

Zeolites - Earliest Solid State Acids

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Abstract

A description of zeolites is followed by applications in three important areas of catalysis, gas separation and ion exchange. Finally some examples of representative zeolite structures are cited.

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Introduction

Three-dimensional crystalline compounds formed with AlO_4 and SiO_4 tetrahedra are called zeolites (Mall-net 2007, Dwyer 1984), Figure 1. Normally they are made under conditions similar to hydrothermal conditions typically found in the earth's crust where some natural zeolites occur (Wikipedia 2007, Smith 1976). Sodium aluminate, sodium silicate, or sodium hydroxide solutions are used. Reactants and synthesis parameters such as temperature, time, and pH, determine the particular zeolite formed. The templating ion is especially critical. Usually an organic cation surrounded by an aluminosilicate lattice forms the templating ion. The main zeolite formula is $\text{M}_2/n\text{O} \cdot \text{Al}_2\text{O}_3 \cdot x\text{SiO}_2 \cdot y\text{H}_2\text{O}$, where M defines the "compensating" cation with valence n (Dwyer 1984). The structural component is $\text{M}_x/n[(\text{AlO}_2)_x(\text{SiO}_2)_y] \cdot z\text{H}_2\text{O}$, and a general structure of tetrahedral building units form ring structures and polyhedra. Zeolite catalysts are strongly desired because of their high density of active acid sites¹, their high thermal/ hydro-thermal stability, and high size selectivity.

Their unique porous properties make zeolites useful in a variety of applications with a global market of several million tons per annum.

¹ Hence zeolites are solid state acids. In fact they are the earliest known solid state acids.

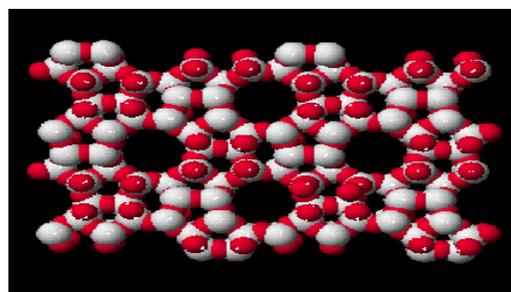


Fig. 1. Zeolite.

Major uses are in petrochemical cracking, ion-exchange (water softening and purification), and gas and solvent separations and removal. They are commonly known as molecular sieves. They are also useful in agriculture, animal husbandry and construction.

A list of interesting websites is shown in the International Natural Zeolite Association INZA page (INZA 2007).

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Description (Wikipedia 2007, Mall-net 2007)

Classically a zeolite is defined as a crystalline porous aluminosilicate. But many materials with properties virtually identical to the classical zeolite have been discovered. They consist of oxide structures with elements other than silicon and aluminum. Hence current definitions include all types of porous oxide structures with well-defined pores caused by high crystallinity.