azowa Ibrahim,[a,*] Norhazlin Zainuddin,[a] Hidayah Ariffin,[b] and Wan Md Zin Wan Yunus [c]

In this study, the effects of chemical modifications of oil palm mesocarp fiber (OPMF) *via* bleaching, silane coupling agents, and combinations of the two on the composition and morphology of OPMF were investigated. The chemically modified OPMF was characterized by Fourier transform infrared spectroscopy (FTIR), thermogravimetric analysis (TGA), and scanning electron microscopy (SEM). The FTIR spectra showed that bleached OPMF became more hydrophilic, while silanized unbleached and silanized bleached OPMF became less hydrophilic. The TGA thermograms indicated that bleaching successfully removed hemicellulose from the OPMF, while TGA analysis showed that silanized unbleached and silanized bleached OPMF had higher thermal stabilities than unbleached or bleached OPMF. The SEM micrographs revealed that the modified OPMF surface was rougher and more porous than that of the unbleached OPMF, further indicating that OPMF was successfully modified.

Keywords: Oil palm mesocarp fiber; Chemical modification; Bleaching; Silane coupling agent

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Q1
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1.549

Published

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PEER-REVIEWED ARTICLE bioresources.com

Sago Biomass as a Sustainable Source for Biohydrogen Production by *Clostridium butyricum* A1

Mohd Azwan Jenol,[a] Mohamad Faizal Ibrahim,[a] Phang Lai Yee,[a] Madihah Md Salleh,[b] and Suraini Abd-Aziz [a,*]

Biohydrogen production from biomass is attracting many researchers in developing a renewable, clean and environmental friendly biofuel. The biohydrogen producer, *Clostridium butyricum* A1, was successfully isolated from landfill soil. This strain produced a biohydrogen yield of 1.90 mol H_2/mol glucose with productivity of 170 mL/L/h using pure glucose as substrate. The highest cumulative biohydrogen collected after 24 h of fermentation was 2468 mL/L-medium. Biohydrogen fermentation using sago *hampas* hydrolysate produced higher biohydrogen yield (2.65 mol H_2/mol glucose) than sago pith residue (SPR) hydrolysate that produced 2.23 mol H_2/mol glucose. A higher biohydrogen productivity of 1757 mL/L/h was obtained when using sago *hampas* hydrolysate compared to when using pure glucose that has the productivity of 170 mL/L/h. A comparable biohydrogen production was also obtained by *C. butyricum* A1 when compared to *C. butyricum* EB6 that produced a biohydrogen yield of 2.50 mol H_2/mol glucose using sago *hampas* hydrolysate as substrate. This study shows that the new isolate *C. butyricum* A1 together with the use of sago biomass as substrate is a promising technology for future biohydrogen production.

Keywords: Biohydrogen; Sago hampas; Sago pith residue; Fermentable sugars; Clostridium butyricum

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Q2
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2.386

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ORIGINAL ARTICLE

A rapid colorimetric screening method for vanillic acid and vanillin-producing bacterial strains

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Keywords
biotransformation, biovanillin, ferulic acid, *Pseudomonas* sp., rapid screening, vanillic acid.

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doi:10.1111/jam.12410

Abstract

Aim: To isolate a bacterial strain capable of biotransforming ferulic acid, a major component of lignin, into vanillin and vanillic acid by a rapid colorimetric screening method.
Methods and Results: For the production of vanillin, a natural aroma compound, we attempted to isolate a potential strain using a simple screening method based on pH change resulting from the degradation of ferulic acid. The strain *Pseudomonas* sp. AZ_{10} UPM exhibited a significant result because of colour changes observed on the assay plate on day 1 with a high intensity of yellow colour. The biotransformation of ferulic acid into vanillic acid by the AZ10 strain provided the yield ($Y_{p/s}$) and productivity (P_r) of 1·08 mg mg^{-1} and 53·1 mg L^{-1} h^{-1}, respectively. In fact, new investigations regarding lignin degradation revealed that the strain was not able to produce vanillin and vanillic acid directly from lignin; however, partially digested lignin by mixed enzymatic treatment allowed the strain to produce 30·7 mg l^{-1} and 1·94 mg l^{-1} of vanillic acid and biovanillin, respectively.
Conclusions: (i) The rapid colorimetric screening method allowed the isolation of a biovanillin producer using ferulic acid as the sole carbon source. (ii) Enzymatic treatment partially digested lignin, which could then be utilized by the strain to produce biovanillin and vanillic acid.
Significance and Impact of the Study: To the best of our knowledge, this is the first study reporting the use of a rapid colorimetric screening method for bacterial strains producing vanillin and vanillic acid from ferulic acid.

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Master Student

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Hindawi

Research Article

Oil Palm Frond Juice as Future Fermentation Substrate: A Feasibility Study

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Oil palm frond (OPF) juice is a potential industrial fermentation substrate as it has high sugars content and the OPF are readily available daily. However, maximum sugars yield and storage stability of the OPF juice are yet to be determined. This study was conducted to determine the effect of physical pretreatment and storage duration of OPF petiole on sugars yield. Storage stability of OPF juice at different storing conditions was also investigated. It was found that OPF petiole squeezed by hydraulic pressing machine gave the highest sugars recovery at almost 40 g/kg, accounting for a recovery yield of 88%. Storage of OPF petiole up to 72 hrs prior to squeezing reduced the free sugars by 11 g/kg. Concentrated OPF juice with 95% water removal had the best storage stability at both 4 and 30°C, when it was stored for 10 days. Moreover, concentrated OPF syrup prepared by thermal processing did not give any Maillard effect on microbial growth. Based on our results, OPF juice meets all the criteria as a good fermentation substrate as it is renewable, consistently available, and easy to be obtained, it does not inhibit microbial growth and product formation, and it contains no impurities.

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2.505

Published

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BIOENERGY/BIOFUELS/BIOCHEMICALS

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Effect of azithromycin on enhancement of methane production from waste activated sludge

Minh Tuan Nguyen · Toshinari Maeda · Mohd Zulkhairi Mohd Yusoff · Hiroaki I. Ogawa

Received: 7 January 2014 / Accepted: 17 April 2014 / Published online: 3 May 2014

Abstract In the methane production from waste activated sludge (WAS), complex bacterial interactions in WAS have been known as a major contribution to methane production. Therefore, the influence of bacterial community changes toward methane production from WAS was investigated by an application of antibiotics as a simple means for it. In this study, azithromycin (Azm) as an antibiotic was mainly used to observe the effect on microbial changes that influence methane production from WAS. The results showed that at the end of fermentation, Azm enhanced methane production about twofold compared to control. Azm fostered the growth of acid-producing bacterial communities, which synthesized more precursors for methane formation. DGGE result showed that the hydrolysis as well as acetogenesis stage was improved by the dominant of B1, B2 and B3 strains, which are *Clostridium* species. In the presence of Azm, the total population of archaeal group was increased, resulting in higher methane productivity achievement.

Keywords Azithromycin · Bacterial community · Methane production · Sludge hydrolysis · Waste-activated sludge

Q2
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Dr. Hidayah Ariffin
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Article

The Influence of Green Surface Modification of Oil Palm Mesocarp Fiber by Superheated Steam on the Mechanical Properties and Dimensional Stability of Oil Palm Mesocarp Fiber/Poly(butylene succinate) Biocomposite

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Abstract: In this paper, superheated steam (SHS) was used as cost effective and green processing technique to modify oil palm mesocarp fiber (OPMF) for biocomposite applications. The purpose of this modification was to promote the adhesion between fiber and thermoplastic. The modification was carried out in a SHS oven at various temperature (200–230 °C) and time (30–120 min) under normal atmospheric pressure. The biocomposites from SHS-treated OPMFs and poly(butylene succinate) (PBS) at a weight ratio of 70:30 were prepared by melt blending technique. The mechanical properties and dimensional stability of the biocomposites were evaluated. This study showed that the SHS treatment increased the roughness of the fiber surface due to the removal of surface impurities and hemicellulose. The tensile, flexural and impact properties, as well as dimensional stability of the biocomposites were markedly enhanced by the presence of SHS-treated OPMF. Scanning electron microscopy analysis showed improvement of interfacial adhesion

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Q2
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Synthesis of Bio-based Monomer from Vegetable Oil Fatty Acids and Design of Functionalized Greener Polyester

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In order to design sustainable materials from vegetable oil-based fatty acids, we propose herewith a method to obtain unsaturated dicarboxylic acids as a polymerizable monomer through metathesis reaction of oleic and linoleic acids with the 2nd generation Grubbs catalyst. Subsequently, functional green polyester was produced from dicarboxylic acids and aromatic diol. Dicarboxylic acid having similar structure i.e., octadec-9-enedioic acid was successfully obtained from metathesis of both oleic and linoleic acids. Condensation polymerization of octadec-9-enedioic acid with 1,6-hexanediol and 4,4′-biphenol was carried out and it was shown that polymer with aromatic backbone had higher glass-transition temperature than aliphatic polyester.

Table 1. Synthesis of dicarboxylic acids from vegetable oil fatty acids

Entry	Fatty acid[b] /mmol	G2 /μmol	Reduced pressure[c]	Time /h	Temp /°C	Yield /%
1[a]	OA (35.4)	3.2	×	24	50	43.7
2	OA (35.4)	3.2	○	24	50	62.0
3	LA (35.7)	3.2	×	72	50	27.5
4	LA (35.7)	3.2	○	24	50	35.9

[a]Control conditions.[13] [b]OA: oleic acid, LA: linoleic acid. [c]×: no reduced pressure applied, ○: reduced pressure applied.

Published

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Hindawi

Research Article

Impact Strength and Flexural Properties Enhancement of Methacrylate Silane Treated Oil Palm Mesocarp Fiber Reinforced Biodegradable Hybrid Composites

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Natural fiber as reinforcement filler in polymer composites is an attractive approach due to being fully biodegradable and cheap. However, incompatibility between hydrophilic natural fiber and hydrophobic polymer matrix restricts the application. The current studies focus on the effects of incorporation of silane treated OPMF into polylactic acid (PLA)/polycaprolactone (PCL)/nanoclay/OPMF hybrid composites. The composites were prepared by melt blending technique and characterize the composites with Fourier transform infrared spectroscopy (FTIR), thermogravimetric analysis (TGA), and scanning electron microscopy (SEM). FTIR spectra indicated that peak shifting occurs when silane treated OPMF was incorporated into hybrid composites. Based on mechanical properties results, incorporation of silane treated OPMF enhances the mechanical properties of unmodified OPMF hybrid composites with the enhancement of flexural and impact strength being 17.60% and 48.43%, respectively, at 10% fiber loading. TGA thermogram shows that incorporation of silane treated OPMF did not show increment in thermal properties of hybrid composites. SEM micrographs revealed that silane treated OPMF hybrid composites show good fiber/matrix adhesion as fiber is still embedded in the matrix and no cavity is present on the surface. Water absorption test shows that addition of less hydrophilic silane treated OPMF successfully reduces the water uptake of hybrid composites.

Q3
IMPACT FACTOR
1.687

Published

Zuraidah Zanirun
PhD Student

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Effect of Physical and Chemical Properties of Oil Palm Empty Fruit Bunch, Decanter Cake and Sago Pith Residue on Cellulases Production by *Trichoderma asperellum* UPM1 and *Aspergillus fumigatus* UPM2

Zuraidah Zanirun • Ezyana Kamal Bahrin • Phang Lai-Yee • Mohd Ali Hassan • Suraini Abd-Aziz

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Published online: 2 October 2013

Abstract The effect of cultivation condition of two locally isolated ascomycetes strains namely *Trichoderma asperellum* UPM1 and *Aspergillus fumigatus* UPM2 were compared in submerged and solid state fermentation. Physical evaluation on water absorption index, solubility index and chemical properties of lignin, hemicellulose and cellulose content as well as the cellulose structure on crystallinity and amorphous region of treated oil palm empty fruit bunch (OPEFB) (resulted in partial removal of lignin), sago pith residues (SPR) and oil palm decanter cake towards cellulases production were determined. Submerged fermentation shows significant cellulases production for both strains in all types of substrates. Crystallinity of cellulose and its chemical composition mainly holocellulose components was found to significantly affect the total cellulase synthesis in submerged fermentation as the higher crystallinity index, and holocellulose composition will increase cellulase production. Treated OPEFB apparently induced the total cellulases from *T. asperellum* UPM1 and *A. fumigatus* UPM2 with 0.66 U/mg FPase, 53.79 U/mg CMCase, 0.92 U/mg β-glucosidase and 0.67 U/mg FPase, 47.56 U/mg and 0.14 U/mg β-glucosidase, respectively. Physical properties of water absorption and solubility for OPEFB and SPR also had shown significant correlation on the cellulases production.

Q2
IMPACT FACTOR
1.687

Published

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Ball Milling Pretreatment of Oil Palm Biomass for Enhancing Enzymatic Hydrolysis

Mohd Rafein Zakaria • Shinji Fujimoto • Satoshi Hirata • Mohd Ali Hassan

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Published online: 8 June 2014

Abstract Oil palm biomass, namely empty fruit bunch and frond fiber, were pretreated using a planetary ball mill. Particle sizes and crystallinity index values of the oil palm biomass were significantly reduced with extended ball mill processing time. The treatment efficiency was evaluated by the generation of glucose, xylose, and total sugar conversion yields from the pretreatment process compared to the amount of sugars from raw materials. Glucose and xylose contents were determined using high-performance liquid chromatography. An increasing trend in glucose and xylose yield as well as total sugar conversion yield was observed with decreasing particle size and crystallinity index. Oil palm frond fiber exhibited the best material yields using ball milling pretreatment with generated glucose, xylose, and total sugar conversion yields of 87.0, 81.6, and 85.4 %, respectively. In contrast, oil palm empty fruit bunch afforded glucose and xylose of 70.0 and 82.3 %, respectively. The results obtained in this study showed that ball mill-treated oil palm biomass is a suitable pretreatment method for high conversion of glucose and xylose.

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Hindawi

Research Article

Enhancement of Mechanical and Dynamic Mechanical Properties of Hydrophilic Nanoclay Reinforced Polylactic Acid/Polycaprolactone/Oil Palm Mesocarp Fiber Hybrid Composites

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In previous studies, the effect of the addition of 1 wt% hydrophilic nanoclay on polylactic acid (PLA)/polycaprolactone (PCL)/oil palm mesocarp fiber (OPMF) biocomposites was investigated by tensile properties, thermogravimetric analysis (TGA), and scanning electron microscopy (SEM). The current studies focus on the effect of addition of 1 wt% hydrophilic nanoclay on mechanical (flexural and impact properties) and dynamic mechanical properties of composites. The composites were characterized by the Fourier transform infrared spectroscopy (FTIR) and dynamic mechanical analysis (DMA). FTIR spectra show that peak shifting occurs when 1 wt% hydrophilic nanoclay was added to composites. The addition of 1 wt% hydrophilic nanoclay successfully improves the flexural properties and impact resistance of the biocomposites. The storage modulus of biocomposites was decreased when nanoclay was added which indicates that the stiffness of biocomposites was reduced. The loss modulus curve shows that the addition of nanoclay shift two t_g in composites become closer to each other which indicates that the incorporation of nanoclay slightly compatibilizes the biocomposites. Tan δ indicated that hybrid composites dissipate less energy compared to biocomposites indicate that addition of clay to biocomposites improves fiber/matrix adhesion. Water sorption test shows that the addition of nanoclay enhances water resistance of composites.

Published

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Master Student

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IMPACT FACTOR
0.177

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EFFECT OF DIFFERENT ALKALINE TREATMENT ON THE RELEASE OF FERULIC ACID FROM OIL PALM EMPTY FRUIT BUNCH FIBRES

FAIROUZ JAHAAN MOHD AANIFAH*; PHANG LAI YEE*; HELMI WASOH* and SURAINI ABD-AZIZ*

ABSTRACT

Serious thought on sustainability of palm oil industry triggers ways to minimise the impacts caused to the environment by recycling oil palm empty fruit bunch (OPEFB). An alkaline treatment strategy was developed for ferulic acid (FA) release from OPEFB fibres. The selected treatment of autoclaving OPEFB (120°C, 3 hr) and hydrolysing it with 20 g kg^{-1} NaOH (90°C, 3 hr) yielded 62.52 ± 6.24 mg litre^{-1} FA. Based on alkali selection (5 to 50 g kg^{-1} of NaOH, KOH and K_2CO_3), 20 g kg^{-1} KOH showed almost similar FA release to 20 g kg^{-1} of NaOH, as it solubilised 56.94 ± 3.52 mg litre^{-1} FA. The addition of sodium bisulphite ($NaHSO_3$) resulted in an increase of 4.23 mg litre^{-1} FA using KOH treatment. FA decreased when subjected to prolonged reaction times at high temperature, while at ambient temperature, only about 30 to 35 mg litre^{-1} FA was released. Fourier transform infrared (FTIR) analysis showed evidence of decrease in aromatic groups, lignin and ester linkage stretching. The selected treatment method using 20 g kg^{-1} NaOH and KOH solubilised 4.24 mg and 3.84 mg FA from 1 g of OPEFB lignin, respectively. From this finding, OPEFB exhibited a great potential as a feedstock for FA production. FA obtained from this treatment is very useful precursor for vanilic acid, vanillin and other value-added products formation through microbial conversion.

Keywords: oil palm empty fruit bunch, lignin, alkaline hydrolysate, ferulic acid, sodium bisulphite.

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Dr. Ahmad Muhaimin Roslan
Group Researcher

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Investigation of Oil Palm Frond Properties for Use as Biomaterials and Biofuels

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Key words: Composition, Non-food feedstock, Oil palm plantation

Introduction

Elaies guineensis is an oil-producing plant commonly known as oil palm. Palm oil processing produces biomass including empty fruit bunches (EFB), mesocarp fibre (MF), palm oil mill effluent (POME), palm kernel cake (PKC), shells, oil palm trunk (OPT) and oil palm frond (OPF). In 2009, a total of 83 million tons of OPF was produced (ASM, 2010) and left in the plantation for nutrient recycling. Our previous study revealed that the oil palm frond (OPF) petiole contains a large amount of sugars (Zahari *et al.*, 2012), suggesting that it is an excellent resource for the production of biomaterials and for bioenergy. However, for OPF utilisation two problems must be addressed, namely the disturbance of the nutrient recycling and the logistics related to the transport of OPF from the plantation to the palm oil mill. Hence the objectives of the present study were to investigate the properties of each part of OPF, including petiole, stem, rachis and leaflet not only for potential use as non-food feedstock for the production of biomaterials and for bioenergy, but also for maintaining the nutrient balance in the plantation.

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In Press

Dr. Mohd Rafein Zakaria

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Hydrothermal pretreatment enhanced enzymatic hydrolysis and glucose production from oil palm biomass

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HIGHLIGHTS

- Hydrothermal pretreatment as suitable method for oil palm biomass.
- Removal of hemicellulose correlated with hydrothermal treatment severities.
- Tannic acid as potential cellulase inhibitor from oil palm treated slurries.
- Specific surface area and pore volume correlated with glucose yield.
- 87.9% and 100% of glucose conversion from OPFF and OPEFB.

ARTICLE INFO

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Keywords:
Oil palm biomass
Hydrothermal pretreatment
Tannic acid
Specific surface area
Enzymatic hydrolysis

ABSTRACT

The present works investigate hydrothermal pretreatment of oil palm empty fruit bunch and oil palm frond fiber in a batch tube reactor system with temperature and time range from 170 to 250 °C and 10 to 20 min, respectively. The behavior of soluble sugars, acids, furans, and phenols dramatically changed over treatment severities as determined by HPLC. The cellulose-rich treated solids were analyzed by SEM, WAXD, and BET surface area. Enzymatic hydrolysis was performed from both pretreated slurries and washed solid, and data obtained suggested that tannic acid derived from lignin degradation was a potential cellulase inhibitor. Both partial removal of hemicellulose and migration of lignin during hydrothermal pretreatment caused structural changes on the cellulose–hemicellulose–lignin matrix, resulting in the opening and expansion of specific surface area and pore volume. The current results provided important factors that maximize conversion of cellulose to glucose from oil palm biomass by hydrothermal process.

In Press

Dr. Ahmad Amiruddin Mohd Ali

Q1
IMPACT FACTOR
3.59

Journal of Cleaner Production 91 (2015) 96–99

Contents lists available at ScienceDirect

Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro

Sustainable and integrated palm oil biorefinery concept with value-addition of biomass and zero emission system

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Keywords:
Biorefinery
Oil palm biomass
Sustainability
Zero emission

ABSTRACT

The problem of biomass residues and effluent from the palm oil milling process has become a big concern for the industry, the public and the environment. Furthermore, the modern palm oil mill can no longer rely solely on traditional crude palm oil and palm kernel products for profit generation. In order to remain truly sustainable in the future, we propose the solid biomass residues and liquid effluent to be managed and utilized via a biorefinery concept to generate new value-added products, in-line with zero emission system. Modern and efficient boiler and turbine systems utilizing biomass and biogas captured from the anaerobic effluent treatment can provide the steam and electricity required for the palm oil mill operations. The solid biomass residues can be channeled towards the production of value-added products such as biofertiliser, biochar, biofuels and biomaterials. The liquid final discharge can be further treated to meet river water quality, making it suitable to be recycled - hence achieving zero emission. Such an integrated approach will not only solve the issue of proper biomass disposal and effluent treatment, but also more importantly create a win-win-win situation for profit, people and planet - the three pillars of sustainability.

In Press

Dr. Mior Ahmad Khushairi Mohd Zahari

Q1
IMPACT FACTOR
3.59

Journal of Cleaner Production 87 (2015) 284–290

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Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro

Case study for a palm biomass biorefinery utilizing renewable non-food sugars from oil palm frond for the production of poly(3-hydroxybutyrate) bioplastic

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Biorefinery
Oil palm frond
Poly(3-hydroxybutyrate)
Renewable sugars
Oil palm biomass

ABSTRACT

In this paper, we assess the economic viability of renewable non-food sugars from oil palm frond (OPF) as fermentation feedstock for the production of the bioplastic, poly(3-hydroxybutyrate), P(3HB) within an integrated palm biomass biorefinery. The production cost of P(3HB) is estimated based on 9900 t/y of the potential amount of renewable sugars that can be produced from OPF in a typical palm oil mill in Malaysia. Based on the case study, approximately 99,780 t/y of renewable sugars could be produced from 10 neighbouring palm oil mills, each with the capacity to process an average of 200,000 t/y of fresh fruit bunch (FFB). With 20,000 t/y of P(3HB) production, the specific production cost of P(3HB) using renewable sugars from OPF is estimated at $ 3.44/kg P(3HB), which is 41% lower compared with that produced from commercial glucose.

Q1
IMPACT FACTOR
3.59

In Press

Juferi Idris

Journal of Cleaner Production 89 (2015) 257–261

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Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro

Note from the field

Self-sustained carbonization of oil palm biomass produced an acceptable heating value charcoal with low gaseous emission

Juferi Idris [a, b, c], Yoshihito Shirai [a], Yoshito Andou [a], Ahmad Amiruddin Mohd Ali [a], Mohd Ridzuan Othman [e], Izzudin Ibrahim [d], Mohd Ali Hassan [d, e, *]

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Self-sustained carbonization
Charcoal
Heating value
Oil palm biomass
Oil palm empty fruit bunch

ABSTRACT

Charcoal production with higher heating value (HHV) requires high capital investment and high energy requirement for large scale production. In this study, charcoal production under self-sustained carbonization from oil palm biomass was proposed and tested at pilot scale, whereby temperature and exhaust gas flow rate were monitored but not controlled. This proposed system under self-sustained carbonization, whereby oil palm biomass is combusted to provide the heat for carbonization in inadequate oxygen is preferable to the industry due to its simplicity, ease of operation and low energy requirement. Moreover, the gaseous emissions are below the permitted level set by the environmental authorities. The considerable HHV obtained was between 23 and 25 MJ/kg with low gaseous emissions. The results obtained are acceptable and comparable to other studies on oil palm biomass conducted under controlled conditions with electrical heating elements.

Q1
IMPACT FACTOR
3.361

In Press

Dr. Mohamad Faizal Ibrahim

Renewable Energy 77 (2015) 447–455

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Renewable Energy

journal homepage: www.elsevier.com/locate/renene

Simultaneous enzymatic saccharification and ABE fermentation using pretreated oil palm empty fruit bunch as substrate to produce butanol and hydrogen as biofuel

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Biobutanol
Biohydrogen
Clostridium acetobutylicum
Saccharification
Lignocellulosic biomass
Simultaneous saccharification fermentation

ABSTRACT

Simultaneous saccharification and acetone–ethanol–butanol (ABE) fermentation was conducted in order to reduce the number of steps involved in the conversion of lignocellulosic biomass into butanol. Enzymatic saccharification of pretreated oil palm empty fruit bunch (OPEFB) by cellulase produced 31.58 g/l of fermentable sugar. This saccharification was conducted at conditions similar to the conditions required for ABE fermentation. The simultaneous process by *Clostridium acetobutylicum* ATCC 824 produced 4.45 g/l of ABE with butanol concentration of 2.75 g/l. The butanol yield of 0.11 g/g and ABE yield of 0.18 g/g were obtained from this simultaneous process as compared to the two-step process (0.10 g/g of butanol yield and 0.14 g/g of ABE yield). In addition, the simultaneous process also produced higher cumulative hydrogen (282.42 ml) than to the two-step process (222.02 ml) after 96 h of fermentation time. This study suggested that the simultaneous process has the potential to be implemented for the integrated production of butanol and hydrogen from lignocellulosic biomass.

