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INVESTIGATION OF THE CORRELATION OF MODIFIED Al/B RATIO WITH STRUCTURAL DISTORTION AND Ni^{2+} INCORPORATION IN ZSM-5 ZEOLITES

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ZSM-5 zeolite, an aluminosilicate having high silica content, is used in catalysis and adsorption. The framework is formed by connecting TO_4 tetrahedra (T = Si, Al), making intersected pores, with ten-member ring openings. B/ZSM-5 zeolites contain boron (B) atoms within the framework. Though the individual effects of Al/ZSM-5 and B/ZSM-5 zeolites have been investigated, the systematic influence of Al/B ratio on framework distortion, Bronsted acidity, and efficiency of Ni incorporation has not been comprehensively examined. This study aimed to synthesise Al/B modified ZSM-5 zeolites and determine the effect of compositional differences on structural order, Bronsted acidity, and Ni^{2+} addition. Five samples of ZSM-5 zeolites with varying Al/B ratios - 100% Al; 75% Al, 25% B; 50% Al, 50% B; 25% Al, 75% B; and 100% B were synthesised using a hydrothermal method with $NaAlO_2$, NaOH, tetraethylammonium bromide, colloidal silica, and H_3BO_4. The catalysts were made by impregnating each composition with nickel using $[Ni(H_2O)_6](NO_3)_2$. The characteristic ZSM-5 peak in Raman spectroscopy was located at 385 cm^{-1}; therefore, all the compositions exhibit a sharp peak around this value, indicating the presence of zeolite crystals. As the B content increased, this peak became sharper, suggesting a reduction of framework distortion. B reduces the lattice strain through its smaller ionic size, thereby minimising vibrational dephasing and inhomogeneous broadening. Other prominent peaks could be observed at 845 cm^{-1} and 1320 cm^{-1}, corresponding to the symmetric stretching of T-O vibrations within the framework. UV-visible spectroscopy was employed to confirm the incorporation of Ni. The absorbance values for Ni decreased gradually when the B content was increased. The incorporation of Ni^{2+} diminished with the increasing B content. This study demonstrates that the nature of the Bronsted acid sites within the crystal framework influences Ni^{2+} incorporation. Al-rich samples possess Al-OH-Si linkages within the framework, featuring highly acidic and polarizable O-H bonds that govern effective ion exchange. In contrast, B-substituted zeolites have weaker Bronsted acid sites, resulting in reduced ion exchange capacity and inefficient Ni incorporation.

Keywords: B/ZSM-5 zeolites, Bronsted acidity, Ion exchange, Ni incorporation