UNIVERSITI PUTRA MALAYSIA

OPTIMIZATION AND KINETICS OF CITRONELLA OIL EXTRACTION BY OHMIC HEATED HYDRO DISTILLATION

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By

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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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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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Chair: Associate Professor Hasfalina Che Man, PhD

Faculty: Engineering

Citronella grass is an aromatic plant with a variety of applications and tremendous economic potentials. The essential oil from the citronella grass has a variety of uses such as in traditional medication, perfume industry and soap manufacturing. A proposed method for citronella oil extractionwas developed with the application of ohmic heated hydrodistillation. The main objective of this research was to determine the parameters of the citronella oil extraction to achieve maximum oil yield by ohmic heated hydro distillation. The parameters affecting citronella oilextraction by ohmic heated hydro distillation such as powerinput, extraction time, solvent to solid ratio and crushing frequency were investigated.The optimum parameters were found at a power input of 77 V up to the boiling point of water and followed by 50 V until the end of extraction, 2 hours extraction time, a solvent to solid ratio of 3:1 and a crushing frequency of once. The optimized parameters were then applied to hydro distillation and steam distillation. Thekinetics of extraction was proposed and validated based on asecond-order model.The maximum amount of yield of optimized

parameters in kinetic study by ohmic heated hydro distillation was 7.64 mL/kWh in comparison with hydro distillation and steam distillation methods that resulted oil yield 3.87 mL/kWh and 1.69 mL/kWh, respectively. The proposed model fitted well with the experimental data showed that the coefficient of determination, R^2 more than 0.97. The chemical, physical and biological properties of citronella oil and leaves extracted using three different extraction methods were also determined. Gas chromatography-mass spectrometry analysis found that the major constituents of citronella oil for the different extraction methods were citronellal, citronellol and geraniol. The results for specific gravity and refractive index at 20 °C were ranged from 0.8879 to 0.8916 and 1.4671 to 1.4743, respectively. The citronella oil colour intensity in terms of red and yellow units was 2.0 Y to 0.7R 4Y. Scanning electron micrographs of citronella grass showed some microfractures and cell wall became less rigidity for ohmic heated hydro distillation. Results of this research revealed that ohmic heated hydro distillation could be introduced as an alternative technology to conventional methods.

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

PENGOPTIMUMAN DAN KINETIK PENGEKSTRAKAN MINYAK SERAI WANGI OLEH PENYULINGAN HIDRO PEMANASAN OHMIK

Oleh

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Jun 2013

Pengerusi: Profesor Madya Hasfalina Che Man, PhD

Fakulti: Kejuruteraan

Serai wangi adalah tumbuhan beraroma yang mempunyai pelbagai aplikasi dan potensi ekonomi yang besar.Minyak serai wangi mempunyai pelbagai kegunaan seperti digunakan dalam ubat tradisional, industri minyak wangi dan pembuatan sabun.Satu cadangan kaedah pengekstrakan minyak serai wangi telah dibangunkan dengan menggunakan penyulingan hidro pemanasan ohmik.Objektif utama penyelidikan ini adalah bertujuan menentukan parameter pengekstrakan minyak serai wangi untuk mendapatkan hasil minyak yang maksimum melalui penyulingan hidro pemanasan ohmik. Parameter yang mempengaruhi pengekstrakan minyak serai wangi oleh penyulingan hidro pemanasan ohmik adalah seperti input kuasa, masa pengekstrakan, nisbah pelarut kepada pepejal dan frekeunsi menghancur telah dikaji. Parameter optimum ditemui pada input kuasa 77 V sehingga takat didih air dan diikuti dengan 50 V sehingga akhir pengekstrakan, masa pengekstrakan selama 2 jam, nisbah pelarut kepada pepejal sebanyak 3:1 dan sekali frekuensi menghancur. Parameter optimum kemudiannya diaplikasikan dalam penyulingan hidro dan penyulingan wap.

Kinetik pengekstrakan telah dicadangkan dan disahkan berdasarkan model tertib kedua. Jumlah hasil maksimum pada parameter optimum bagi kajian kinetik oleh penyulingan hidro pemanasan ohmik ialah 7.64 mL/kWj berbanding dengan kaedah penyulingan hidro dan penyulingan stim yang menghasilkan masing-masing 3.87 mL/kWj dan 1.69 mL/kWj. Model yang dicadangkan disesuaikan baik dengan data eksperimen menunjukkan pekali penentuan, R^2 lebih daripada 0.97.Sifat kimia, fizikal dan biologi minyak dan daun serai wangi dengan menggunakan tiga kaedah pengekstrakan berbeza juga ditentukan. Analisis gas kromatografi-jisim spektrometri menunjukkan juzuk utama kandungan minyak serai wangi untuk kaedah pengekstrakan berbeza iaitu citronellal, citronellol dan geraniol. Keputusan bagi graviti spesifik (20 °C) dan indeks biasan (n_D 20 °C) masing-masing antara 0.8879 hingga 0.8916 g/mL dan 1.4671 hingga 1.4743. Keamatan warna minyak serai wangi daripada segi unit merah dan kuning adalah 2.0 K hingga 0.7M 4K.Imbasan mikrograf elektron serai wangi menunjukkan sedikit pecahan mikro dan menjadikan dinding sel kurang kukuh untuk penyulingan hidro pemanasan ohmik.Keputusan penyelidikan ini membuktikan bahawa penyulingan hidro pemanasan ohmik boleh diperkenal sebagai teknologi alternatif kepada kaedah konvensional.

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I certify that a Thesis Examination Committee has met on 4 June 2013 to conduct the final examination of Muhammad Hazwan bin Hamzah on his thesis entitled "Optimization and Kinetics of Citronella Oil Extraction by Ohmic Heated Hydro Distillation" 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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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment 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.

MUHAMMAD HAZWAN BIN HAMZAH

Date: 4 June 2013

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