In Press

Sharifah Soplah Syed Abdullah

Q2
IMPACT FACTOR
3.361

Industrial Crops and Products 63 (2015) 357–361

Contents lists available at ScienceDirect

Industrial Crops and Products

journal homepage: www.elsevier.com/locate/indcrop

Fresh oil palm frond juice as a renewable, non-food, non-cellulosic and complete medium for direct bioethanol production

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Keywords:
Oil palm frond juice
Bioethanol
Non-food fermentation medium
Renewable feedstock

ABSTRACT

Oil palm frond (OPF) is the largest biomass source in the palm oil industry. Fresh OPF juice can be readily obtained by just pressing the fresh OPF, similar to sugarcane juice. OPF juice contains sugars and other nutrients such as nitrogen, magnesium, calcium, zinc, phosphorus and sulphur, making it a potential medium for bioethanol fermentation. In this study, the potential of fresh OPF juice as a complete non-food medium for direct bioethanol production was evaluated. A promising yield of 0.38 g bioethanol per g sugars consumed was obtained after 24 h of fermentation of fresh OPF juice without nutrient supplementation and without pH correction, which is comparable to synthetic medium at 0.40 g/g. This value is also comparable to the 0.4 g/g yield obtained from sugarcane juice in the Brazilian bioethanol industry. Therefore, this study provides an opportunity for the use of fresh OPF juice as a new renewable, non-food and non-cellulosic feedstock for the bioethanol industry.

In Press

Professor Dr. Mohd Ali Hassan

Q2
IMPACT FACTOR
1.455

Thermal and Biodegradation Properties of Poly(lactic acid)/Fertilizer/Oil Palm Fibers Blends Biocomposites

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Poly(lactic acid) (PLA) and NPK fertilizer with empty fruit bunch (EFB) fibers were blends to produced bioplastic fertlizer (BpF) composites for slow release fertilizer. Thermal properties of BpF composites were investigated by thermogavimteric analysis (TGA), differential scanning calorimetry (DSC), and morphological and degradation properties were anlayzed by scanning electron microscopy (SEM), soil burial test, respectively. TGA themogram display that neat PLA, PLA/NPK, and BpF composites degradate at different temperatures. DSC curves of PLA and other composites exhibited same glass transition temperature (T_g) value indicating that both major blend components are miscible. The T_g, crystallization temperature (T_c), melting temperature (T_m) values also decreased with increased amount of fertilizer and fibers. The T_m of BpF composites did not change with an increase in fertilizer content because thermal stability of PLA and PLA/NPK composites was not affected. Soil burial and fungal degradation test of PLA, PLA/NPK, and BpF composites were also carried out. Soil burial studies indicated that BpF composites display better biodegradation as compared with neat NPK. Fungal degradation study indicated that fungi exposure times of BpF composites show higher value of degradation as compared with PLA/NPK. We attribute that developed BpF composites will help oil palm plantation industry to use it as slow release fertilizer. POLYM. COMPOS., 00:000–000, 2014. © 2014 Society of Plastics Engineers

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Q3
IMPACT FACTOR
1.322

In Press

Dr. Hidayah Ariffin

Hindawi Publishing Corporation
International Journal of Polymer Science
Volume 2014, Article ID 715801, 8 pages
http://dx.doi.org/10.1155/2014/715801

Hindawi

Research Article

Enhancement of Mechanical and Dynamic Mechanical Properties of Hydrophilic Nanoclay Reinforced Polylactic Acid/Polycaprolactone/Oil Palm Mesocarp Fiber Hybrid Composites

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Academic Editor: Jan-Chan Huang

In previous studies, the effect of the addition of 1 wt% hydrophilic nanoclay on polylactic acid (PLA)/polycaprolactone (PCL)/oil palm mesocarp fiber (OPMF) biocomposites was investigated by tensile properties, thermogravimetric analysis (TGA), and scanning electron microscopy (SEM). The current studies focus on the effect of addition of 1 wt% hydrophilic nanoclay on mechanical (flexural and impact properties) and dynamic mechanical properties of composites. The composites were characterized by the Fourier transform infrared spectroscopy (FTIR) and dynamic mechanical analysis (DMA). FTIR spectra show that peak shifting occurs when 1 wt% hydrophilic nanoclay was added to composites. The addition of 1 wt% hydrophilic nanoclay successfully improves the flexural properties and impact resistance of the biocomposites. The storage modulus of biocomposites was decreased when nanoclay was added which indicates that the stiffness of biocomposites was reduced. The loss modulus curve shows that the addition of nanoclay shift two t_g in composites become closer to each other which indicates that the incorporation of nanoclay slightly compatibilizes the biocomposites. Tan δ indicated that hybrid composites dissipate less energy compared to biocomposites indicate that addition of clay to biocomposites improves fiber/matrix adhesion. Water sorption test shows that the addition of nanoclay enhances water resistance of composites.

CITED

In Press

Noor Ida Amalina Ahamad Nordin

Effect of Milling Methods on Tensile Properties of Polypropylene / Oil Palm Mesocarp Fiber Biocomposite

Nordin, N. I. A. A. [1,2]***, Ariffin, H.*** [1,3*]***, Hassan, M. A.*** [1]***, Ibrahim, N. A.*** [4]***, Shirai, Y.*** [5] ***and Andou, Y.*** [5]

Abstract

The objective of this study was to evaluate the effect of milling methods on tensile properties of polypropylene (PP) / oil palm mesocarp fiber (OPMF) biocomposites. Two types of mills were used, *i.e.* Wiley mill (WM) and disc mill (DM). Ground OPMF from each milling process was examined for its particle size distribution and aspect ratio by sieve and microscopic analyses, respectively. Results showed that DM-OPMF had smaller diameter fiber with uniform particle size compared to the WM-OPMF. Surface morphology study by SEM showed that DM-OPMF had rougher surface compared to WM-OPMF. Furthermore, it was found that PP/DM-OPMF biocomposite had higher tensile strength compared to PP/WM-OPMF, with almost two-fold. It is suggested that small diameter and uniform size fiber may improve stress transfer and surface contact between the fiber and polymer matrix, and cause well-dispersion of filler throughout the polymer resulted in better tensile strength of PP/DM-OPMF compared to PP/WM-OPMF biocomposite. Overall, it can be concluded that disc milling could serve as a simple and effective grinding method for improving the tensile properties of biocomposite.

Keywords**:** *Biocomposite, disc mill, oil palm mesocarp fiber, Polypropylene, tensile properties, Wiley mill*

EB Group Attachment 2014 (OUTBOUND)

Participants	Program	Research Theme	Host/Location	Duration	Sponsor
Noor Farisha Abd Rahim	Research Attachment	Synthesis of novel bio-based polyester from palm oil's fatty acid	Kyushu Institute of Technology (Kyutech), Japan	3 January – 30 March 2014	Mobility programme
Nurhajirah Mohamed Biran	Research Attachment	Enhance PHA production by modified metabolic pathway in *E. coli* harboring PHA biosynthesis operon	Kyushu Institute of Technology (Kyutech), Japan	3 January - 30 March 2014	Mobility programme
Norhayati Ramli	Training	Training for project on promotion of green economy with palm oil industry for biodiversity conservation	Kyushu University, Japan	24 February – 23 May 2014	JICA
Mohd Nor Faiz Norrahim	Research Attachment	Superheated steam and wet disk milling pretreatment for high conversion of biosugars from oil palm mesocarp fibre	National Institute of Advanced Industrial Science & Technology (AIST), Japan	15 June – 25 September 2014	AIST, Japan
Muhammad Nazmir Mohd Warid	Research Attachment	Oil palm biomass powder production and analysis	Kyushu Institute of Technology (Kyutech), Japan	25 June - 25 July 2014	Mobility programme
Siti Suliza Selamat	Research Attachment	Study on microbial community in inorganic fertilizer using DGGE and MiSeq technique	Kyushu Institute of Technology (Kyutech), Japan	1 September 2014 - 28 February 2015	Japan Student Services Organization (JASSO)
Muhammad Azman Zakaria	Research Attachment	*YqiG Escherichia coli* pseudogene related to hydrogen production	Kyushu Institute of Technology (Kyutech), Japan	1 September 2014 - 28 February 2015	Japan Student Services Organization (JASSO)
Dhurga Devi Rajaratnam	Research Attachment	Controlled hydrolysis of poly(3-hydroxybutyrate-co-3-hydroxyhexanoate) for oligoester production	Kyushu Institute of Technology (Kyutech), Japan	1 September 2014 - 28 February 2015	Japan Student Services Organization (JASSO)
Mohd Rahimi Zakaria@Mamat	Research Attachment	Effect of pyrolysis parameters, pretreatments and catalysts on recovery yield of crotonic acid	Kyushu Institute of Technology (Kyutech), Japan	15 December 2014 – 15 March 2015	Mobility programme
EB Lecturers	Research Visit	Discussion and laboratory visit	Kyushu University, Japan	19 December 2014	SATREPS
EB Lecturers	Research Visit	Collaboration meeting for SATREPS project	National Institute of Advanced Industrial Science & Technology (AIST), Japan	23 December 2014	SATREPS

EB Group Attachment 2014 (INBOUND)

Participants	Program	Research Theme	Host/Location	Duration	Sponsor
Assoc. Prof. Dr. Yoshito Ando	Research Collaboration	Research Attachment	Biomass Technology Center, UPM	July – December 2014	Kyushu Institute of Technology (Kyutech), Japan
Yuya Hachiguchi	PhD Student	Research Attachment	Biomass Technology Center, UPM	January - November 2013	Kyushu Institute of Technology (Kyutech), Japan
Ryohei Torii	Undergraduate Student	Student Exchange Programme	Biomass Technology Center, UPM	18 August – 12 September 2014	Kyushu Institute of Technology (Kyutech), Japan
Kyutech students (11 people)	Postgraduate Student	Research Attachment	Biorefinery Complex, UPM	24 August – 4 November 2014	Kyushu Institute of Technology (Kyutech), Japan
Kyutech students (10 people)	Postgraduate Student	Research Attachment	Biorefinery Complex, UPM	21 November – 2 December 2014	Kyushu Institute of Technology (Kyutech), Japan
Kyutech students (22 people)	Postgraduate Student	Research Attachment	Biorefinery Complex, UPM	12 – 23 October 2014	Kyushu Institute of Technology (Kyutech), Japan
Namiki High School, Japan	High School Student	Research visit	Biorefinery Complex, UPM	26 November 2014	Namiki High School, Japan
Hita High School, Japan	High School Student	Research visit	Biorefinery Complex, UPM	3 December 2014	Hita High School, Japan
Yuki Yoshikai	Undergraduate Student	Student Exchange programme	BioTech 3, UPM	1 – 23 September 2014	Kyushu Institute of Technology (Kyutech), Japan
Natrapee Savetsila	Undergraduate Student	Student Exchange programme	Biorefinery Complex, UPM	1 April – 30 May 2014	Kasetsart University, Thailand
Sutthapa Sithornkul	Undergraduate Student	Student Exchange programme	Biorefinery Complex, UPM	1 April – 30 May 2014	Kasetsart University, Thailand
Neceti Berk Bitrak	PhD Student	Research Attachment	Biorefinery Complex, UPM	15 September – 25 December 2014	Suleyman Demirel University, Isparta, Turkey

Consultancy

RESEARCH THEME	CLIENTS/INDUSTRIAL PARTNER	DURATION
Pilot scale co-composting of sewage sludge and green wastes to bio fertilizer with applications for community benefits	Indah Water Konsortium Sdn. Bhd.	August 2012 - July 2013
Treatment of coloured wastewater - color removal of final discharge	Microclear Sdn. Bhd.	June - September 2014
Implementation of readily available technology for bromelain extraction and purification from pineapple wastes for value-added to pineapple plantation industry	Alaf Putra Biowealth Sdn. Bhd.	September 2014 - August 2016

UNIVERSITI PUTRA MALAYSIA
BERILMU BERBAKTI

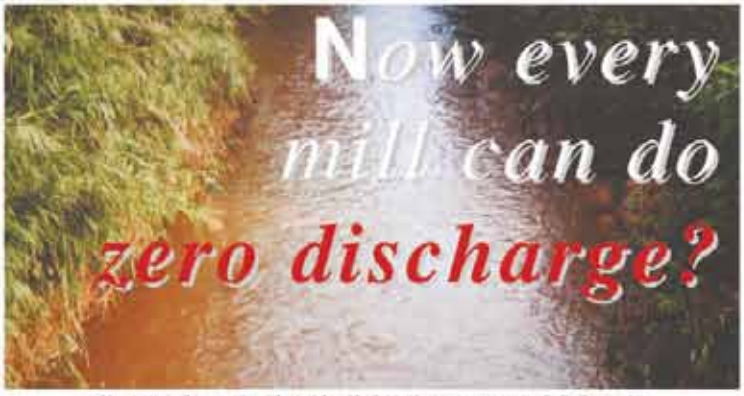
PROFESSOR DR. MOHD ALI HASSAN
UNIVERSITI PUTRA MALAYSIA, 12 FEBRUARY 2014

Anugerah Staf Cemerlang Dalam Jaringan Industri/ Komuniti Berimpak tinggi bagi tahun 2013

Excellent Staff Award in High Impact Industrial/Community Networking for year 2013

The three dons in the Green Economy with Palm Oil Industry Project (from left): Prof Shirai, Prof Mohd Ali Hassan and Prof Charles.

Now every mill can do zero discharge?



Close up of a Pome polluted Sungai Punti in Sook, Keningau, sent to the *Daily Express* by a Head of village who was very upset by a sudden loss of clean drinking water but his protests to the authorities fell on deaf ears, according to the village chief contacted later

Kan Yaw Chong

Prof. Ali

AT last, the Pome (palm oil mill effluents) may be loved instead of being hated.

Villagers hate Pome when it escapes into rivers because they lose every essential - can't drink, cook, bathe, or irrigate crops with the polluted water any more and get very angry for also killing their river fisheries.

But now, zero waste discharge or entirely zero emission at the palm oil mill looks like a distinct possibility, a workshop and project launch last Thursday portrayed that optimism.

The promise is organic-matter-saturated Pome can become "as clean if not cleaner than river water, and we are providing that opportunity," Universiti Putra Malaysia (UPM) Professor Mohd Ali Hassan raised some eyebrows, citing proofs from a pilot project at his university that he and his Japanese collaborators had fixed this hated 40-year old pollutant that had snuffed out dissolved oxygen and rendered many of Sabah' dead, after inflicting similar dead zones in Peninsula Malaysia.

Prof Ali and his Japanese collaborator Prof Shirai exuded confidence about an imminent breakthrough environment wise and business wise, assuring a triple-Win outcome for the 3Ps – Profit, People and Planet.

Mills can be as harmless as a dove

Well, it's refreshing that Malaysian dons and Japanese technocrats have joined forces to push the implementation of what some call 'true sustainability' in an industry that emits a massive cargo of wastes of 60-70 million tonnes of liquid palm oil mill effluents and 83 million dry tonnes of solid biomass.

Just feed these hated wastes through a simple and appropriate technology, it will turn around all the negative feeling into positive money making resources, they argue.

The reasons for their optimism?

First, the dramatic turn-around doesn't take high-tech stuff which is not sustainable, the UPM professor stressed.

Just "appropriate technology" involving simple methods will do!

And Sabah needs not reinvent the wheel.

The simple methods have been developed and used to great success in Japan in the bamboo industry and all UPM had done was to modify it a bit to suit oil palm biomass, Prof Ali articulated his optimism at the launching ceremony of 'Project on Promotion of Green Economy with Palm Oil Industry for Biodiversity Conservation' last Thursday.

It was witnessed by the Secretary of Natural Resources Sabah, and orchestrated in the background by Jica (Japan International Cooperation) and the Japan Technology Industry the collaborative partners of UPM.

Secondly, the "appropriate technology" is based on a fully integrated approach which literally turns a palm oil mill into a one-stop producer of a whole range of smart and functional products, bio-charcoal, bio-absorbants, bio- compost, bio-fertilizer, bio-composites and electricity that are actually used to scrub Pome into clean water which the mill can recycle and recuse in the production of CPO.

So, in effect, palm oil mills become as harmless as a dove.

A break-away method of production to help nature rebound

As Prof Ali puts it: "In our new proposal, we are going for many products and at the same time we reduce pollution, so you can see the water is as clean if not cleaner than river water."

" To make it simple, we have the waste treatment for nano fibre and biocomposite as one project, we have bio-charcoals and bio-absorbents as another project, bio- composts and bio-fertiliser as third project and big project in biodiversity conservation, where we'll be looking for indicator species to assess rebounds of the ecosystem," Prof Ali explained.

" For this purpose, we are collaborating with Kyushu University where we are going to use whatever best techniques involving the use of DNA to identify indicator species which hopefully rebound after this project, because some of them have already been affected by pollution," he added.

So a central theme of this project is biodiversity, Prof Ali said.

Smart products from an integrated project makes the cut

"The difference is in the integrated nature of this project, where we use the resources at the mill to create end products, and we recycle the water, you can see (picture slide at his presentation) from these red dotted lines, that everything is contained, eventually we want to utilise all the biogas for various for various products , meaning zero emission and biodiversity conservation," Prof Ali said.

An eye opening aspect of the 'Appropriate Technology' is the nature of the bio-charcoal UPM has managed to produce in collaboration with the Japanese.

"Bio-char, everybody knows this is charcoal, but we are going for a different kind of charcoal – biocharcoal which is high in pore volume with appropriate size for bacteria to colonise (or for the bacteria-al-stay in the bio-charcoal) because bio-char provide carbons for food sources for bacteria and at the same time high in surface area at first around 300 but now we have achieved 500 in the lab, meaning more absorption capacity for effluent treatment," Prof Ali pointed out.

"So we go for not only bio-charcoal, we call it bio-absorbent which absorbs a lot of waste and this is material we'll use to treat our bio-discharge to as clear as the water in the sea.

"What is important is we produce this bio-charcoal with a very simple method – appropriate technology, just by using a simple treatment for biochar used for bamboo in Japan. But we modified that for oil palm biomass in our pilot plant at UPM and we can produce material that is even better that is produced originally from bamboo in Japan," he said.

Prof Ali also passed around a piece of the bio-composite, to those attending the presentation.

"Not to confuse you with compost which is a fertiliser, a composite is actually where we use the 'appropriate technology to blend 50 per cent plastics with 50 per cent biomass," he said.

"This means we can use the excess fibers which are already shredded and so it's a ready waste, and the boiler is there while the mills have a lot of excess steam which we can use to treat this biomass.

"In terms of science, this process of using super-heated steam is within local capacity and our project we would like to do most, by using the resources available from within the mill," he said.

Testing 'appropriate technology' in real mill in Sabah

But what if the pilot project is put into a real palm oil mill operation?

Will the lofty zero emission at the mill work?

Well, that was what the signing of Letter of Intent between the UPM and Keningau palm oil mill owner, Yap Yun Fook was meant to do – to test the technology in the real world.

"Originally, we wanted to do it in Sandakan but due to the security, Japanese are not allowed to there so we had to switch location and w thank Mr Yap very much for helping us," Prof Ali said.

So the roles of the project parties are as follows:

"Japan has a lot of technology and some of these are not only pioneer technology but also business models, and we would like to promote this these technologies as appropriately as possible in Malaysia," he said.

" We would be working with industries so that these industries can tell us whether these technologies can be implemented after the project has terminated or hopefully even during the duration (four years) the project itself," Prof Ali said.

The role of UPM is obvious but the University of Malaysia Sabah has also been put into the picture, especially on the environment side, Prof Ali said.

"Every party has their role, as well as Japanese companies to promote their technology in collaboration with us. It may not be 100 per cent, as we need to modify things to make it work for oil palm industry and oil palm biomass.

"On top of that, Kyushu University which has a branch in UPM for a few years, will continue, such as more staff and student exchange," he said.

Don: No high-end technology needed to clean Pome up

"What I would like to stress is we do not intend to promote any high end technology, because high end technology is not sustainable. So we would like to promote what is appropriate technology, something that the industry can do by themselves, we just want to show the way in terms of operations, where they can improve, create more value from the biomass and we want to have this 3Ps together, integrating the 3Ps – Profits, People, Planet," Prof Ali pointed out.

"Usually people out there see only either one or maybe only two, maybe only profit and people but not planet , so we say this must be integrated, this is a sustainable model, so we subscribe to this with your help, also together to make it happen," Prof Ali appealed.

Emphasising the 3Ps – Profit, People, Planet

" And I would like also to stress in that order – first Profit, people, and then planet because if you put the planet first, it will not happen, because no body will spend money just to save the environment at their cost, not many people will do that, people need motivation for them to move but at the same time we also want people and planet to move, such as creating jobs for people." Prof Ali noted the delicate balance.

Not forgetting the promotion of education, through for instance, students exchange, eiting students from Japan who had come to Malaysia to enjoy the country, getting to know the culture more and more, and vice versa, he said.

"In terms of the business opportunity, we leave it to the millers to pick up. We have some concept, for instance in the area of fertilizers, where currently, we use about RM8 billion," Prof Ali noted.

" For palm oil, if in our country, if we can generate RM1 billion of bio compost within the resources of the mills maybe from empty fruit brunch alone, that is big value but we do not say: you replace the chemical fertilisers, we only say you can supplement them," Prof Ali explained.

"I would like to stress we are providing a basket of technology, we are not saying you have to do this, you have to do that, this is an opportunity and we also invite other private companies to show their technology and it is up to the mills to choose which technology they want."

Don on why has it taken so long to deal with Pome issue

Asked why have the mills been sitting on the Pome issue since the 1974 which inspired the drafting and gazettement of the Environment Quality Act 1974 because of explosive protests from villagers in Peninsula Malaysia in the late 60s, Prof Ali said:

"Basically they argued that the technology is not there, or the technology is very expensive, such as membrane and so on and so we are introducing 'appropriate technology'."

"Appropriate technology means relevant to the industry which they can use, where they are using their own biomass to produce their bio-charcoals and bio-absorbents which are required to treat effluents to clean water which in turn can be recycled and so there is zero Pome discharge into the rivers," he said.

Asked if he is confident the 'appropriate technology' will perform in a real mill?

"I am confident, very confident but it's a challenge to us to prove that it can be done in a pilot project within a mill. We have done it in our pilot plant at UPM but we have to transport the biomass materials and so it's not integrated . That's so why we want to do it in the mill like that owned by Yap, where it becomes integrated, where we are dealing with the wastes while the actual crude palm oil production is not disturbed but of course we'll spend part of the electricity a lot of which could come from biogas eventually," Prof Ali explained.

Prof Ali asserts that effluents from one whole mill can easily generate one megawatt of electricity or more, which Felda had done.

"But Felda uses only biogas and didn't do the full integration, while other companies do only the compost, we want to show integration," Prof Ali distinguished where the major difference in his project lie.

"Electricity is just from the biogas and based on our calculation, you can have enough energy for electricity just from biogas but many mills don't do that just in case something goes wrong with the biogas plant then they have to shut down so they have also the biomass boilers," he explained the pragmatic side of the mills.

File pic shows Pome discharged directly into a stream from an oil mill in Keningau, prompting protests from villagers.

Yap Yun Fook (centre front), owner of Keningau palm oil mill, signing the Letter of Intent witnessed by a crowd of Japanese and State Natural Resources Office representatives.

A side view of heavy Pome pollution along Sg Punti, Sook Keningau.

Trench filled with foul Pome due to improper treatment in Eastern Sabah.

UPM
UNIVERSITI PUTRA MALAYSIA
BERILMU BERBAKTI

DR. HIDAYAH ARIFFIN

Harian Metro SELASA, 22 APRIL 2014 Variasi

Agro

Rawatan biomas

Saintis UPM berjaya cipta kaedah prarawatan sisa gentian sawit guna stim untuk menjadi bahan bio-komposit ›› 4&5

- **Silver Medal,** Malaysia Technology Expo 2014 (MTE 2014). Treatment of Oil Palm Biomass by Superheated Steam for Biocomposite Production.
- **Silver Medal,** Pameran Rekacipta, Penyelidikan dan Inovasi 2014 (PRPI 2014). Bio-based Crotonic Acid.
- **Silver Medal,** Pameran Rekacipta, Penyelidikan dan Inovasi 2014 (PRPI 2014). Oil Palm Frond Juice: A Future Fermentation Substrate.

V4 Agro

SELASA 22 APRIL 2014 Harian Metro

FOKUS

Jimat kos, mesra alam

Ciptaan dapat selesaikan masalah dihadapi industri pemprosesan bahan bio-komposit

Oleh Mohd Sabran Md Sani
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Sektor pertanian di Malaysia menghasilkan 94 peratus sisa kelapa sawit, empat peratus kayu dan masing-masing satu peratus bagi tebu dan beras.

Industri pemprosesan kelapa sawit mengeluarkan air sisa kilang kelapa sawit atau effluen kilang kelapa sawit (POME) dan sisa buangan pepejal seperti tandan sawit kosong (EFB), kek 'decanter' dan 'mesocarp fibre' atau gentian sabut.

Hakikatnya, EFB banyak dimanfaatkan untuk menghasilkan makanan ternakan haiwan.

