PHOTOCATALYTIC DEGRADATION OF POME OVER LANTHANUM DOPED CALCIUM OXIDE DERIVED FROM COCKLE SHELLS

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SUPERVISOR'S DECLARATION

We hereby declare that we have checked this thesis and in our opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Master of Science.

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STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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Thesis submitted in fulfillment of the requirements
for the award of the degree of
Master of Science

College of Engineering

UNIVERSITI MALAYSIA PAHANG

JULY 2020

ACKNOWLEDGEMENTS

In the name of Allah S.W.T, the Most Beneficent and the Most Merciful. My deepest sense of gratitude to the Almighty for the strength and ability to complete this study.

First and foremost, I would like to thank and express a sincere gratitude to my main supervisor, Dr. Jun Haslinda Binti Shariffuddin, for her constructive guidance, support, encouragement, supervision, useful critiques, and words of motivation throughout the period of this study, which has enabled me to complete my study successfully. I also would like to thank Dr Sureena binti Abdullah as my co-supervisor.

My deepest appreciation goes to my supportive parents, Ghazali bin Senik and Saudah Binti Yusoff and my lovely siblings, whom had always supported morally and been giving their never-ending motivation to ensure that I complete this study successfully. For their endless encouragement and genuine support.

I am also grateful towards lab assistants from the College of Engineering Technology laboratory, UMP for providing and helping me with their technical expertise.

I would like to greatly thank the Ministry of Higher Education (MoHE) for the financial support through Fundamental Research Grant Scheme (FRGS) (no. RDU160153) and Universiti Malaysia Pahang (UMP) for all the support throughout my completion of this study.

Finally, thank you to all my friends, my colleagues and everyone that had been helping me, directly or indirectly, to complete my study.

ABSTRAK

Kumbahan industri kelapa sawit (POME) merupakan salah satu masalah utama yang dihadapi oleh industri kelapa sawit di Malaysia kerana permintaan oksigen kimia (COD) dan permintaan oksigen biokimia (BOD) yang tinggi. Baru-baru ini, fotokatalisis telah digunakan dalam beberapa kajian untuk merawat sisa kumbahan kerana keupayaannya untuk memineralkan sebatian organik. Walau bagaimanapun, fotokatalis umum yang digunakan dalam merawat POME seperti titanium okside (TiO_2) dan zink oksida (ZnO) mengandungi metal yang terhad ketersediaannya. Di sisi lain, kulit kerang telah dibuang dan dibiarkan tanpa dirawat ke alam sekitar. Sebagai salah satu penyelesaian yang boleh menangani kedua-dua masalah alam sekitar ini, kajian ini akan menggunakan kulit kerang sebagai bahan mentah untuk menghasilkan kalsium karbonat yang ditukar kepada kalsium oksida (CaO) untuk digunakan sebagai fotokatalis bagi merawat POME. Oleh itu, tujuan kajian ini adalah untuk mengkaji kebolehan sisa kulit kerang untuk diubah menjadi CaO untuk bertindak sebagai fotokatalis dalam rawatan POME melalui reaksi fotokatalisis. Lanthanum (La) telah digunakan dalam kajian ini sebagai dopan untuk meningkatkan aktiviti fotokatalitik bagi CaO. CaO yang digunakan dalam kajian ini telah ditukarkan dari sisa-sisa buangan kulit kerang melalui proses penalaan di mana kemudian sampel itu dilambangkan sebagai Ca900. Ca900 didopankan dengan 1 wt%, 3 wt% dan 5 wt% daripada La menggunakan kaedah pengawalan basah di mana fotokatalisis dilambangkan sebagai LaCa. Kemudian, fotokatalis ini akan diuji pada POME di bawah cahaya UV dalam sistem berkumpulan dengan beberapa kesan operasi seperti kelajuan pengaduk, dos fotokatalis, dos La dan agen pengoksidaan. Semua serbuk fotokatalis yang baru dan telah yang digunakan akan dicirikan menggunakan penggubah spektroskopi inframerah (FTIR), difraksi sinar-X (XRD), brunauer-emmett-teller (BET), scanning electron microsopy (SEM), dispersi energi X-ray analisis (EDX), analisis termogravimetri (TGA), plasma induktif digabungkan spektrometri massa (ICP-MS) dan spektra reflektansi difus UV-Vis. Hasil yang didapati dari kajian ini menunjukkan bahawa penghasilan CaO yang berasal dari kulit kerang boleh dicapai untuk digunakan dalam degradasi fotokatalitik POME. Melalui kajian ini, didapati 3 wt% dari LaCa dengan 3.0 g/L dos fotokatalis pada 300 rpm mempunyai kecekapan aktiviti fotokatalitik tertinggi dengan penghapusan 54% berbanding fotokatalis yang lain. Walau bagaimanapun, penyingkiran POME meningkat apabila oksigen sebagai agen pengoksida digunakan iaitu 66% daripada ketika kondisi oksigen terhad (54%). Reaksi data kinetik dari degradasi POME adalah mengikuti model kinetik Langmuir-Hinshelwood sebagai reaksi urutan pertama. Kesimpulannya, penemuan kajian ini membayangkan bahawa bahan pencemar dalam POME dapat dikurangkan dengan memanfaatkan La yang didopankan CaO dimana CaO diperoleh dari sisa kulit kerang.

