Au/Fe nanoreactors to directly generate ROS in water for environmental remediation and therapies

Gubakhanim Shahnazarova[a]
Nour Al Bast[a], Josep Nogues[a], Albert Serra[b], Maria Jose Esplandiu[a], Borja Sepulveda[c]
a- Catalan Institute of Nanoscience and Nanotechnology, Campus de la, Universitat Autònoma de Barcelona, Edifici ICN2, 08193 Bellaterra, Barcelona, Spain
b- University of Barcelona, Gran Via de les Corts Catalanes 585, 08007, Barcelona, Spain
c- Institute of Microelectronics of Barcelona, Universitat Autònoma de Barcelona, Campus, Carrer dels Til·lers, 08193, Barcelona, Spain
gubakhanim.shahnazarova@icn2.cat

Abstract

Reactive oxygen species have been widely studied and industrially used due to their applications in various environmental and biomedical areas. ROS can be generated *via* the Fenton reaction, which generally requires high hydrogen peroxide (H_2O_2) concentration, UV light, and acidic conditions. Here, we present galvanic Fe/Au nanoreactors that can directly generate ROS in water at neutral pH without the need for any additive. The electrochemical nanoreactors are based on anisotropic Fe/Au layers deposited in a semi-shell fashion on mesoporous silicon oxide nanoparticles. The bimetallic coating has been designed to enable the *in-situ* production of H_2O_2 and Fe^{2+} in water by exploiting the different work functions and electrochemical potential of the metals, thereby triggering the Fenton chemical path for ROS production. In this study, as proof of concept, we analyzed the degradation and mineralization of the die methylene blue and the antibiotic tetracycline. The degradation was monitored by spectrophotometry at pH7 and it was correlated with Total Organic Carbon (TOC) analysis. The analysis showed a very fast degradation of the contaminants within the first 15 min of the reaction. This reactivity was achieved with a very low concentration of nanoreactors (i.e.,20 µg/mL). In addition, the nanoreactors were applied for the ROS generation in the vicinity of cancer cells *in vitro*, showing a substantial viability reduction even when the nanoreactors were located 100 µm away from the cells. In conclusion, the *in-situ* generated hydrogen peroxide (H_2O_2) at the Au semi-shell surface produced efficient •OH *via* the Fenton reaction catalysed by the Fe^{2+} ions released from the Fe semi-shell layer. Therefore, these nanoreactors are a new highly effective route to produce fast local oxidations without the need for any chemical additive.

Keywords
Nanoreactor,
Reactive Oxygen Species,
Fe,Au