Berbeza dengan gentian sabut kerana sejumlah besar bahan buangan itu digunakan industri pemprosesan kelapa sawit sebagai bahan bakar untuk menghasilkan stim sebagai sumber tenaga bagi penggunaan di kilang.

Pemprosesan sawit berlaku setiap hari, oleh itu, gentian sabut terhasil dalam jumlah banyak.

Pembakaran dilakukan bagi melupuskan sisa ini di kilang pemprosesan kelapa sawit.

Ia menghasilkan stim dalam jumlah yang melebihi keperluan kilang sawit. Banyak stim dilepaskan begitu saja.

Cara itu tidak efisien dan menyebabkan pembaziran tenaga.

Ada alternatif lain bagi melupuskan gentian sabut di kilang kelapa sawit ini dan ia boleh dimanfaatkan untuk pembuatan produk bio komposit.

Namun, gentian sabut sisa buangan sawit bersifat liat dan sukar dipurukan menyebabkan sukar dalam proses pengisaran bahan itu.

Proses pengisaran perlu dilakukan bagi menghasilkan serbuk gentian sawit dalam saiz yang bersesuaian bagi digunakan dalam industri polimer dan bio-komposit.

Justeru, Penyelidik Universiti Putra Malaysia (UPM) memenuh cara bagi menyelesaikan kedua-dua masalah itu dengan menggabungkan penggunaan stim dan biomas.

Cara lain ialah dengan memperkenalkan kaedah prarawatan menggunakan stim untuk biomas (sisa gentian sawit) bagi penghasilan bahan untuk bio komposit.

Ia dikenali rawatan biomas kelapa sawit menggunakan alat stim panas lampau.

Penyelidikan itu dilakukan Pensyarah Kanan Fakulti Bioteknologi dan Sains Biomolekul UPM yang juga penyelidik bersekutu di Institut Perhutanan Tropika dan Produk Hutan (INTROP) UPM, Dr Hidayah Ariffin.

Penyelidikan pada 2011 itu adalah projek kerjasama dengan Kyushu Institute of Technology (Kyutech), Jepun yang dijayakan bersama beberapa rakan penyelidik lain.

Antaranya Noor Ida Amalina Ahamad Nordin, Prof Dr Mohd Ali Hassan, Prof Dr Yoshihito Shirai, Prof Dr Hamdan Nishida dan Prof Madya Dr Yoshito Ando.

Ia mengharumkan nama universiti itu apabila memenangi pingat perak dalam Ekspo Teknologi Malaysia 2014 (MTE 2014) di Pusat Dagangan Dunia Putra (PWTC) Februari lalu.

Dr Hidayah berkata, penyelidikan itu berkaitan penggunaan biomas daripada kelapa sawit.

"Biomas kelapa sawit berkaitan dengan sisa kelapa sawit yang terdiri daripada EFB, POME, kek 'decanter' dan gentian sabut.

"Gentian sabut merujuk kepada sisa daripada sawit yang terhasil selepas buah sawit diproses untuk pengeluaran minyak.

"Apabila gentian sabut dikisar, silika yang bersifat keras ini boleh merosakkan mata pisau pengisar.

"Silika juga akan menganggu proses penghasilan bio-komposit dalam ek-

PRODUK bio-komposit yang terdapat di INTROP, UPM.

DR Hidayah bersama pingat dan sijil penyertaan dimenangi Februari lalu.

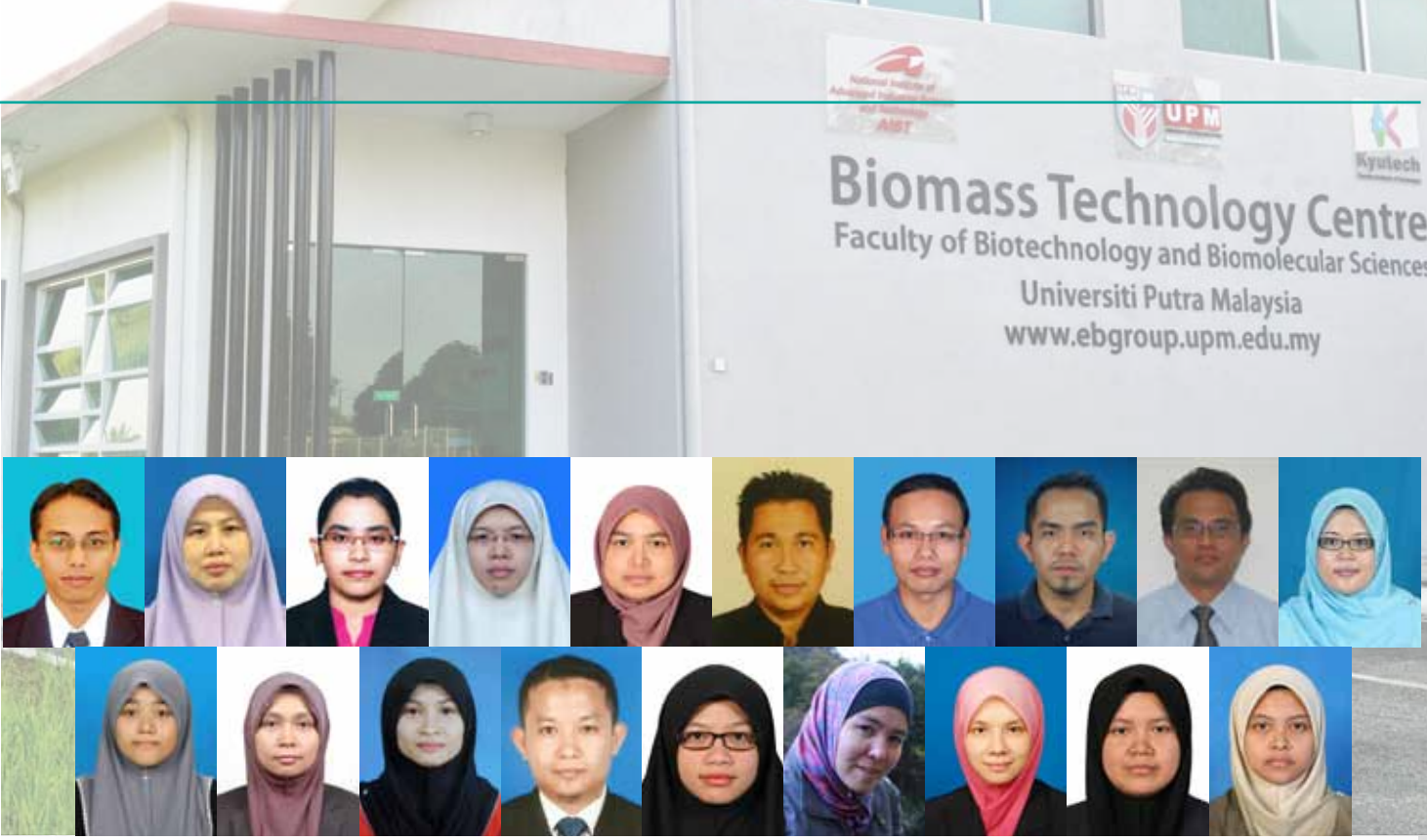
PERBEZAAN gentian sabut selepas diproses.

PENYEDIAAN bahan gentian sabut untuk diproses dengan stim panas lampau.

PENYELIDIK menunjukkan perbezaan gentian sabut sebelum dirawat (kanan) dan dirawat (kiri).

CONFERENCES AND WORKSHOPS

Event name	Date	Venue	Name of participant
DGGE Workshop	4-7 February 2014	Faculty of Biotechnology and Biomolecular Sciences, Universiti Putra Malaysia (UPM), Malaysia	Dr. Norhayati Ramli, Diana Mohd Nor, Mohd Hafif Samsudin, Mohd Huzairi Mohd Zainudin, Siti Suliza Selamat
Asian Federation of Biotechnology (AFOB) Regional Symposium 2014 (ARS 2014)	9-11 February 2014	Seri Pasific Hotel, Kuala Lumpur, Malaysia	EB Group members
Eco Materials Research Society Conference, Tokyo University, Japan	28 February 2014	Institute of Industrial Science, University of Tokyo, Japan	Noor Farisha Abd. Rahim
BioBorneo Conference	5-7 May 2014	Dewan Tunku Abd Rahman, UNIMAS	Dayang Salwani Awang Adeni
International Symposium on Advanced Polymeric Materials (ISAPM)	14-15 May 2014	Putra World Trade Centre (PWTC), Kuala Lumpur, Malaysia	Noor Farisha Abd. Rahim
The 8th Korea-ASEAN Joint Symposium on Biomass Utilization and Renewable Energy: Integration of Agriculture and Biotechnology	18-22 August 2014	Seoul, Korea	Prof. Dr. Suraini Abd-Aziz
Mass Spectrometry Workshop	19-20 August 2014	Institute of Bioscience, Universiti Putra Malaysia (UPM), Malaysia	Nur Sharmila Sharip
AFOB Bioenergy & Biorefinery Divison Annual Meeting and Bioenergy & Biorefinery Summit	24-27 August 2014	Jinan, China	Prof. Dr. Suraini Abd-Aziz Dr. Mohamad Faizal Ibrahim
UPM Innovation Open Day (IOD)	10 September 2014	Faculty of Biotechnology and Biomolecular Sciences, Universiti Putra Malaysia (UPM), Malaysia	Nur Falia Shazana Manja Farid Muhammad Nazmir Mohd Warid
Biomass Biorefinery AIST, Japan Symposium	10 September 2014	Tokyo, Japan	Mohd Nor Faiz Norrahim
Surface Science and Catalyst Characterization Workshop	23 September 2014	Faculty of Science, Universiti Putra Malaysia (UPM), Malaysia	Mohammed Abdillah Ahmad Farid
AFOB International Symposium 2014 and AFOB Delegate Meeting	6-8 October 2014	Changwon & Songdo, Korea	Prof Dr Mohd Ali Hassan Prof. Dr. Suraini Abd-Aziz
Malaysia Agriculture, Horticulture and Agrotourism Exhibition (MAHA)	14 November 2014	Malaysia Agro Exposition Park Serdang (MAEPS)	Nur Sharmila Sharip Nur Falia Shazana Manja Farid Muhammad Nazmir Mohd Warid
High Performance Liquid Chromatography (HPLC) Phenolics Analysis	26-27 November 2014	Institute of Bioscience, Universiti Putra Malaysia (UPM), Malaysia	Nur Sharmila Sharip
International Symposium on Chemical Engineering (ISChE)	5-7 December 2014	Putra World Trade Centre (PWTC), Kuala Lumpur, Malaysia	Mohd Rahimi Zakaria@Mamat
2nd International Symposium on Applied Engineering and Sciences (SAES) 2014	20 December 2014	Kyushu Institute of Technology, Fukuoka, Japan	EB Group members



EB STUDENTS Research Summary

PhD Student EB GROUP

Akbar Ciptanto

PhD. Environmental Biotechnology (Semester 6)
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The effect of iron and nickel for hydrogen production from POME under thermophilic condition

The generation of bio-hydrogen from cheap and renewable carbon sources had become an attractive approach due to the abundance availability and rising price of petro-fuels within the global market. Concerning the environmental friendly and sustainability approach, researchers have proposed the utilization of organic wastewaters as the alternative substrates such as palm oil mill effluent (POME) for the bio-fuel generation. POME contains rich organic materials that can be used as the nutrients for microorganisms to produce hydrogen through dark fermentation. Nevertheless, there are still gaps that have to be filled in order to improve the production of hydrogen especially in bioprocess and physical operation that are considered as the important factors contributing to the optimal hydrogen production.

Iron and nickel are important micronutrients in H_2 fermentation, as they are constituents of hydrogenases. The addition of both micronutrients in media enhances the hydrogen production. The iron could induce metabolic change and be involved in the expression of both Fe-S and non Fe-S proteins operating in hydrogenase. Meanwhile, nickel was known as supplementation which have effect on (NiFe)-containing microorganisms.

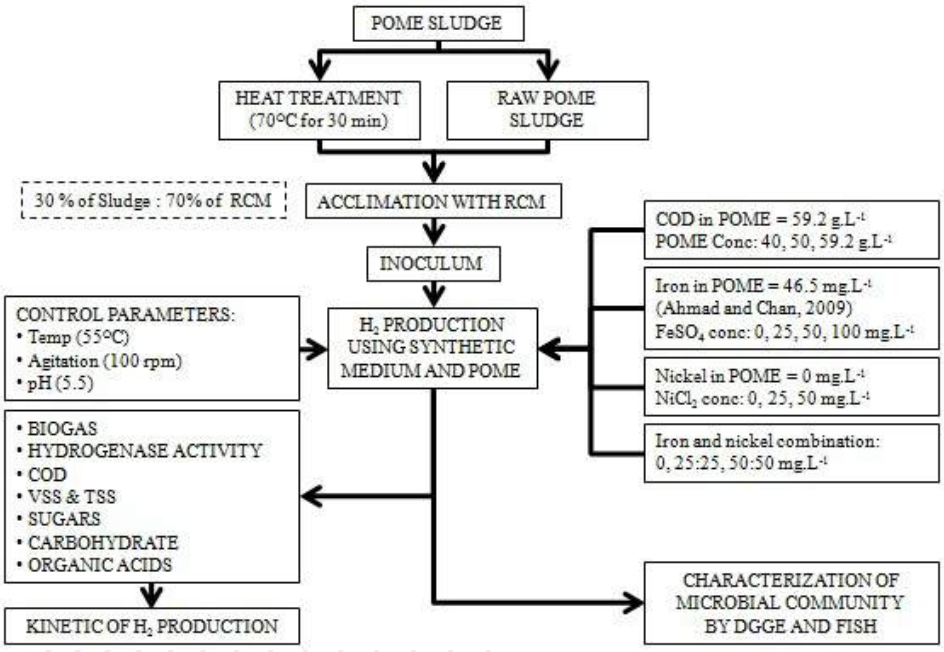

Figure 1 : Flow chart of the project

Supervisor
Professor Dr. Mohd Ali Hassan

Objectives
1. To enhance hydrogen production by the addition of iron and nickel using synthetic medium and POME in batch under thermophilic condition.
2. To characterize the micobial community during hydrogen production using DGGE and FISH in batch under thermophilic condition.

Dayang Salwani Awang Adeni

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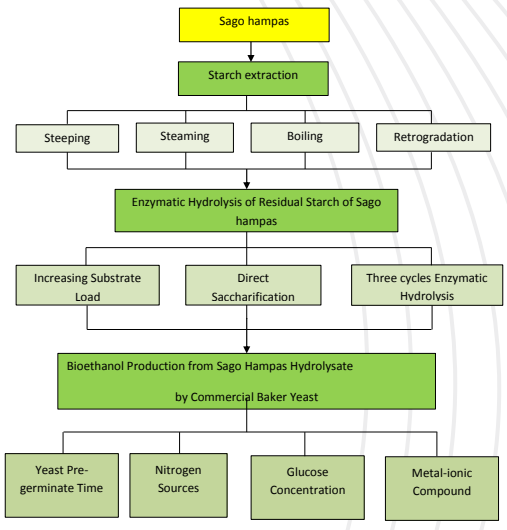
Bioethanol production from residuals of sago hampas

Sago palm which is mostly found in Sarawak usually generated huge amount of solid waste upon the starch extraction process, where starch was accounted to be about 50-58% (dry weight) in this solid waste. This residual starch was used in this study which was converted into glucose via enzymatic hydrolysis process and act as the carbon source for production of bioethanol. Sago hampas initially undergo simple pretreatment steps which were drying, grinding and boiling to render the residual starch more susceptible to enzymatic digestion at the saccharification stage using a commercial enzyme, dextrozyme. Boiling process for at least 30 mins which gelatinized the sago hampas has indicated that 7% (w/v) of the substrate load was sufficient and suitable for enzymatic hydrolysis since residual starch was not observed in the fibrous residue. However in order to increase glucose concentration at the end of hydrolysis process, substrate load need to be increase as well which was not possible due to the complexity and voluminous physical properties of sago hampas. Thus an alternative method was introduced by recycling the hydrolysate upon hydrolysis of the same (7% w/v) amount of sago hampas during the enzymatic hydrolysis process. The hydrolysate obtained from each cycle was used for subsequent enzymatic hydrolysis, thus the concentration of glucose was increased at the end of each cycle due to total glucose accumulated based on the glucose produced after previous cycles plus the glucose produced in the current cycle. This method was termed as cycle I-II-III, exhibiting the number of cycles that the hydrolysate was reused. A maximum of three cycles was attempted in this project. Greater improvement of glucose concentration (138.45 g/L) and better conversion yield (52.72%) was achieved with the completion of three cycles of hydrolysis. In comparison cycle I and cycle II had glucose concentration of 27.79 g/L and 73.00 g/L, respectively.

The study on pre-germination time of CBY indicated that at 9 h and 12 h, the ethanol fermentation showed complete substrate utilization (100%), good product yield (0.47 – 0.48 g/g) as well as high fermentation efficiency (93.29%) compared to 6 h. Following these, ethanol fermentation was performed utilizing various concentrations of glucose from SHH (g/L: 80, 100, 150, 200, 250.At 100 g/L initial glucose, maximum yield of ethanol fermentation, Yp/s (0.50g/g) and theoretical conversion yield (98%) were obtained compared to other glucose concentrations. The major by-product in this process was glycerol, with lesser amounts of lactic acid and acetic acid. The effects of various nitrogen sources has shown both urea and ammonium sulfate were capable of replacing yeast extract since these alternatives exhibited comparable ethanol yield, ethanol volumetric productivity as well as fermentation efficiency. Supplementations of metal ions did not enhance the fermentation process, as similar profiles of ethanol production and glucose consumption was observed. From the present study it can be concluded that hydrolysate of sago hampas which contain mainly glucose shows high potential to be effective substrate as well as economical fermentation medium for bioethanol production utilizing commercial bakers' yeast (CBY).

Bioethanol fermentation using hydrolysate of sago hampas in 3L bioreactor

Debarked sago logs – ready for starch extraction by rasping



Flow chart of the research project

Supervisor
Professor Dr. Suraini Abd-Aziz

Objectives

1. To hydrolyse residual starch in sago hampas for glucose production at different substrate load.
2. To obtain high glucose concentration in hydrolysate using commercial enzymes preparation.
3. To evaluate the suitability of sago hampas hydrolysate as fermentation medium for bioethanol production by commercial baker's yeast.
4. To determine the effects of nitrogen and metal ionic compound on fermentability of bioethanol from sago hampas hydrolysate.

PhD Student EB GROUP

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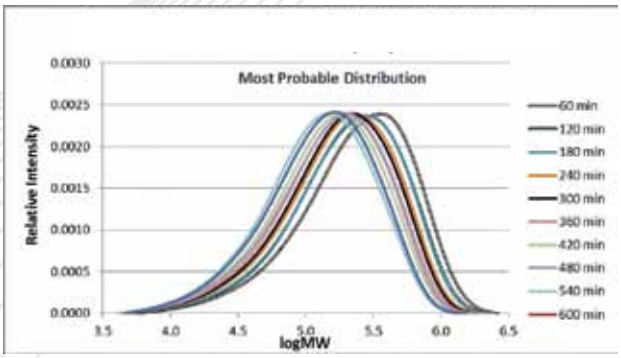
Controlled hydrolysis of poly (3-hydroxybutyrate-co-3-hydroxyhexanoate) for oligoester production

Gel Permeation Chromatography (GPC) analysis of SHS treated PHA samples

Polyhydroxyalkanoate (PHA) is a type of biodegradable plastic that belongs to the family of microbial polyesters. These natural polymers are being produced by many types of bacteria as an intracellular energy reserve material under the condition of substrate limitation and in the presence of excessive carbon source. However, the intracellularly produced PHAs have high molecular weight (200 - 3000 kDa) and this feature makes them undesirable for the production of specialty polymers that require a low, specific range of molecular weight (1 - 5 kDa). Therefore, an effective degradation method is necessary to produce oligoesters with desired low range of molecular weight to produce specialty polymers for various applications. In the present study, controlled degradation of PHA by superheated steam (SHS) is being studied using two types of PHA, poly(3-hydroxybutyrate), PHB and poly(3-hydroxybutyrate-co-3-hydroxyhexanoate), PHBHHx. Effect of SHS temperature and reaction time on the characteristics of hydrolyzed PHA will be determined. Kinetic parameters of PHA hydrolysis in SHS will also be evaluated by adapting kinetic model by Yoon et al. (1997) for non-autocatalytic and Nishida et al. (2000) for autocatalytic hydrolysis mechanism. The influence of HHx unit composition in PHBHHx SHS hydrolysis also will be clarified. It is postulated that controlled SHS condition will cause the hydrolysis to occur specifically at the ester bond to produce PHA oligoesters.

The PHA film that prepared using compressed molding technique will be used throughout the study. Then, controlled degradation of PHA films by SHS hydrolysis will be studied by monitoring the mass and molecular mass changes at different treatment temperatures. The effect of PHA side-chain formed on the mechanism of PHA degradation as well as the characteristics of PHA degradation products will be clarified. The kinetic parameters and the effect of HHx unit towards the degradation mechanism also will be evaluated to predict the behavior of PHB and its copolymer in the aqueous medium such as human body. The finding of this research is foreseen to aid controlled degradation and depolymerization of PHA in a green route with the utilization of superheated steam (SHS) hydrolysis, is a remarkable approach to produce the PHBHHx oligoesters for various packaging and medical applications.



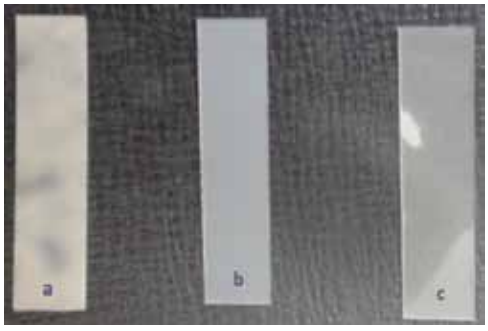
Changes in size-exclusion chromatography (SEC) profile of PHB-co-11% HHx during super heated steam hydrolysis at 130°C for 600 min.

Supervisor
Dr. Hidayah Ariffin

Objectives

1. To depolymerize PHBHHx using superheated steam (SHS) hydrolysis and to characterize the produced PHBHHx oligoesters.
2. To determine the mechanism of PHBHHx hydrolysis by SHS
3. To determine the functionality of PHBHHx oligoesters for the production of amphiphilic block copolymer (PHBHHx-co-PEG)

Superheated steam (SHS) oven



Hot-pressed PHA films for superheated steam (SHS) treatment (a=PHB, b=PHB-co-6% HHx and c=PHB-co-11% HHx)

Diana Mohd Nor

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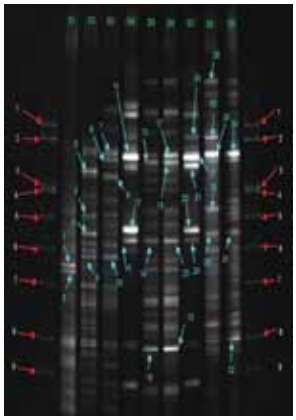
Microbial community adaptation and its community changes in different stages of palm oil mill effluent treatment

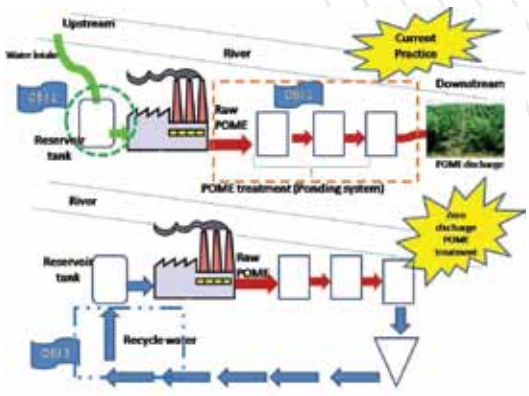
The growing demand for palm oil has caused a substantial increase in the generation of palm oil mill effluent (POME). However, the current wastewater treatment system for POME regularly fails to treat the effluent efficiently. To meet the discharge limit proposed by the Malaysian Department of the Environment, the POME must be treated effectively before being released into the receiving water bodies. The open system is presently being used to treat the POME because of the low cost and less maintenance is required. One way to promote the zero-discharge system of POME is through application of suitable treatment by recycling the final discharge wastewater to the mill. However, palm oil mills release POME in tremendous volumes with its attendant polluting potential. POME has adverse environmental impacts including land and aquatic ecosystem contamination and the biodiversity loss. Little is known about microbial diversity involved in POME wastewater treatment, either in terms of their community structure and function or their response to the environment. Therefore, the study on the microbial community structure and function during POME treatment is proposed. The changes of microbial community structure and function at each stage of POME treatments will be described and compared using microbiota approach. Several samples from POME treatment system will be collected, including the water sample from reservoir, the wastewater from anaerobic and facultative ponds, and at the final discharge point, as well as the water sample after zero-discharge implementation. To achieve these objectives, culture-independent approaches such as Denaturing Gradient Gel Electrophoresis (DGGE) and Next Generation Sequencing will be applied. In addition, the correlation between microbial community compositions and water physicochemical characteristic will be investigated. As a conclusion, the microbial community and its changes during POME treatment is expected to be explored and identified, thus will bring to the microbial community rebound after implementation of zero discharge system.

