Measuring Carbon Dioxide Adsorption into Zeolite Structures Using High-Pressure TGA (TGA-HP)

ABSTRACT

This paper discusses the use of high-pressure TGA (TGA-HP) to investigate adsorption of carbon dioxide into the zeolite mineral chabazite.

INTRODUCTION

Zeolites were formed from ancient volcanic ash flows settling in seas and lakes. This unique group of naturally-occurring minerals is often referred to as 'molecular sieves'. Zeolite is the world's only mineral with a naturally-occurring negative charge. Zeolites simply lock and hold many positive ions, absorbing a multitude of environmental contaminants such as sodium, potassium; barium and calcium, and positively charged groups such as water and ammonia. Nearly every application of zeolites has been driven by environmental concerns, or plays a significant role in reducing toxic waste and energy consumption. It is the highly porous and consistent matrix of zeolite that provides the adsorption qualities.

Zeolites and other inorganic molecular sieve membranes have shown potential for separations based on molecular size and shape because of their small pore sized, typically less than 1 nm, and their narrow pore size distribution. The high thermal and chemical stability of these inorganic crystals make them ideal materials for use in high temperature applications such as catalytic membrane reactors. Zeolites also have the potential to achieve precise and specific separation of gases including the removal of H_2O, CO_2 and SO_2 from low-grade natural gas streams, as separation experiments through zeolite-containing membranes indicate that competitive adsorption can selectively separate light gas mixtures.

RESULTS & DISCUSSION

High-Pressure TGA is an excellent tool to investigate a material's efficiency for absorbing and storing gases such as hydrogen, at a variety of temperatures and pressures. The TA Instruments TGA-HP Series products are specialty gravimetric analyzers designed to provide unique capabilities for High-Pressure, Ultra-High Vacuum, and High-Temperature under static or dynamic reactive atmospheres. These instruments are designed for sorption studies using water vapor, organic vapors, hydrogen, methane and carbon dioxide as well as permanent gases and corrosive gases.

Using the continuous flow method, the TGA-HP Analyzers provide isotherms, isobars and time course data for the study of:

- General gas/solid reactions
- Oxidation/reduction of metals
- Degradation of ceramics
- Catalysts, zeolites, activated carbons and other specialty materials
- CO_2 Sequestration techniques

Chabazite is the most important member of the 48 minerals in the zeolite group. Chabazite's structure has a typical zeolite openness that allows large ions and molecules to reside and actually move around inside the overall framework. The structure actually contains open channels that allow water and large ions to travel into and out of the crystal structure. The size of these channels controls the size of the molecules or ions and therefore a zeolite like chabazite can act as a chemical sieve, allowing some ions to pass through while blocking others. The figure below contains the TGA-HP data for the adsorption of CO_2 into raw chabazite at 60°C and at pressures up to 20 Bar. Note how the quantitative gravimetric sorption is easily determined using the TGA-HP technology.

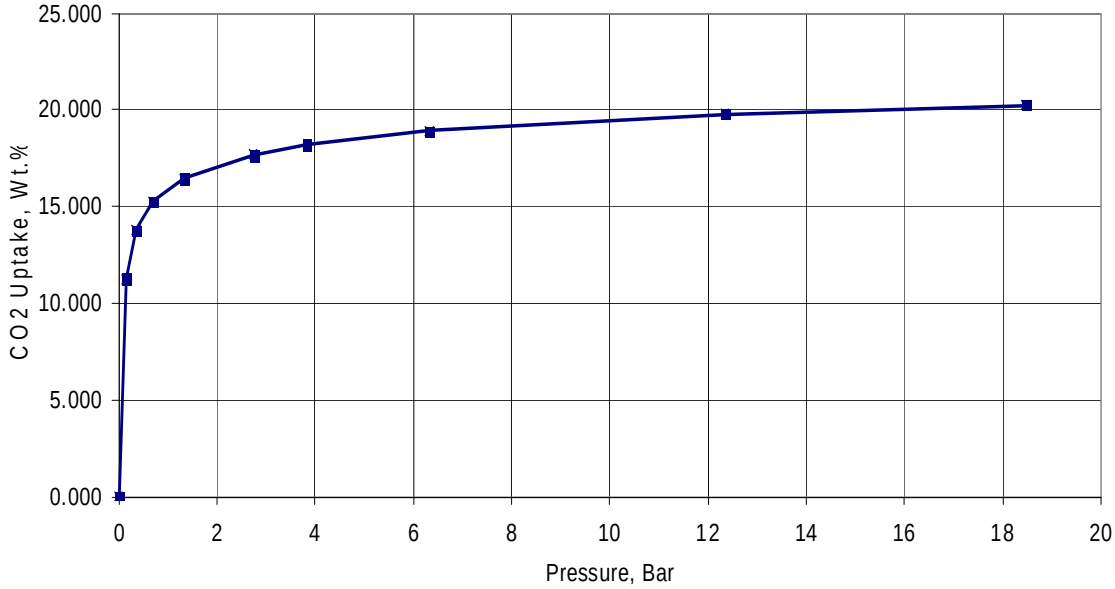

Figure 1: TGA-HP Data of the CO_2 Sorption into Raw Chabazite

REFERENCES

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