

## Review

A review on the effect of amination pretreatment for the selective separation of CO<sub>2</sub>Adedeji Adebukola Adelodun<sup>a</sup>, Ki-Hyun Kim<sup>b,\*</sup>, Jane Catherine Ngila<sup>a</sup>, Jan Szulejko<sup>b</sup><sup>a</sup> Department of Applied Chemistry, Faculty of Science, University of Johannesburg, Doornfontein 2028, Johannesburg, South Africa<sup>b</sup> Department of Civil and Environmental Engineering, Hanyang University, 222 Wangsimni-Ro, Seoul 133-791, Republic of Korea

## HIGHLIGHTS

- A review of surface chemical characteristics of activated carbon (AC) is provided.
- The significance of enhanced surface energy through amination of AC is described.
- Pretreatment prior to amination is assessed to improve selective adsorption of CO<sub>2</sub>.
- The efficiency of different adsorbents is assessed for CO<sub>2</sub> adsorption.
- KOH is found to be the most efficient pre-treatment for improving amination.

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## ABSTRACT

For the cost-effective control of unregulated CO<sub>2</sub> emissions, its capture through modifications to adsorbents has recently gained much attention. In this respect, amination through basification of activated carbon (AC) surface is one of the practical approaches to separate CO<sub>2</sub>. To learn more about such mechanism, a number of key variables (e.g., the nature of the AC surface groups, their CO<sub>2</sub> absorption enthalpy, and the effect of amination on adsorption) are reviewed. The potent role of amination is hence described with respect to the significance of pretreatment prior to amination technique by comparing the performance of diverse media (e.g., advanced oxidation processes (AOP), Ca(NO<sub>3</sub>)<sub>2</sub>, and KOH) for such application. The analysis of collected adsorption data suggests that the efficiency of amination and eventual selective adsorption of CO<sub>2</sub> can be improved by such pretreatment as KOH sintering in terms of inducing stronger surface CO<sub>2</sub> binding energy.

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## 1. Introduction

The two most abundant greenhouse gases ( $\text{H}_2\text{O}$  vapor and  $\text{CO}_2$ ) contribute more than 60% to the anthropogenic global warming, as the concentration of the latter was reported to have risen to 400 ppm in 2015 compared to the preindustrial level of about 275 ppm [1]. Recently, ever more increasing attention has been paid toward reducing  $\text{CO}_2$  emissions, which is viewed as a serious environmental problem. The major concern regarding anthropogenic  $\text{CO}_2$  emissions into the atmosphere is hence still related to its contribution to global warming. This aspect has attracted more attention than any other climate-related issues in recent decades. Although excessive  $\text{CO}_2$  levels (e.g., >350 ppm) are commonly regarded as an outdoor pollution issue, it is also a major indoor hazard; the significance of the latter has not often been taken seriously in a relative sense. Poor indoor air quality (i.e.,  $[\text{CO}_2] > 1000$  ppm) often leads to various health-related symptoms that are popularly referred to as sick building syndrome (SBS). It represents an acute, non-specific symptoms experienced by a majority of people because of their lengthy working and transportation periods (about 87% and 6% of their time inside buildings and vehicles, respectively) under adverse indoor environmental conditions [2,3]. As the effects of SBS have been widely recognized, various governmental bodies have begun to impose stringent regulations on indoor air quality (IAQ) [4]. This calls for the need for efficient control and management of indoor gas levels.

Carbon capture and storage (CCS) is a wide research field which has drawn significant technical interests, e.g., [5]. Fig. 1 shows the six major separation techniques available for  $\text{CO}_2$  control. There are numerous published works on this subject. In order to avoid undue repetition and unnecessary emphasis, a very detailed and useful review is recommended [5]. Among many available CCS

technologies, absorption has been the most conventional and industrialized option for large-scale applications with economic feasibility. However, high energy costs and difficulties in regeneration are some of the shortcomings of this technology, especially with the use of the most popular absorbent, monoethanolamine (MEA). Therefore, adsorption has emerged as a more promising alternative to circumvent the aforementioned limitations of absorption. In this respect, activated carbon (AC) is of huge potential interest, as it shows the merits of high availability and accessibility with low affinity to moisture (relative to zeolite, silica, and many other materials).

As the increase in atmospheric  $\text{CO}_2$  levels continues incessantly, the selective adsorption of  $\text{CO}_2$  has become one of the major focuses in the CCS research [6,7]. Many published works have reported the selective separation of  $\text{CO}_2$  in  $\text{N}_2$  with the aid of metal–organic frameworks [8,9], synthetic zeolites [10,11], polymers [12], and carbon-based adsorbents [13–15]. As a basic tool for separation between gases, adsorption, which is a surface energy phenomenon, has thus been favored over others such as absorption, decomposition, or precipitation due to its properties including accessibility of precursors, ease of handling, regeneration, and cost-effectiveness. Hence, many researchers have pursued applications such as seeking solutions for one of the most debated environmental issues-global warming. Therefore, the preparation/modification of adsorbents has received increasing research interest.

In this review, a detailed analysis is provided to describe the effect of amination pretreatment with respect to the enhancement of selective adsorption of  $\text{CO}_2$ . The scope of this review is set to describe surface chemistry of activated carbon (Section 2) and to help explain the relevant techniques for basification of AC (Section 3). The eventual significance of such approach is then explained for the sake of effective control of atmospheric  $\text{CO}_2$

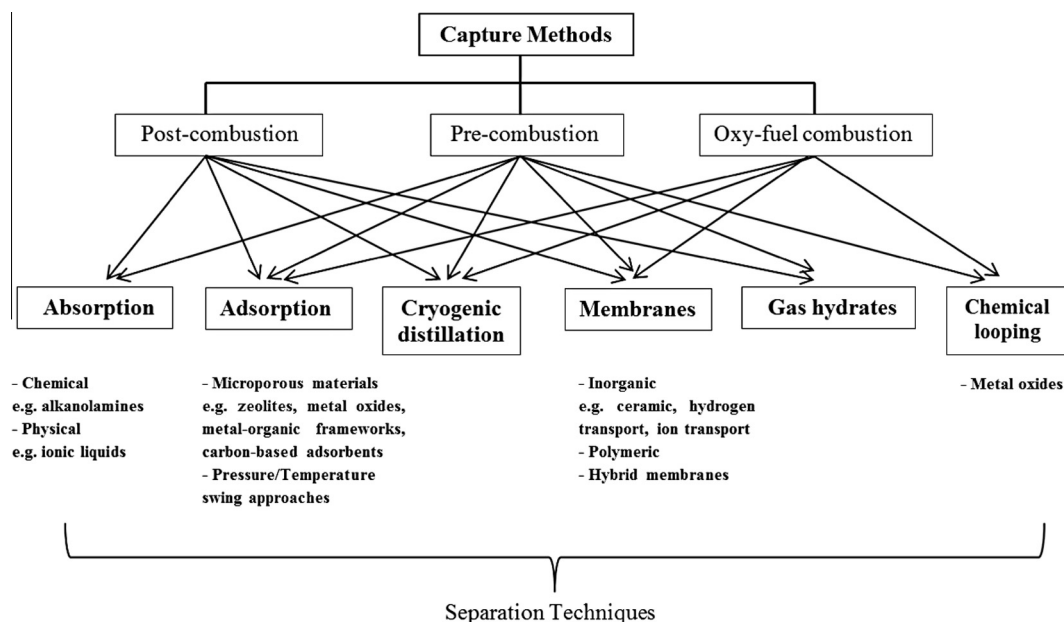


Fig. 1. Types of carbon separation techniques [5].

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