Chemical Engineering Journal 200–202 (2012) 399–404

Contents lists available at SciVerse ScienceDirect

Chemical Engineering Journal

journal homepage: www.elsevier.com/locate/cej

Thermodynamics for the adsorption of SO_2, NO and CO_2 from flue gas on activated carbon fiber

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HIGHLIGHTS

- The adsorption isotherm of SO_2, NO and CO_2 was constructed to characterize isotherms.
- Thermodynamic parameters were used to understand adsorption behavior.
- The Extended Langmuir model was used to simulate competition adsorption.

ARTICLE INFO

Article history:
Received 27 April 2012
Received in revised form 1 June 2012
Accepted 5 June 2012
Available online 19 June 2012

Keywords:
Adsorption equilibrium
SO_2, NO and CO_2
ACF
Thermodynamics

ABSTRACT

For researching the co-adsorption behavior of SO_2, NO and CO_2 in flue gas, the adsorption characteristics of pure component on activated carbon fiber (ACF) at temperatures ranging from 323.15 K to 363.15 K have been experimentally measured by a volumetric apparatus. The equilibrium data were analyzed by the Langmuir and Freundlich model, which revealed that Freundlich model was more suitable to describe the three gases adsorption than Langmuir model. The Henry's Constant was investigated based on the adsorption isotherms. The results showed that adsorption affinity follows the order SO_2 > NO > CO_2 on ACF. Thermodynamic functions integral Gibbs' free energy, enthalpy and entropy were calculated to characterize adsorption behavior. Finally, The Extended Langmuir (EL) Model was used to predicted multicomponent competed adsorption. We compared the experimental data both for the individual adsorption and for the mixture adsorption in our research. This work can provide helpful information to understanding the removal SO_2, NO and CO_2 via simultaneous adsorption on ACF in further studies.

1. Introduction

SO_2, NO and CO_2 are major pollutants in the atmosphere, which contribute to acid rain, photochemical smog, ozone depletion and greenhouse effects [1–3]. It was estimated that SO_2 and NO_x emission of China in 2020 will be 30.6 and 26.6 Mt, respectively. CO_2 emission may be at peak between 2020 and 2035 [4]. Hitherto, many methods for protecting SO_2 and NO have been proposed and applied such as wet scrubbing, spray-dry scrubbing, and dry scrubbing using lime or limestone as absorbents, NO_x selective catalytic reduction (SCR). A lot of technologies such as membrane separation, the conventional temperature swing adsorption (TSA) or pressure swing adsorption (PSA) have been proposed to sequester CO_2 from the flue gases. However, removal techniques of the three gases alone have some disadvantages. Wet scrubbing was highly efficient but it tended to generate wastewater. Spray-dry scrubbing was suffering from many shortcomings such as the blockage of the spray nozzle and production of sludge. The main disadvantage of dry scrubbing was its low removal efficiency of SO_2 [5]. But the adsorption was considered as one of the most promising technologies in the commercial and industrial applications because of the low energy requirement, cost advantage, and ease of applicability over a relatively wide range of temperatures and pressures [6–8]. Active carbons fibers (ACFs) had been actually used in removal apparatus for noxious gas because of their extended specific surface area, high adsorption capacity, well-developed microspores, safety, reproducibility, process ability, and so on [9]. At present, research in the field of adsorbents had made rapid progress for adsorbing single pollutant in flue gas. Gaur [10] had performed lots of experiments to investigate the adsorption properties for SO_2 on ACF in the presence of O_2 and H_2O. Shirahama et al. [11] had tested the adsorption of NO_2 on ACF at different NO_2 concentrations. Liu [12] had researched modified ACF for adsorption of SO_2 and NO.

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http://dx.doi.org/10.1016/j.cej.2012.06.013