Sample collection

Reactor tank for palm oil mill effluent treatment



Microbial community analysis



Flow chart of the research project

Supervisor
Dr. Norhayati Ramli

Objectives

1. To assess microbial community profiles in different stages of palm oil mill effluent (POME) treatment.
2. To characterize the physicochemical properties and compounds profile of the treated POME.
3. To assess the biodiversity rebound in terms of microbial community after POME treatment with zero discharge.

PhD Student EB GROUP

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Controlled degradation of polyhydroxyalkanoates by high pressure steam hydrolysis for chemical recycling

Saturated steam reactor

Polyhydroxyalkanoate (PHA) has unique characteristics of thermoplastic, biodegradable and biocompatible biopolymer that can be produced intracellularly by microorganism and some plant species. This promising biopolymer has been researched since its discovery in 1920s, remarkably starts the green revolution of non-petrochemical aliphatic polyester that is producible via fermentation biosynthesis and has been commercialized as early as in 1962. The constituent of PHAs, polyhydroxybutyrate acid (PHB) is biocompatible with human as it is also a built compound of blood, made this producible biopolymer able to contribute very significantly in the biomedical applications especially in tissue engineering. This biodegradable carbon reserve plays important role in the environmental carbon storage. Cascade utilization of polymers could be introduced before they are finally being released to the environment. Single use of bioplastics does not support the sustainability of the carbon cycle; therefore a process to depolymerize polymers is needed. Nevertheless, biological production of PHA sometime able to produced ultra-high molecular weight to suit variation of thermo-mechanical properties needed. On the other hand, medium to low-molecular weight PHA are important for slow release and short term coating applications. Medium to low-molecular-weight materials are suitable feedstock for blending and re-polymerization process. Several methods have been used to depolymerize PHA, namely pyrolysis and hydrolysis. Pyrolysis, abiotic hydrolysis and enzymatic hydrolysis of PHA have been extensively studied; however steam hydrolysis of PHA is yet to be studied. Controlled depolymerization of PHA in this study, involved with the concept of the material conversion to molecules that built up of the original material or lowering of its origin molecular weight. This research is aimed at recovering low to medium-molecular weight polymers with hydroxyl and carboxyl chain-ends from polyhydroxyalkanoates (PHA) by steam hydrolysis. These low to medium- molecular weight polymers can be used as feedstock for re-polymerization and other applications. Degradation of PHA by steam hydrolysis will be controlled by several parameters, namely; temperature and retention time. The experiments will be conducted using saturated and superheated steam input. The hydrolysis products will be characterized and the effect of controllable parameters toward the target product formation will be investigated in details. The analysis of molecular weight will be carried out using gel permeation chromatography (GPC) and the depolymerization is projected theoretically to follow autocatalytic random degradation mechanism with the identification of critical point, hydrolysis rate constant and activation energy based on relative molecular weight of polystyrene as the standard. The hydrolyzed products will be characterized by using 1H and 13C NMR, FTIR, DSC, XRD, XPS and AFM. Mass balance for the PHAs hydrolysis will also be studied. At the end of this study, it is expected that the depolymerization mechanisms and kinetics for PHA hydrolysis can be proposed, with the selective formation of targeted products for cascade utilization of PHA.

Flow chart of the research project

Supervisor
Dr. Hidayah Ariffin

Objectives

1. Characterization of low to medium molecular weight PHB hydrolyzed by steam.
2. Determination of PHB hydrolysis kinetics in saturated steam.
3. Proposition of mechanism involved in superheated steam hydrolysis of PHB.
4. Evaluation of steam hydrolysis for chemical recycling and surface modification of PHA.

Saturated steam reactor: bottom part

PHB disks arrangement prior to steam hydrolysis

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Biochar production from empty fruit bunch biomass under self-sustained carbonization for the development of Yamasen carbonization oven

Fig.1 Pilot Scale (30 kg) brick self-sustained carbonization reactor

The usage of OPEFB biomass as an alternative source for renewable energy such as biochar has a great potential to overcome the shortage of fossil fuel. Moreover, the utilization of biomass as a source of biofuel can reduce the problem of environmental pollution particularly on the issues related to greenhouse gases. Being the second largest oil palm producer in the world, Malaysia has a great potential to produce clean renewable energy from biomass. The self-sustained carbonization was proposed and tested in this study, whereby oil palm biomass itself was combusted to provide heat for self-carbonization in inadequate oxygen without electrical heating element.

Temperature profiles and gaseous emission during self-sustained carbonization of OPEFB biomass in a pilot scale reactor (30 kg capacity) has been carried out. Different particles sizes (100-150, 30-99 and less than 29 mm) under natural and fixed exhausted gas flow rate were evaluated. For natural and fixed exhausted gas flow rate, the maximum temperatures were ranged 417-580^{o}C and 493-564^{o}C, respectively at all particle size tested which was suitable for biochar production. The average concentration of CO_2, CO and CH_4 released during the carbonization process for both natural and fixed exhausted gas flow rate at all particles sizes were low compared to other studies, meanwhile SO_2, HCl, NOx and particulate matter, (PM10) were well below permitted level.

Under natural exhausted gas flow, harvesting carbonization temperature of < 500^{o}C of OPEFB biomass at 100-150 mm particle size produced the highest biochar yield and quality (calorific value, CV) between 23-25% and 22.6-24.7 MJ/kg, respectively. Meanwhile, under fixed exhausted gas flow rate, the OPEFB biochar at particle size 100-150 mm produced the highest yield (25-27%), harvested at carbonization temperature of < 500^{o}C with low retention time and higher yield compared to natural exhausted gas flow rate. The CVs were found between 23.0-24.4 MJ/kg and comparable with other studies.

Self-sustained carbonization in a scaled-up pool type reactor using OPEFB biomass (3 tones capacity) for the development of YAMASEN oven was carried out. The maximum temperature for pressed-shredded and whole bunch OPEFB biomass was ranged 583-695^{o}C while CV between 21.9-24.3 and 19.6-22.9 MJ/kg, respectively and comparable to small scale production. This study to produce biochar for fuel usage has been achieved and it is preferable to the industry due to its simplicity, ease of operation and low energy requirement.

Fig.2 Pool type (scaled-up) self-sustained carbonization reactor

Supervisor
Professor Dr. Yoshihito Shirai
Professor Dr. Mohd Ali Hassan

Objectives

1. To evaluate the temperature profiles and gaseous emission during self-sustained carbonization of empty fruit bunch biomass in a pilot scale reactor.
2. To evaluate the effect of exhausted gas flow rate and OPEFB biomass particle size on biochar yield and quality under self-sustained carbonization in a pilot scale reactor.
3. To evaluate OPEFB biochar yield and quality in a scaled-up pool type reactor under self-sustained carbonization.
4. To evaluate energy balance and potential energy saving of raw OPEFB and biochar in a scaled-up pool type self-sustained carbonization reactor.

PhD Student EB GROUP

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Microbial diversity changes during co-composting of oil palm empty fruit bunch with palm oil mill effluent anaerobic sludge

One way to promote the zero-discharge system and creating value added product from the oil palm mill by-products is through Co-composting of oil palm empty fruit bunch (OPEFB) with palm oil mill effluent (POME) anaerobic sludge. In Malaysian oil palm industries, the development for treating oil palm residue such as oil palm empty fruit bunch and palm oil mill effluent anaerobic sludge through co-composting has been of great interest due to its ability to serve as potential renewable resources for production of value added product. OPEFB compost is manageable product which can be use as soil amendment and organic fertilizer. Composting is an aerobic biodegradative process of organic materials into simpler substance under controlled condition driven by bacteria community and their association between each others during composting process. While the inoculation of pure microbe has been applied as a method to enhance the productivity of compost, it is however, have yet to be proven commercially viable in large scale operation due to potential operating cost preparation of inoculums. In present system, the enhanced co-composting process can be achieved without the addition of microbe. In this system we rely on the indigenous microbes that present in POME anaerobic sludge which is thought to be responsible for enhancing the compost productivity. Therefore, the enhanced co-composting of OPEFB and POME anaerobic sludge process has spurred the increased attention into how microbial diversity carryout the degradation process and what microbes are involved during the process. The investigation of microbial diversity of co-composting were generally based on community analysis technique such as culture dependent method through isolation and characterization of cultivable microbe and culture independent method through Polymerase Chain Reaction-Denaturing Gradient Gel Electrophoresis (PCR-DGGE) or small sequence library. The overall objective of this study was to elucidate the microbial community participating in the enhanced composting process through isolation and characterization of cultivated microbe, PCR-DGGE and 16s rRNA clone library technique. The microbial community as well as the patterns of their diversity was then further described by using next generation sequencing; 454-pyrosequencing.The findings of this study expends our knowledge in understanding the collective microbial community during composting process and in future will help to optimize the composting conditions to increase the quality and productivity of compost.

Isolation of Cellulase producing bacteria on agar plate containing carboxymethyl-cellulose (CMC)

Isolation of xylanase producing bacteria on agar plate containing xylan

Supervisor
Professor Dr. Mohd Ali Hassan

Objectives

1. To isolate and characterize the indigenous cellulolytic and hemicellulolytic bacteria of enhanced co-composting of oil palm empty fruit bunch with palm oil mill effluent anaerobic sludge
2. To identify the bacterial community structure and biochemical changes associated with co-composting of lignocellulose oil palm empty fruit bunch
3. To assess in-depth bacterial community during rapid co-composting of OPEFB and palm oil mill effluent anaerobic sludge via pyrosequencing

Co-composting of OPEFB with POME anaerobic sludge

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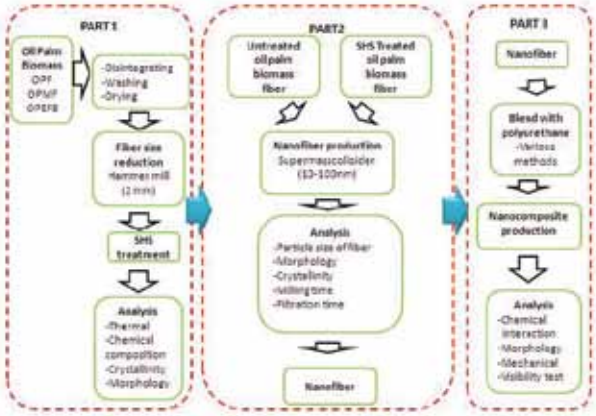
Nanofiber and nanocomposite production from super heated steam treated oil palm biomass

In Malaysia, oil palm biomass annually generates 19.8 million tonnes of biomass on a wet basis and 6.93 million tonnes on a dry basis. This provides huge resources for the conversion into value added products such as biogas, organic acids, bioplastic, cellulose, biocomposite and cellulose nanofiber production. Oil palm biomass namely oil palm mesocarp fiber (OPMF), oil palm empty fruit bunch (OPEFB) and oil palm frond (OPF) are potential candidates for nanofibers and nanocomposites production. However, the recalcitrant structure of these lignocellulosic materials make fibrillation into nanofibers difficult, therefore pretreatments of these materials are needed. There are several treatments can be applied to the oil palm biomass such as chemical, mechanical and hydrothermal treatment in order to overcome this issue. The main purpose of pretreatments is to separate the cellulose from the matrix polymers, thus improving processing of nanofiber and subsequent composite production. Nanocomposites based on waterborne polyurethane (PU) is a promising polymer to improve in mechanical properties due to the hydrophilic properties. In this study, effectiveness of pretreatment by superheated steam (SHS) followed by wet disk milling (WDM) in order to obtain high degree of fibrillation into nanofibers will be studied. SHS treatment will be conducted at reaction temperature ranging from 160 – 230°C for 1-3 h, aimed at high amount of hemicelluloses removal. WDM pretreatment will subsequently be carried out to facilitate fibrillation of oil palm biomass fiber. The effectiveness of pretreatments will be characterized by chemical compositional, morphological and particle size analyses. Beside that, nanocomposite will be prepared by blending the nanofibers with PU polymer. Performance of nanocomposite will be characterized by mechanical properties, visibility, morphology and coefficient of thermal expansion. It is expected, combined SHS and WDM pretreatment will enhance the fibrillation of oil palm biomass into nanofiber. Moreover, the resulting PU-nanofiber composites are also expected to exhibit improved mechanical properties compared to lone PU polymers.

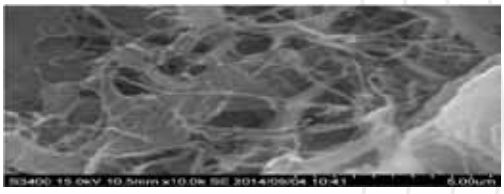
Wet Disk Milling

Oil palm mesocarp fiber (OPMF)



Flow chart of the research project

Delignified OPMF



Nanofiber from treated OPMF

Supervisor
Dr. Hidayah Ariffin

Objectives

1. To pretreat oil palm biomass aimed for high amount of cellulose recovered.
2. To optimize the wet disc milling parameter for nanofiber production from untreated and superheated steam treated oil palm biomass.
3. To prepare nanocomposite from oil palm biomass nanofiber and polyurethane.

PhD Student EB GROUP

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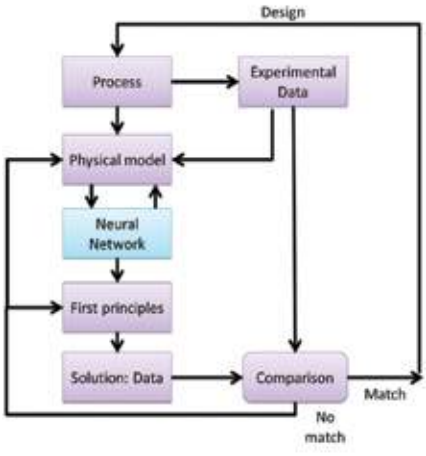
Compost hybrid modeling of organic waste

The findings of literature review in the mathematical model type, in composting. It shows the current status of research and several gap automatically proposed research suitable to execute. Example of gap available are validation for the mathematical model was not thoroughly done and tested, rare of hybrid mathematical model in composting and lack of important parameters in modeling. Experiment has to be made to fulfill the parameter data required in the modeling. Research design proposed such as factorial design to run real experiment. The aim is to validate the previous model, to test experiment with different raw material input and process parameter range, and established data for neural network model training dataset and testing. Physical model of to run the experiment already justified base on review made on design, size and capacity.

Technique mathematical model hybrid identified. There are about five common techniques has been applied. Most popular is a neural network output as an input to deterministic model example reaction rate generated from neural network. Second, knowledge fusion (incorporated into a single model). Third is direct inclusion of the possible interactions between the states as part of the model's structure. Fourth is the combination of correlation and neural network into clusters. Composting is most dynamic type of process hence hybrid modeling could gain new insight which compensates neural network (black box) and flexibility to first principle mathematical model (deterministic).This study could introduce practicality in modeling for dynamic behavior such as composting.



Big Picture

Temperature and Humdity Sensor with Datalogger

Supervisor
Professor Dr. Mohd Ali Hassan

Objectives

1. To assess mathematical model for composting of organic waste.
2. To investigate model sensitivity analysis of different ratio organic wastes towards microbial population dynamics.
3. To progress mathematical model by categorizing substrate, basic microbiological approach, physical transport and output compost as a stable product using first principle and artificial neural network (hybrid model) and outlook of compost quality

Composter

Compost

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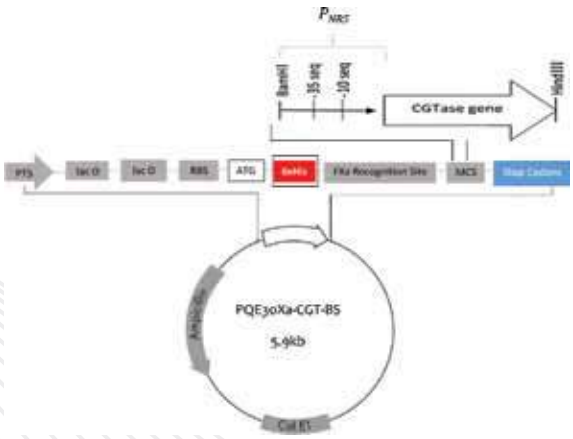
Expression, purification and characterization of polyhistidine-tagged recombinant cyclodextrin glycosyltransferase from *Escherichia coli*

Cyclodextrin glycosyltransferase (CGTase) (EC 2.4.1.19) represents one of the most important groups of microbial amylolytic enzymes. This enzyme is a member of alpha-amylase family or glycosidase hydrolase family 13, which forms circular α-(1, 4)-linked oligosaccharide substrates via a covalent intermediate. The non-reducing end of this intermediate is subsequently used as the acceptor that cleaves the covalent enzyme-substrate bond, and a cyclodextrin (CD) is released. However, their use in industry has been limited due to the necessity for a high temperature of starch liquefaction.

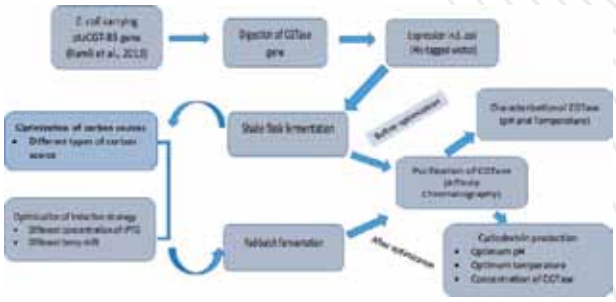
The over expression of CGTase gene using bacterial expression system offers a great advantage in the enhancement of the product yield and provide a straightforward way of satisfying the anticipated expansion of the CD market. Given the potential uses of recombinant CGTase, fermentation process of recombinant microorganism has been developed for production of high value product and the development of low cost industrial media formulation.

This study proposes to express and purify recombinant CGTase from *E. coli*. Polyhistidine-tag vector will be used as an affinity tag for purifying recombinant proteins from crude cell lysates using affinity chromatography. The pure CGTase obtained after enhancement of the production will be characterized in terms of thermostability and tested for its capability in releasing CD. Several problems in enzymatic production of CD can be solved; eliminate the starch liquefaction, reduce time, improve enzyme stability and production, simplify the purification and increase the CD yield.

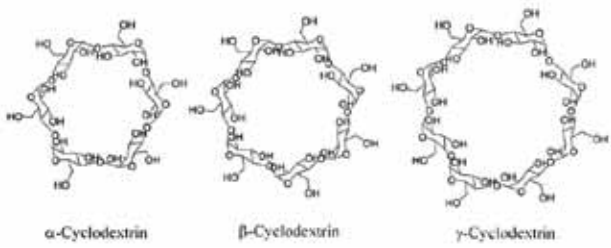
Example of sago waste



Schematic representation of the expression vector in *E. coli*



Big picture



Schematic diagram of cyclodextrin

Supervisor
Dr. Norhayati Ramli

Objectives

1. To express the polyhistidine-tagged cyclodextrin glycosyltransferase in *Escherichia coli* and purification using affinity chromatography.
2. To determine the carbon source and induction strategy for cyclodextrin glycosyltransferase production in E. coli and enhance the enzyme production by fed-batch cultivation.
3. To characterize the recombinant cyclodextrin glycosyltransferase produced and determine the cyclodextrin production.

PhD Student EB GROUP

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Design of functionalized polyester from palm oil's fatty acids

There has been increased interest in renewable resources from both academia and industry due to worldwide concern over the shortage of non-renewable resources such as petroleum. The huge demand for polymers and other chemicals has opened the potential of vegetable oils to be used as feedstock as it contains different composition of triglycerides. Since vegetable oils are abundantly available, have various chemical structures due to the variety of triglyceride composition and are biodegradable, fatty acid derivatives from vegetable oils have been an attractive resource for the production of polyester materials. Among all fatty acids, oleic and linoleic acids can be found in most vegetable oils.

This study focuses on the potential development of sustainable bio-based polymer from palm oil. Components of palm oil; oleic and linoleic acids were used as precursor, while the performance of enzyme catalyst for polymerization was compared to its chemical catalyst counterpart. The synthesis processes involved two steps of reaction, starting from the preparation of the monomers, and the polymerization of the monomers. Metathesis coupling reaction of fatty acid catalyzed by second generation Grubbs catalyst and fermentation of fatty acids by *Candida tropicalis* ATCC20962 were conducted in order to prepare α,ω-dicarboxylic acids which were then used as precursor for polymerization. Subsequently, polymerization was conducted in order to obtain polyesters from original α,ω-dicarboxylic acids. Two types of catalysts; Novozym 435 and tetra n-butyl titanate (Ti(OBu)4), each presented biological and chemical catalyst, respectively, were used in order to compare the effect of catalyst on polymerization. Characteristics of the polyester produced can be varied depending on the type of precursors used during polymerization, thus allowing further modification for improvement of the properties. Last but not least, the functionality of the polyester will be determined by chemical modification. Overall, versatile bio-based polyester can be developed from palm oil's fatty acids. Further evaluation and combination of the characteristics of greener and hybrid polyester will be needed in order to clarify the potential as practical useful material. It is expected that renewable bio-based polyester that will be produced in future can be beneficial for green technology and sustainable development.

Preparation of dicarboxylic acid monomers from palm oil's fatty acids by chemical approach

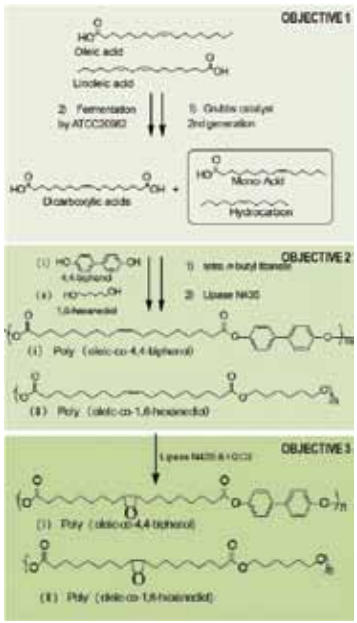
Preparation of dicarboxylic acid monomers from palm oil's fatty acids by fermentation approach

Supervisor
Dr. Hidayah Ariffin

Objectives

1. To synthesized dicarboxylic acid monomer from palm oil's fatty acids by chemical and biological approach.
2. To produce palm oil based polyester from dicarboxylic acid and to evaluate the effect of co-monomers on the characteristics of the polyester.
3. To determine the functionality of polyester from palm oil's fatty acid by chemical modification.

Polyester from palm oil's fatty acid



Big Picture

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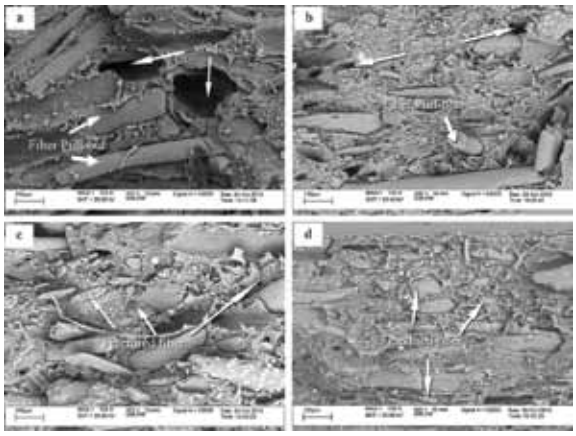
Superheated steam treatment of oil palm mesocarp fiber for biocomposite production

Project achievement: Biocomposite products and Silver medal won in MTE 2014



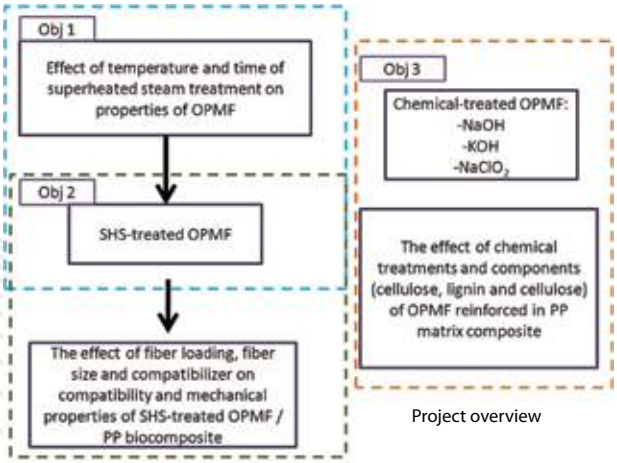
SEM micrographs of fractured biocomposite samples from untreated and SHS-treated OPMF

Development of biocomposites reinforced with natural fibers has attracted great interests in the polymer industries. However, incompatibility of hydrophilic natural fibers with non-polar thermoplastics is the main obstacle in the production of biocomposites due to poor adhesion between the two. Steam treatment has been proven to be able to improve the compatibility of plastics and fiber by extracting the most hydrophilic component of the fiber i.e. hemicellulose. This reduced the hydrophilicity of the fiber and hence provides better adhesion between plastics and fiber which results in improved mechanical properties of the biocomposite.

In this study, Superheated Steam (SHS) treatment was used to treat Oil Palm Mesocarp Fiber (OPMF). Tensile, flexural and impact strength of the biocomposite were then evaluated.

It was found that SHS-treated OPMF biocomposite had better mechanical properties compared to untreated. Tensile strength of 50% SHS-treated OPMF biocomposite was 2 times higher compared to untreated OPMF biocomposite. It is also interesting to note that mechanical properties of biocomposites were affected by fiber loading. Mechanical properties of untreated and SHS-treated biocomposites were reduced as the fiber loading was increased. At higher fiber loading, mechanical properties of untreated OPMF biocomposite sample was largely affected. The reduction in mechanical properties upon increasing the fiber loading was due to interruption caused by the fiber in transferring the stress along applied force. Meanwhile, SHS-treated OPMF biocomposites was able to possess higher tensile strength even at 50% fiber addition.

