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Impregnation of palm shell-based activated carbon with sterically hindered amines for CO_2 adsorption

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HIGHLIGHTS

- A new methodology was adopted to prepare the amine impregnated activated carbons.
- Equimolar amounts of sterically hindered amines were impregnated.
- This made the comparison of different amines in CO_2 adsorption become effective.
- Three sterically hindered amines were investigated in this study.
- 2-Amino-2-methyl-1-propanol showed the best performance in CO_2 adsorption.

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ABSTRACT

In this work, equimolar amounts of three types of sterically hindered amines (e.g. 2-amino-2-methyl-1,3-propanediol, 2-amino-2-methyl-1-propanol and 2-(methylamino)ethanol) were impregnated onto the surface of palm shell-based activated carbon. Breakthrough curves of CO_2 adsorption were determined using a continuous gas–solid adsorption column. Effects of the type of amine and gas flow rates on the breakthrough time were studied. The results showed that impregnated activated carbon have higher adsorption capacity than virgin activated carbon despite the dramatic decrease in surface area during impregnation. Among the three investigated amines, 2-amino-2-methyl-1-propanol showed the highest bed adsorption capacity.

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1. Introduction

Carbon dioxide emissions which largely caused by fossil fuel combustion, have become a serious concern in relation to global warming and health issues. Gas purification plays an important role in creating a better environment for the living community. Many efforts have been dedicated to develop technologies for CO_2 removal such as cryogenic separation, chemical separation, membrane separation and adsorption method. Among the various chemical and physical methods available for CO_2 removal, adsorption is one of the commonly used method as it is cost effective. Usually, practical pressure swing and thermal swing adsorption processes are designed to separate and purify gas mixtures [1].

Activated carbon is the common adsorbent used in adsorption industries whereby it provides a large spectrum of pore structures and surface chemistry for gas adsorption [2,3]. Generally, activated carbons are relatively cheap, stable in acidic or basic solutions and cost effective as they can be regenerated after used [4,5]. The characteristics of activated carbon can be varied by activation processes such as physical or chemical activation, and the intrinsic nature of the precursors which are usually obtained from different ranks of coals and lignocellulosic materials [6]. Besides, surface chemistry of activated carbon also is an important criteria to be considered in adsorption process [7–9]. Internal and external surface of activated carbon can be modified using functional groups, small or large molecules/species and also by macromolecules (polymer chain). There are several methods by which activated carbons can be modified to improve their adsorption capacity, including oxidation, heat treatment, chemical treatment with acidic, basic solutions or metallic species, etc. [10–12]. Most prominent method to enhance the CO_2 adsorption capacity is by promoting basic species such as alkanolamine on the surface of activated carbon through chemical impregnation [13–17].

Generally, alkanolamine can be divided into three major groups such as primary, secondary and tertiary amines. Most commercial processes for CO_2 removal use monoethanolamine (MEA), diethanolamine (DEA), diisopropanolamine (DIPA) and β,β′-hydroxyami-

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