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Utilization of oil palm biodiesel solid residue as renewable sources for preparation of granular activated carbon by microwave induced KOH activation

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HIGHLIGHTS

▸ Highlight the renewable use of oil palm biodiesel solid residue.
▸ Explore the potential of microwave heating.
▸ Low activation time of 10 min.
▸ High monolayer adsorption capacity for MB of 343.94 mg/g.

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ABSTRACT

In this work, preparation of granular activated carbon from oil palm biodiesel solid residue, oil palm shell (PSAC) by microwave assisted KOH activation has been attempted. The physical and chemical properties of PSAC were characterized using scanning electron microscopy, volumetric adsorption analyzer and elemental analysis. The adsorption behavior was examined by performing batch adsorption experiments using methylene blue as dye model compound. Equilibrium data were simulated using the Langmuir, Freundlich and Temkin isotherm models. Kinetic modeling was fitted to the pseudo-first-order, pseudo-second-order and Elovich kinetic models, while the adsorption mechanism was determined using the intraparticle diffusion and Boyd equations. The result was satisfactory fitted to the Langmuir isotherm model with a monolayer adsorption capacity of 343.94 mg/g at 30 °C. The findings support the potential of oil palm shell for preparation of high surface area activated carbon by microwave assisted KOH activation.

1. Introduction

The world is facing the worst energy crisis in its entire history. For the past two decades, the search for alternative energy, namely the solar, wind, hydrothermal, geothermal and biofuel, which is renewable and environmental friendly, has been carried out extensively (Foo and Hameed, 2009a). According to the estimation predicted by the International Energy Agency, the global energy consumption is foreseen to increase approximately 88.1% by 2030, with 34.8% of crude oil, 29.2% of coal, 24.1% of natural gas, 5.5% of nuclear energy and 6.4% of hydroelectricity (IEA, 2009). At the current production rates, the global proven reserves for crude oil and natural gas are expected to last for the next 41.8 and 60.3 years (Ong et al., 2011). The progressive escalation of oil price and diminishing fossil fuel reserves has led to a shift towards alternative fuel sectors (Foo and Hameed, 2009b).

Among all, biodiesel, defined as the mono-alkyl esters of long chain fatty acids, is produced from biological sources such as vegetable oils or animal fats using a biological process known as transestification (Foo and Hameed, 2012a). Biodiesel has been identified as the most attractive and practical choice to replace fossil fuel as the main source of energy, due to the similarity with conventional diesel in terms of chemical structure and energy content (Foo and Hameed, 2012b). Additionally, no modification in diesel engine is required as biodiesel is compatible with the exiting engine model (Mendow et al., 2012).

Today, the biodiesel is booming in Europe and the United States. In Malaysia, the national palm oil biofuel policy framework has been drafted by the government, and 12 biodiesel plants are fully operational with capacity of producing 1 million tonnes of biodiesel per year (Mekhilef et al., 2011). The refining and fractionation process however, is accompanied by the generation of oil palm biomass, in the form of oil palm trunk, empty fruit bunch, fiber, shell and discharged waste of palm oil mill effluent (POME) (Foo and Hameed, 2010a). In the formal practice, some quantity of these

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