

Ruthenium-iron containing catalysts for Fischer-Tropsch liquid-phase synthesis

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Relevance of the research. Fischer-Tropsch synthesis (FTS) allows a wide range of gaseous, liquid, and solid products to be obtained. Modern research in FTS is mainly aimed at obtaining a high yield of liquid hydrocarbons. The liquid-phase FTS process using a high-boiling inert solvent makes it possible to control the stage of the chain growth. Besides, it decreases the probability of oxygen-containing and low-weight by-products formation. Nowadays, the process of carbon oxides hydrogenation is of great interest. Thus, according to the Scopus database, from 500 to 800 publications on FTS are published per year. Currently, the Fischer-Tropsch synthesis is being studied by G. Froment, B. Davis, G. Jacobs, E. Iglesia, Y. Li, N. Tsubaki, A. Khodakov, A. Y. Krylova, A.A. Khasin, R.S. Yarullin, A.L. Lapidus, etc. The researchers' interest is focused on the development of new highly efficient and stable catalysts for FTS. The typical FTS catalysts have disadvantages such as active phase leaching during the process, fast deactivation due to surface carbonization, sensitivity to the composition of synthesis gas, and the presence of water. The relevance of this work consists in the development of new active catalytic systems that provide high selectivity to gasoline hydrocarbons in the Fischer-Tropsch liquid-phase synthesis process.

The work aims to develop and synthesize mono- and bimetallic catalysts in subcritical water and to study their catalytic properties in the Fischer-Tropsch liquid-phase process.

Research objectives:

1. The choice of conditions and synthesis of active, stable mono- and bimetallic catalysts in the medium of subcritical water for the liquid-phase Fischer-Tropsch process.
2. Study of the influence of catalysts composition and structure on the synthesis-gas conversion and the yield of gasoline fraction hydrocarbons.
3. Study of the influence of FTS parameters on the reaction rate and yield of C₅-C₁₁ hydrocarbons and identification of the basic kinetic regularities.
4. Analysis of the structure and composition of the most active catalysts.
5. The hypothesis on the mechanism of the process and mathematical modeling of the kinetics of liquid-phase FTS in the presence of heterogeneous catalysts synthesized in subcritical water.

The scientific novelty of the work. A new method of catalytic systems synthesis in subcritical water was proposed. The obtained catalysts are characterized by high availability of catalytically active sites, high stability of active phase particles to leaching and aggregation was confirmed by a number of physical methods. The influence of catalyst synthesis parameters on the composition and structure of the support and the active phase was determined. Optimal conditions for the synthesis of catalysts were selected. The principles of the liquid-phase FTS process over the catalysts synthesized in subcritical water were formulated for the first time based on experimental data. A hypothesis on the mechanism and a new mathematical model of liquid-phase FTS kinetics which describes the processes of reagent consumption, product formation, and catalyst inhibition with a high degree of convergence have been proposed.

The practical significance of the work. The synthesis of new catalysts with high activity and stability will improve existing technologies of FTS for the production of liquid gasoline fraction alkanes.

The main thesis to be defended. Approaches to the synthesis of mono- and bimetallic catalysts by active phase deposition in a subcritical water medium; composition, structure, and morphology of iron- and ruthenium-containing catalysts synthesized in subcritical water; data on the activity and selectivity of the obtained catalysts in the hydrogenation of CO in the medium of n-dodecane; kinetic peculiarities and hypothesis about the mechanism of Fischer-Tropsch synthesis in the medium of n-dodecane in the presence of catalysts synthesized in subcritical water; mathematical model of the kinetics of CO hydrogenation in the medium of n-dodecane in the presence of catalysts synthesized in subcritical water.