Composite zinc oxide with zeolite for organic pollutants photodegradation

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Introduction:

Wastewater containing even traces of organic dyes can cause severe environmental pollution, as they affect the organoleptic characteristics of surface water, reduce light penetration, inhibit vital processes, and prevent photosynthesis in water. In addition, some dyes are carcinogenic [1-3].

The photocatalytic method of destruction is the most promising and photocatalysis using composite semiconductors, including ZnO/Zeolite composites, is a new approach to expand the light absorption range, as well as to achieve more efficient charge distribution and increase their service life.

Work purpose:

Synthesis of a ZnO/Zeolite composite and study of its photocatalytic properties towards dyes under static conditions.

Research methods:

To test the photocatalytic activity of the ZnO/Zeolite composite under static conditions, it was first synthesized. The synthesis consisted of the following steps: preparation of the initial precursor solution, dropwise addition of the precipitating agent sodium hydroxide, hydrolysis at 50°C for 30 minutes of the solution with which the initial NY zeolite was impregnated, and subsequent drying and calcination.

Fig. 1 – The synthesis scheme of ZnO/Zeolite composite.

The photocatalytic experiment was carried out as follows: a 0.01 g weight of the composite powder was added to 15 ml of a model dye solution with different initial concentrations of 8.0, 25.0, and 50.0 mg/L. The photocatalyst suspension in the dye solution was pre-dispersed using ultrasound. After dispersion, a UV lamp with a wavelength of 254 nm and a power of 24 W was switched on and exposed to irradiation for different time intervals. After photocatalytic degradation, the suspension was filtered through a syringe membrane filter.

Research results:

Photocatalytic experiments with Congo red, which was used to study the catalytic properties of the zeolite composite, showed that the Congo red dye with an initial concentration of 8.0, 25.0, and 50.0 mg/L completely discolored even after 1 minute of UV irradiation. Pure ZnO, synthesized and tested under similar conditions, showed almost complete decomposition of Congo red with the lowest concentration (8 mg/L) only after 25 minutes of UV irradiation. The cationic dye methyl blue degraded less actively in the presence of the zeolite composite, even at a low initial concentration of 8.0 mg/L.

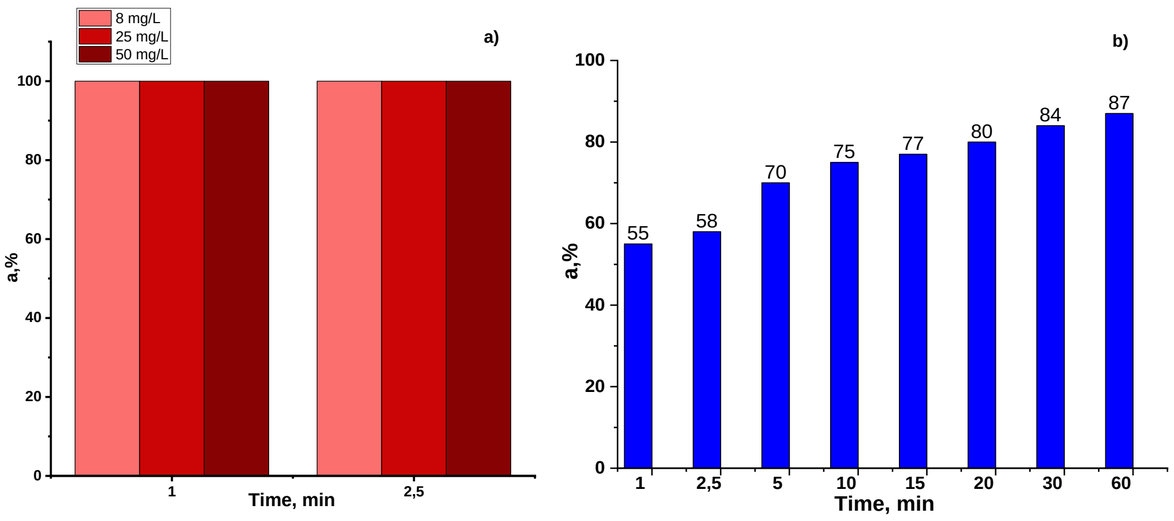

Fig. 2 - Photocatalytic activity of the ZnO/Zeolite composite towards: a) Congo red (C_0=8.0; 25.0 and 50.0 mg/L); b) methyl blue (C_0=8.0 mg/L).

According to the results of titration using the method of adsorption of Hammett indicators, only centers with pK_a = 9.45, which are OH groups attached to the surface edges, are present in a noticeable amount on the surface of the original zeolite. The number of these groups doubles after the deposition of zinc oxide on the zeolite, which is quite understandable, since ZnO nanoparticles tend to interact with water molecules to form weak basic Brönsted centers, resulting in OH groups covering the edge areas of the ZnO surface.

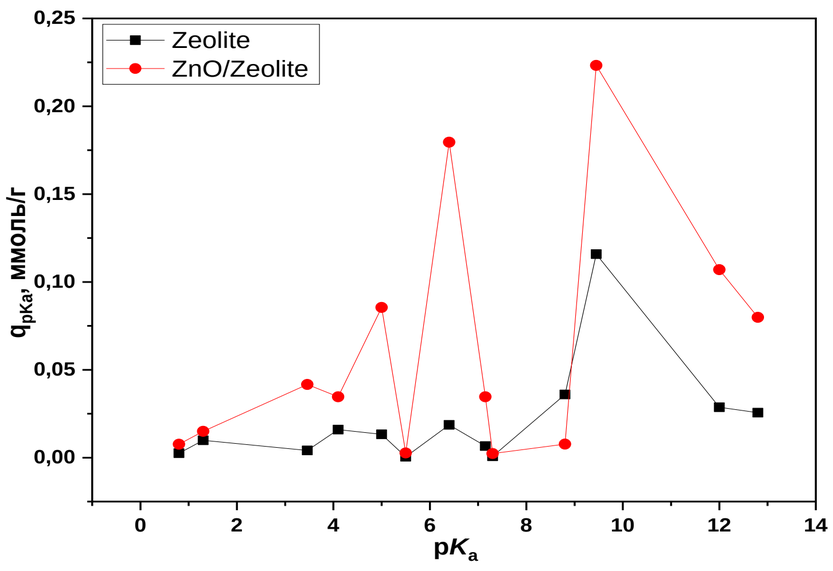

Fig. 3 - Acid-base properties of the ZnO/Zeolite composite surface.

Conclusions:

A powder of ZnO/Zeolite composite was synthesized by the precipitation method. Its photocatalytic activity under static conditions was investigated. The obtained experimental results showed a higher affinity of the composite for an anionic dye, which is explained by the chemistry of its surface. Since the adsorption of the studied dyes on the surface of the composite, as the initial stage of the heterogeneous photocatalytic process, proceeds by the ion exchange mechanism, and the anionic Congo red dye dissociates in water to form anions, it enters into an exchange reaction with OH groups, which are twice as numerous as positively charged groups on the surface of the zeolite composite.

References:

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