
Activity of composite oxides in the formation of oxygen species for advanced oxidation processes in the presence of hydrogen peroxide

Kamila Sobańska^{a*}, Łukasz Wolski^b, Piotr Pietrzyk^a

^a Jagiellonian University, Faculty of Chemistry, Gronostajowa 2, 30-387 Kraków, Poland

^b Adam Mickiewicz University, Faculty of Chemistry, Uniwersytetu Poznańskiego 8, 61-614 Poznań, Poland

kamila.sobanska@uj.edu.pl

The decomposition of H₂O₂, leading to the formation of reactive oxygen species (ROS), is commonly catalyzed by redox-active materials that exhibit typical Fenton-like reactivity. In addition, amorphous oxides of metals of the IV and V groups, less conventional materials of a nonredox nature, appeared to be active in generating ROS, but this process is not trivial and involves an interfacial electroprotic mechanism. Such two mechanisms can be involved in one chemical system by combining two types of oxide, redox-active crystalline and non-redox amorphous oxides, into one composite material.

The enhancement of peroxidase-like activity, which underlines advanced oxidation processes, is achieved by the formation of amorphous-crystalline composites with redox nanocrystals that exhibit Fenton-like reactivity (CuO, Fe₃O₄, Co₃O₄). Furthermore, we have shown that the relative concentration of ROS can be effectively controlled by changing the pH of the reaction medium. With the change of pH, the reactivity can shift from peroxidase- to catalase-like activity. The investigated materials of peroxidase-like activity have been applied to the degradation of organic pollutants (ciprofloxacin and methylene blue). On the basis of the Nb₂O₅ system, we have shown that ROS play an important role not only in the chemical degradation of pollutants, but their significantly modify the adsorption process. Depending on the dopants, the activity of niobia can be tailored towards electron-transfer processes (doping with ceria results in the formation of radicals) or energy-transfer processes (doping with phosphates results in the formation of singlet oxygen).

Acknowledgements

This research was financially supported by the National Science Center, Poland (NCN), grants Sonata Bis7 (no. 2017/26/E/ST4/00794) and by the program “Excellence Initiative – Research University” at the Jagiellonian University in Krakow.