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Design of catalysts based on silver nanoparticles and diatomite for photocatalytic decomposition of phenol

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Phenol is one of the most important organic compounds that is widely used in industry. However, it poses a serious threat to many ecosystems, water supply, the environment and human health due to its toxicity, inertia, ability to destroy the endocrine system, teratogenicity and mutagenicity [1]. In this regard, it is relevant to develop an effective method for removing phenol from wastewater. The photocatalytic decomposition of phenol is one of the promising methods of controlling phenol emissions. Recently, there has been a growing interest in silver-containing photocatalysts. Ag-containing photocatalysts are known as water purification catalysts operating under visible light [2]. Silver is often used in conjunction with oxides such as TiO_2 , Fe_2O_3 , ZnO , etc., which increase the stability of Ag_2O and improve its photocatalytic properties. In this context, the joint use of silver and iron (III) oxide seems quite promising. Fe_2O_3 is widely used due to its magnetic properties, and is also well known for its catalytic and photocatalytic properties. This oxide has a band gap of 2.2–2.7 eV and directly acts as an active photocatalytic material of visible light.

The aim of this work was to design Ag- Fe_2O_3 catalysts for the photocatalytic degradation of phenol. A series of Ag- and Fe_2O_3 -containing photocatalysts based on diatomite was synthesized by incipient wetness impregnation with varying the order of introduction of the components (sequential impregnation, co-impregnation and reducing impregnation). The synthesized samples were studied by a number of physico-chemical methods, including the low-temperature adsorption of nitrogen, XRD, TPR, UV-vis spectroscopy, etc. The photocatalytic properties of catalysts were studied in the phenol decomposition under solar-like light.

By the method of low-temperature nitrogen adsorption, it was shown that the synthesized samples are characterized by a hysteresis loop H3 on the isotherms of adsorption-desorption of N_2 which are typical for macroporous samples. When active components were supported, the specific surface area and pore volume decreased (from 25 m^2/g to 13 m^2/g and from 0.062 cm^3/g to 0.057 cm^3/g respectively), which indicates the distribution of active components on the surface of the diatomite, as well as partial blocking of pores by active components.

It was shown by the XRD method that the structure of the diatomite is mainly represented by phases of amorphous silicon oxide (silicate halo 16–30) and quartz phases (peaks at 26.6, 36.5, 39.4, 45.5, 50.2, 54.8 ° 2 θ). In addition, iron silicate inclusions were also found in the diatomite structure (peaks at 27.4, 29.9, 37.4 ° 2 θ), which may lead to the catalytic activity of pure diatomite. For diatomite modified with iron oxide the peaks of Fe_2O_3 phase were detected on XRD patterns (33.2, 35.5, 54.1, 62.6, 64.2 ° 2 θ). At the same time, the Fe_3O_4 and FeO peaks were not detected, which indicates that iron oxide on the surface of the diatomite is formed mainly in the form of the Fe_2O_3 phase. High-intensity narrow peaks at 38.5 and 44.6 ° 2 θ were also detected on the X-ray images of silver-containing samples, which indicates a formation of silver particles on the surface of the diatomite.

Thus, the synthesized samples are characterized by the presence of interacting iron (III) oxide and silver particles distributed on the surface of the diatomite. Such interaction affects the redox properties of catalysts and, accordingly, will have a positive effect on their catalytic and photocatalytic properties.

References

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