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MORPHOLOGICAL FEATURES OF HYDROTHERMALLY SYNTHESIZED NaY ZEOLITE REVEALED BY SCANNING ELECTRON MICROSCOPY

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Abstract: ***This study presents the morphological characterization of NaY zeolite hydrothermally synthesized from chemically pure reagents using scanning electron microscopy (SEM). SEM images obtained at different magnifications revealed a heterogeneous aggregated morphology consisting of smaller crystalline structural units. Higher magnifications showed a developed surface microrelief with protrusions, local depressions, and faceted regions. Comparison of images recorded at ×2,000, ×5,000, ×10,000, and ×15,000 demonstrated the preservation of characteristic morphological features at different observation scales. The results provide a basis for further investigation of the relationship between the morphology and physicochemical properties of synthesized NaY zeolite.***

Keywords: ***NaY zeolite, hydrothermal synthesis, SEM, surface morphology, particle aggregation, microstructure.***

INTRODUCTION

Zeolite Y is a crystalline aluminosilicate belonging to the FAU framework type and is widely used in adsorption, ion-exchange, and catalytic processes due to its three-dimensional pore system, high specific surface area, and structural stability [1-3]. The presence of exchangeable cations and accessible intracrystalline cavities makes NaY zeolite particularly attractive for applications requiring controlled adsorption and molecular transport.

The physicochemical properties of synthetic NaY are strongly influenced by synthesis conditions, including the composition of the initial gel, Si/Al ratio, alkalinity, aging, and crystallization parameters [2-5]. These factors affect not only the formation and crystallinity of the FAU phase but also the size, shape, aggregation, and surface morphology of the resulting particles. Therefore, morphological characterization is an important step in evaluating hydrothermally synthesized NaY zeolite.

Scanning electron microscopy (SEM) provides direct information on particle morphology, aggregation, surface heterogeneity, and microstructural organization [4-6]. Examination at different magnifications enables the overall particle arrangement to be correlated with the finer structural features of individual aggregates. In the present study, SEM was used to investigate the morphological features of NaY zeolite hydrothermally synthesized from chemically pure reagents, with particular attention to particle aggregation and surface microrelief.

METHODOLOGY AND MATERIALS

NaY zeolite hydrothermally synthesized from chemically pure starting reagents was used as the experimental material. The surface morphology and microstructural features of the synthesized sample were investigated by scanning electron microscopy (SEM).

SEM analysis was performed at an accelerating voltage of 15.0 kV. Micrographs were acquired at magnifications of ×2,000, ×5,000, ×10,000, and ×15,000, allowing the

morphology to be examined from the overall particle distribution to the surface features of individual aggregates.

The SEM images were comparatively analyzed with respect to particle shape, aggregation, surface heterogeneity, and microrelief. The obtained micrographs were used for qualitative morphological characterization of the hydrothermally synthesized NaY zeolite.

RESULTS AND DISCUSSION

SEM analysis revealed that the hydrothermally synthesized NaY zeolite exhibits a heterogeneous and aggregated morphology. Figure 1 presents SEM images obtained at magnifications of ×2,000, ×5,000, ×10,000, and ×15,000, allowing the morphological organization of the material to be examined at different observation scales. At ×2,000 magnification (Fig. 1a), the sample consists of numerous closely contacting particles forming relatively dense agglomerates. The surface is heterogeneous, and no isolated large monolithic particles are observed. Such aggregation may be associated with nucleation, crystal growth, and subsequent intergrowth of crystallites during hydrothermal crystallization [2-5].

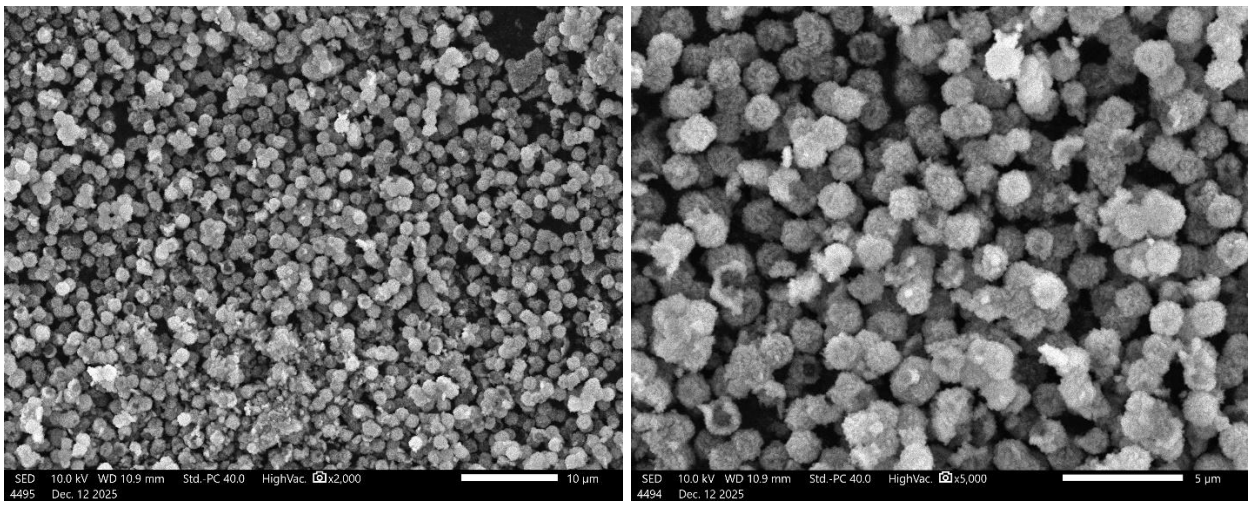
At ×5,000 magnification (Fig. 1b), the internal organization of the aggregates becomes more evident. They are composed of numerous smaller structural units with irregular outlines, while relatively flat and faceted regions can also be distinguished. These morphological features indicate heterogeneous particle growth and aggregation during zeolite formation.