Our results demonstrate that SHS-treated OPMF biocomposites had better mechanical properties compared to untreated OPMF biocomposites. The findings from this study revealed that SHS-treatment was able to improve the adhesion between fiber and polymer due to the removal of hydrophilic moieties from the fiber. Thus, it is concluded that SHS could be an effective treatment process for fiber preparation for biocomposites production.



Project overview

Supervisor
Dr. Hidayah Ariffin

Objectives

1. Characterization of superheated steam treated mesocarp fiber in comparison with untreated mesocarp fiber
2. Production and characterization of polypropylene/superheated steam treated OPMF biocomposite on mechanical and thermal properties with respect to SHS temperature, fiber loading and the use of compatibilizer
3. The effect of fiber treatment and its chemical composition on properties of PP/OPMF biocomposite

PhD Student EB GROUP

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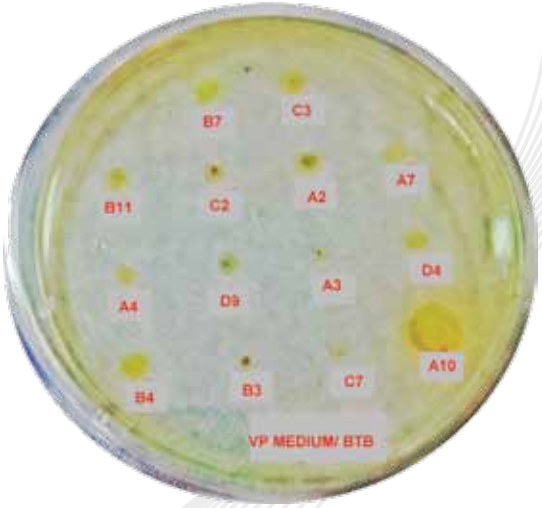
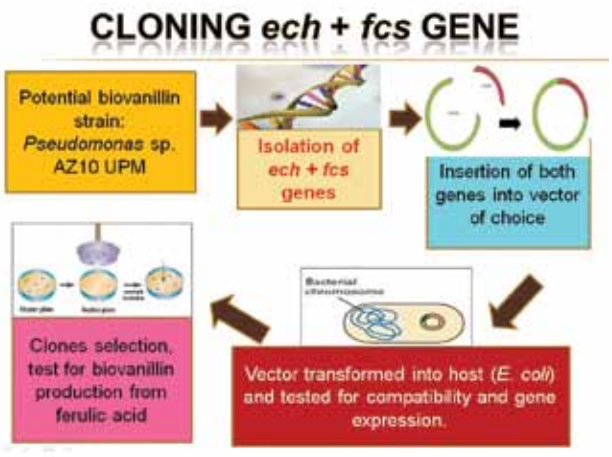
One-step biotransformation of ferulic acid into biovanillin using genetically engineered *Escherichia coli*

Vanillin is the major component of natural vanilla and a secondary metabolite of plant which is an important aromatic component as well as flavouring compound in the industry of food and personal products. Natural vanillin extracted from vanilla pods has a very high price and limited supply in the market due to it involved a time-consuming process which required intensive cultivation, pollination, harvesting and ripening of pods. It is also very dependable on the suitability of soil and climate conditions. Thus, current market demand for vanillin is fulfilled by the chemically synthesized vanillin. However, this artificially derived vanillin flavour could not be referred as a natural product. Therefore, recent increasing demand for natural flavours production through biotransformation by microorganism has been proposed towards a sustainable and environmental friendly process.

Ferulic acid, biovanillin precursor is used in this study due to the chemically close relationship to vanillin, low cost, and readily available. It has been reported that the bacterium from 'Pseudomonas' family have the ability to produce vanillin via biotransformation process involving ferulic acid obtained from biomass. Based on the common pathway of bacteria for biovanillin production, vanillin will be further oxidized into vanillic acid due to oxidation of vanillin was easily occurred in compared to ferulic acid. As a result, vanillin as an intermediate was nearly undetectable at the end of the fermentation process. Thus, the aim of this study is to develop a methodology for biovanillin production using genetically engineered *E. coli* by one step pathway without further oxidation of vanillin into vanillic acid. From this study, bacteria named as *Pseudomonas* sp. AZ10 UPM has been successfully isolated as a potential biovanillin producer using ferulic acid as sole carbon source. By using this strain, isolation of functional genes for biovanillin production can be carried out using DNA walking strategy and later can be cloned and expressed into pUC18 vector. The construction of genetically engineered *E. coli* containing biovanillin functional genes is expected to produce biovanillin in one step fermentation without further oxidation of vanillin into vanillic acid.



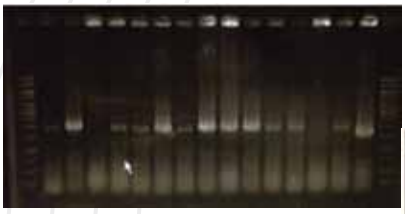
Rapid screening for vanillic acid producing bacteria



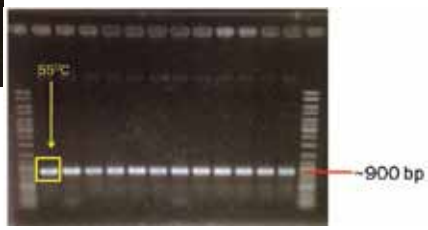
Big picture

Supervisor
Professor Dr. Suraini Abd-Aziz

Objectives
1. To screen, isolate and identify potential biovanillin producing bacteria.
2. To isolate the functional genes for biotransformation of ferulic acid into biovanillin and further construct genetically engineered *E. coli*.
3. To produce biovanillin in one step fermentation using genetically engineered *E. coli*.



Colony PCR for insert verification



PCR optimization for target gene, enoyl coA hydratase

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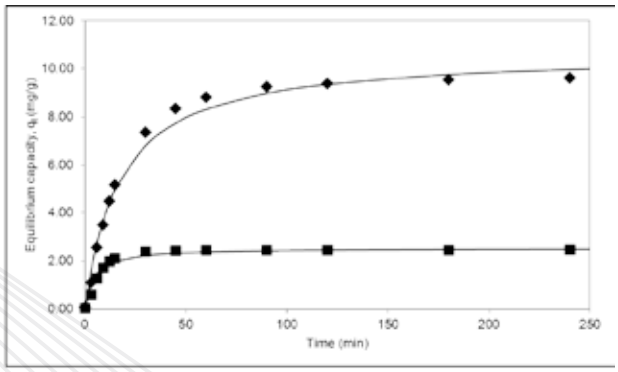
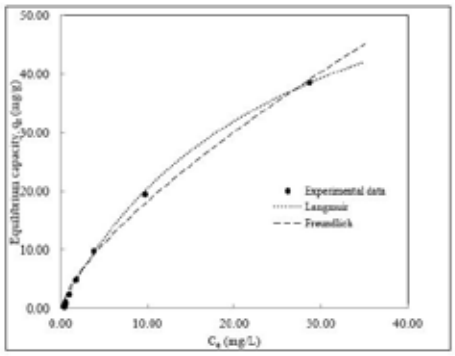
Development of a recovery system for biovanillin

Macroporous resins were tested for vanillin adsorption from aqueous solution, which were Amberlite XAD-16, Amberlite XAD-2, Sepabeads SP207, Diaion HP-20, DM11 and H103. All the resins gave more than 95% adsorption except for Amberlite XAD-2 and DM11. Resin H103 was selected for the subsequent work due to high adsorption capacity and low cost. Adsorption parameters were determined in batch mode in order to obtain the preliminary conditions for vanillin adsorption onto resin H103. Tests at different temperatures between 25°C and 55°C yielded almost similar adsorption performance, which led to the selection of 25°C as the reaction temperature. It was also observed that within the range of pH tested (pH 3.0 to 7.0), no considerable different in the amount of vanillin adsorbed. For that reason, pH 6.0 was selected as the reaction pH, mainly due to the pH of freshly prepared vanillin solution was around pH 5.9 to pH 6.1. Kinetics analysis revealed that the adsorption followed pseudo-second order kinetic model and occurred rapidly, after which it reached equilibrium after 90 minutes of reaction. Adsorption isotherm was also determined at 25°C and it was fitted to Langmuir and Freundlich equations using linear regression and non-linear regression (sum of squares) methods. The regression shows that the vanillin adsorption onto resin H103 followed Langmuir model (R^2 of 0.9984), with a maximum capacity of 73.015 mg/g.

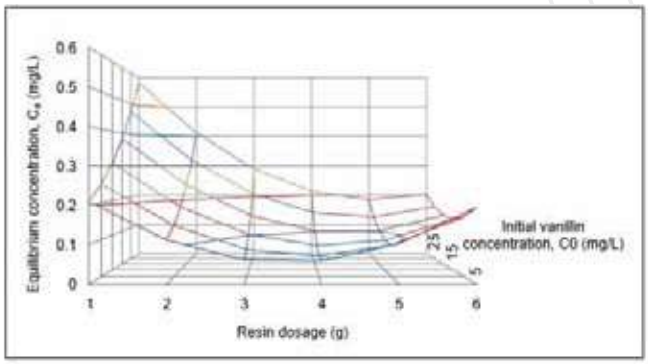
Fractional factorial screening and response surface methodologies were used in order to explain the effect of several factors affecting the adsorption of vanillin onto resin H103 in batch mode. The factors were contact time, initial vanillin concentration, resin dosage, pH and temperature. With the aid of Design Expert version 7.1.6, initial vanillin concentration and resin dosage were determined as significant. The analysis of variance (ANOVA) gave a very good of determination coefficient (R^2) of 0.9996. The two significant factors were further optimized in order to determine the optimum condition, using response surface method (RSM). A good R^2 was also obtained for the optimized condition (0.9463). A plot of response surface also gave a minimum point, which indicated that within the range tested, an optimum condition to obtain the lowest equilibrium concentration of vanillin in the aqueous was achieved.



Contact time profile of vanillin adsorption onto resin H103.



The equilibrium adsorption isotherms at 25-¦C for vanillin adsorption onto adsorbent resin H103



Response surface plot for the effect of resin dosage and initial vanillin concentration on vanillin adsorption onto resin H103

Supervisor
Professor Dr. Suraini Abd-Aziz

Objectives

1. To determine the suitable resins on the absorption capacity of vanillin in term of its kinetics and reaction parameters
2. To elucidate vanillin adsorption behaviour in fixed bed column via dynamic adsorption capacity and rate constant
3. To perform scale-up analysis of vanillin adsorption onto fixed bed resin H103

PhD Student EB GROUP

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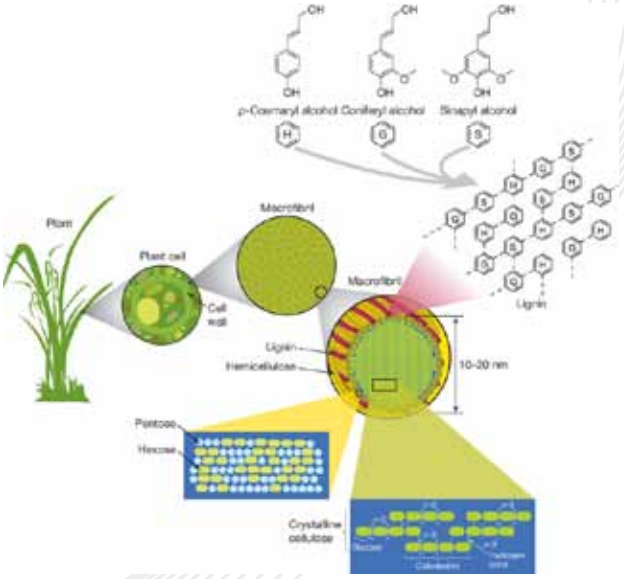
Development and optimization of lignocellulolytic enzyme cocktail for fermentable sugars production from oil palm empty fruit bunch

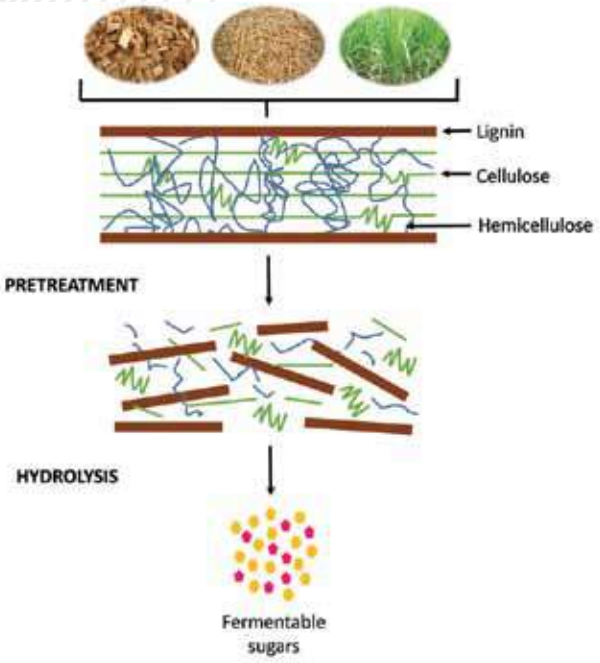
To date, Malaysia rank in the second place as a global palm oil producer. However, a non-systematic biomass management system despite the rapid growth of oil palm plantation in Malaysia contributes a lot to biomass accumulation in huge amount. Oil palm empty fruit bunch (OPEFB) can be categorized as one of the toughest lignocellulosic biomass to be degraded naturally due to its complexity in structure. Common industrial practice used chemical and physical treatment to treat the OPEFB as it performs faster in hydrolyzing the biomass than biological treatment does. However, as the world is moving towards green concept nowadays, chemical treatment is no longer suitable to be practiced because it produce harmful by-product and it give low yield of fermentable sugar. Bioethanol is a green product that was commonly blended in up to 1-2% with gasoline to reduce the consumption of fossil fuel for vehicle use. The idea of converting the unwanted OPEFB into a useful product such as bioethanol came up due to the biomass pile up from oil palm plantation activity and palm oil refinery industry. In this study, the OPEFB was treated biologically using crude enzyme extract instead of using common physicochemical method due to environmental concern. The OPEFB is subjected to enzymatic hydrolysis by crude lignocellulolytic enzyme to produce a fermentable sugars. Hence, the biological approach for delignification and saccharification process is expected to results in high lignin removal and consequently produces high fermentable sugars concentration.

Pycnoporus sanguineus

Oil palm empty fruit bunch (OPEFB)



Structure of lignocellulose



Overview of lignocellulose hydrolysis

Supervisor
Professor Dr. Suraini Abd-Aziz

Objectives

1. To improve the ligninolytic enzyme production using *Pycnoporus sanguineus* through the effect of inducers
2. To optimize the parameters for delignification and saccharification of oil palm empty fruit bunch using statistical approach for higher fermentable sugars production

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Efficient bioethanol production from oil palm frond petiole

The growing interest in bioenergy and particularly in second generation bioethanol (SGB) is a great challenge as the development of lignocellulose-related technologies are not very well established in the world. Another major constraint is the relatively higher cost of SGB, both in terms of investment costs and final energy costs. This causes the commercialization of research findings on SGB faces stiff competition from fossil fuels. Hence, this study was aimed to produce SGB but using a straight forward technology of first generation bioethanol from sugarcane juice. A newly identified lignocellulosic material having such characteristics is the fresh oil palm frond (OPF). OPF is the largest biomass source in the palm oil industry contributing 61% of total biomass. Fresh OPF juice can be readily obtained by just pressing the fresh OPF petiole, similar to sugarcane. OPF juice was identified rich in fermentable sugars and other nutrients, making it a potential medium for bioethanol fermentation. A promising yield of bioethanol per g sugars consumed was obtained after 24 hours of fermentation of fresh OPF juice without nutrient supplementation and without pH correction, which is comparable to synthetic medium as well as the bioethanol yield from sugarcane juice in the Brazilian bioethanol industry. Therefore, this study provides an opportunity for the use of fresh OPF juice as a new renewable, non-food and non-cellulosic feedstock for the bioethanol industry. However, the major challenge of using liquid feedstock as a fermentation medium is rapid degradation of sugars during storage. Therefore, the effect of OPF juice concentration and mild temperature storage on glucose content were studied.

In order to commercialise the bioethanol production from OPF petiole, the usage of sugars from both OPF juice and OPF pressed fibre were proposed as the percentage of fermentable sugars present in both portions is economically feasible as compared to usage of OPF juice alone. Therefore, a new approach of integrating a biorefinery plant for bioethanol production to an existing palm oil mill (POM) was examined. The concept proposed the production of fermentable sugars from OPF at six neighboring POMs before being transported to the nearest biorefinery plant located at one of the POMs. All the processes was targeted to use the excess energy at the current POM in order to reduce the utility cost. This research expected the low production cost of bioethanol from OPF by integrated approach similar to production cost of corn bioethanol and cheaper than the current SGB cost. This finding suggests that an integrated approach is an economically feasible option to commercialise bioethanol production in the near future, provided that the government make a move towards the commercialisation by introducing a policy on SGB.

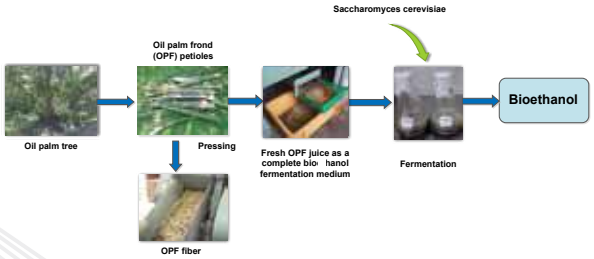

Figure 2: Bioethanol production from oil palm frond juice

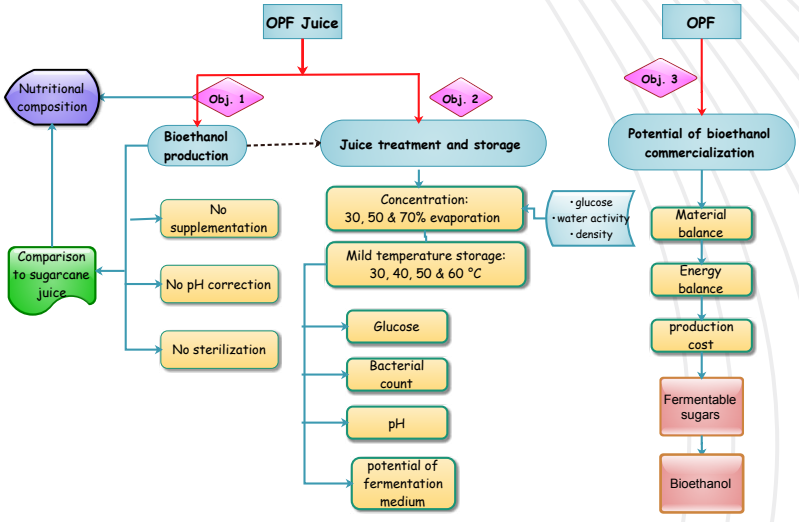

Figure 1: Overall experimental outline

Supervisor
Professor Dr. Yoshihito Shirai

Objectives

1. To exploit the OPF juice as a renewable, non-food, non-cellulosic and complete medium for direct bioethanol production
2. To investigate the effects of OPF juice concentration and mild temperature storage on glucose content in OPF juice
3. To evaluate the feasibility of bioethanol commercialization from fresh OPF by introducing integrated technology approach of bioethanol plant to existing palm oil mill (POM).

PhD Student EB GROUP

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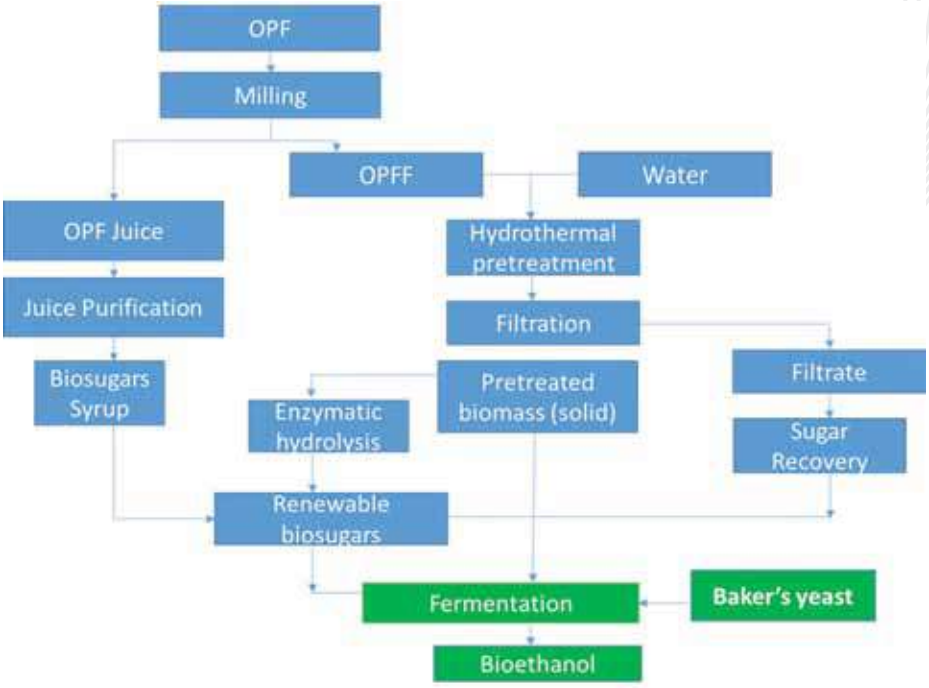
Development of biorefinery process for the production of bioethanol from oil palm frond

Lignocellulosic materials are currently been considered as the most promising source of fermentable sugars as feedstock for biofuel and biobased material production. In 2010 only, Malaysia generated approximately 80 million tonne of dry solid biomass from the oil palm industry and it is predicted to increase up to 110 million tonnes in the year of 2020 (Che Maail et al., 2014). Oil palm empty fruit bunch, oil palm mesocarp fiber and oil plan frond are among the main oil palm wastes produced, with oil palm frond being the largest (Zahari et al., 2014, Ofori-Boateng & Lee 2014). The main concern in the application of lignocellulosic materials is that it requires aggressive pretreatment which contributes to high production cost. Since initial conversion of biomass to sugars is considered as the key bottleneck in biomaterial production, researchers are looking at more efficient, environmental friendly methods which results in more lignin removal and higher surface area for enzymatic reaction. Hydrothermal pretreatment appeared to effectively improve the digestibility of lignocellulosic biomass (Goh et al., 2012, Zakaria et al., 2014, Zakaria et al. 2015). At high temperature, hydronium ions cause the catalytic depolymerisation of hemicellulose to xylooligomers and xylose, and the cleavage of acetyl groups to acetic acid, which increases the hydronium concentration in the reaction media (Sabiha-Hanim et al., 2011). Interestingly, under these condition water possess very interesting and unique properties which make it a powerful solvent suitable for solvolysis of complex polysaccharides (Orozco et al., 2012).

This study will investigate hydrothermal pretreatment of oil palm biomass in the presence of gases such CO2 and nitrogen. The hydrothermal hydrolysis of the biomass will be conducted at various combined severity factor and held at selected pressure to assess the influence of these operating conditions on the lignocellulosic content, surface morphology, crystallinity and other physical changes, apart from sugar recovery following enzymatic hydrolysis. Apart from that, kinetic study for the hemicellulose and cellulose hydrolysis will be performed to assist in the evaluation of mechanism and process design. Finally, the biorefinery process for the production of bioethanol will take place, using the sugars obtained earlier. Findings from this study are expected to provide better understanding on hydrothermal hydrolysis and further highlight the potential of OPF as renewable carbon source.



