Photocatalytic decomposition of azo dyes using zinc (II) oxide

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Introduction:

The efficiency of the photocatalytic method using semiconductor photocatalysts is a relatively new but very promising method of wastewater treatment from pollutants of different nature. Dyes are a big problem, as today there is virtually no technology for their complete removal. Therefore, improving the conditions for photocatalytic processes and developing new effective photocatalysts is an urgent practical task [1].

Work purpose:

Synthesis of zinc (II) oxide photocatalyst and study of its photocatalytic properties with respect to dyes, both anionic and cationic in nature under static and circulating conditions.

Research methods:

The photocatalyst zinc oxide (II) was synthesized by precipitation method [2]. The photocatalytic method was used to degradation of azo dyes (Congo red, methyl blue, and methyl green) from aqueous solutions of different concentrations. It consisted of the following stages: ultrasonic treatment, stirring on a magnetic stirrer, irradiation with an ultraviolet lamp (254 nm) under static and circulating conditions, and separation of the photocatalyst from the suspension by filtration through a syringe membrane filter. The initial and residual dye concentrations were determined by photocolorimetric method.

Research results:

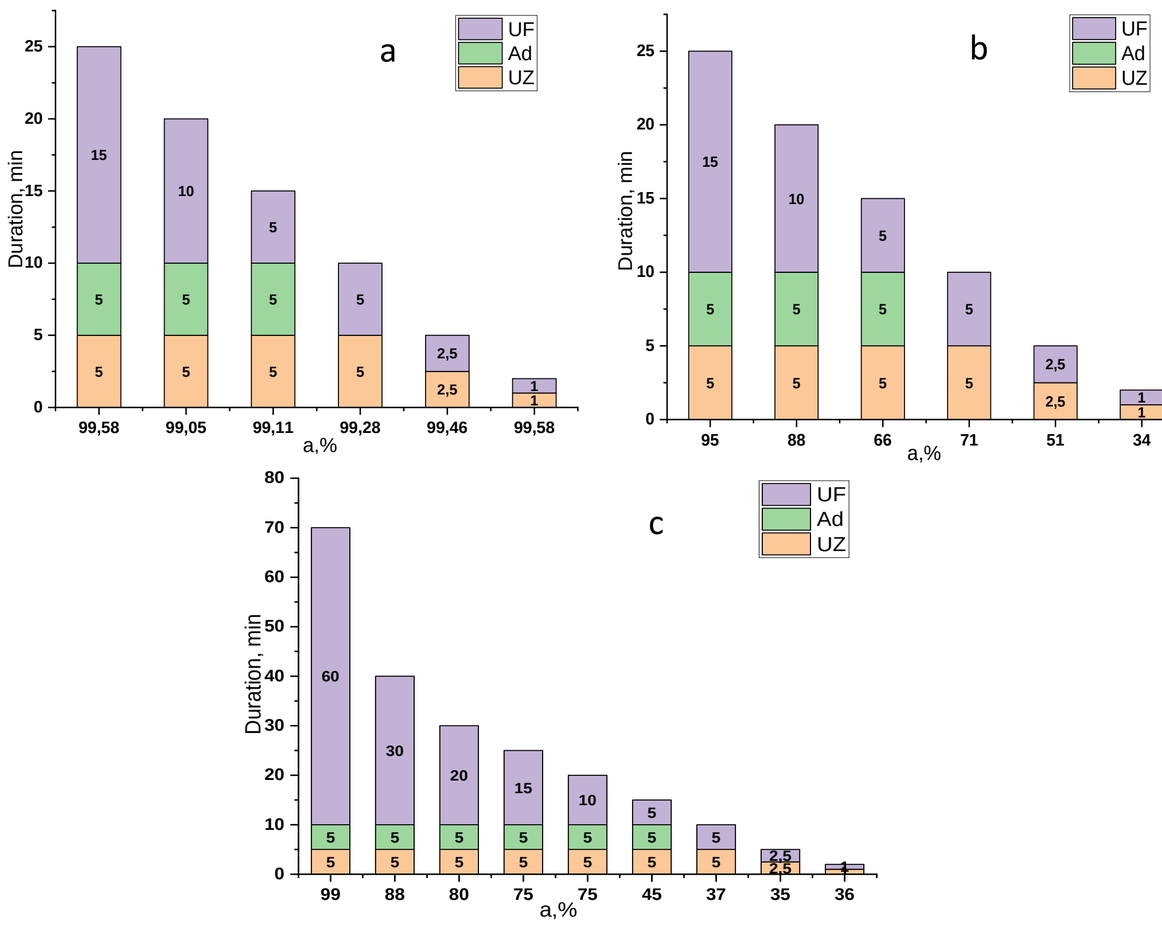

Fig. 1 - The degree of photocatalytic decomposition of azo dyes (C_0 =8 mg/L) depending on the process organization: a) Congo red; b) methyl blue; c) methyl green.

Under ultraviolet irradiation of Congo red with the initial concentration of 8mg/L in static conditions in the presence of the synthesized sample of zinc (II) oxide 99,6% of degradation was reached in 2 minutes (Fig. 1-a). In contrast to Congo red, for the cationic dye methyl blue, only 35% of degradation degree was achieved in 2 minutes, and 95% - after 15 minutes of irradiation (Fig.1-b). The cationic methylene green dye decomposed by 85% in 30 minutes of irradiation and by 99% after 60 minutes of ultraviolet irradiation; which indicates a greater influence of the model photocatalytic process organization on the destruction of cationic dyes [2] (Fig. 1-c).

Almost complete discoloration (by 98%) of Congo red with the initial concentration of 25mg/L was observed under ultraviolet irradiation in circulating conditions with a process duration of 120 min. The degree of discoloration at 90% was reached in the first 10 minutes, and it increased to 98% after 30 minutes and remained constant (Fig. 2-a).

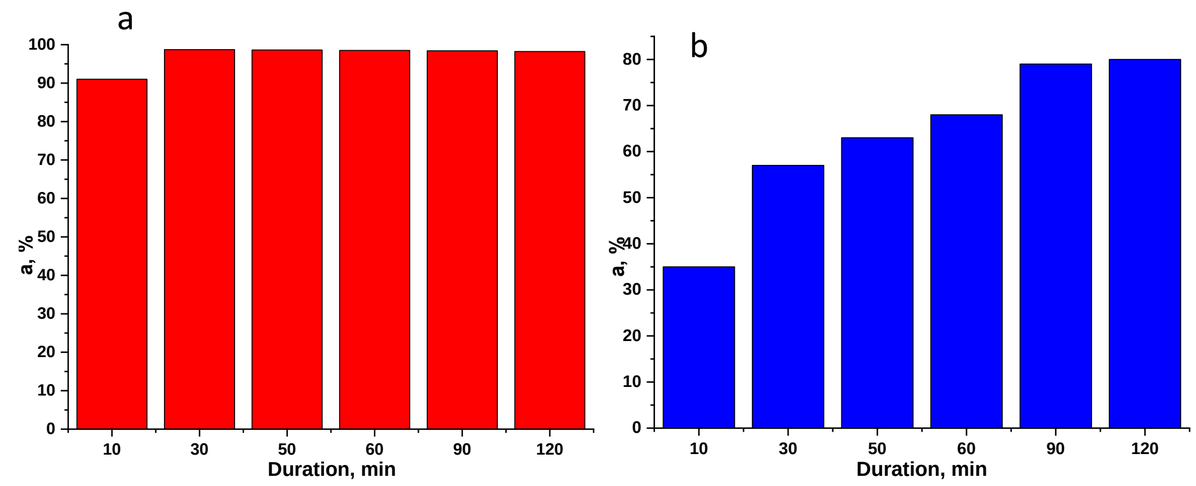

Fig. 2 - The degree of photocatalytic decomposition of: a) Congo red (C_0=25.0 mg/L); b) methyl blue (C_0=15.0 mg/L), under circulating conditions.

