Studies on preparation, physicochemical characterization of TiO_2 nanocomposites based on spinel and hexagonal ferrites for oxidation of organic compounds in the aqueous phase

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Approximately 3000 pharmaceuticals are in general use today in the European Union. Many of these pharmaceuticals and/or their transformation products are found ubiquitously in rivers in the developed world, at concentrations from 5 to 3500 ng/dm^3. Some of the commonly used pharmaceuticals (anticonvulsant carbamazepine), analgesic and demulcent drugs (ibuprofen, diclofenac, ketoprofen, naproxen) are not susceptible to biological degradation, therefore passes through cycle of biological treatment in the unchanged form and are detected in lakes, rivers and sewage treatment plants.

Among Advances oxidation processes, heterogeneous photocatalytic oxidation of organic pollutants occurred to be a promising method for water purification, since many recalcitrant organic compounds at low concentration can be oxidized at a room temperature in the presence of a semiconductor photocatalyst.

TiO_2-based photocatalytic process has shown a great potential as a low-cost, environmentally friendly and sustainable treatment technology to remove persistent organic compounds in wastewater to overcome the shortcomings of the conventional technologies. However, this technology suffers from some main technical barriers that impede its commercialization, i.e., the inefficient exploitation of visible light, low adsorption capacity for hydrophobic contaminants, uniform distribution in aqueous suspension and post-recovery of the TiO_2 particles after water treatment.

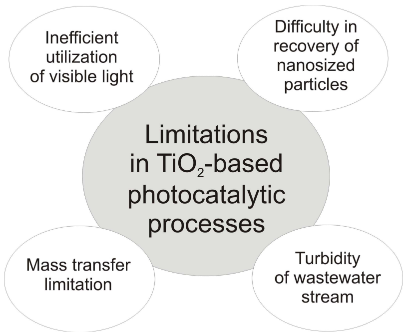

Figure 1. Limitations in application of TiO_2-based particles for photocatalytic degradation of organic compounds

A significant limitation of the TiO_2 use in large-scale wastewater treatment processes is the range of radiation needed to excite the photocatalyst. The use of UV light in photocatalysis generates considerable costs in energy for intensive process of irradiation using eg. mercury lamp. In addition, in the photocatalyst structure occurs the recombination of generated by photoexcitation electrons and holes, resulting in a significant reduction in quantum efficiency that occurs in the presence of a photocatalyst in reaction. In order to overcome this limitation of TiO_2 the noble metal nanoparticles have often been used to enhance the photocatalytic activity of titanium (IV) oxide and to extend the absorption wavelength from the ultraviolet to visible region.

Another problem in large-scale application of TiO_2 for wastewater treatment is a step of separation and re-use of photocatalyst. The separation of the pure TiO_2 slurry is a costly and energy intensive.

In this regard it is proposed to deposit TiO_2 nanoparticles modified with platinum and copper or platinum and iodine on the surface of the spinel ferrites having the structure MFe_2O_4 (M = Mn, Mg, Zn, Fe); $CoFe_{2-x}M_xO_4$ (M = Zn^{2+}, Mn^{2+}) and hexagonal ferrites $BaFe_{12}O_{19}$, $BaFe_{12}O_{19}$-$M_2Fe_4O_8$ (M = Mg, Fe, Zn). Obtained magnetic nanocomposites can be easily separable from the system and reused in the photocatalytic reaction of the degradation of pharmaceuticals in the aqueous phase. Nanocomposites will obtained by microemulsion method, which will allow to obtain expected core-shell structures.

Designated physicochemical properties of magnetic photocatalysts, kinetics of degradation reaction of selected pharmaceuticals, as well as investigation the effect of pH, temperature, radiation intensity, the quantity of photocatalyst and the type and content of the metal deposited on the surface of the nanocomposite will allow to optimize the degradation process, and therefore more efficient photocatalytic degradation of pharmaceuticals from wastewater.