UNIVERSITI PUTRA MALAYSIA

ULTRASONIC ASSISTED MICROWAVE PROCESSING SYSTEM FOR OPTIMIZED PRODUCTION OF BIODIESEL FROM COCONUT OIL

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By

AZYAN HAZWANI JABAR

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Science

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DEDICATION

To my beloved mother and father whom I owe every success in my life

♥ROHANI BINTI YAAKUB♥
♥JABAR BIN AWANG♥

My dearest Aunt
RODZIAH BINTI YAAKUB

My eldest brother
AZMI BIN JABAR

My Nephews

☺ YUSUF AZAMUDDIN BIN AZMI ☺
☺ ALIF HAFIZUDDIN BIN AZMI ☺

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the Degree of Master of Science

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Chairman: Professor Kaida Bin Khalid, PhD
Faculty: Science

Biodiesel, a liquid fuel derived from plant oils or animal fats, represents a renewable energy source. The purpose of this research is to improve the coconut biodiesel production process using microwave transesterification and ultrasonic assisted microwave transesterification. This system will identify the yield from the combined ultrasonic and microwave, in terms of its rapidity and efficiency to transesterified. Some of the problems faced when the biodiesel production currently done at 1 to 2 hour in industry, so the technique obtained in this study probably can solved the problem in case of time consuming.

A process for the production of the methyl ester of coconut oil for use as a biodiesel fuel has been studied. The essential part of the process is the transesterification of the coconut oil with methanol, in the presence of a catalyst, to yield the methyl ester as a product and glycerine as a by-product. Experiments have been performed to determine the optimum conditions for the preparation of the coconut biodiesel. The optimum conditions were: (1) 1.0% sodium hydroxide catalyst (dissolved in methanol) based on weight of coconut

oil and 100% excess of the stoichiometric amount of required anhydrous alcohol; (2) extremely vigorous agitation with 24 kHz ultrasonic frequency until the reaction mixture (oil and methoxide) becomes thoroughly mixed; (3) microwave irradiation of the mixture. Maximum yields of 95%, were obtained for coconut oil by microwave transesterification in 3 mins. Whereas the washing process only takes 7 mins for every cycle by using microwave method compared to 45 mins in conventional method. When the reaction was assisted with ultrasonic, the optimum yield is 97.20%, where the time taken for ultrasonic was about 5mins and microwave about 3min, which gives total time 8mins. This results extremely favorably to the hour of processing required by conventional methods.

A factor that is highly important during microwave heating is dielectric properties of material. Dielectric properties of coconut oil, methanol, sodium hydroxide, mixture of methanol and catalyst and first mixture between coconut oil and methoxide were determined using an open-ended, connected to a network analyzer. The important part of this dielectric measurement is the microwave dielectric detection of transesterification process at frequency 2.45 GHz. Result of the measurement over the frequency range shows drastic changes on the dielectric properties in the first 3 minutes of the reaction and after 3 minutes, the dielectric properties slowly decreases and approaches to the dielectric properties of biodiesel and glycerin. This result gives valuable information on the optimum mixing time of transesterification reaction. These properties could also be used to estimate absorbed power by the mixture for the application in microwave transesterification process as dielectric loss of the mixture change from 20 to about 0.5 as the transesterification reaction complete.

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

SISTEM PEMPROSESAN ULTRASONIK DIBANTU GELOMBANGMIKRO UNTUK PENGHASILAN OPTIMUM BIODIESEL DARIPADA MINYAK KELAPA

Oleh

AZYAN HAZWANI BINTI JABAR

November 2011

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Biodiesel, bahan bakar cair yang berasal dari minyak tumbuhan atau lemak haiwan, merupakan sumber tenaga boleh diperbaharui. Tujuan daripada projek ini adalah untuk membantu dan meningkatkan proses pengeluaran biodiesel kelapa dengan menggunakan penyinaran gelombang mikro dan ultrasonik. Sistem ini akan mengenalpasti hasil dari gabungan gelombang mikro dan ultrasonik, bagi kelajuan dan kecekapan untuk ditransesterifikasi. Di dalam industry sebahagian daripada masalah yang dihadapi apabila pengeluaran biodiesel mengambil masa selama1 hingga 2 jam, maka teknik yang diperolehi dalam kajian ini mungkin boleh menyelesaikan masalah dalam penggunaan masa.

Satu proses untuk penghasilan metil ester minyak kelapa untuk digunakan sebagai bahan bakar biodiesel telah dikaji. Bahagian penting dari proses ini adalah pengtransesteran

minyak kelapa dengan methanol bersama pemangkin, untuk menghasilkan metil ester sebagai produk dan gliserin sebagai produk kedua. Eksperimen telah dilakukan untuk menentukan keadaan optimum untuk penyediaan biodiesel kelapa. Keadaan optimum adalah: (1) natrium hidroksida 1.0% mangkin (dilarutkan dalam metanol) berdasarkan berat minyak kelapa dan kelebihan 100% dari nilai stoikiometri alcohol anhidrat diperlukan; (2) tindakan yang berkesan dengan frekuensi ultrasonik 24 kHz sehingga reaksi campuran (minyak dan metoksida) menjadi campuran sebenar; (3) iradiasi gelombang mikro pada campuran. Hasil maksima kira-kira 95% telah berjaya diperoleh dengan pengtransesteran gelombang mikro dalam masa 3 minit. Sedangkan proses pencucian hanya memerlukan masa 7 minit untuk setiap kitaran dengan menggunakan kaedah gelombang mikro berbanding dengan 45 minit dalam kaedah konvensional. Ketika reaksi itu dibantu dengan penyinaran ultrasonik, hasil optimum adalah 97.20%, di mana masa yang diperlukan untuk ultrasonik adalah sekitar 5 minit dan gelombang mikro sekitar 3 minit, iaitu 8 minit jumlah masa keseluruhan. Keputusan ini sangat baik jika dibandingkan dengan masa pemprosesan yang diperlukan dengan kaedah konvensional.

Faktor yang sangat penting semasa pemanasan gelombang mikro adalah sifat dielektrik bahan. Sifat dielektrik minyak kelapa, metanol, sodium hidroksida, campuran metanol dan pemangkin dan campuran pertama antara minyak kelapa dan metoksida ditentukan dengan menggunakan sensor sepaksi hujung terbuka yang disambung ke penganalisa rangkaian. Bahagian penting dari pengukuran ini adalah pengesanan dielektrik gelombang mikro proses pengtransesteran pada frekuensi 2.45 GHz. Hasil pengukuran menunjukkan perubahan yang cepat pada sifat dielektrik dalam 3 minit pertama

tindakbalas dan selepas 3 minit, sifat dielektrik perlahan-lahan menurun dan menghampiri sifat dielektrik biodiesel dan gliserin. Keputusan ini memberikan maklumat yang penting bagi menentukan masa pencampuran optimum tindakbalas pengtransesteran. Sifat ini juga boleh digunakan untuk menganggarkan kuasa yang diserap oleh campuran untuk aplikasi dalam proses pengtransesteran gelombang mikro dimana faktor kehilangan dielektrik dari campuran berubah dari 20 menjadi sekitar 0.5 pada pengtransesteran lengkap.

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfillment of the requirement for the degree of **Master of Science**. The members of the Supervisory Committee were as follows:

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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.

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AZYAN HAZWANI BINTI JABAR

Date: 11 November 2011

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