ANALYSIS OF POWDER SYNTHESIZED IN Mo–C–N SYSTEM BY SCANNING ELECTRON MICROSCOPY

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Hydrogen is a sustainable, renewable, and environmentally friendly energy source. As known, one of the possible effective methods for its producing is electrochemical water splitting [1–2]. However, this method requires highly active electrocatalysts. Currently, platinum is the most promising catalyst, but it has high cost and is limited in resources. The materials of the molybdenum-carbon-nitrogen system can become substitutes for such a metal, because they have physical and chemical properties: electrical conductivity, chemical stability and high catalytic activity [3–4].

One of the methods for obtaining materials of the molybdenum-carbon-nitrogen system is the method of synthesis in a DC arc plasma under atmospheric conditions [5]. This method is based on the generation of an arc discharge between graphite electrodes, as a result of the combustion of which a protective environment of CO and CO_2 is formed, which shields the synthesis zone from oxidation by oxygen.

The aim of the paper is to analyze the particles morphology of the synthesized powder material obtained by a vacuum-free electric arc method in molybdenum-carbon-nitrogen system, as well as to study its elemental composition.

Experimental studies were carried out on an electric arc reactor with a horizontal system of electrodes made in the form of graphite rods. The initial reagents were a mixture of molybdenum, graphite and melamine powders in the ratio $Mo:C:C_3N_6H_6 = 2:1:1$. The initial mixture was evenly distributed on the bottom of a graphite crucible, in the cavity of which an arc discharge was initiated. The distance from the discharge initiation zone to the location of the initial reagents was 9 mm. The synthesis took place at an amperage of 200 A for ~10 seconds.

The study of particle morphology and elemental composition was perfomed using a Tescan VEGA 3 SBU scanning electron microscope (Czech Republic). The study was carried out without any preliminary preparation of the initial material: the powder was applied to a special tape.

Figure 1 shows SEM images of the obtained particles in the Backscattered-Electron (BSE) and Secondary Electrons (SE) modes. As can be seen, the sample contains accumulations of newly formed particles ranging in size from 10 to 70 μm, with single nanosized crystallites. According to the analysis of the elemental composition, the main elements are C (~36.79 %), Mo (~53.05 %) and O (~6.37 %).

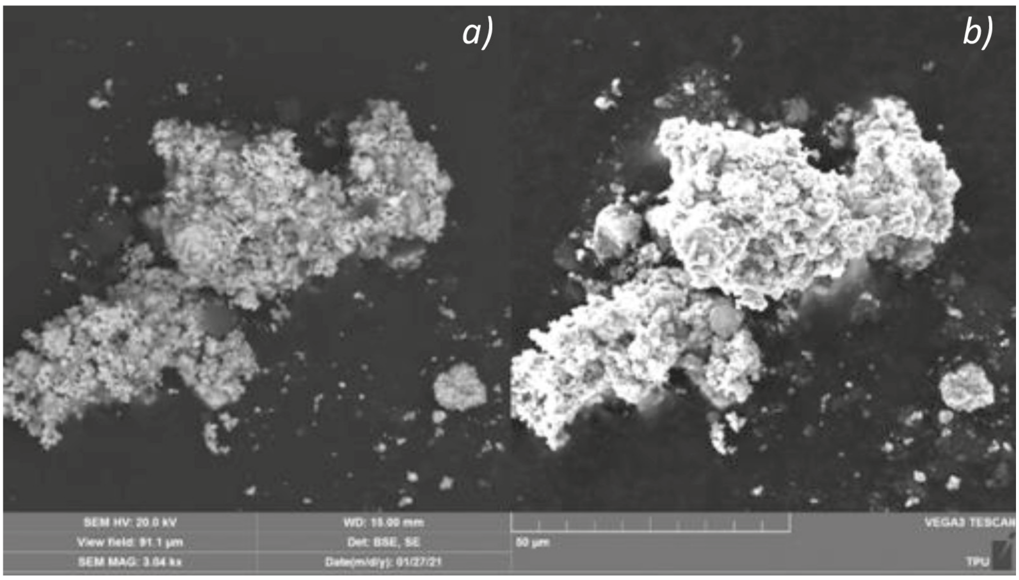

Fig. 1. *SEM images of the sample using (a) SE mode and (b) BSE mode*

Also, impurities of S, Ti, W, Pb, Bi, Pd are found, the total mass of which does not exceed ~3.5% on average, which indicates a fairly high purity of the resulting product.

Thus, the paper shows the results of the analysis of powder materials of the molybdenum, carbon, nitrogen system by scanning electron microscopy.

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HYDROCRACKING FEEDSTOCK COMPOSITION AND PROPERTIES INVESTIGATION FOR HYDROCARBON GROUP ANALYSIS

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The basic principle of hydrocracking is the transformation of large high boiling hydrocarbon molecules in the presence of hydrogen into smaller molecules with a lower boiling point. This transformation occurs due to the breaking of carbon-carbon bonds or the removal of heteroatoms connecting the two unbonded parts of the hydrocarbon. The feedstock of hydrocracking is usually vacuum gas oil, and primary products of the process are more valuable and light motor fuels and their components.

The quality of the products varies greatly depending on the process conditions and the feedstock composition. The product yield decreases over time due to catalyst deactivation. For these reasons, constant feedstock and products quality monitoring as well as catalyst activity monitoring are very important. Laboratory analysis of feedstock, products and catalyst samples is time-consuming and cannot provide real-time control. In this case, it is most expedient to apply a predictive model of the hydrocracking process, developed by the mathematical modeling based on the feedstock and products composition data. The predictive model is based on actual operational data of the hydrocracking unit and, therefore, describes the actual process conditions, which allows high level quality control of the products. The aim of this work is to obtain data on the refractive indices (RI) of feedstock and products of hydrocracking process to enhance the predictive model.

RI of hydrocarbons makes it possible to estimate their structure, as well as their mixtures composition, since for a chemical compound at a certain temperature it is constant, and for mixtures it is additive [1]. The RI of hydrocarbons or petroleum products depends on the compounds chemical structure and increasing in the following order: alkanes < alkenes < alkylcyclopentanes < alkylcyclohexanes < alkylbenzenes < alkylnaphthalenes [1]. The relationship between density and RI is linear. RI of the hydrocarbon increases with density increasing. Different hydrocarbon groups have different dependency factor of RI on molecular weight. The molecular weight has the greatest influence on the RI of paraffinic hydrocarbons, and increases with chain lengthening. Alkyl aromatic hydrocarbons are an exception. The RI of this hydrocarbons group decreases with lengthening of the side chains and an increase in their amount [1]. It is possible to calculate the structure-group composition of oil fractions, knowing the RI in combination with density value and molecular weight. Therefore, the values of these features play a key role in development of mathematical model of vacuum gas oil hydrocracking process.