

PECULIARITIES OF CATALYTIC ACTIVE METALS' NANOCLUSTERS INSIDE NANOSTRUCTURAL CARBON MATERIALS

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Introduction

The fractal route to structure analysis of disordered nanosized and nanostructured materials is successfully used in up-to-date researches [1,2]. In this work we try to apply such approach to analysis the structure peculiarities of nickel nanoclusters that formed in carbon nanopores and compare obtained characteristics with activity of these catalysts in different reactions.

Materials and methods

A nanostructured high porous carbon material was prepared by template synthesis [3,4]. Nickel was deposited on carbon support by method [5] from nickel glyoximate with subsequent its reduction to metal state in flowing hydrogen gas.

The small-angle X-ray scattering (SAXS) experiments were performed using a Kratky camera. The global unified equation of Beaucage [6] was used to fit the SAXS intensity curves.

Nitrogen adsorption-desorption isotherms were measured by Sorptometer "KELVIN-1042". Pore size distributions were calculated by BJH method.

Activity Ni/C catalysts in reaction of cathodic reduction of hydrated protons was carried out in electrochemical equipment [7] and isopropyl benzene hydrocracking was made in membrane reactor [8].

Results and discussion

Pore size distribution studying showed that effective pore diameter of initial templated carbon decreases on about 1.6 nm after nickel deposition and weak depend on Ni concentration. So, an effective size of Ni nanoclusters is about 0.8 nm.

SAXS curve analysis of initial templated carbon showed that the primary pores had mean diameter about 6 nm that have wavy surface. The 2nd structure level corresponds to mass fractal aggregates of primary pores with mean diameter about 30 nm. At small Ni content in catalyst the main structure peculiarities of initial nanocarbon material are saved. But at certain Ni concentration (about 2.5% Ni by weight for templated carbon) the size of primary particles enlarges and the slope of correspondent segments in SAXS curves fits to mass fractal aggregation. The dendritic structure of

Ni clusters appears on the inner surface of carbon pores. Dendrites of Ni nanoclusters sprout into neighboring pores enlarging the size of primary particles. With increasing of metal content in carbon support the size of primary particles decreases because branchy dendritic shape aggregates of Ni nanoclusters at high concentrations are converted into condense metal layer that forms pores of catalyst apparently in borders of initial carbon support pores.

Catalytic activity studies showed that nanostructured carbon material with dendritic structure of Ni nanoclusters had maximum catalytic activity in both tested processes.

Conclusions

The structure peculiarities of templated nanoporous carbon material with Ni nanoclusters were studied by SAXS and nitrogen adsorption methods. The catalytic activity of these materials in processes of cathodic reduction of hydrated protons and hydrocracking of alkylaromatic hydrocarbons was investigated. It was established that dendritic shape aggregates of Ni nanoclusters showed maximum catalytic activity. This investigation may be of interest for preliminary optimization of catalyst's performance without direct labour-intensive catalytic testing.

References

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