

# CATALYSIS: from science to industry



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## Ferrite nanoparticles $\text{Fe}_x\text{Co}_{3-x}\text{O}_4$ are active catalysts for the organic dyes degradation

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$\text{Co}_3\text{O}_4$  oxide is a semiconductor, an antiferromagnetic material with a spinel structure, one of the few compounds in which cobalt ions are in two charge states ( $\text{Co}^{2+}$  and  $\text{Co}^{3+}$ ) and occupy two types of positions in the crystal - tetrahedral (A) and octahedral (B). The  $\text{Co}^{2+}/\text{Co}^{3+}$  sublattice distribution may differ from the distribution in normal 8/16 spinel and is determined by various external (magnetic field and temperature) and internal (particle size and slightly distorted  $\text{CoO}_6$  octahedra) conditions. The replacement of some cobalt ions with ions of other metals causes strong changes in the magnetic and other properties. A special place is occupied by the compounds  $\text{Fe}_x\text{Co}_{3-x}\text{O}_4$  [1-3]. Although ferrites have a suitable band gap for photocatalytic applications, their fast electron-hole relaxation time reduces their activity in photoreactions. The creation of mixed nanoparticles ferrites with different stoichiometry makes it possible to influence this process. Thus, the practical use of ferrite nanoparticles as catalysts in the decomposition reactions of organic pollutant molecules dissolved in water is an important area of modern science. The use of  $\text{Fe}_x\text{Co}_{3-x}\text{O}_4$  nanoparticles as a catalyst is due to the formation of hydroxyl radicals (oxidizing agents) on their surface, promoting chemical oxidation/reduction of non-biodegradable organic pollutants, and their degradation to carbon dioxide, water and other substances, or transformation into harmless components, which is in demand method of water purification from organic dyes [4-7].

This work is devoted to the study of the photocatalytic properties of  $\text{Fe}_x\text{Co}_{3-x}\text{O}_4$  nanoparticles, synthesized by the spontaneous combustion method using a citrate precursor and subjected to additional annealing at various temperatures for the degradation of organic dyes - Methylene blue (MB), Congo red (CR) and rhodamine (Rh), depending on duration of interaction, presence of oxidizing agent and interaction with UV radiation. The average crystallite size according to X-ray diffraction data varied from 5.2 to 48 nm when the additional annealing temperature varied from 400 to 800 °C for 1 hour. And the magnetization of nanoparticles increased non-monotonically with temperature, and at an annealing temperature of 700 °C, magnetic hysteresis appeared. In the sample without additional treatment and at processing temperatures from 400 to 600 °C, the magnetization is very low and its field dependences are close to super-paramagnetic. Of particular interest are the results of the degradation of the dyes MB and Rh, since these dyes tend to very easily reversibly transform into a colorless "leuco" form with subsequent regeneration of color and are difficult to decompose, for example, in comparison with the dyes CR and Methyl orange [8]. For catalysis experiments, nanoparticles were mixed with MB solution in the presence of oxalic acid  $\text{H}_2\text{C}_2\text{O}_4$  (60 min at 30 °C in the dark). Next, the solutions in quartz cuvettes were subjected to UV irradiation, and the change in the optical density of the solution was recorded every 2 minutes. Within 10 minutes of UV irradiation, complete 100 % conversion of the MB dye occurred.

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