At higher magnifications of ×10,000 and ×15,000 (Fig. 1c, d), the surface microrelief is clearly resolved. Protruding structural elements, local depressions, particle boundaries, and faceted regions are observed. The aggregates consist of closely interconnected smaller crystalline formations, resulting in a complex and non-uniform surface morphology.

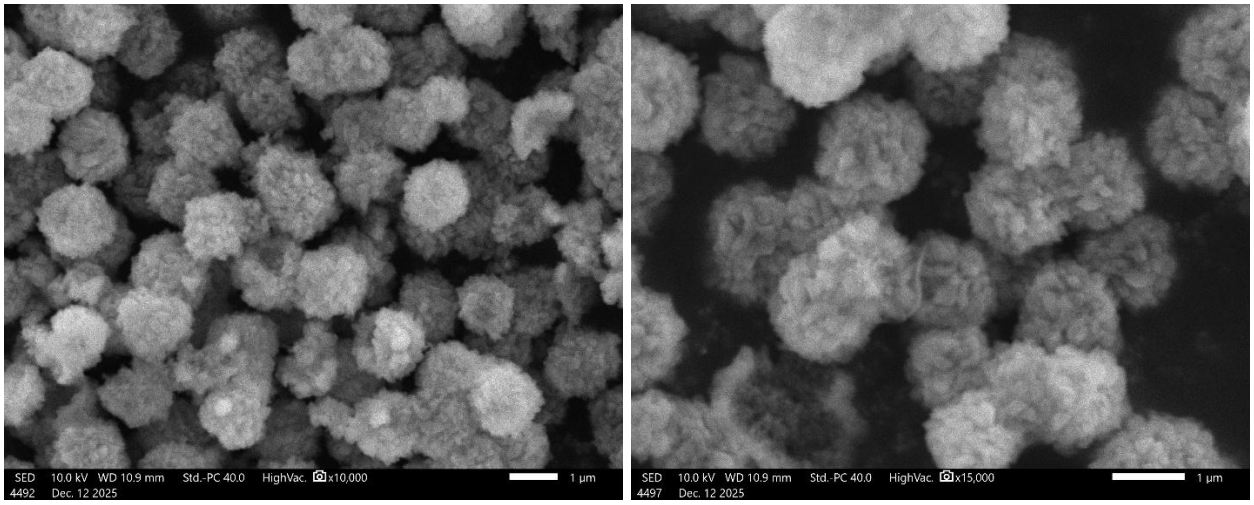
Comparison of the SEM images shows that the characteristic aggregated

morphology is preserved with increasing magnification. The transition from ×2,000 to ×15,000 progressively reveals finer structural details of the same aggregates rather than fundamentally different particle types. This confirms that the observed heterogeneous microrelief is a characteristic morphological feature of the synthesized NaY zeolite. Such morphological organization is consistent with literature data describing the formation and subsequent aggregation of primary crystalline particles in synthetic and nanosized NaY zeolites [4–6].

Thus, SEM analysis demonstrates that the hydrothermally synthesized NaY zeolite is characterized by an aggregated microstructure, heterogeneous surface relief, and fine structural elements with different degrees of faceting. These morphological features provide useful information for further investigation of the relationship between the structure and functional properties of NaY zeolite.



a) ***b)***



c) *d)*

Fig. 1. SEM images of the synthesized NaY zeolite at different magnifications: (a) ×2,000; (b) ×5,000; (c) ×10,000; (d) ×15,000.

CONCLUSION

SEM analysis demonstrated that hydrothermally synthesized NaY zeolite exhibits a heterogeneous aggregated morphology with a well-developed surface microrelief. Images obtained at different magnifications revealed that the aggregates consist of closely interconnected fine structural units with local depressions, protrusions, irregular contours, and faceted regions. The preservation of these characteristic features from ×2,000 to ×15,000 magnification confirms the complex and hierarchical morphological organization of the synthesized material. The obtained results provide important morphological information and may serve as a basis for further studies aimed at correlating the microstructure of NaY zeolite with its structural, textural, and adsorption properties.

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