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SYNTHESIS OF BIFUNCTIONAL CATALYSTS BASED ON MESOPOROUS ALUMINOSILICATES FOR HYDROAROMATIZATION OF MODEL COMPOUNDS

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1. Introduction

Currently, new catalytic systems are being studied to address energy and environmental challenges. In the field of renewable energy, increasing the aromatic content of diesel fuels is an essential consideration because it lowers the fuel's quality and can result in harmful emissions when burned [1]. One way to reduce the aromatic content is by converting aromatic compounds into cyclic alkanes. This can increase the cetane number of the fuel and improve its quality [2]. Mesoporous aluminosilicates promoted with nickel and molybdenum catalysts have shown promise in the hydroprocessing of aromatic hydrocarbons, contributing to their effectiveness and efficiency.

2. Experimental procedure

Mesoporous aluminosilicates synthesized using the templating method and activated bentonite were utilized as carriers for bifunctional catalysts. Hexadecylamine was used as a templating agent. The composite consisted of mesoporous aluminosilicates and activated bentonite in a 35/65 (mass %) ratio. The obtained catalysts were promoted with nickel and molybdenum. G. Vassilina et al. provided complete description of the synthesis methodology [3].

The samples were characterized by means of conventional techniques: SEM, N_2 adsorption- desorption isotherms at 77, XRD, FTIR, and ICP-AES.

The study of the catalytic properties of bifunctional catalysts based on mesoporous aluminosilicate and bentonite in the conversion of n-hexadecane-methylnaphthalene was conducted. A specialized batch reactor was used to investigate the catalytic performance. The following conditions were applied to the reactor: a temperature range of 240-360°C and H_2 pressure 3 MPa.

3. Results and discussion.

The visual morphology of synthesized mesoporous aluminosilicates was examined using scanning electron microscopy (SEM). SEM images reveal ordered hexagonal arrays of mesopores with uniform pores.

The nitrogen adsorption-desorption isotherms of the synthesized samples, according to the International Union of Pure and Applied Chemistry (IUPAC) standards, are classified as Type IV with a more pronounced hysteresis loop closer to H4. Type IV isotherms demonstrate a narrow pore size distribution ranging from 2 to 50 nm. Furthermore, the hysteresis loop at relative pressures exceeding P/P_0=0.4 indicates the presence of mesopores [4].

Furthermore, the synthesized materials differ in specific surface area, average pore diameter, and pore volume. For instance, mesoporous aluminosilicate (MAS), Ni-MAS-H-bentonite, and Mo-MAS-H-bentonite have specific surface areas of 375.1, 214.9, and 161.6 m^2/g, respectively. The reduction in specific surface area and pore volume suggests that some pores in the catalyst structure are blocked by Ni and Mo metals. The pore size distribution of the carrier and catalyst materials is relatively narrow. In the case of promoted catalysts, a bimodal pore size distribution was observed in the lower range of pore sizes.

The amorphous nature of the mesoporous aluminosilicate is confirmed by X-ray diffraction analysis. The sample exhibits only a broad halo in the 2θ range from 40° to 60°, which is characteristic of the amorphous nature of the material. The XRD peaks of the bifunctional catalysts Ni-MAS-H-bentonite and Mo-MAS-H-bentonite indicate that these samples have a crystalline structure without any traces of amorphous material.

The mesoporous structure of the synthesized samples was confirmed by infrared spectroscopy (FTIR). The corresponding peaks detected at 807.36 cm^{-1}, 803.52 cm^{-1}, and 789.29 cm^{-1} indicate the presence of Si-O-Si and Si-O-Al bonds, which are characteristic of aluminosilicates.

The obtained catalysts showed activity in the hydrogenation of 2-methylnaphthalene in n-hexadecane. It was found that the Ni-MAS-H-bentonite and Mo-MAS-H-bentonite catalysts exhibited high activity and selectivity in the hydrodearomatization process.

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