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Carbon dioxide capture utilizing zeolites synthesized with paper sludge and scrap-glass

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Abstract

The present work introduces the study of the CO_2 capture process by zeolites synthesized from paper sludge and scrap glass. Zeolites ZSM-5, analcime and wairakite were produced by means of two types of Structure Directing Agents (SDA): tetrapropilamonium (TPA) and ethanol. On the one hand, zeolite ZSM-5 was synthesized using TPA; on the other hand, analcime and wairakite were produced with ethanol. The temperature programmed desorption (TPD) technique was performed for determining the CO_2 sorption capacity of these zeolites at two sorption temperatures: 50 and 100°C. CO_2 sorption capacity of zeolite ZSM-5 synthesized at 50°C was 0.683 mmol/g representing 38.2% of the value measured for a zeolite ZSM-5 commercial. Zeolite analcime showed a higher CO_2 sorption capacity (1.698 mmol/g) at 50°C and its regeneration temperature was relatively low. Zeolites synthesized in this study can be used in the purification of biogas and this will produce energy without increasing the atmospheric CO_2 concentrations.

Keywords

Air treatment, carbon dioxide, zeolites, wastes

Introduction

Zeolites are used extensively in many industrial applications mainly in catalysis, adsorption and separation of gases and ion exchange purposes. Since the first attempts made by Barrer and Milton to synthesize zeolites (Barrer, 1948; Milton, 1959), different raw materials and methodologies have been used to create new structures and to improve some physicochemical properties. The synthesis of zeolites for catalytic applications has arisen a special interest worldwide. Moreover, wastewater treatment and capture of greenhouse gases (GHGs) are some interesting applications for mitigating the effects of the climate change.

This research group has used in several works solid wastes generated in industrial processes such as the mining tailings and drinking water sludge for synthesizing zeolites. The main objectives have been to reduce costs and the environmental problems associated to their disposal by producing adsorbent materials. The present work shows the results in the synthesis of zeolite ZSM-5, analcime and wairakite by using paper sludge ash and pulverized scrap glass issued from the construction industry. The objective was to determine the CO_2 sorption capacity of the synthesized zeolites and to evaluate the feasibility to use them in the separation process of CO_2 and CH_4 from biogas generated in landfills.

Materials and methods

The synthesis of zeolites was achieved by using Si and Al extracted from paper sludge ash and adding scrap glass. A paper sludge sample was collected in the wastewater treatment plant of a Mexican paper industry. This residue was first dried at 100°C overnight and afterwards calcined at 550°C during 2 hours. After this treatment, samples of paper sludge ash (PSA) and PSAL (pulverized sludge ash treated with a 2M HCl solution for leaching interferences of the zeolite synthesis process) were characterized by using X-ray fluorescence (XRF) (analyses were performed in a Siemens SRS 3000) and X-ray diffraction (XRD) (analyses were performed in a Bruker D8 diffractometer). Pulverized scrap glass (PS) was obtained from residues of the construction industry. Glycerol (J.T. Baker) grade analytical was used for hydrolysis of Si and Al species from PS.

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