The degree of decomposition in ~80% was achieved for methyl blue with the initial concentration of 15 mg/L under ultraviolet irradiation in circulating conditions with a process duration of 120 min. Only 35% of this dye decomposed in the first 10 minutes, and 55% in half an hour (Fig. 2-b).

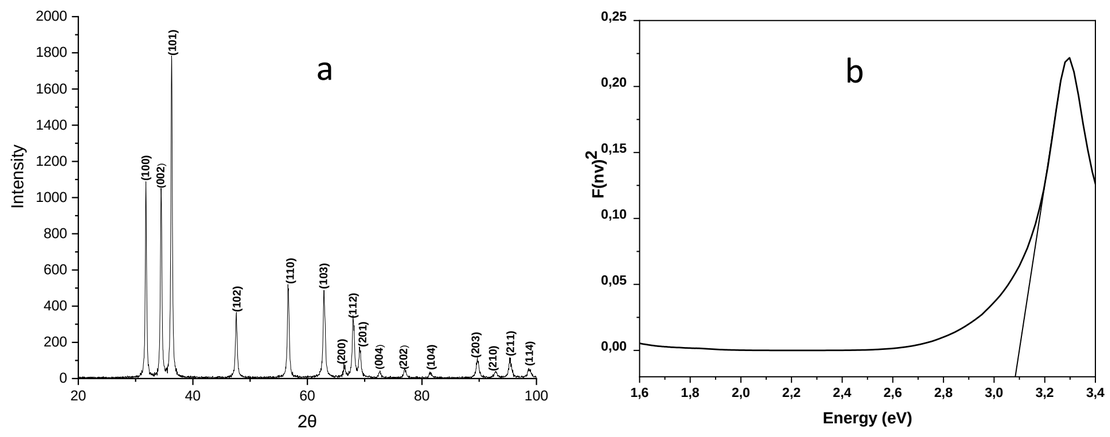

Fig. 3 – Diffractogram (a); and optical band gap (b) of the obtained zinc (II) oxide powder.

According to the standard card №00-036-1451of the International Center for Diffraction Data, the pure phase of zinc (II) oxide with the hexagonal syngony of the wurtzite type is identified in the obtained sample, due to the mineral classification. The synthesized ZnO contains all the largest planes of this syngony (Fig. 3-a). The mathematical calculation of the obtained diffractogram, according to Scherrer's formula, allowed to establish the size of the crystallites of the obtained ZnO, which is 26.7 nm.

The optical bandgap of the obtained powder is ~3.1 eV, which confirms that the synthesized zinc (II) oxide is a well-crystallized solid material with semiconductor properties and a clear bandgap (Fig. 3-b).

Conclusions:

The method of zinc (II) oxide synthesis by precipitation of zinc (II) acetate precursor has been developed. Zinc (II) oxide was synthesized, and it was found that ZnO particles have the size of less than 100 nm, ie are in the nanometer range. It contains a pure phase of zinc (II) oxide of the hexagonal syngony of the wurtzite type, which contains all the largest plans of this syngony.

The synthesized zinc (II) oxide is a well-crystallized solid material with semiconductor properties and the clear bandgap, starting at 3.1 eV.

The photocatalytic activity of the synthesized zinc (II) oxide is very high towards the dyes of both, anionic and cationic natures. The experimentally achieved values of the photocatalytic decomposition degree of the studied dyes indicate to an ambiguous influence of the model photocatalytic process organization on the efficiency of ZnO.

References:

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2. Ivanenko I. The precipitation synthesis of zinc (II) oxide for photocatalytic degradation of anionic and cationic dyes / Ivanenko I., Hutsul K., Krymets G. // Applied Nanoscience. – 2021. – V. 11. – P. 1-5.