ABSTRACT

Palm Oil Mill Effluent (POME) is one of the main problems faces by oil palm industry in Malaysia due to its high chemical oxygen demand (COD) and biochemical oxygen demand (BOD). Recently, photocatalysFis has been used in several studies to treat wastewater due to its ability to mineralize the organic compounds. However, the common photocatalysts used in treating POME such as titanium oxide (TiO_2) and zinc oxide (ZnO) consist of metals that have limited availability. On the other hand, cockle shells have been dumped and left untreated to the environment. As one possible solution to address both environmental problems, this study utilized cockle shell as renewable feedstock of calcium carbonate which was converted to calcium oxide (CaO) that was used as photocatalyst to treat POME. Therefore, the aim of this study is to investigate the ability of cockle shell waste to be transformed to CaO to act as photocatalyst in the treatment of POME via photocatalysis reaction. Lanthanum (La) was used in this study to act as dopant to enhance the photocatalytic activity of CaO. The CaO used in this study was converted from cockle shell wastes through calcination process at 900◦C where later the sample was denoted as Ca900. Ca900 was doped with 1 wt%, 3 wt% and 5 wt% of La using wet impregnation method where the doped photocatalyst were denoted as LaCa. Then, the photocatalysts were tested on POME under UV light in batch system by varying the effect of several operational parameters such as stirring speed, photocatalyst loadings, La loadings and oxidizing agent. All fresh and spent photocatalysts powder were characterized using fourier transform infrared spectroscopy (FTIR), X-ray diffraction (XRD), brunauer-emmett-teller (BET), scanning electron microsopy (SEM), energy dispersion X-ray analyser (EDX), thermogravimetric analysis (TGA), inductively coupled plasma mass spectrometry (ICP-MS) and UV-Vis diffuse reflectance spectra. The results obtained from this study show that it is achievable to produce CaO from cockle shell that can be used in photocatalytic degradation of POME. Through this research, it was found that 3 wt% of LaCa with 3.0 g/L of photocatalyst loadings at 300 rpm has highest photocatalytic activity with 54% removal compared to others. However, the removal efficiency of POME increases when oxygen as oxidizing agent were used which is 66% rather than during limited oxygen condition (54%). The kinetic data of POME degradation were fitted Langmuir-Hinshelwood kinetic model as first order reaction. In conclusion, the findings of this study imply that the contaminants in POME can be greatly reduced by utilizing La doped CaO which CaO derived from cockle shell waste.

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