Catalysts based on mixed metal oxides for elimination of antibiotic contaminants from water via a photo-assisted ozonation process

Antibiotics are common pharmaceuticals used as a medicines but also as growth promoters in agriculture, aquaculture, bee-keeping, and livestock. Nowadays, antibiotics can be detected not only in sewage and wastewater treatment plants, but also in natural ecosystems like rivers and lakes. Still increasing concentration of these pollutants in the environment is severe problem because it may contribute to development of bacteria resistance to antibiotic treatment. In a long-term perspective, accumulation of the antibiotics in the environment may result not only in the reduction of therapeutic potential of the pharmaceuticals against human and animal pathogens, but also cause failure of antibiotic treatments in human medicine, leading to increased morbidity and mortality. In order to avoid this situation, many scientists all over the world are developing new methods for efficient elimination of the antibiotic pollutants from industrial and municipal sewage. From among these methods, *advanced oxidation processes* (AOPs) are attracting particular attention and are considered as one of the most promising and environmentally benign approaches to attain this goal. The so-called *advanced oxidation processes* constitute a family of similar but not identical technologies that are based on generation of highly oxidative species, such as *reactive oxygen species* (ROS, e.g. *hydroxyl radicals*). During the last decades, great progress in catalytic degradation of antibiotics via AOPs has been made, but there are still some issues needed to be solved. Particularly important are evaluation of toxicity of products formed during the degradation processes and improvement of antibiotics mineralization[i] by AOPs. Both these issues are very important from practical point of view because some of the products of antibiotics degradation may have higher toxicity than the parent pollutants.

The main idea of the project is to develop novel binary and ternary Nb_2O_5 and WO_3-based bifunctional catalysts that will combine i) high sorption capacity of these metal oxides, and ii) their unique ability to modify properties of other components by *strong metal-support interaction effect* with high reactivity of other inorganic components in degradation of organic pollutants via AOPs, to provide more favorable conditions for efficient mineralization of selected antibiotic pollutants. The main goal of the project is to gain new fundamental knowledge on the relationship between composition and properties of these Nb_2O_5 and WO_3-based bifunctional catalysts, their ability to form ROS during AOPs, as well as activity of these novel nanomaterials in mineralization of selected antibiotics. Significant part of the project will also include the elucidation of reaction mechanisms on the surface of the catalysts, analysis of antibiotics degradation pathways and unraveling the role of ROS in mineralization of selected antibiotic pollutants. Since some of the degradation products may have higher toxicity than parent antibiotic pollutants, the project will also cover identification of the most important degradation products and analysis of their biological activity. The project will also include optimization of catalysts composition and methodology of oxidation processes to obtain the highest efficiency in adsorption and mineralization of the antibiotics pollutants.

Fig. 1. *Sustainable Development Goals* in which the proposed project fits in.

The project fits well within the current scientific trends focused on searching for a new highly efficient and environmentally benign methods for elimination of antibiotic pollutants from water (*Sustainable Development Goals*, scopes no. 6 - Clean Water and Sanitation, 3 - Good Health and Well-being and 12 - Responsible Consumption and Production, **Fig. 1**). It is expected that fundamental knowledge resulting from implementation of this project will provide new insight into the role of niobium species in modifying properties of various transition metals via *strong metal-support interaction* effect, as well as reactivity of these transition metals in catalytic elimination of antibiotic pollutants via AOPs. Deep insight into the activity of ROS in antibiotics degradation combined with in depth analysis of antibiotics degradation pathways will enable better understanding of the role of ROS in degradation/mineralization of these organic pollutants via AOPs. Fundamental studies on evaluation of biological activity of degradation products will allow to optimize the catalysts composition and reaction conditions to get the highest degradation efficiency toward formation of simple and non-hazardous products of antibiotics mineralization. From a long-term perspective, results obtained during implementation of this project may contribute to development of new and more efficient methods/catalysts for removal of antibiotic pollutants from wastewater under environmentally benign conditions with the use of ozone and/or energy of light. Thus, implementation of this project may result in development of new approaches to ensure clean and safe water for all human beings, and it may have an impact on quality of every live on Earth.

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[i] *Mineralization is the last step of degradation processes, leading to complete breakdown of organic substances with the end products being carbon dioxide, water and simple inorganic salts.*