UNIVERSITI PUTRA MALAYSIA

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By

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Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirement for the degree of Master of Science.

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April 2012

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Faculty: Faculty of Engineering

Malaysia is a developing country. With the rise in income and standard of living together with the rate of industrial growth in Malaysia, the demand of materials will keep increasing. This directly increases the amount of waste generated. In Malaysia, almost all type of solid wastes are disposed off into landfill sites. Due to the limitation of the available landfill sites, many solutions are introduced by the Malaysia government to reduce the solid wastes being dumped to the landfill. Polyethylene terephthalate (PET) bottle is one of the plastic solid wastes that can be easily found in Malaysia. One of the solutions that can be used to solve the abundant of PET wastes is chemical recycling of PET wastes to produce other value added product. This method not only can decrease the PET waste in landfill sites but also can produce many useful recycled PET products. This research is focusing on the purification processes used in chemical recycling of PET waste. Crystallization and two stages evaporation processes were selected to purify the contaminated bis(2-hydroxyethyl) terephthalate (BHET) obtained from glycolysis of PET waste. This research was divided into two parts: first part was simulation of the two stages evaporation and crystallization processes using ASPEN PLUS to investigate the

effect of operating temperature and pressure of two stages evaporation toward the percentage of ethylene glycol (EG) removed, heat duty needed and percentage of BHET recovered. Based on the simulation findings, the first stage evaporation was simulated at pressure range of 130 Pa to 10,000 Pa and temperature range of 90 °C to 180 °C while the second stage evaporation was simulated at pressure range of 50 Pa to 250 Pa and temperature range of 120 °C to 180 °C. The crystallization was simulated at temperature range of 5 °C to 30 °C to study the effect of crystallization temperature toward the percentage of BHET recovered. The second part of the research was verification of simulation result by conducting experiments using conventional crystallization and two stages evaporation processes.

The ASPEN PLUS simulation results showed that increasing the operating temperature and decreasing the operating pressure of the two stages evaporation might increase the percentage of EG removed and at the same time increased the heat duty required and reduced the percentage of BHET recovered. The optimum conditions was selected based on higher EG removed with lower heat duty needed and higher BHET recovered. Optimum conditions of first and second stage evaporation were 105 °C and 1000 Pa and 130 °C and 50 Pa respectively. Two stages evaporation process was capable to reduce the composition of EG in glycolyzed mixture from 77 % to 0.15 % while increase the composition of BHET from 19 % to 82.48 %. Crystallization process using second purification route at 1 °C, with ratio of water used to glycolyzed solid of 5:1 and 3 hours cooling time was capable to remove EG yielding white crystallized solid consists of 93.02 % BHET. This shows that both methods can be used to purify glycolysis product.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains.

PENULENAN PRODUK GLIKOLISIS DARIPADA SISA POLIETILENA TEREPHTHALATE (PET) OLEH PROSES DUA-PERINGKAT PENYEJATAN

Oleh

GOH HUI WEN

April 2012

Pengerusi: Prof. Madya Salmiaton Ali, PhD

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Malaysia merupakan sebuah negara yang sedang membangun. Kenaikan pendapatan dan taraf hidup rakyat Malaysia termasuk kenaikan kadar pertumbuhan industri menyebabkan permintaan terhadap bahan mentah seperti petrol, makanan, plastik dan lain-lain lagi meningkat. Ini akan meyebabkan jumlah penghasilan sampah meningkat. Di Malaysia, hampir semua sampah berbentuk pepejal dibuangkan ke tapak pelupusan. Oleh sebab tapak pelupusan terhad, dengan itu kerajaan Malysia telah melaksanakan banyak kaedah untuk menyelesaikan masalah pertambahan sisa sampah berbentuk pepejal. Polyethylene terephthalate (PET) botol merupakan salah satu jenis plastik sisa pepejal yang senang dijumpai di merata tempat. Salah satu cara penyelesaian yang boleh digunakan untuk menyelesaikan masalah PET sisa bahan buangan ialah kitar semula PET sisa buangan secara kimia untuk menghasilkan bahan yang berguna. Cara ini bukan sahaja boleh mengurangkan PET sisa buangan di tapak pelupusan tetapi juga boleh menghasilkan banyak jenis bahan PET yang berguna.

Penyelidikan ini menumpukan pada kaedah penulenan yang digunakan dalam kaedah kitar semula sisa PET buangan secara kimia. Kaedah penghabluran secara konvensional

dan peyejatan proses secara dua peringkat telah digunakan untuk menulenkan bis(2-hydroxyethyl) terephthalate (BHET) yang diperolehi dari PET sisa buangan glikolisis proses.

Penyelidikan ini telah dibahagikan kepada dua bahagian: bahagian pertama ialah simulasi peyejatan dan penghabluran proses dengan mengunakan ASPEN PLUS untuk mengkajikan hubungan antara operasi suhu dan tekanan dan peratusan penyingkiran ethylene glycol (EG), duti haba yang diperlukan dan peratusan pemulihan BHET. Simulasi data menunjukkan peringkat pertama penyejatan proses boleh beroperasi pada 130 Pa ke 10,000 Pa dan 90 °C ke 180 °C manakala peringkat kedua penyejatan proses boleh beroperasi pada 50 Pa ke 250 Pa dan 120 °C ke 180 °C. Penghabluran proses dijalankan pada suhu 5 °C ke 30 °C untuk mengkajikan perubahan suhu penghabluran terhadap peratusan pemulihan BHET. Bahagian kedua merupakan pengesahan simulasi data dengan menjalankan eksperimen.

ASPEN PLUS simulasi data menunjukkan peratusan penyingkiran EG dan duti haba yang diperlukan menambah manakala peratusan pemulihan BHET menurun apabila operasi suhu meningkat dan operasi tekanan menurun bagi penyejatan proses. Keadaan optimum bagi penyejatan proses dipilih dengan merujuk pada maksimum peratusan penyingkiran EG dan minimum duti haba serta maksimum peratusan pemulihan BHET. Keadaan optimum bagi peringkat pertama dan kedua proses penyejatan ialah 105 °C dan 1000 Pa serta 130 °C dan 50 Pa masing-masing. Dua peringkat proses penyejatan mampu mengurangkan komposisi EG dalam campuran *glycolyzed* daripada 77% kepada 0.15% manakala meningkatkan komposisi BHET daripada 19% kepada 82.48%. Proses penghabluran menggunakan laluan penulenan kedua pada 1 ° C, dengan nisbah air yang

digunakan kepada pepejal glycolyzed 5:1 dan 3 jam masa penyejukan mampu membuang EG untuk menghasilkan pepejal kristal putih mengandungi 93.02%. Ini menunjukkan bahawa kedua-dua cara boleh digunakan untuk menulenkan produk glikolisis.

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I certify that a Thesis Examination Committee has met on 23 April 2012 to conduct the final examination of GOH HUI WEN on her thesis entitled "**Purification of Glycolytic Product from Polyethylene Terephthalate Waste by a Two-stage Evaporation Process**" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Science.

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DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institution.

GOH HUI WEN

Date: 23 April 2012

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