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Synthesis and characterization of boron-modified Linde Type-A zeolites investigate the influence of varying boron-to-aluminum ratio on their structural properties

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Zeolites are crystalline aluminosilicates with a three-dimensional porous framework, widely used in chemical industry as catalysts, ion-exchangers, and adsorbents due to their unique physicochemical properties. Tetrahedral sites in zeolites can undergo isomorphous substitution with other atoms to create catalysts with enhanced activity and selectivity. This study investigates the synthesis of boron-modified Linde Type A zeolites with varying boron-to-aluminum (B/Al) ratio to assess their impact on the material's structural properties. In this study, boron-modified Linde Type A zeolites were synthesized using a microwave-assisted method at 900 W and 110 °C for 3 hours. A series of samples were prepared by varying B/Al ratio with gel mixtures having molar compositions of 7.82 Na_2O : Al_2O_3 : 1.1 SiO_2 : 245 H_2O. The obtained samples were characterized by Powder X-ray diffraction (PXRD), Scanning Electron Microscopy (SEM), Fourier-Transform Infrared (FTIR) spectroscopy, and Raman microscopy. The PXRD pattern showed the successful formation of the Linde Type A zeolite structure. Notably, a subtle decrease in peak intensity is observed following boron incorporation, suggesting a slight reduction in crystallinity due to boron loading. SEM images reveal that increasing the B/Al ratio disrupts the well-defined crystal morphology of Linde Type A zeolites. This observation suggests that higher boron content may hinder the formation of the desired Linde Type A zeolite phase, potentially due to alterations in the crystallization process or framework stability. The FTIR and Raman microscopic data provide detailed insights into bonding characteristics and crystal lattice vibrations, confirming the successful integration of boron within the zeolite structure. During this microwave-assisted method, borosilicate materials were successfully synthesized. However, excessive incorporation of boron significantly influenced the topology of boron-modified Linde Type A zeolites. This over-incorporation disrupted the aluminosilicate framework, inhibiting the nucleation and growth of crystalline phases, leading to decreased crystallinity and the formation of amorphous phases.

Keywords: Boron, Microwave synthesis, Ratio, Topology, Zeolites