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Photocatalytic decomposition of vancomycin in the presence of NPs ZnO obtained by pulsed laser ablation

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The rapid development of pharmaceutical industry promotes development and subsequent uncontrolled use of antibacterial drugs that poses a threat for aquatic environment and human health due to the resulting formation of antibiotic-resistant pathogenic bacteria [1]. Today, amongst the most promising ways of water purification from organic pollutants and pathogenic microorganisms are improved oxidation processes, which include creation of strong chemical oxidizing agents. For example, exposure of water to ultraviolet radiation while in the presence of semiconductor heterogeneous photocatalyst, such as nanoparticles titanium dioxide or zinc oxide (NPs TiO_2 or ZnO), stimulates the formation of hydroxyl radicals, hydrogen peroxide and other reactive oxygen species (ROS). However, some questions remain. Which ROS induce photocatalytic action of semiconductor oxide NPs during decomposition organic compounds? To what extent ROS formation is a result of light irradiation? In this study, NPs ZnO, obtained by pulsed laser ablation (PLA) in air [2], was used as a photocatalyst for decomposition of vancomycin – antibiotics from the group of glycopeptides. The results of the photocatalytic activity and vancomycin's degradation were then compared with the formation of OH-radicals and hydrogen peroxide which were determined by spectral luminescent methods the presence of terephthalic acid и KI respectively [3].

The study of spectral-luminescent properties showed that water solution of vancomycin has intense absorption in the range from 180 to 230 nm. This range is mainly due to $\pi \rightarrow \pi*$ transitions in peptide bonds. Long wavelength band peaks at 280 nm, due to the presence of aromatic amino acids. Vancomycin weakly luminesces with a maximum in the region of 330 nm. The photocatalytic experiment was carried out at a catalyst concentration ZnO 5 g/L, irradiation was carried out by LED with "soft" radiation UV-A (λ=375 nm, 51 mW). Before training, the dark sorption of vancomycin at the studied concentrations on ZnO NPs was determined, which leads to a decrease in the optical density of the solution by ~10%. Without a catalyst, the decomposition of vancomycin does not occur, since the molecule does not absorb in this spectral range. Significant changes are observed in the absorption spectrum of the antibiotic in the presence of ZnO. At the beginning of irradiation, long-wavelength absorption of photoproducts appears with band maxima at 316 and 355 nm. Their intensity increased within four hours. In this case, the absorption intensity of the vancomycin band with a maximum at 280 nm decreases. Further irradiation leads to the decomposition of both the original molecule and photoproducts. After 20 hours of irradiation, only the edge of the absorption band shorter than 250 nm is observed. The rate constant of vancomycin decomposition calculated from the 280 nm band was 0.16 h^{-1}. To study the mechanisms of photodecomposition in a parallel experiment, ROS (OH-radicals and H_2O_2) formed upon irradiation of ZnO with the same light source were determined. It was shown that OH-radicals are formed in the ZnO dispersion and in the absence of learning, which is the reason for the antibacterial activity of these NPs [2]. Their concentration is proportional to the concentration of NPs. In turn, irradiation of ZnO NPs leads to an increase in the concentration of OH-radicals up to 2 orders of magnitude, which leads to a high activity of these NPs in photooxidative processes.

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