

of 20 2.1° angles indicates the presence of a mesoporous structure. For HMS and Mo/HMS-H-bentonite samples, the intensity peak is in the region of 2.1°, and for Ni/HMS-H-bentonite – 2.3°, which corresponds to an interplanar distance of 4.2 at the wavelength of the radiation used, and 3.9 nm, respectively.

To determine the relative strength of the Brønsted and Lewis acidic centers on the surface of mesoporous aluminosilicates and bifunctional catalysts based on them used in this study, we analyzed IR spectroscopy using diffuse reflectance infrared Fourier transform spectroscopy (DRIFT) of adsorbed pyridine samples (Fig. 4). The absorption bands at 1445, 1490, and 1595 cm⁻¹ are fixed on the studied samples. The observed bands at 1445 and 1595 cm⁻¹ in the spectra are explained by the presence of hydrogen bonded pyridine adsorbed on sites of Lewis acids [13,14]. The band observed at approximately 1490 cm⁻¹ is due to the adsorption of pyridine in both the Lewis and Brønsted acid sites. The introduction of Ni (5 wt%) and Mo (1 wt%) into the mesoporous aluminosilicate leads to a significant decrease in the intensity of the bands of 1445, 1490, and 1595 cm⁻¹, indicating that some of the alumina oxygen tetrahedra are blocked by the modifier. DRIFT spectra provide clear evidence that Mo/HMS-H-bentonite has a higher acidity than Ni/HMS-H-bentonite.

The catalytic conversion of n-hexadecane on (a) Ni/HMS-H-bentonite and (b) Mo/HMS-H-bentonite catalysts is shown in Fig. 5. From the obtained experimental data, it can be seen that, under conditions of low temperature aluminosilicate catalysis (320 °C), the basic direction of the hexadecane conversion is the isomerization process. It should also be noted that isomerized hexadecane structures are obtained due to the isomerization process, without the participation of cracking. When the temperature rises from 320 °C to 340 °C, along with isomerization reactions, the cracking reaction also proceeds. The highest yield of the target products (*iso*-C₁₆H₃₄) during hydroisomerization of n-hexadecane is observed on a sample of the catalyst Mo/HMS-H bentonite at a temperature of 320 °C and is 42 mass. % with a selectivity of 91%. Slightly low activity of the Ni/HMS-H-bentonite sample in the process under study is probably due to the low acidity necessary for hydroisomerization of n-hexadecane [15,16].

4. Conclusion

The ordered mesoporous HMS carrier was prepared using copolycondensation method. Nickel and molybdenum-containing catalysts deposited on a mesoporous aluminosilicate containing 5 wt% Ni and 1 wt% Mo were synthesized by wet impregnation method. The prepared samples were studied using various characterization methods, namely BET, nitrogen adsorption/desorption, XRD and DRIFT. The presence of a mesoporous and ordered structure in the aluminosilicate and catalysts based on it is confirmed by the data of low-temperature adsorption/desorption of nitrogen and X-ray diffraction. A correlation was established between the structural, acidic and catalytic properties of HMS-based catalyst samples. The catalytic activity of Ni/HMS-H-bentonite (a) and Mo/HMS-H-bentonite (b) was investigated during the conversion of n-hexadecane. It was shown that the highest activity and selectivity in then-hexadecane hydroisomerization process under optimal conditions (320 °C, 1 h⁻¹) is possessed by a sample

molybdenum-promoted HMS-based catalyst. The yield of isoparaffins on this sample is 42 wt% with a selectivity of 91%.

CRedit authorship contribution statement

Gulzira Vassilina: Supervision, Project administration, Conceptualization, Methodology, Writing - review & editing. **Kamilla Umbetkaliyeva:** Conceptualization, Writing - review & editing, Investigation, Formal analysis. **Nuray Oktar:** Formal analysis, Resources. **Birce Pekmezci Karaman:** Formal analysis, Resources. **Tursunay Vassilina:** Investigation, Writing - review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Further Reading

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