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Preparation and Characterization of Impregnated Commercial Rice Husks Activated Carbon with Piperazine for Carbon Dioxide (CO_2) Capture

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Abstract: Development of effective materials for carbon dioxide (CO_2) capture technology is a fundamental importance to reduce CO_2 emissions. This work establishes the addition of amine functional group on the surface of activated carbon to further improve the adsorption capacity of CO_2. Rice husks activated carbon were modified using wet impregnation method by introducing piperazine onto the activated carbon surfaces at different concentrations and mixture ratios. These modified activated carbons were characterized by using X-Ray Diffraction (XRD), Brunauer, Emmett and Teller (BET), Fourier Transform Infrared Spectroscopy (FTIR) and Field Emission Scanning Electron Microscopy (FESEM). The results from XRD analysis show the presence of polyethylene butane at diffraction angles of 21.8° and 36.2° for modified activated carbon with increasing intensity corresponding to increase in piperazine concentration. BET results found the surface area and pore volume of non-impregnated activated carbon to be 126.69 m^2/g and 0.081 cm^3/g respectively, while the modified activated carbons with 4M of piperazine have lower surface area and pore volume which is 6.77 m^2/g and 0.015 cm^3/g respectively. At 10M concentration, the surface area and pore volume are the lowest which is 4.48 m^2/g and 0.0065 cm^3/g respectively. These results indicate the piperazine being filled inside the activated carbon pores thus, lowering the surface area and pore volume of the activated carbon. From the FTIR analysis, the presence of peaks at 3312 cm^{-1} and 1636 cm^{-1} proved the existence of reaction between carboxyl groups on the activated carbon surfaces with piperazine. The surface morphology of activated carbon can be clearly seen through FESEM analysis. The modified activated carbon contains fewer pores than non-modified activated carbon as the pores have been covered with piperazine.

Keywords: Activated carbon; rice husks; adsorbent; piperazine

1. INTRODUCTION

Rice husk is the outermost layer of the paddy grain that being separated throughout the milling process which consist of 20% from overall paddy production and approximately, there are 100 million tons of rice husks generated worldwide per annum (Olawale et al. 2012). Rice husk usually categorized as agricultural waste product and often disposed by dumping or burning to produce rice husk ash (Nagrale et al. 2012). The high content of hydrocarbon in the rice husk enhances its potential as the feedstock for activated carbon preparation (Kumar et al. 2012). Activated carbon usually used as adsorbent for environmental control in the form of a fixed bed due to its large internal surface area and pore volume, and its ability to adsorb organic vapors for a low cost (Jahangiri et al. 2013). Activated carbon was also considered as one of the highly potential adsorbent for CO_2 adsorption (Dali et al. 2012). Adsorption is a process of mass transfer occurs from bulk of gas or liquid to adsorbents and it has been thoroughly used as separation methods in chemical and other industries (Arie et al. 2016). Activated carbon consists of acidic and basic surfaces while CO_2 gas is an acidic gas. As the CO_2 gas interacts with activated carbon, the basic groups on the activated carbon surfaces will attract CO_2 gas. To enhance the adsorption capacity of the activated carbon, amine groups have been introduced by wet impregnation method onto the activated carbon due to their high efficiency and selectivity for CO_2 capture (Wang et al. 2012). It has been proved by Kangwanwatana et al. (2013), that the modified activated carbon with piperazine enhanced the adsorption capacity significantly. Piperazine will react with CO_2 which involves the mass transfer of CO_2 from the gas phase into the aqueous phase of amine as in (1):

$$\underset{\text{carbon dioxide}}{CO_2} + \underset{\text{piperazine}}{2C_4H_{10}N_2} \rightleftharpoons \underset{\text{carbamate anion}}{C_4H_{10}NCOO^-} + \underset{\text{diethylamine cation}}{C_4H_{10}NH_2^+} \quad (1)$$

In this research work, the rice husk activated carbon was impregnated with piperazine which expected to enhance the CO_2 adsorption capacity. The research aims to study the characteristics of non-modified activated carbon and modified activated carbon with piperazine at different concentration and mixture ratio. The concentration used in this study were 2M, 4M, 6M, 8M and 10M while the mixture ratio used were 1:1, 1:2 and 2:1 of activated carbon to