ICCE-18 Achorage 4-10 July 2010

Nanoengineered Zeolite/Carbon Composites for Selective Adsorbents for CO_2

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Introduction

Zeolites and carbons are often used to adsorb and control air and liquid-phase pollutants and toxic agents.

Natural raw materials, such as coconut husk and wood, produce unique porous carbons with little pore volume in the mesopore and macropore range. CO_2 activation (1123-1173K), however, gives a predominately microporous structure. Phenolic resin monoliths have also been used to produce carbon monoliths. The porous MAST^{TM} carbon monolith used in this study has a resistivity (of between 0.1 and 50 ohms/m).

Zeolites are crystalline hydrated aluminosilicates. They are commonly used for the recovery of chemicals and radioactive ions, as well as drying gases, separating molecules, catalysis, and to remove atmospheric pollutants. Size and shape of a zeolite pore system controls access of molecules due to steric influence and so zeolites are also known as shape selective catalysts.

Experimental

LTA (4A) and NaX (13X) zeolite has been grown (see the micrograph in Figure 1) in the macrostructure of four 'unmodified' carbons (MAST™, willow, pine and rattan) without blocking the meso/micropores of the substrate. A lack of modification reduces costs, avoids weakening the substrate and prevents side reactions.

Results

The composites can be rapidly regenerated in-situ by electrical heating using the resistivity of the carbon substrate. Calcination of the composites removes the carbon produces a zeolite-only replica. The zeolite loading could be increased from 3% to 44% by extending substrate time in the precursor solution. Hence, growth rates were found to be different inside the carbon pores as crystal growth continued after it was arrested in the external solution. However, XRD and ^{29}Si MAS-NMR analysis indicated that, in the first 14h, NaX zeolite synthesis was slower inside the carbon pores than the external liquor.

These composites had surface areas only slightly different from the carbon host alone.

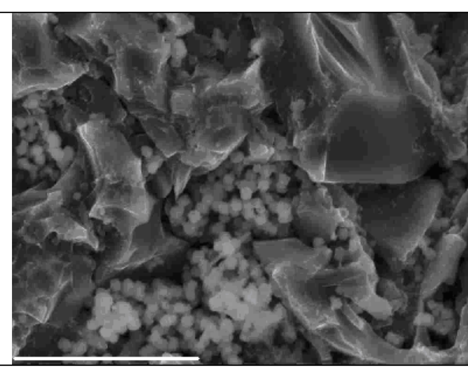

Fig 1. LTA zeolite grown in the pores of MastCarbon monolith. Scale bar = 20μm.

Mass spectrometry showed that the carbon monolith and NaX desorb water at a lower temperature than CO_2. However, LTA desorbs CO_2 at a lower temperature than H_2O, as does the NaX/LTA/carbon nanocomposite.

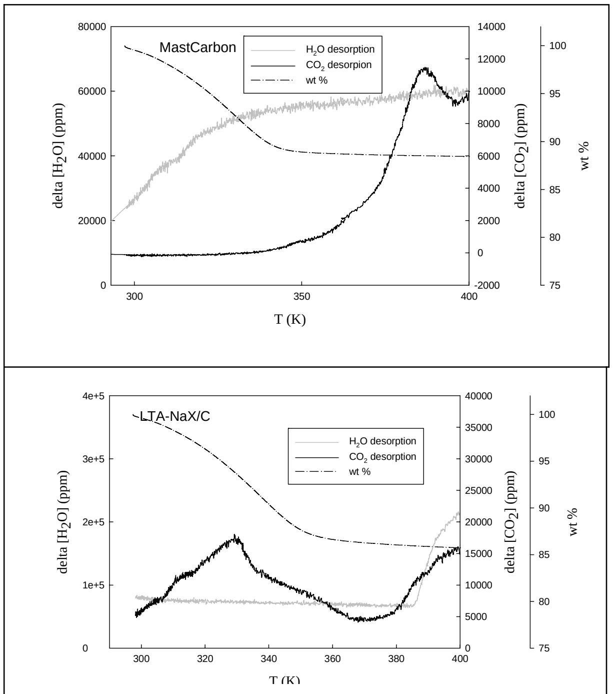

Fig 2. CO_2 and water desorption from carbon monolith and LTA-NaX/carbon composite

Conclusions

This bodes well for the design of zeolite/carbon composites for CO_2 capture from the free atmosphere.