Abstract of the Doctoral Thesis

Production and characterization methods of hybrid nanostructures based on molybdenum disulfide and carbon nanomaterials for catalytic and lubricating applications

This doctoral dissertation is devoted to developing a new method for synthesizing hybrid nanostructures based on molybdenum disulfide and carbon nanomaterials (MoS_2/CNMs). The first stage of the work was to determine the influence of the synthesis parameters of pure molybdenum disulfide obtained using impinging jet reactors on the properties of the product. The obtained results made it possible to establish favorable process conditions for the production of hybrid nanostructures. As a result of the heterogeneous nucleation, MoS_2 nanoparticles are formed on the surface of carbon nanomaterials. The foreign substance present in the supersaturated solution reduces the nucleation energy, so heterogeneous nucleation occurs earlier than homogeneous nucleation. In this way, the surface of carbon nanomaterials is covered with MoS_2 nanoparticles. Wet chemical synthesis can be carried out in commonly used tank reactors, but also in the impinging jet reactors. The latter, in particular, are suitable for the controlled production of such particles. The high mixing intensity is related to the formation of an area with a high energy dissipation rate in the contact zone of the inlet streams. This allows to obtain materials with the desired and repeatable properties in an inexpensive, continuous, and easy to scale way. Due to the potential use of MoS_2 as a hydrogen evolution catalyst, the properties of hybrid nanostructures were tested for this application. The maximum current density obtained at a potential of 0.2 V vs. RHE for the best hybrid sample was 16 times higher than in the case of pure molybdenum disulfide. Furthermore, MoS_2 is commonly used as a lubricant. Therefore, it was checked how hybrid nanostructures affect the lubricating properties of engine oil. Studies of the size distribution of particulate matter in the engine exhaust gas showed that the use of oil with the addition of MoS_2/CNMs allowed to reduce the total volume of particulate matter in the exhaust gas by 91% and 49% under idling conditions and with load compared to work with the base oil.

Keywords: molybdenum disulfide, carbon nanomaterials, impinging jet reactors, hydrogen evolution reaction, nanoadditives for engine oils