# UNIVERSITI TEKNOLOGI MARA

# AMBIENT $CO_2$ ADSORPTION USING COCONUT SHELL ACTIVATED CARBON: STUDY ON THE OPTIMIZATION OF THE CHEMICAL ACTIVATION CONDITIONS USING RESPONSE SURFACE METHODOLOGY (RSM), ISOTHERMS AND THERMODYNAMICS

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# ABSTRACT

The development of activated carbon from biomass precursors to adsorb $CO_2$ from various sources of emission is challenging since numerous factors affect the adsorption capacity, including the chemical activation parameters chosen. There is a shortage of comprehensive data on optimizing chemical activation parameters to modify the surface properties of activated carbon utilizing Response Surface Methodology (RSM) and discussing the interaction between the activation conditions and the pore properties produced. Thus, the goal of this work is to optimize the chemical activation parameters of activated carbon, determine its $CO_2$ adsorption capacity at ambient conditions and analyze the adsorption isotherms and thermodynamics of the process. The activated carbon was produced by carbonizing a low-cost coconut shell, followed by potassium hydroxide (KOH) activation. Response Surface Methodology (RSM) was used to optimize chemical activation parameters such as activation temperature (500-800 °C), activation agent ratio (1-3) and activation time (32-120 minutes). As this is a fundamental study to observe the effectiveness of activated carbon produced from biomass precursor and due to the equipment and time constraint, the $CO_2$ adsorption capacity was determined at 25 °C and 1 bar using a volumetric sorption analyzer. The equilibrium data were then fitted to the Langmuir, Freundlich, Sips and Toth isotherm models. Important thermodynamic parameters such the standard Gibbs free energy, standard enthalpy change, entropy change and isosteric heat of adsorption were determined using the Van't Hoff and Clausius–Clapeyron equations. The activation temperature (A), followed by two-way interaction time-time (CC), activation agent ratio (B) and ratio-temperature (BC), has the greatest impact on the BET specific surface area of the activated carbon, according to the results obtained using Response Surface Methodology (RSM). The activation temperature of 902.27 °C, the activation agent ratio of 3.68 and the activation time of 54.32 minutes are the optimum conditions for producing activated carbon with the maximum BET specific surface area (2157.98 $m^2/g$). To achieve maximum $CO_2$ uptake (4.21 mmol/g), the optimum parameters were activation temperature 650 °C, activation agent ratio 2 and activation time 76 minutes. $CO_2$ uptake in this study is not entirely dependent on the BET specific surface area, but rather on the microporosity and small average pore diameter. With the greatest $R^2$ value (0.9997) approaching unity, the Sips isotherm model provided the best fit for the experimental data, illustrating the heterogeneity of the adsorbent surface. Thermodynamic studies revealed that the process was a physisorption process, exothermic and non-spontaneous in nature. It is hoped that the study would provide fundamental data on the $CO_2$ capture process, allowing for the development of greener technology in future.

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