Flow chart of project

Supervisor
Professor Dr. Mohd Ali Hassan

Objectives

1. To evaluate the effect of hydrothermal pretreatment at combined severity factors in enhancing enzymatic hydrolysis for sugar recovery from oil palm frond fiber (OPFF)
2. To study the kinetic of hemicellulose and cellulose hydrolysis for hydrothermal pretreated OPFF
3. To develop biorefinery process for bioethanol production from renewable sugars of oil palm frond

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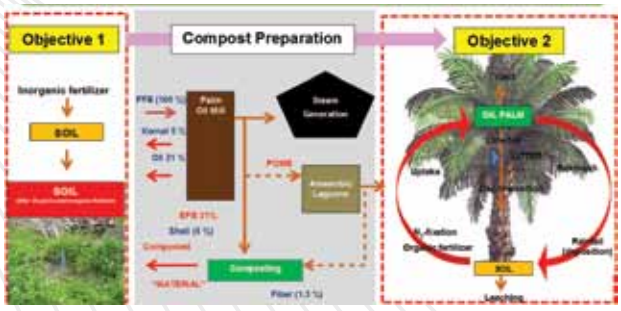
The use of oil palm empty fruit bunch and palm oil mill effluent compost in oil palm plantations: Nutrients recycling system for oil palm industry

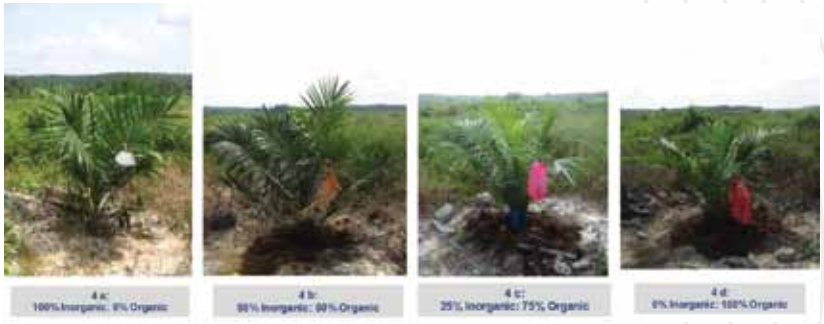
Oil palm industry in Malaysia plays a vital role for oil production since early 1980s. Malaysia is the second oil palm producer after Indonesia accounted for almost 85 % of crude palm oil (46.5 million tons) produced in the word (Oil World, 2013). Although oil palm industry is a strong driver for economic development in Malaysia by providing jobs and incomes to millions of people (USDA, 2007), but it is undeniable that this industry also triggering deforestation, loss of biodiversity, peat land degradation and greenhouse gas (GHG) emissions (Comte et al., 2012; Greenpeace, 2011; WWF, 2011). Furthermore, an environmental issue related to oil palm plantation is also associated with the excessive usage of fertiliser (Foks et al., 2011). The best practise for fertiliser management at oil palm plantation is based on nutrient balance principle by estimating the total demand of the palm and matches with the supplemented nutrient and fertiliser (Goh et al., 1999). Long-term impact of inorganic fertiliser usage is notified based on soil properties (chemical and physical composition) and microbial community (Masto et al., 2007). Therefore, this research will use empty fruit bunch (EFB) with palm oil mill effluence (POME) as compost. The benefit of EFB with POME as compost application in an oil palm plantation has been reported in many literatures. The limitations of poor soil structure and sandy texture can be partly ameliorated by the use of organic matter such as EFB (Paramanthan, 2003). Furthermore, Zulkornain et.al., (2002) also stated that the chemical properties of soil treated with EFB/POME compost were significantly increased root proliferation and encouraged root penetration especially for the oil palm planted in a terrace area. Compost are able to improve soil physical, reduce soil bulk density, nutrients, increase total porosity in soils over a wide range of textural class and enormous community of microorganism. Therefore, in this study the interaction between EFB/POME compost and oil palm growth will be measured based on soil quality analyses.

Compost production at Biorifenary Technology Centre (BTC), University Putra Malaysia

Field trip to FELDA Serting Hilir, Negeri Sembilan



Flow chart of the research project



Treatment of oil palm plantation at FELDA Serting Hilir, Negeri Sembilan

Supervisor
Professor Dr. Mohd Ali Hassan

Objectives

1. To conduct baseline study, characterize macro-,micronutrient and microbial diversity of soil planted with oil palms
2. To evaluate the effect of organic and inorganic fertilizer on changes of oil yield, the physical characteristics of oil palm and the soil microbial diversity

PhD Student EB GROUP

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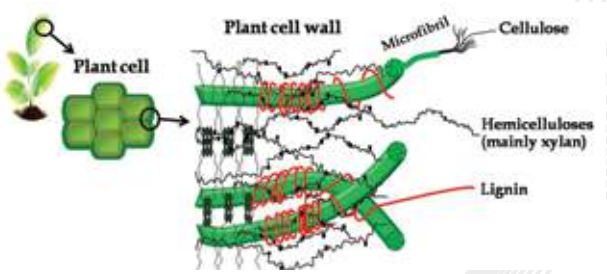
Production of fermentable sugars from oil palm empty fruit bunch using crude lignocellulolytic enzyme cocktail

Worldwide lignocelulosic residues generation every year with inefficient waste management resulted with environmental pollution and loss of valuable materials that can be bio-converted to many of value-added products. Oil palm empty fruit bunch were produced extensively in Malaysia and Indonesia particularly which contributes to the largest fraction of agricultural wastes in the country. The utilization of these agricultural wastes has been seen as promising substrates to be used in various areas of application. As part of the wealth generation strategy, government support to the use and its utilization as well as the incentives given has made it possible to be implemented.

The basic fundamental of the utilization of lignocellulosic residue may arise from the knowledge deals with the rigid structure of lignin and involvement of cellulose and hemicellulose that entail the valued disaccharide and monosaccharide of sugar. Theoretically, lignin gave a strong structure to plants whilst the component of cellulose and hemicellulose were scaffold in between. Thus, the utilization of cellulose and hemicellulose was blocked by the present of lignin. The responsible enzyme was classified into two categories which is ligninolytic enzyme (lignin peroxidase, laccase and mangan peroxidase) and cellulolytic enzyme (FPase, CMCase and β-glucosidase). All of the enzymes were secreted in nature by the ascomycetes and basidiomycetes species of fungi and the manipulation of enzyme to be used in targeted process are very useful. A lot of research together with the fungi in the process took a long time to achieve a specific target of partial lignin removal or modification. Many experiments have been made and a lot of efforts have been invested using fungi for technical lignin removal in the pulping process and for biobleaching. However, the incubation time has to be extended to attain a satisfactorily lignin removal. Incubation time and conditions is still an obstacle to a broad commercial application. Today's goals of fungal pretreatment have changed from the lignin removal (as much is possible) in the beginning, to a modification of lignin. Latest improvement has been made to the use of only enzyme to implementing the removal or modification of lignin instead of fungal pretreatments. Through this research, we are aiming to fulfill the gaps in bringing more environmentally approach by using enzymatic pretreatment using ligninolytic enzyme at the early stage of lignin modification with addition of mediators compound to improve the efficiency and followed by the actions of crude cellulolytic enzyme for the production of sugars which both produced by local isolates to replace the current practices of using list of chemical catalyst as a favorite choices.



Flow chart of project

This research study will covers the screening and isolation of locally isolated white rot fungi for the production of the best selected ligninolytic producer. The enzyme extracted was used to carry out the effect of enzymes with the addition of mediators on the partial removal of OPEFB and further effect on the enzymatic hydrolysis of cellulose was also studied. In another section, cellulase improvement from locally isolated ascomycetes *Trichoderma asperrellum* UPM1 and *Aspergillus fumigatus* UPM2 was done through solid state and submerged fermentation using oil palm empty fruit bunch, sago pith residue and oil palm decanter cake. Physical and chemical characteristic of each substrates were studied in relation to the effects on the cellulase production. Holocellulose content, cellulose crystallinity and water solubility and absorption were determined. At the final part, both enzymes from the white rot and ascomycetes fungi were applied to studied substrate of OPEFB and the potential sugars produced obtained.

Supervisor
Professor Dr. Suraini Abd-Aziz

Objectives

1. To delignify OPEFB using crude ligninolytic enzymes from locally isolated fungi
2. To improve cellulases enzyme production by *Trichoderma asperellum* UPM1 and *Aspergillus fumigatus* UPM2
3. To produce fermentable sugar from OPEFB by two step of enzymatic degradation and hydrolysis using crude lignocellulolytic enzyme cocktail

Type of white rot fungi

Shredded OPEFB

EB GROUP Master Student

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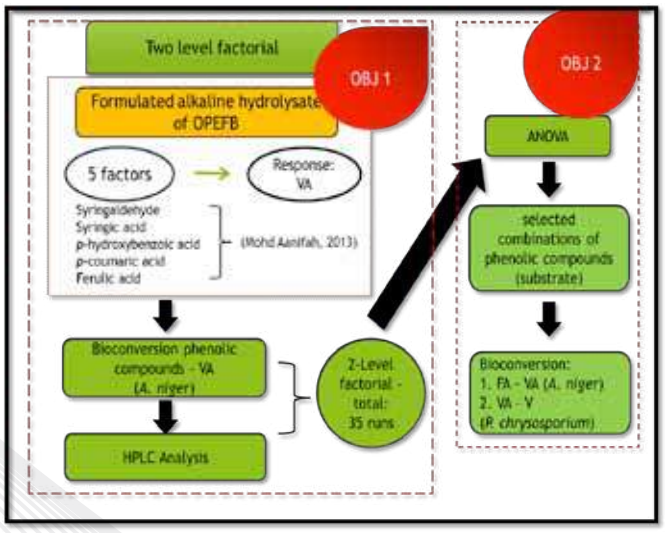
Bioconversion of selected phenolic compounds into biovanillin using formulated alkaline hydrolysate of oil palm empty fruit bunch

Vanillin is one of the most commonly used flavours in food, beverages, perfumes and pharmaceutical products which normally extracted from the beans of *Vanilla planifolia*. It is known that natural vanillin has high demand and high market price than synthetic vanillin. Due to these factors, extensive studies are carried out on the production of biovanillin via microbial bioconversion. *Aspergillus niger, Pycnoporus cinnabarinus* and *Phanerochaete chrysosporium* are the common fungi used for the biovanillin production. Phenolic compounds such as ferulic acid, vanillic acid and eugenol or isoeugenol have been proved as precursors for biovanillin production. Instead of using synthethic biovanillin precursors, researchers now had found an alternative to use the phenolic compounds extracted from lignocellulosic biomass such as oil palm empty fruit bunch (OPEFB). Based on the composition of phenolic compounds in alkaline hydrolysate of OPEFB, there are five major phenolic compounds selected which are syringic acid, syringaldehyde, p-hydroxybenzoic acid, p-coumaric acid and ferulic acid. The interactions of those compounds are studied in order to see the significance of each phenolic compound towards vanillic acid production using two level full factorial designs. The imitation of alkaline hydrolysate of OPEFB is carried out using synthetic phenolic compounds. For second objective, the best combination of phenolic compound in producing vanillic acid is used as substrate for biovanillin production using two stages of fermentation involving *Aspergillus niger* and *Phanerochaete chrysosporium* as producers.



Research overview

Aspergillus niger

Phanerochaete chrysosporium

Vanilla planifolia

Oil palm empty fruit bunch

Supervisor
Professor Dr. Suraini Abd-Aziz

Objectives

1. To determine the interactions of phenolic compounds in formulated alkaline hydrolysate of OPEFB towards vanillic acid production using 2-level factorial approach
2. To obtain biovanillin using selected combinations of phenolic compounds

Master Student EB GROUP

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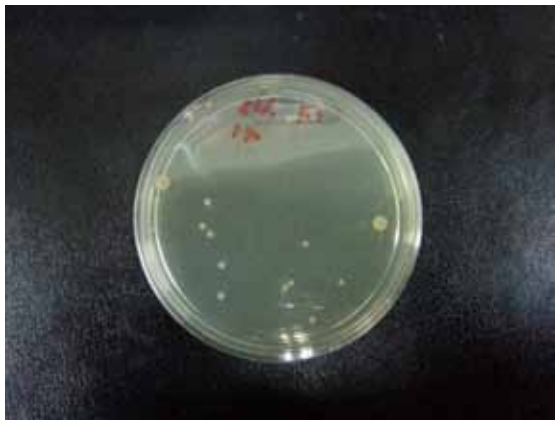
Feasibility of oil palm frond petiole as fermentation substrate

Palm oil is the most profoundly traded vegetable oil in the world, leading approximately 60% of vegetable oil market volume in 2008 (Oil World, 2009). It is majorly planted in South East Asia and Malaysia being as second largest of global palm oil producer which contributing 40% of world production and lead by Indonesia which currently contribute 45% of total oil palm production in the world. Current strategies of managing the residues are by formulating it into ruminant feed. Ongoing research found that the OPF juice contain high sugar composition that can be developed for another rising industries like fermentation, biohydrogen and other high end products. Depolymerizing cellulose using enzyme is a known way to extract sugars. Rather using enzyme for extraction, the sugars is obtained directly from the oil palm frond petiole by using conventional sugarcane press machine. Storage evaluation was also been done to examine the critical sugar degradation in OPF prior to pressing. Besides, this study research was proposed to optimize the production of the juice extraction with the means of pre-treatments as well as techniques to preserve the juice after extraction. The pre-treatment involve including shredding, direct pressing with hydraulic pressing machine and applied optimizing of OPF petiole storage evaluation for preserving the juice. As much as 38 g/kg of free sugars extracted from OPF using the hydraulic pressing machine. Currently, the juice storage was evaluated using water removal technique via heat treatment. Removing water was found to inhibit the microbial growth due to the severe conditioned caused by reduction of water activity. This kind of treatment suffices to preserve the juice within short times 10 days prior to be used as fermentation substrate with merely 8-10% sugar degradation due to the high heat exposure. This study is part of a growing research on oil palm field and economically beneficial to the country. It will explore the potential available on fermentation industry.



Microbial colony capable to grow on OPF juice incorporated to agar

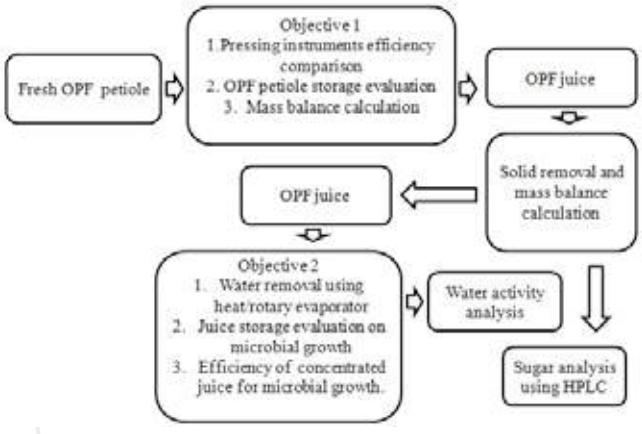
Fresh OPF after pruning

OPF juice extracted from the petiole

Supervisor
Dr. Hidayah Ariffin

Objectives

1. To investigate the effect of OPF petiole storage period and physical pretreatments on recovery and characteristics and fermentable sugars from OPF petiole.
2. To concentrating OPF juice by heat treatment and determine storage stability of concentrated OPF juice at ambient temperature.



Big picture of research

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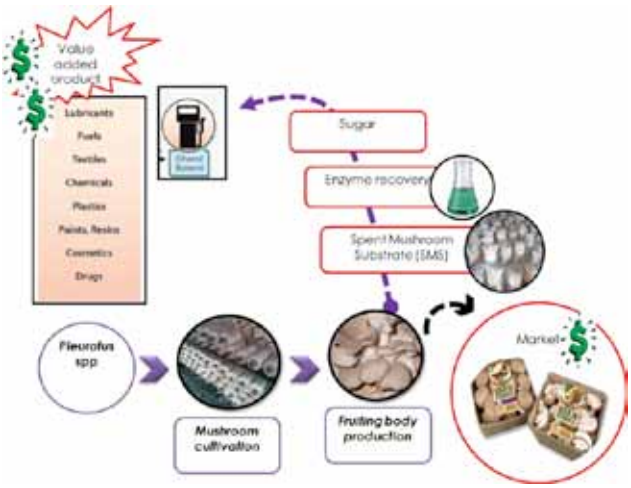
Utilization of spent mushroom compost for cellulase enzyme production

Lignin is the second most abundant biological material on the planet, plant – originated polymer having complex three – dimensional network consists of monomethoxylated, dimethoxylated and non - methoxylated and about 15-25% of the dry weight of woody plants. This macromolecule plays a vital role in providing mechanical support to bind plant fibers together. Removal of lignin from plant cell wall contributes enormously towards many industrial sectors but the resistance of lignin to breakdown is a major obstacle.

Mushroom, fall in the class of basidiomycetes, is a fruiting part of the fungus. This protein – rich biomass was produced through a mechanism known as nutritive absorption and can thrive over wide range of agro-waste materials. Over others, *Pleurotus* spp. has drawn an attention and it has been shown that *Pleurotus* spp. can be cultivated successfully on saw dust, coir waste, rice straw, olive mill waste, wheat straw, cotton stalks and other lignocellulosic biomass. Pleurotus genus is listed as the second most cultivated edible mushroom in worldwide right after *Agaricus bisphorus* and particularly accounted for 90% of mushroom production in Malaysia. Its capability in secreting various degradatory enzymes which grouped into three, ligninases, hemicelullases and cellulases which become the major key to enable them to grow on various substrates.

Changes in enzyme profile are correlated with vegetative growth and fruiting body development of *Pleurotus* sp. To investigate the enzyme activities during fructification phase, samples from mycelia colonised substrate (sawdust) of *P. pulmonarius* and *P. floridanus* were taken during fruiting body formation for five times harvesting period. The result showed both strains were able to produce laccase and manganese peroxidase (MnP). Presence of laccase and manganese peroxidase at the end of cultivation period offering great potential of spent mushroom compost for various applications.

Crude ligninolytic enzyme extract



Schematic flowchart of enzyme recovery from mushroom cultivation

Oven – dried spent mushroom compost

Pleurotus pulmonarius

Pleurotus floridanus

Supervisor
Professor Dr. Suraini Abd-Aziz

Objectives

1. To determine the ligninolytic enzyme activities produced during the growth of two commercial mushrooms (*P. floridanus* and *P. pulmonarius*)
2. To evaluate the potential of spent mushroom compost (SMC) as substrate for cellulase enzymes production

Master Student EB GROUP

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Production of activated carbon from oil palm biomass for treatment of palm oil mill final discharge

Biomass activation process

Activated carbon (AC) from biomass gain interest as an abundant, cheap and renewable substitute of commercial AC. Conventional AC production uses non-renewable sources such as coal and renewable sources such as peat, coconut shell and pine wood. Feasibility of AC production from oil palm biomass (mesocarp fiber and empty fruit bunch) on small scale has been proven, but the ability of said AC produced in treating palm oil mill final discharge (POMFD) is not yet researched. Oil palm biomass activated carbon is expected to reduce the color, chemical oxygen demand (COD) and suspended solid of POMFD down to river water quality. All raw materials was first pyrolyzed in low oxygen atmosphere before activated using steam and phosphoric acid. Final activated samples and biochar produced was analyzed and compared in terms of BET surface area. Adsorption capacity and capability of said activated samples in treating POMFD was also inspected.

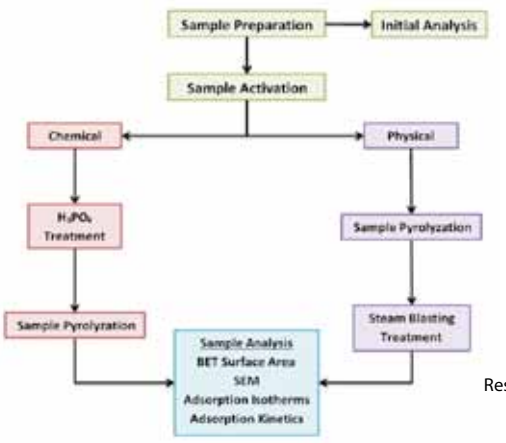
It is expected that the surface area of both chemically and steam activated samples will exceed 500 m^2/g with pore size of about 5-20 nm. It is also expected that the activated carbon produced will be able to treat palm oil mill final discharge to acceptable level.

Use of activated carbon in industry

Supervisor
Professor Dr. Mohd Ali Hassan

Objectives

1. To produce activated carbon with minimum surface area of 500 m^2/g and mesoporous surface morphology (2-50 nm) from oil palm biomass using pyrolysis and activation.
2. To determine the characteristics and quality of activated carbon produced in treating POMFD.



Research flow chart

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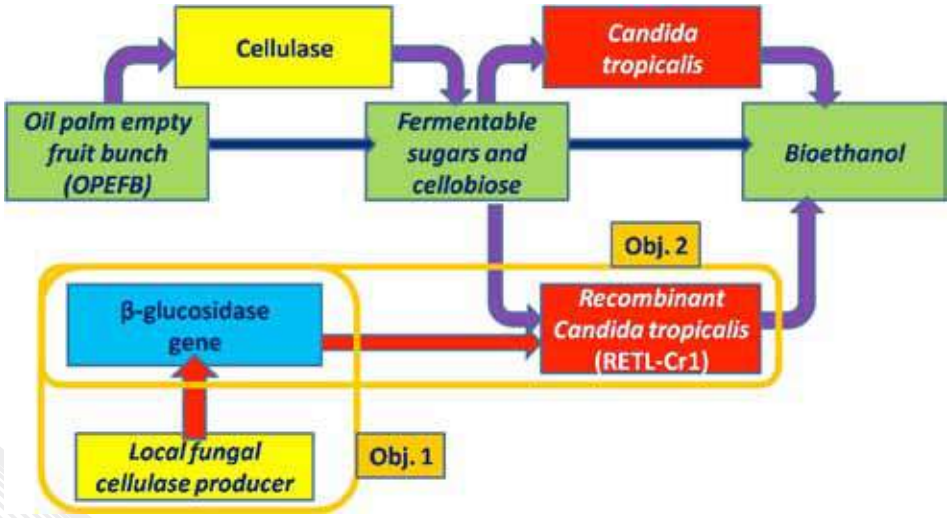
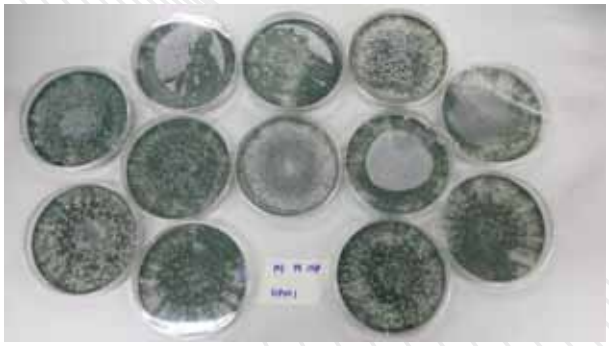
Molecular cloning of β-glucosidase gene into *Candida tropicalis* for enhancement of bioethanol production from oil palm empty fruit bunch

Environmental and economic concerns related to fossil fuel consumption have driven the need for alternative renewable fuel such as bio-ethanol. In Malaysia, abundance of oil palm empty fruit bunch (OPEFB) as waste following oil palm production offers great potential as lignocellulosic substrate. To this aim, locally isolated *Candida tropicalis* yeast strain has been used for fermentation of sugar intermediates into bioethanol. In comparison to conventional ethanol producing yeast *Saccharomyces cerevisiae*, the alternative yeast strain offers possibility of operation at higher temperatures due to its thermotolerance, ability to ferment pentose sugars and decompose toxic phenols. For efficient lignocellulose hydrolysis, high conversion rates from the cellulase constituents, endoglucanase, exoglucanase and β-glucosidase, are deemed essential. However, common low β-glucosidase expression has resulted in cellobiose buildup, in turn causing feedback inhibition. Thus to achieve increased saccharification rate and reduced inhibition, along with tackling the high cost of enzymes in general, consolidated bioprocessing has been proposed. Previous genetic engineering efforts to achieve heterologous β-glucosidase expression has been made on *S. cerevisiae* capable of industrial scale fermentation, of which has not been demonstrated in *C. tropicalis* utilizing OPEFB hydrolysate derived cellobiose. Similar success is expected to enhance both cellobiose degradation and subsequent bioethanol fermentation. To this effort, isolation and characterization of putative genes from local fungal isolate will be done, followed by expression within *C. tropicalis*.



Big picture



Fungal plates for spore collection

Shredded oil palm empty fruit bunch

Using cDNA synthesised from extracted mRNA as template, RACE-PCR will be carried out for gene sequencing, prior to molecular cloning and transformation in the yeast strain. In short, this research represents progression in enhancement of bioethanol production from oil palm biomass hydrolysates.

Supervisor
Dr. Norhayati Ramli

Objectives

1. To isolate and characterize β-glucosidase gene from local fungal isolate used for degrading cellulosic biomass
2. To express the ethanol producing strain carrying β-glucosidase gene for enhancement of cellobiose saccharification and bioethanol fermentation

Master Student EB GROUP

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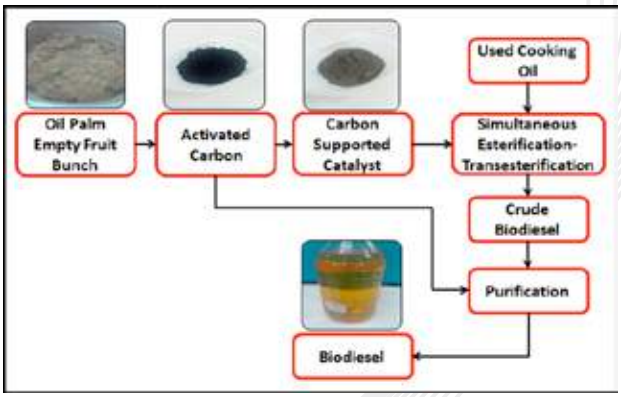
Utilization of activated carbon produced from biomass in biodiesel production using used cooking oil as feedstock

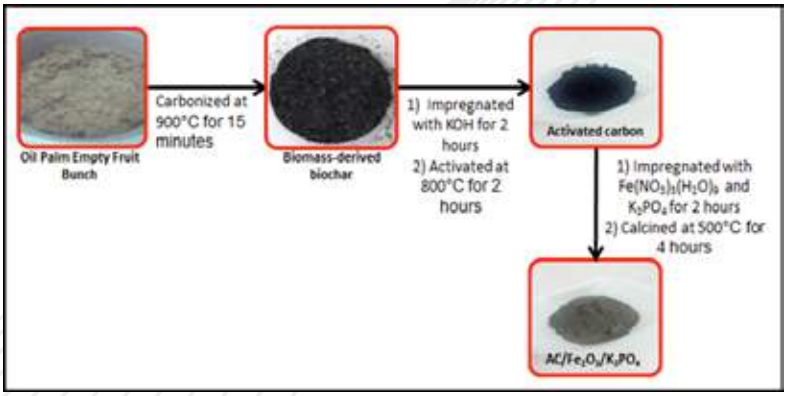
Today, biodiesel is seems to be as an alternative for depleting petroleum diesel. It is renewable and environmental friendly, thus giving a new prospect for a greener future. Unfortunately, high price of feedstock, non-reusable catalyst, and incompetence purification method have made the production of cost–effective biodiesel fuel very challenging by which consequently had prohibiting the spread of its applications. Nevertheless, utilization of cheaper feedstocks and reusable catalysts found to be the alternatives to tackle the problem.

