UNIVERSITI PUTRA MALAYSIA

EQUILIBRIUM AND KINETIC STUDIES ON REMOVAL OF PHENOLIC COMPOUNDS USING ACTIVATED CARBON COATED MONOLITH

ABDOLHOSSEIN SADRNIA

EQUILIBRIUM AND KINETIC STUDIES ON REMOVAL OF PHENOLIC COMPOUNDS USING ACTIVATED CARBON COATED MONOLITH

By

TEOH YI PENG

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

July 2014

COPYRIGHT

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

EQUILIBRIUM AND KINETIC STUDIES ON REMOVAL OF PHENOLIC COMPOUNDS USING ACTIVATED CARBON COATED MONOLITH

By

TEOH YI PENG

July 2014

Chair: Prof. Ir. Thomas Choong Shean Yaw, Ph.D
Faculty: Engineering

Activated carbon coated monolith (ACCM) was prepared by dipcoating method using a polymer mixture (furfuryl alcohol, and poly ethylene glycol). The adsorptive performance of phenol, 4-chlorophenol (4-CP), 2,4-dichlorophenol (2,4-DCP) onto the ACCM was comparatively evaluated by batch mode. Experiments were carried out at varying pH, contact time, initial adsorbate concentration and reaction temperature. Regeneration performance of ACCM was also assessed. This study showed an optimum adsorption for 2,4-DCP, followed by 4-CP, and phenol at pH 5. The adsorption equilibrium time for phenol, 4-CP, 2,4-DCP were 600 min, 500 min, and 400 min, respectively. The equilibrium adsorption capacity were increased 50.3 - 62.9 mg/g (phenol), 88.9 - 111.5 mg/g (4-CP), and 89.9 - 117.5 mg/g (2,4-DCP), respectively at an increasing initial concentration of 400 – 600 mg/L. The adsorption was monolayer as depicted by linear and non-linear isotherm models. The adsorption kinetics was best represented by the pseudo-second order kinetics model. The adsorption capacity increases with increasing reaction temperature from 30 to 50^{o}C, showing an endothermic process. Excellent recovery of phenol was observed during regeneration using ethanol, which showed an 81% efficiency after four consecutive cycles.

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

KAJIAN KINETIK DAN KESEIMBANGAN KE ATAS PENYINGKIRAN KUMPULAN FENOLIK MENGGUNAKAN MONOLIT KARBON BERSALUT TERAKTIF

Oleh

TEOH YI PENG

Julai 2014

Pengerusi: Prof. Ir. Thomas Choong Shean Yaw, Ph.D
Fakulti: Kejuruteraan

Monolit bersalut karbon aktif (ACCM) digunakan untuk mengkaji prestasi penyerapan ke atas fenolik compound seperti fenol, 4-klorofenol (4- CP) dan 2, 4-diklorofenol (2, 4- DCP). Eksperimen telah dikaji berdasarkan beberapa parameter seperti, pH, masa sentuhan, kepekatan awal fenol dan suhu larutan. Kajian pemulihan juga dijalankan dalam kajian ini. Keupayaan penyerapan bagi CCM terhadap 2, 4-DCP adalah lebih baik berbanding dengan penyerapan 4-CP dan diikuti dengan fenol pada nilai pH 5.. Kajian-kajian masa sentuh menunjukkan masa penyeimbangan penyerapan fenol, 4- CP dan 2, 4- DCP adalah berada pada 600 min, 500 min, dan 400 min. Kajian keseimbangan penyerapan nenunjukkan peningkatan julat kepekatan 400 - 600 ppm telah menyebabkan nilai penyerapan meningkat dari 50.3 - 62.9 mg/g bagi fenol, 88.9 - 111.5 mg/g bagi 4-CP, dan 89.9 - 117.5mg/g bagi 2,4-DCP. Kajian isoterma linear dan bukan-linear mendapati data keseimbangan peyerapan fenolik compound adalah mematuhi model isoterma Langmuir. Kajian kinetik menunjukkan model kinetic psuedo tertib kedua mempunyai pretasi yang memuas hati. Kajian termodinamik menunjukkan tindak balas antara fenolik compound denagan ACCM adalah endotermik. Nilai penyerapan meningkat dengan peningkatan suhu dari 30^{o}C sehingga 50^{o}C. Kajian penyah-serapan dan pemulihan menunjukkan CCM berupaya untuk digunakan semula selepas pemulihan. Kesimpulannya, etanol, sebagai bahan penyah-serapan menunjukkan hasil kecekapan pemulihan yang baik sehingga mampu mencapai 81% walaupun berada pada kitaran keempat.

