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Quantification and Characterization of Aluminum Distributions in Commercial Beta and Mordenite Zeolites by Cobalt Exchange

Rebecca L. Reitzel, Claire T. Nimlos and Rajamani P. Gounder
Department of Chemical Engineering, Purdue University

ABSTRACT

The aluminum distribution throughout the zeolite framework determines the structural, ion-exchange and catalytic properties of the zeolite. Several methods have been proposed to control the Al distribution, but in order to accurately assess these methods a procedure is needed to quantify Al distribution in various zeolite frameworks. Co^{2+} ions exchange onto the zeolite framework at Al pairs, and atomic absorbance spectroscopy (AAS) can be used to quantify the number of exchanged Co^{2+} ions and, in turn, the overall number of Al pairs. Each framework exhibits differences in pore size and channel configuration which affect the equilibrium conditions needed for saturation of all paired Al sites with Co^{2+} ions. In order to achieve saturation of the Co^{2+} ions, a reproducible exchange procedure must be developed for each framework of interest. Commercial beta (BEA) and mordenite (MOR) zeolites were subjected to liquid-phase cobalt ion exchange with varying exchange solution molarity, temperature, number of repetitions and time of exchange. The zeolites were then washed and treated in an oxidizing environment at high temperatures before undergoing AAS analysis to determine Co^{2+} concentration and diffuse reflectance UV-Vis spectroscopy (DRUV-VIS) to ensure only bare Co^{2+} ions were present. The BEA framework was found to achieve saturation at the following conditions: 0.50 M $\text{Co}(\text{NO}_3)_2$ exchange solution, ambient temperature, 1 repetition and 12 hour exchange time. The exchange procedure for MOR zeolites requires a 0.05 M $\text{Co}(\text{NO}_3)_2$ solution, ambient temperature, 24 hour exchange time and 1 repetition. These procedures will aid in the creation of an accurate catalog of the Al distribution in various commercially available BEA and MOR zeolites, as well as aiding in further synthesis studies to control the Al distribution in BEA and MOR zeolites.

KEYWORDS

Beta, mordenite, aluminum siting, cobalt exchange