In this study, biodiesel production from used cooking oil (UCO) was carried out using a developed biomass-derived carbon supported catalyst. The activated carbon (AC) is first been prepared through KOH-activation using oil palm empty fruit bunch (OPEFB) before been functionalized with ferric oxide/potassium phosphate tri-basics (Fe_2O_3/K_3PO_4) through calcination. The developed AC/Fe_2O_3/K_3PO_4 catalyst subsequently is used in simultaneous esterification-transesterification biodiesel production using UCO as feedstock.

While in biodiesel refining process, the carbon derived from OPEFB will act as an adsorbent to improve the quality of the final product and fulfill the biodiesel specifications standards. It is presumed that the quality and yield of final biodiesel product will be enhanced as well as its properties. Conclusively, the employment of biomass in biodiesel production represents a potential technology to improve biodiesel production as well as environmental conservation.



An overview methodology of research project



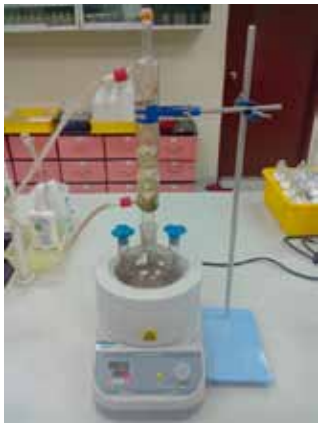
Flow steps involved in biomass-derived carbon supported Fe_2O_3/K_3PO_4 (AC/Fe_2O_3/K_3PO_4)

Supervisor
Professor Dr. Mohd Ali Hassan

Objectives

1. To synthesize, characterize and optimize biodiesel production from used cooking oil using carbon supported ferric oxide doped tri-potassium phosphate (AC/Fe_2O_3/K_3PO_4)
2. To compare the quality of biodiesel purified using activated carbon produced from biomass with water-washing, silica gel, magnesium silicate, and bentonites purification methods

Crude biodiesel product after simultaneous esterification-transesterification process



Digital bifunctional heating and stirring mantle used in biodiesel production

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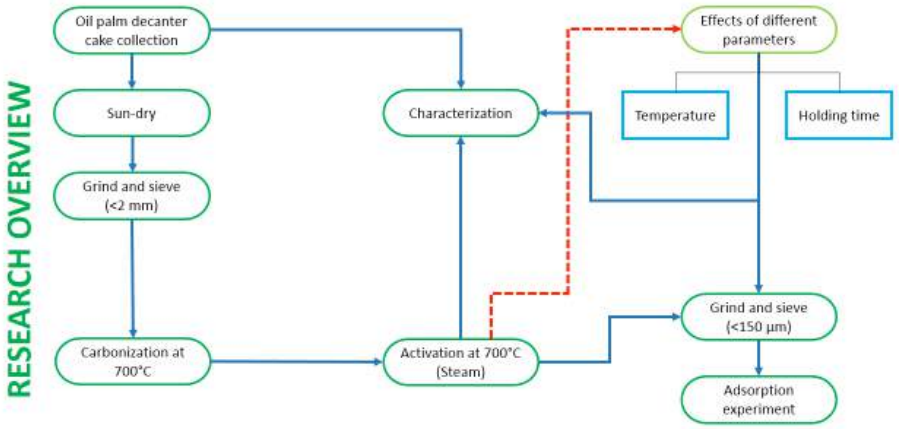
Activated carbon as a bioadsorbent produced from oil palm decanter cake by carbonization and physical activation process

Heavy metals were among the prominent hazardous wastes contain in wastewater. Due to rapid growth of population, industrial expansion, and unorganized urbanization, there is great amount of wastewater produced from all of these activities. Therefore, the wastewater needed to be treated adequately to meet the discharge standard. Various treatment processes were used for the treatment of heavy metals, however, adsorption process shown the most efficient treatment. Commercial activated carbon is commonly used for the treatment due to its high effectiveness. Due to the high cost involved in the usage of commercial activated carbon, alternatives activated carbon should be investigated. This study involves the treatment of heavy metals using the oil palm decanter cake (OPDC) as a precursor for activated carbon production. The OPDC will be activated by physical activation process, preceded by carbonization at 700°C and followed by steam activation at temperatures between 600°C to 800°C. The effects of activation temperatures and holding times on the characteristics of the activated carbon produced will also be investigated. Characterization of activated carbon yield, specific surface area, porousity, and heavy metals (Cu(II) and Pb(II)) adsorption will be conducted and will be compare to commercial activated carbon. It is expected that with carbonization and physical activation process, a quality activated carbon can be produced from the OPDC due to its higher specific surface area and highly porous structure.



Big picture

Dried raw OPDC

Activated OPDC

Reactor used for carbonization and activation

Supervisor
Professor Dr. Suraini Abd-Aziz

Objectives

1. To produce activated carbon from oil palm decanter cake with the minimum surface area of 500 m^2/g by carbonization and physical activation process for the treatment of heavy metals
2. To enhance the surface area of activated carbon produced from oil palm decanter cake by differentiating holding times and temperatures

Master Student EB GROUP

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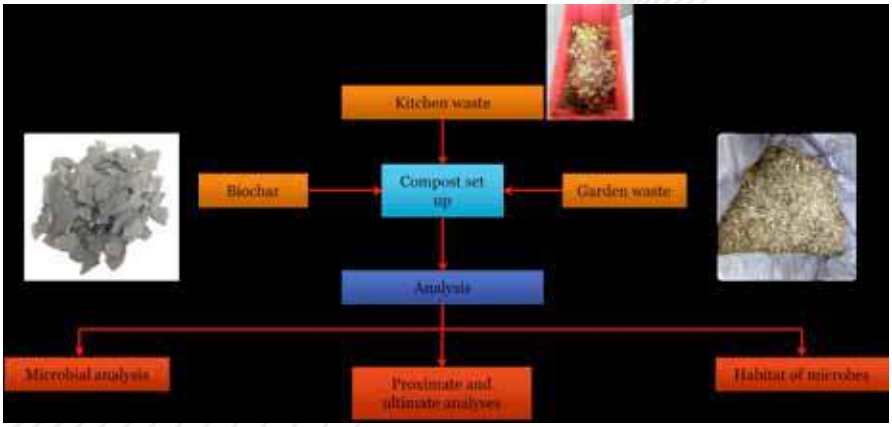
Pilot scale co-composting of kitchen and garden wastes with addition of biochar

Biochar is commonly added in compost mainly to increase carbon content, provide suitable habitat for microbes and accelerate the composting process. By applying this knowledge, biochar from coconut shell is added to the compost to increase degradation efficiency and add value to the compost. In this study, the effect of biochar addition on co-composting of kitchen and garden wastes in pilot scale is investigated. Percentages of 1%, 2%, 4% of biochar from coconut shell are added. Kitchen waste is mixed with garden waste collected from local authority to act as co-agent. Composting is carried out in tumbling drum with 0.5 m^3 operating capacity for 14 days with continuous monitoring of temperature, pH, moisture content and aeration rates and then left in windrow for curing stage, prior to analysis of microbial community. Proximate and ultimate analyses are also done to determine nutrient content, trace element and heavy metal of the end product. Microbial community structure are analysed by using Denaturing Gradient Gel Electrophoresis (DGGE). The microbial DNA is the mixture of genomic DNA which extracted from the compost sample and amplifies using Polymerase Chain Reaction (PCR). The amplified products were separated to identify the specific bacterial community by applying DGGE. The band is sent for sequencing after confirming PCR product as a single band. BLAST (Basic Local Alignment Search Tool) network service of GenBank Database is used to check sequence similarity and Ribosomal Database Project II (RDP) for identifying nearest relatives of partially sequenced 16S rRNA gene and prominent excised band. From the findings, it is biochar can be proved to accelerate the composting process and enhance microbial activity inside.

Pilot scale tumbling composter



Big picture

Supervisor
Professor Dr. Mohd Ali Hassan

Objective
1. To determine the effect of biochar on microbial communities of co-composting of kitchen and garden wastes by using denaturing gradient gel electrophoresis (DGGE).

Kitchen waste collected from Serdang area

Biochar from coconut shell used as treatment to improve composting process

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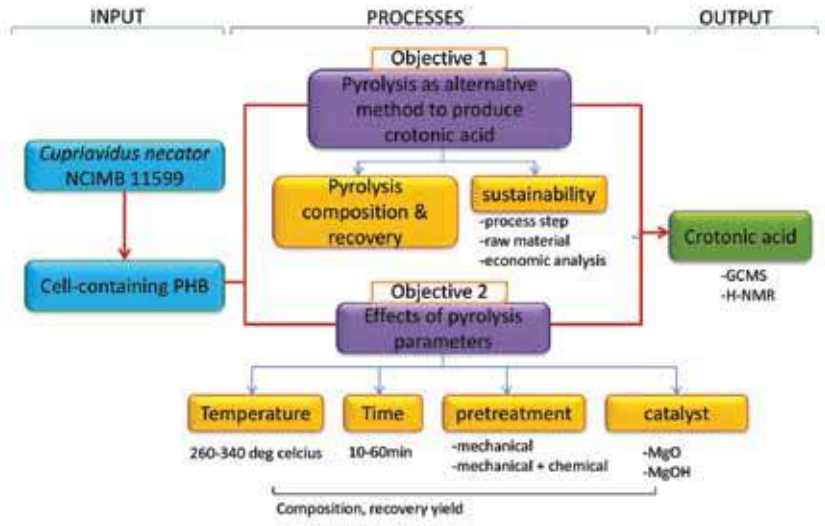
Development of bio-based production of crotonic acid via pyrolysis of polyhydroxybutyrate (PHB) biomass

Fermentation of PHB by *C. necator* NCIMB 11599 in 20 L bioreactor



Big picture

Crotonic acid is a short chain unsaturated carboxylic acid. Crotonic acid and its derivatives have various specific applications; for example as a component in dental materials, cosmetics, hair styling products, plasticizers, herbicides, compatibilizers, paints and hydrogels. Current production of crotonic acid is via petrochemical synthesis. However, it has several drawbacks. The chemical synthesis of crotonic acid involves many steps. Furthermore, purification of crotonic acid by crystallization may contribute to the environmental pollutions as it causes the formation of about one ton of highly contaminated effluents per ton of processed crotonic acid. This is accompanied by about 1500 m^3 of contaminated air per ton of crotonic acid from the drying process. Moreover, the crystallization process also causes product loss. The present proposed research provides an alternative route to crotonic acid production which involves biological synthesis and eco-friendly methods. This can be done by the use of PHB-producing bacteria biomass. The bacteria accumulate PHB as energy reserve materials under suitable conditions during fermentation. PHB can later be converted into its dehydrated monomer which is crotonic acid via thermal degradation. In this research, recovery of crotonic acid from PHB biomass will be conducted by mean of pyrolysis. Pyrolysis process will be conducted in a glass tube oven, and pyrolyzate collected will be analyzed by GC-MS and 1H-NMR. This study is expected to contribute to new method for green route for crotonic acid production.

Method	Petrochemical	Bio-based
Feedstock	Non-renewable	Renewable
No. of production steps	5	3
Crotonic acid yield (%)	30	87
Estimated selling price (USD)	6.57-13.13	7.80-11.05

Comparison between petrochemical-based and bio-based crotonic acid production

Supervisor
Dr. Hidayah Ariffin

Objectives

1. To develop environmental friendly method for crotonic acid production via pyrolysis of PHB biomass
2. To evaluate the effect of pyrolysis parameters, pretreatment and catalyst on the composition and recovery of crotonic acid

Master Student EB GROUP

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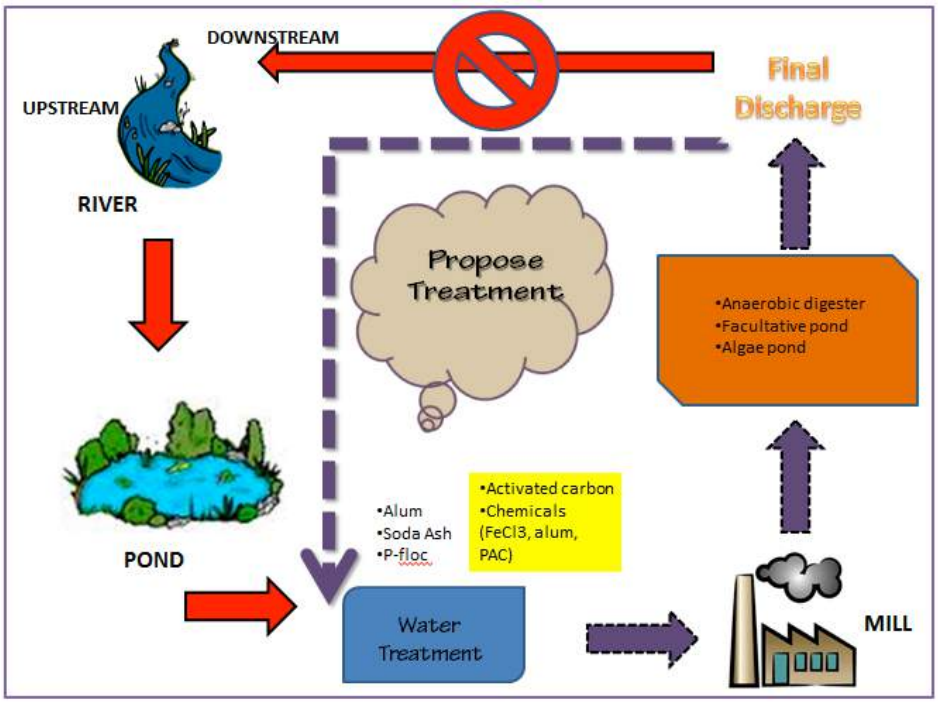
Treatment of effluents from palm oil mill process to achieve river water quality for reuse as recycled water in a zero emission system

In palm oil industry, huge amount of water have been utilized for palm oil sterilization and extraction process. The processing system has been applying widely in Malaysia for year. It has been estimated that around one tonne of fresh water was needed for processing every tonne of fresh fruit bunch (FFB). As a return, huge amount of wastewater has been generated, treated and discharged to river every day. Current treatment system applying in oil palm industry is using river water, treated and use for mill.

In this study, the effect of chemical coagulant and activated carbon application as appropriate treatment of palm oil mill final discharge wastewater have been evaluated in order to recycled water for the mill to achieve zero discharge. Current chemical treatment used at the mill will be used to treat final discharge wastewater. Activated carbon or biochar is used as absorbent material due to its large number of cavernous pores that provide a large surface area relative to the size of the actual carbon particle and its visible exterior surface.

A jar test method is used to stimulate the coagulation and flocculation process that encourage the removal of COD and suspended solids in final discharge wastewater which can lead to turbidity, color, odor and taste problem. In this research, jar test is used to determine the optimum operating conditions for final discharge wastewater by optimizing dosage of coagulant and activated carbon, mixing and sedimentation time and pH value of existing treatment system to reduce capital expenditure on new treatment system.



Overall big picture of current project

Supervisor
Professor Dr. Mohd Ali Hassan

Objectives

1. To study the effectiveness of chemical coagulants for the treatment of palm oil mill final discharge wastewater.
2. To investigate the potential of biochar to polish treated palm oil mill final discharge wastewater.

Jar test equipment

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Escherichia coli yqiG pseudogene in hydrogen production

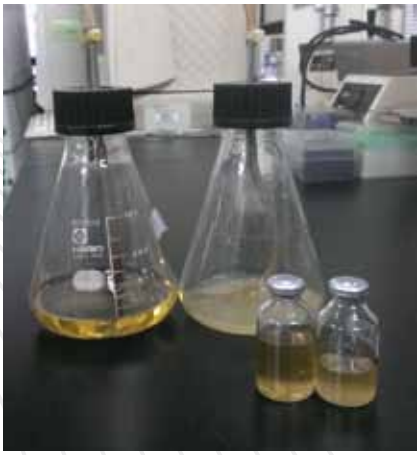
In recent trends, world depends on fossil fuels as source of energy. Continues usage of fossil fuel as main energy sources is not sustainable due to limited world fuel reserved. Moreover, since the world depend so much on natural resources for generation of energy, environment need to bear the consequences where the air is polluted, global warming, wastes from nuclear plant and others.

Hydrogen considered as environmental friendly fuel and renewable energy if it produced from renewable sources. Hydrogen contain higher energy content and only produce water and energy from hydrogen oxidation compared to fossil fuel and methane gas. Hydrogen can be produced by several biological methods such as biophotolysis, photofermentation, and dark fermentation. Hydrogen production through dark fermentation considered as an effective biological approach which brings several advantages such as easy operation of bioreactor, higher production rate, and may utilize various substrates. Besides, dark fermentation more practical for industrial production compared to other methods since it can consume organic waste as source of substrate, adopted simple technology and less energy required. *Escherichia coli* has been extensively used in hydrogen production. *E. coli* is well characterized bacteria and the metabolic engineering best-studied. Mutant strain can be constructed by genetically manipulate their metabolic pathway so called metabolic engineering.

Pseudogenes are from active genes which turn into junk genes because of transcription and translation disruption. The presence of stop codons, repetitive element frame shift and lack of transcription might interrupt the gene to function well. However, the function of pseudogenes are still unknown. In our preliminary study, we found out that *yqiG* pseudogene is essential for hydrogen production. Thus, in this study, we try to characterize the function of *yqiG* pseudogene in *Escherichia coli* for hydrogen evolution. Knock-out of *yqiG* gene in *E. coli* resulted in less hydrogen formation in complex glucose compared to complex formate media. Without the presence of *yqiG* gene, the hydrogen metabolic pathway was interrupted. Hence, *yqiG* pseudogene is important for hydrogen production and prove that some of the pseudogenes are functions in *E. coli*.

Transcriptional analysis (gene expression) was analyzed by using RT PCR

The gas samples were analyzed by gas chromatography



Small serum bottles and anaerobic flask were used for fermentation purpose

Inoculum was transferred into vials containing media in anaerobic chamber

Supervisor
Dr. Mohd Zulkhairi Mohd Yusoff

Objective

1. To characterize the function of *yqiG* pseudogene in hydrogen production

Master Student EB GROUP

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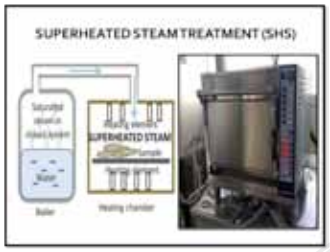
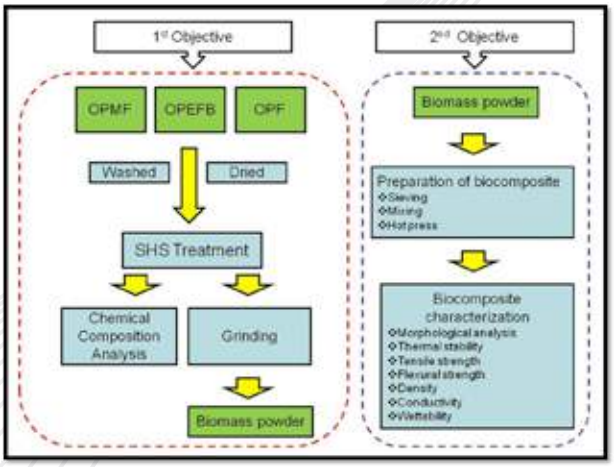
Optimization of superheated steam treatment for oil palm biomass to be used in biocomposite

Incompatibility between hydrophilic lignocellulose fiber and hydrophobic polymer has become the resistance in producing biocomposite with good mechanical properties. Pretreatment of fiber is necessary to improve the compatibility between fiber and polymer. It has been demonstrated that superheated steam (SHS) treatment is an effective method for surface modification of lignocellulose, whereby removal of hemicellulose from fiber can be achieved, making the fiber more hydrophobic. Nevertheless, the current retention time and temperature used for SHS treatment cause degradation of cellulose which is an important component in lignocellulose. Cellulose should be retained to provide high crystalline fiber. Therefore, this study was aimed at optimizing SHS treatment conditions for oil palm biomass fiber in such a way hemicellulose will be removed while cellulose needs to be retained. Response Surface Methodology (RSM) was used in order to generate the optimal time and temperature of SHS treatment in term of fiber's chemical composition.

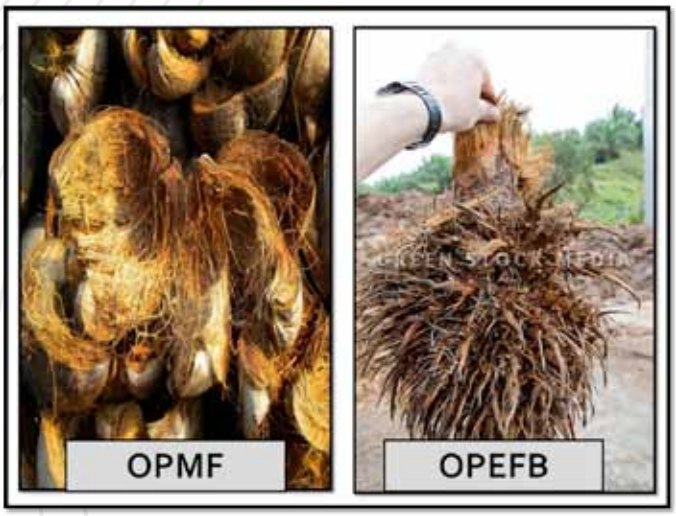
Two types of oil palm biomass fiber were used as the raw materials, Oil Palm Mesocarp Fiber (OPMF) and Oil Palm Empty Fruit Bunch (OPEFB). For OPMF, 63% of hemicellulose content is removed at SHS treatment 260°C / 5 mins while for OPEFB, 61% of hemicellulose content is removed at SHS treatment 260°C / 17.5 mins. In comparison, 69% of hemicellulose content in OPMF is removed when treated at SHS treatment 230°C / 120 mins as reported from previous work. Based on the statistical analysis which is done using RSM, optimal SHS treatment temperature and time for both OPMF and OPEFB were generated; OPMF - SHS treatment 270°C / 5 mins (67% hemicellulose removal, 3% cellulose removal), OPEFB - SHS treatment 285°C / 5 mins (55% hemicellulose removal, 5% cellulose removal). Thus, hemicellulose content in OPMF and OPEFB can be reduced by 50-70% through SHS treatment at shorter time with the used of high temperature, without affecting cellulose content much. Low hemicellulose and high cellulose content of fiber can be a good prospect as more compatible filler in biocomposite.



The concept of superheated steam (SHS) treatment.



Overall big picture of current project



Oil palm biomass; oil palm mesocarp fiber (OPMF) and oil palm empty fruit bunch (OPEFB).

Supervisor
Dr. Hidayah Ariffin

Objectives

1. To optimize time and temperature of SHS treatment to produce fiber with high cellulose and low hemicellulose content prior to biocomposite production.
2. To determine the effect of optimized time and temperature of SHS treatment towards the characteristics of the oil palm biomass fiber/PP composites.

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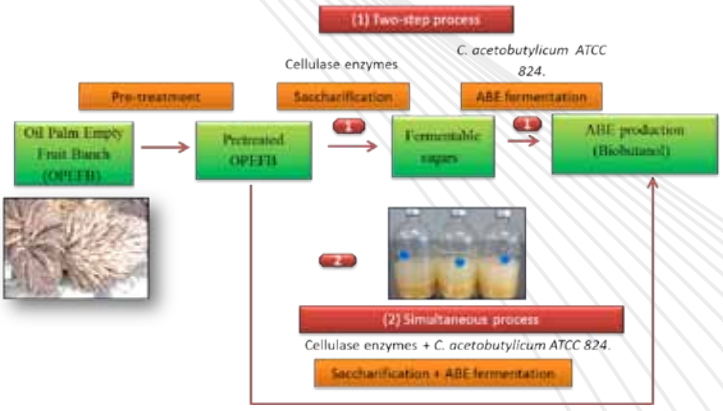
Optimization of simultaneous saccharification and fermentation using oil palm empty fruit bunch for biobutanol production

Biobutanol is one of the potential biofuels which can be an alternative to the fossil fuels as the source is being crucially stringency/scarcity and also coop the demands need for fuels. Biobutanol can be produced through Acetone-Butanol-Ethanol (ABE) fermentation using biomass as the substrates. Oil palm empty fruit bunch (OPEFB) is one of the promising renewables lignocellulosic biomass that can be used as substrates in the ABE fermentation process. The ABE fermentation process can be either undergoes two step or one step process for ABE production. One-step process or simultaneous saccharification and ABE fermentation is a viable process for biobutanol production which involves the one-step addition of microorganism, cellulase enzymes and substrates in a vessel.