ACKNOWLEDGEMENTS

I wish to express my greatest gratitude to my supervisor, Prof. Dr. Ir. Thomas Choong Shean Yaw for their guidance and encouragement throughout the study. I would also like to give a great appreciation to co-supervisor, Prof. Luqman Chuah Abdullah, for providing me the enlightenment and valuable suggestions in the research. A big appreciation I give to all of the lecturers, administrators and also technical assistants of Chemical and Environmental Engineering Department, UPM.

I would like to express my most sincere and warmest gratitude to all of my friends who had giving me supports and helps during my study. Special thanks must go to Willie for his friendship and support.

I would like to thank my parents for their unquestioning love and support. Without support and also continuous encouragement, I believe it is impossible for me to complete this tough journey.

I certify that a Thesis Examination Committee has met on 23 July 2014 to conduct the final examination of TEOH YI PENG on his thesis entitled "Equilibrium And Kinetic Studies on Removal of Phenolic Compounds Using Activated Carbon-Coated Monolith" 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.

Members of the Thesis Examination Committee were as follows:

Tinia Idaty Mohd. Ghazi, PhD
Associate Professor
Department of Chemical and Environmental Engineering
Faculty of Engineering
Universiti Putra Malaysia
(Chairman)

Suraya Abdul Rashid, PhD
Associate Professor
Department of Chemical and Environmental Engineering
Faculty of Engineering
Universiti Putra Malaysia
(Internal Examiner)

Zurina Zainal Abidin, PhD
Associate Professor
Department of Chemical and Environmental Engineering
Faculty of Engineering
Universiti Putra Malaysia
(Internal Examiner)

Marappa Gounder Ramasamy, PhD
Professor
Universiti Teknologi Petronas
Malaysia
(External Examiner)

NORITAH OMAR, PhD
Associate Professor and Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 18 August 2014

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:

Thomas Choong Shean Yaw, Ph.D
Professor
Faculty of Engineering
University Putra Malaysia
(Chairman)

Luqman Chuah Abdullah, Ph.D
Professor
Faculty of Engineering
University Putra Malaysia
(Member)

_____
BUJANG BIN KIM HUAT, PhD
Professor and Dean
School of Graduate Studies
University Putra Malaysia

Date:

Declaration by graduate student

I hereby confirm that:

- this thesis is my original work;
- quotations, illustrations and citations have been duly referenced;
- this thesis has not been submitted previously or concurrently for any other degree at any other institutions;
- intellectual property from the thesis and copyright of thesis are fully-owned by Universiti Putra Malaysia, as according to the Universiti Putra Malaysia (Research) Rules 2012;
- written permission must be obtained from supervisor and the office of Deputy Vice-Chancellor (Research and Innovation) before thesis is published (in the form of written, printed or in electronic form) including books, journals, modules, proceedings, popular writings, seminar papers, manuscript, posters, reports, lecture notes, learning modules or any other materials as stated in the Universiti Putra Malaysia (Research) Rules 2012;
- there is no plagiarism or data falsification/fabrication in the thesis, and scholarly integrity is upheld as according to the Universiti Putra Malaysia (Research) Rules 2012. The thesis has undergone plagiarism detection software

Signature:_____ Date:_____

Name and Matric No.: _____

Declaration by Members of Supervisory Committee

This is to confirm that:

- the research conducted and the writing of this thesis was under our supervision;
- supervision responsibilities as stated in the Universiti Putra Malaysia (Graduate Studies) Rules 2003 (Revision 2012-2013) are adhered to.

Signature:		Signature:	
Name of Supervisory Committee:		Name of Supervisory Committee:	
Signature:		Signature:	
Name of Supervisory Committee:		Name of Supervisory Committee:	

TABLE OF CONTENTS