

# Spectroscopic Study on Multicyclic Stability of CO<sub>2</sub> Adsorbent in Flue Gas Conditions

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Carbon dioxide Capture and Sequestration (CCS) has been receiving widespread attention over the years as an effort to mitigate anthropogenic CO<sub>2</sub> [1]. Supported amine adsorbents emerged as advantaged candidate materials for post-combustion CO<sub>2</sub> capture due to their high CO<sub>2</sub> capacity and selectivity [2]. As commercialization of this capture process is realized, the assessment of the performance of these materials under realistic conditions is of importance. This entails the understanding of the presence of flue gas impurities such as SO<sub>x</sub> and NO<sub>x</sub>. In this work, the stability of amine-functionalized silica sorbents was evaluated in multiple temperature swing adsorption (TSA) cycle in the presence of flue gas impurities such as water, oxygen and acid gases.

The amine-functionalized silica sorbents were prepared by chemical incorporation of mono- and diamino organosilanes through incipient wetness technique. Three samples were used: (3-aminopropyl)trimethoxysilane (1NS-P), N-[3-(trimethoxysilyl)propyl]ethylenediamine (2NS), and 2NS modified with epoxypropane (EP-2NS). Thermogravimetric analysis (TG) and high-throughput equipment were used to evaluate the stability of the sorbents over 20 cycles at an adsorption and desorption temperature of 30 and 150°C, respectively. Coadsorption experiments were employed using the following test gases: CO<sub>2</sub>/N<sub>2</sub>, NO<sub>2</sub>/CO<sub>2</sub>/N<sub>2</sub>, and SO<sub>2</sub>/CO<sub>2</sub>/N<sub>2</sub>. Subsequently, the spent adsorbents were analyzed through in-situ FT-IR to determine the degradation products.

The amine ratio (primary and secondary amine content) of the organosilanes used was

determined and was ranked as 1NS-P < 2NS < EP-2NS in order of increasing amount of secondary amines. Fig. 1 summarizes the multicyclic performance of the adsorbents. It was observed that the higher the amount of secondary amines in the sorbent, the more resistant it is to degradation. Additionally, the presence of SO<sub>2</sub> caused the highest degradation due to its relatively high Lewis acidity. The results of FT-IR analysis are shown in Fig. 2. It was observed that CO<sub>2</sub>-induced degradation produces linear urea (for primary amine) and cyclic urea (for secondary amine), and acid gas-induced degradation produces nitro group (nitramine).

In addition to these results, the effects of oxygen and moisture in flue gases on adsorbents were also investigated in detail.

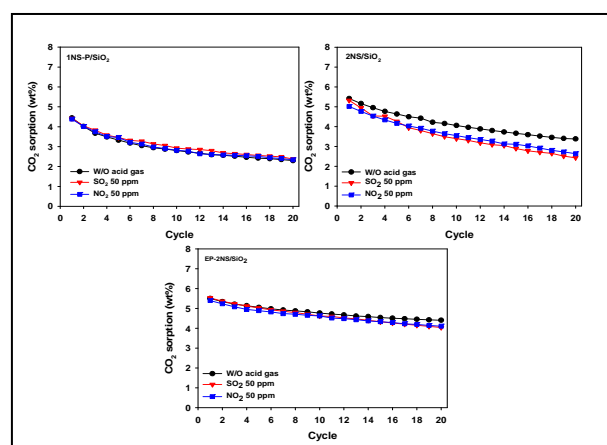


Fig.1 CO<sub>2</sub> adsorption capacity over 20 cycles.

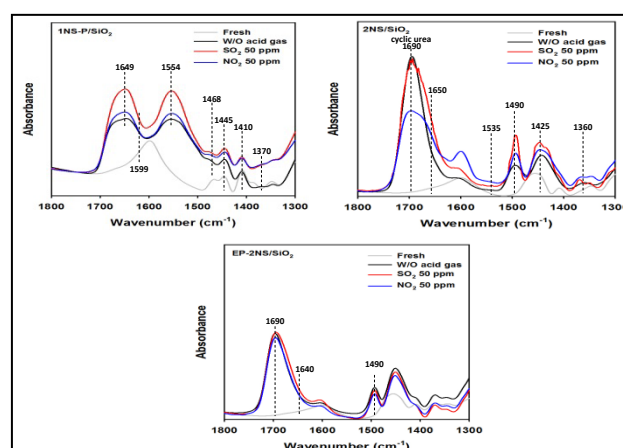


Fig. 2 FT-IR spectra before and after exposure to flue gases.

## REFERENCES

- [1] A.A. Olajire, Energy, 35 (2010) 2610-2628.
- [2] A. Samanta, A. Zhao, G. Shimizu, P. Sarkar and R. Gupta. Ind. Eng. Chem. Res. (2011) 1438-1463.