In this present study, an enhancement of the simultaneous cellulosic biobutanol production is conducted through an optimization study using two statistical softwares tools which is Response Surface Methodology (RSM) and Artificial Neural Network (ANN) to obtain conditions which is optimally suitable for high biobutanol production. *Clostridium acetobutylicum* ATCC 824 is employed together with the crude cellulase cocktail from *Trichoderma asperellum* UPM 1 and *Aspergillus fumigatus* UPM 2 on the pretreated OPEFB with 2% NaOH with autoclave to perform on the simultaneous saccharification and ABE fermentation process to produce biobutanol. Several parameters being reviewed and the most influenced parameters will be tested on the simultaneous saccharification and ABE fermentation process. Further on, the simultaneous saccharification and ABE fermentation with the optimum conditions from the lab scale fermentation will be undergo a scaling up to determine the potential of biobutanol being produced at larger scale through this one-step process.

This study is expected to get the best condition for biobutanol production through simultaneous saccharification and ABE fermentation and also discover the potential of the process to be up-scaled.



Research overview

Fermentation of simultaneous saccharification and fermentation for biobutanol production

Left (oil palm fresh fruit bunch) and right (oil palm empty fruit bunch)

Supervisor
Professor Dr. Suraini Abd-Aziz

Objective
1. To optimize simultaneous saccharification and fermentation for biobutanol production using Response Surface Methodology and Artificial Neural Network.

Master Student EB GROUP

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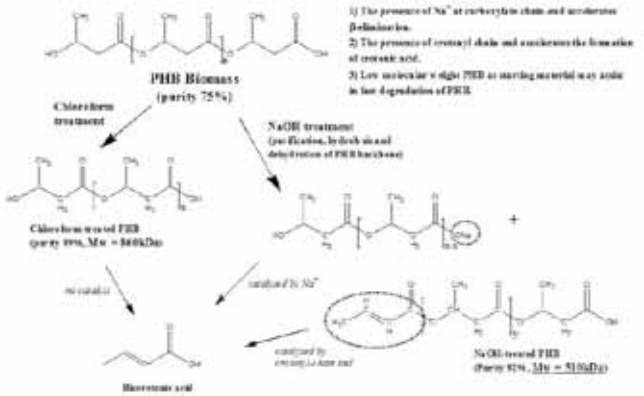
Improved production of bio-based crotonic acid

Crotonic acid is an unsaturated carboxylic acid conventionally derived from petroleum resource through multiple-step chemical processes. Nevertheless, research has showed that crotonic acid is also dehydrated monomer of poly(3-hydroxybutyrate) (PHB) which is a bio-based and biodegradable microbial polymer. It has been demonstrated that pyrolysis of PHB under controlled temperature and retention time yielded crotonic acid. Direct pyrolysis of PHB inclusions in bacterial cell has been recently studied, and it was exhibited that low purity of crotonic acid at around 54% was obtained from the process which could be contributed by the presence of other organic compounds in the cell that volatilized together with the crotonic acid during pyrolysis. In this study, improved crotonic acid production and recovery was achieved by introducing a pre-treatment step prior to pyrolysis of PHB inclusions. PHB inclusions obtained from fed-batch fermentation of *Cupriavidus necator* KCTC 2649 utilizing glucose were treated with mild alkali (0.05M NaOH). This treatment saponified lipid layer of the bacterial cell and increased the cell wall permeability, resulted in PHB isolation from bacterial cell. PHB isolated from cell had purity of 90 %, compared to the original untreated PHB with purity of 75 %. Isolated PHB was then pyrolyzed in a glass tube oven and the pyrolyzates were analyzed by GC-MS and 1H-NMR. A marked increase of crotonic acid purity was observed when isolated PHB was used in pyrolysis compared to the original PHB inclusions. Overall, it is concluded that pre-treatment of PHB inclusions with mild alkali assisted the isolation of PHB which resulted in the production of higher purity crotonic acid.

Recovery of PHB Biomass by 0.05 M NaOH

Collected pyrolyzate (crotonic acid)



Pathway of biocrotonic acid production from chloroform-treated and NaOH-treated PHB

Supervisor
Dr. Hidayah Ariffin

Objectives

1. Effect of PHB recovery method on purity of crotonic acid.
2. Effect of alkali earth compounds catalyst on the production and diastereoselectivity of crotonic acid.

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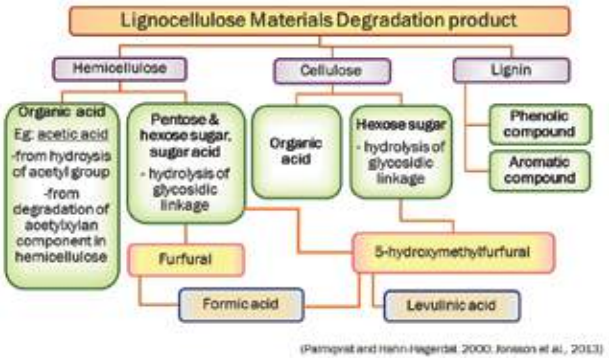
Characterization and antimicrobial properties of oil palm mesocarp fiber superheated steam condensate

Superheated steam (SHS) treatment has been recently used as a method for hydrolyzing lignocelluloses material. Under controlled temperature, SHS hydrolyzes mainly hemicellulose, low molecular weight lignin and some amount of cellulose to form acidic, furanic and phenolic compounds. These compounds have antimicrobial properties and may be useful as antifungal agents. In this study, oil palm mesocarp fiber (OPMF) was hydrolyzed by SHS at temperature of 190°C to 240°C. Volatile hydrolysis products were condensed, collected and concentrated to 98% volume reduced. Chemical composition of the condensate was identified by using using LC-MS and HPLC. Major product from the hydrolysis of OPMF obtained in the condensate was acetic acid from hemicellulose, followed by phenolic compounds from lignin, for all reaction temperatures tested. Additionally, the types of hydrolysis products produced from SHS treatment of OPMF were increased with SHS temperature. OPMF condensate from 240 °C was found to have 34 compounds, followed by condensate from 220, 200 and 190 °C having 32, 23 and 21 compounds, respectively. This shows formation of new products when higher reaction temperature was used. Complex phenolic compounds started to be observed when the SHS hydrolysis was conducted at 230°C, indicating more degradation of lignin component compared with the hydrolysis at 190°C. Increased in reaction temperature also caused the increment in the concentration of hydrolysis products. Condensate from 240°C SHS temperature with highest number of compounds was tested for its inhibitory effect on the growth of five fungi and six bacteria species.



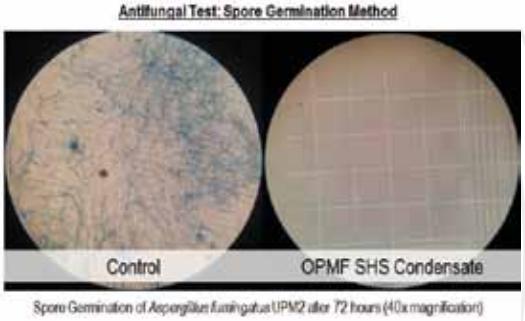
Lignocellulose degradation product

The antifungal property of the condensate was tested on *Aspergillus flavus, Aspergillus fumingatus* UPM2, *Trichoderma asperellum* UPM1, *Trichoderma harzianum* and *Ganoderma boninense* UPM13. *Aspergillus* sp. and *Trichoderma* sp. are common fungi that often found on building surface (sick-building) while *Ganoderma boninense* cause Basal Stem Rot Disease (BSRD) in oil palm plantation. Agar dilution and spore germination test were conducted for 15 days and 72 hours incubation period with concentration of 5% (v/v) and 30% (v/v) concentrated condensate, respectively. For agar dilution method, the concentrated condensate exhibits total inhibition on *Ganoderma boninense* UPM13 with antifungal index (AI) of 100±0.00% and slow growth on others. When the growth of fungi on control plate reach maximum the AI% for *Aspergillus flavus, Aspergillus fumingatus* (UPM2), *Trichoderma asperellum* (UPM1) and *Trichoderma harzianum* was 25.29±0.83, 48.24±1.66, 54.51±1.36 and 67.84±1.36 %, correspondingly. High concentration of condensate sample used in spore germination test inhibits spore germination of all fungi.

Agar disc diffusion method was conducted on *Bacillus cereus, Escherichia coli, Salmonella enteritidis, Salmonella typhs, Shigella sonei* and *Staphylococcus aureus* for antibacterial test. Bacterial suspension adjusted to Mc Farland standard was spread on Mueller Hinton agar (MHA) to form a bacteria lawn. Filter paper disc (6mm diameter) impregnated with 20 µL OPMF condensate was placed on the agar plate. The diameter of clear zone produced was measured to identify the susceptibility of OPMF condensate to inhibit the bacterial growth.

Overall, this study is expected to enable details identification of lignocellulose degradation product from superheated steam treatment and its inhibitory potential to be used as antimicrobial agent.

Antibacterial test: Agar disc diffusion method



Antifungal test: Spore germination test

Supervisor
Dr. Hidayah Ariffin

Objectives

1. To determine the effect of steam hydrolysis reaction time and temperature on the composition of oil palm mesocarp fiber condensate.
2. To characterize oil palm mesocarp fibre superheated steam condensate and evaluate its antimicrobial activity.

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Enhancement of polyhydroxyalkanoates production from *Escherichia coli* through molecular biotechnology approaches

Polyhydroxyalkanoates (PHA) are biodegradable, water-insoluble polyesters that are accumulated intracellularly as carbon storage compounds in the cytoplasm (Steinbuchel and Fuchtenbusch 1998; li et al., 2009). PHA biosynthesis in bacteria mainly involve three basic enzymatic steps (Naik et al., 2008). There are three genes responsible for the biosynthesis of PHA which are PHA synthase (phaC), acetyl-CoA acetyltransferase (phaA) and acetoacetyl-CoA reductase(phaB) enzymes (Figure 1).

PHA biosynthetic process is initiated by the condensation of two acetyl-CoA molecules to produce acetoacetyl-CoA and this is catalyzed by phaA. Next, acetoacetyl-CoA is then reduced to (R)-3-hydroxybutyryl-CoA by the phaB. Finally, PHA is synthesized by phaC (Rehm and Steinbuchel, 1999). PHA biosynthesis operon has been introduce into new host to produce recombinant strain and *E. coli* is one of the most widely used as hosts. PHA production using recombinant strain has advantages over wild-type PHA producers due to an easier manipulation for higher productivity, lack of native degradation machinery and fragility of the cell membranes, which facilitates an easy purification and recovery process (Aldor and Keasling. 2003).

Yee et al. (2012), has introduced PHA biosynthesis operon of *Comamonas* sp. EB172 (phaCAB) in *E. coli* JM109 and about 46.4% of PHA produced with 1% (w/v) glucose as the carbon source. Biosynthesis of PHA in *E. coli* also affected by many other factors such as acetyl-CoA as an essential central intermediate, which can increase 3-hydroxybutyrl-CoA formation and cell growth and another one is the abundances of NADPH. Thus, the aim of this study is to improved the PHA production by modified the metabolic pathway in *E. coli* pathway which harbouring the PHA biosynthesis operon of *Comamonas* sp. EB172. Figure 3 showed the metabolic pathway of glucose and several genes related to accumulation of acetyl-coA was chosen to be deleted in order to improve the PHA production in *E. coli* BW25113. These single genes knockout has been studied the PHA production and several genes such as fdnG, frdC, pta, poxB, pgl and gltA showed some PHA improvement compared to the wild-type. (Figure 3)

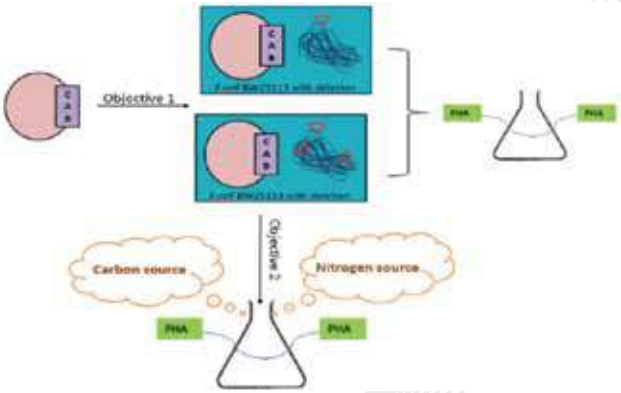

Figure 1: Biosynthesis of PHA

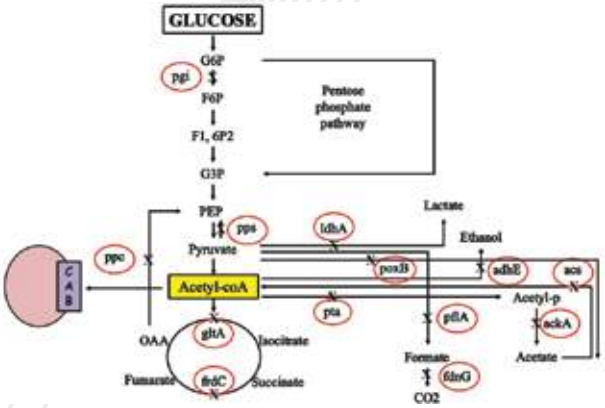

Figure 2: Metabolic pathway of glucose

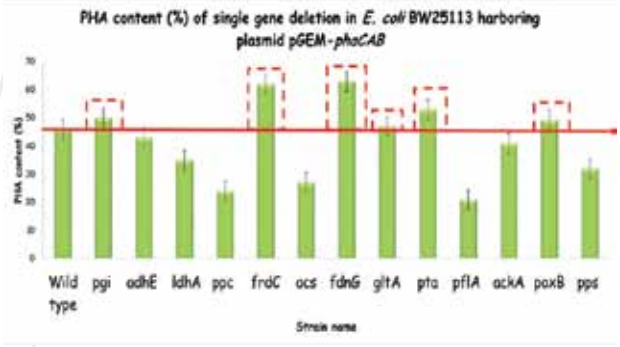

Figure 3: PHA content in single gene deletion harboring plasmid pGEM-phaCAB

Supervisor
Dr. Mohd Zulkhairi Mohd Yusoff

Objectives

1. To construct a new engineered *E. coli* strain for higher PHA production.
2. To optimize the fermentation condition of new engineered *E. coli* strain for higher PHA production.

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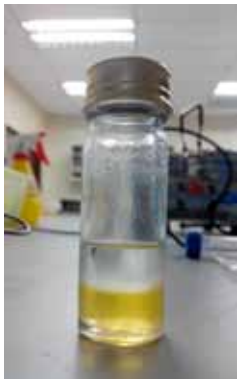
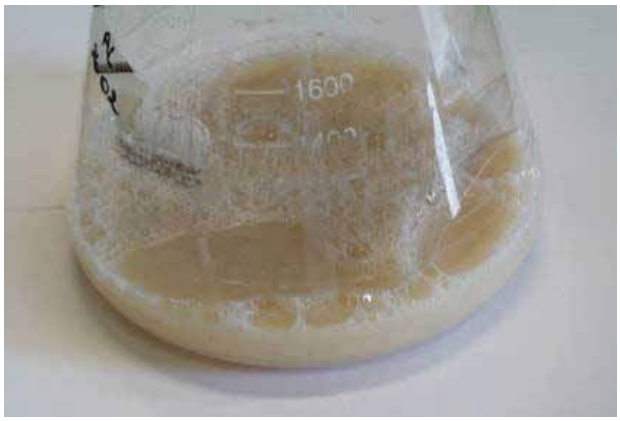
Biosurfactant production from used cooking oil by local isolates for heavy metals removal

The microbial surfactants or biosurfactants have gained attention because of their biodegradability, low toxicity, ecological acceptability, and ability to be produced from renewable and cheaper substrates compared to chemical surfactants. Biosurfactants are amphipathic molecules that partition preferentially at the interface between fluid phases with different degrees of polarity and hydrogen bonding such as oil/water or air/water interfaces. There is an increasing interest in the possible use of biosurfactants in environmental applications such as removal of heavy metals from waste water streams, sewage sludge, and industrial effluents. Biosurfactants interaction with metals such as lead, cadmium, and mercury leads to separation of metal from the waste stream. The interaction of microorganisms with metals occurs through metal binding to the cell surface or within the cell wall, translocation of metal into the cell, volatilization of the metal as a result of a biotransformation reaction, and many more.

Biosurfactants spontaneous release and function are often related to hydrocarbon uptake; therefore, they are predominantly synthesized by hydrocarbon-degrading microorganisms. Used cooking oil is an excellent candidate as substrate for the biotransformation into biosurfactants because it is cheap and renewable hydrocarbon source. Thus it can reduce the total production cost as well as minimizing the oil pollution in the environment. In this study, the production of biosurfactant from used cooking oil by biosurfactant-producing microorganisms is conducted. The characterization of biosurfactant such as the effect of temperature, pH, and salt content on the stability of biosurfactant is determined. This step is vital as environmental factors are extremely important in the yield and characteristics of the biosurfactant produced in terms of surface tension, interfacial tension, and emulsification index. Optimization study for the biosurfactant production is conducted through Artificial Neural Network (ANN) tool and parameters being tested for this stage are substrate concentration, agitation speed, aeration, temperature, and pH. Further step is to evaluate the capability of the biosurfactant and its ability on enhancing removal of heavy metals in the water systems contaminated with heavy metals.

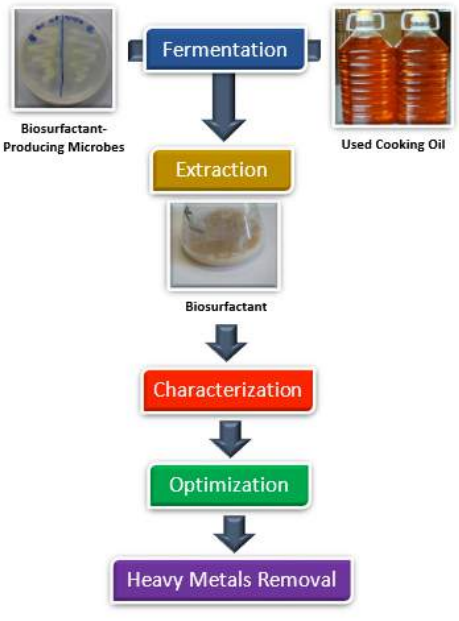


Fatty acids methyl esters, FAME (upper layer) and hexane (lower layer) from used cooking oil



Rhamnolipid (biosurfactant) produced by *Pseudomonas aeroginosa*

Impurities inside used cooking oil trapped in the filter



Big picture

Supervisor
Professor Dr. Suraini Abd-Aziz

Objectives

1. To produce and characterize biosurfactant from used cooking oil by local isolates.
2. To optimize biosurfactant production from used cooking oil using artificial neural network.

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Co-composting of municipal sewage sludge with landscaping wastes by pilot scale

Composting process is one of effective ways of recycling biomass that been generated from the natural environment since decades ago.

Landscaping waste is defined as the accumulation of biodegradable waste as the result of care of the landscape area that normally be disposed into the landfill sides, or sometimes burn them in open burning. On the other hands, municipal sewage sludge is the wastes generated during treatment of domestic sewage (primary, secondary or advanced wastewater treatment) before being released back into the nature, usually in form of solid, slurry, or liquid residue. Renewable materials such as municipal sewage sludge, landscaping wastes, and others are examples of biomass that can be utilized to produce high value product with nutrient-rich organic matter such as biocompost. However, based on current research, these material are still not being utilized completely in Malaysia. With the nutrient availability present within both materials, biocompost production can be established directly by aerobic fermentation.

The aim in this research is to obtain the optimum condition for the production of biocompost from landscaping wastes and municipal sewage sludge. This research is focusing on the co-composting process of landscaping wastes and municipal sewage sludge that been carried out using windrow system and bioreactor system, which can be considered as semi-pilot scale for producing the compost products in the industry. The composting process was monitored for the crucial parameters for composting i.e. temperature, oxygen level, moisture content and pH. Compost performance was being determined using proximate and ultimate analysis of the product produced as well as the maturity test for compost product.

Other than that, this research is done to evaluate the potential of biocompost from landscaping wastes and municipal sewage sludge on the growth performance of *Tagetes erecta* as an indicator of ornamental plant. With the information obtained from this research, it can be considered as the indicator for other ornamental plants usage and also environmental purposes.

Landscaping wastes

Municipal sewage sludge (wet)

Municipal sewage sludge (dried)

Compost product

Supervisor
Professor Dr. Mohd Ali Hassan

Objectives

1. To obtain the optimum condition for the production of biocompost from landscaping wastes and municipal sewage sludge.
2. To evaluate the potential of biocompost from landscaping wastes and municipal sewage sludge on the growth performance of ornamental plant.

Physical comparison of Tagetes erecta by different types of biocompost

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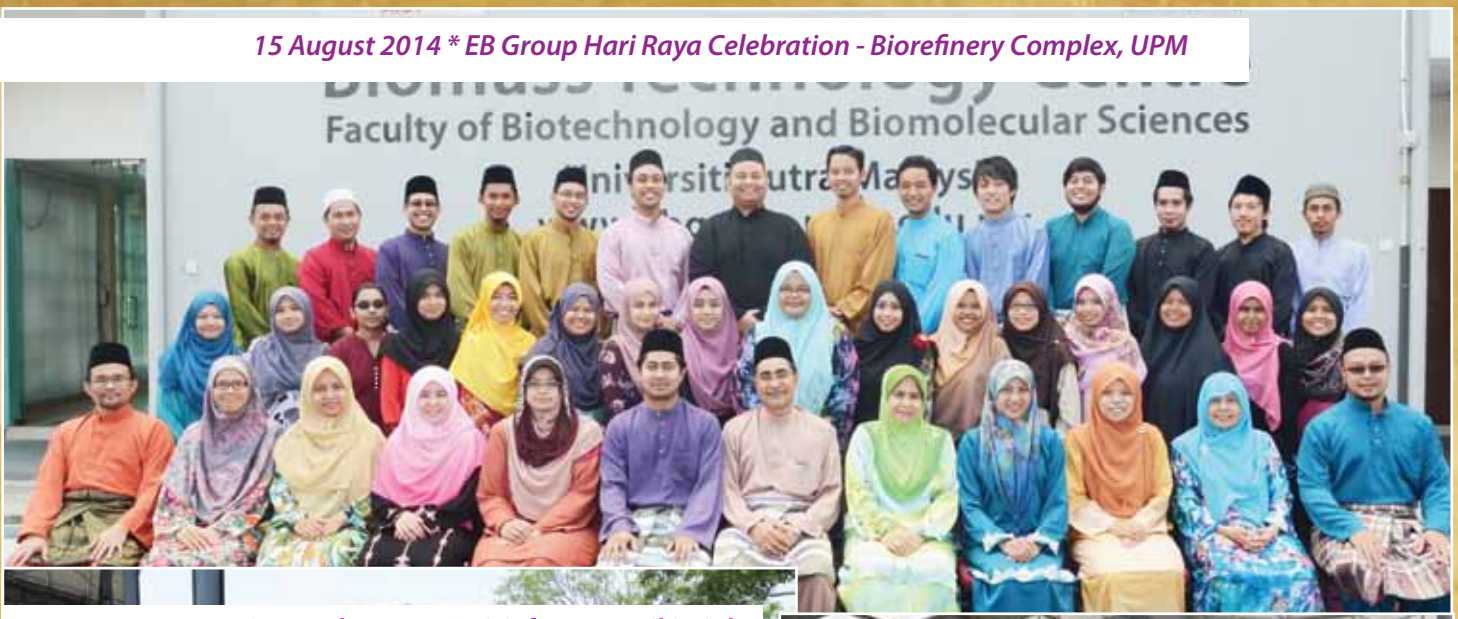
*9 - 11 February 2014 * AFOB Regional Symposium 2014 - Seri Pacific Hotel, Kuala Lumpur*

*26 - 27 April 2014 * EB Writing Workshop & Retreat - Regency Resort, Port Dickson*

*15 August 2014 * EB Group Hari Raya Celebration - Biorefinery Complex, UPM*



*26 September 2014 * Visit from Namiki High School, Japan - Biorefinery Complex, UPM*

*16 October 2014 * Visit from Universiti Malaysia Terengganu - Biorefinery Complex, UPM*

*17 July 2014 * Launcing Ceremony of SATREPS & Workshop - Kota Kinabalu, Sabah*

Site visit to Keningau Palm Oil Mill, Sabah

*20-21 December 2014 * 2nd International Symposium in Applied Engineering and Sciences (SAES 2014) - Kyushu Institute of Technology, Japan*

*23 December 2014 * Visit to National Institute of Advanced Industrial Science and Technology (AIST), Japan*

*22-26 December 2014 * EB retreat - Fukuoka, Japan*

*14 April 2014 * Dinner after SATREPS Discussion at Kyushu University, Japan*

*24-27 August 2014 * AFOB Bioenergy & Biorefinery Divison Annual Meeting and Bioenergy & Biorefinery Summit*

*28 November 2014 * Professor Dr. Suraini Abd-Aziz Inaugural Lecture - UPM*

*6-8 October 2014 * AFOB International Symposium 2014 and AFOB Delegate Meeting. Changwon & Songdo, Korea*

*11 December 2014 * Professor Shirai receiving SMS Award from Sultan Selangor at Sultan Selangor's Palace*

*12 December 2014 * Dr Hidayah's appearance at MHI TV3*

Professor Matsunaga, KyuTech President, receiving Honorary Doctorate from UPM

*18-22 August 2014 * The 8th Korea-ASEAN Joint Symposium on Biomass Utilization and Renewable Energy*