Development of antibacterial functionalized textiles by 3D printing

Antoine Farcy, Benoit Heinrichs, Julien G. Mahy, S. D. Lambert

University of Liège, Nanomaterials, Catalysis, Electrochemistry (NCE) - Department of Chemical Engineering, Liège Belgium (Antoine Farcy: Antoine.Farcy@uliege.be)

ABSTRACT

Water is vital for life and the essential key to important industrial processes. Due to the increasing consumption and contamination, the access, treatment and safety of water is becoming challenging and costly. Therefore, new technologies have to be developed to ensure sustainable protection and safe access to water for both human consumption and industrial use. The DAF3D project aims to develop an innovative and sustainable 3-D-printed filter based on antibacterial functionalized textiles with zinc oxide (ZnO) for water disinfection. The expected application is centred on production and reusability of process water from diverse industrial sectors and grey water within households. For instance, in the chemical and food industries, water recycling is enforced and cost-saving but biological safety is a major concern. Thus, the 3-D-printed filter composed of antibacterial functionalised textiles is a promising solution for these issues and can be implemented in a wide diversity of applications, configurations and dimensions.

The innovative filter for disinfection will be composed of a thermoplastic for 3-D-printing in combination with textile materials pre-impregnated with antibacterial agents, such as zinc oxide nanoparticles with oxygen vacancies. These new antibacterial textiles are capable of generating in situ highly reactive oxidizing species (ROS), which can degrade a wide range of organic substances, including microorganisms. It has been shown that ZnO can be used for water hygienisation due to its antimicrobial capacity. Species generated by ZnO break through the cell wall, causing irreversible damage and leading to the cell death.

Zinc oxide could be synthesized by different chemical method such as sol/gel, precipitation, hydrothermal… methods. In our lab, some routes were tested and and two of them are optimised. The advantages of these syntheses pathways are that ZnO is directly formed in solution in contrast to other syntheses where thermal treatment are required.

At first, to confirm the activity of pure ZnO samples, p-nitrophenol (PNP), a model molecule, degradation was performed under UV light. The PNP concentration is calculated after 4, 8 and 24 hours of illumination under UV. The ZnO samples synthesized with one of the two methods show the best results with a complete degradation (100%) of PNP after 4 h.

In order to understand the differences between these degradation results, characterizations of the material formed are performed by usual methods such as nitrogen adsorption-desorption isotherms, XRD, PL and EPR.

Since functionalized filters must have antibacterial activity in the dark and to compare results obtained under UV, various investigations will be carried out. To this end, it was shown in the literature that the creation of oxygen vacancies in the crystalline network of ZnO increases its activity in the dark. Indeed, these oxygen vacancies allow increasing the generation of ROS in the dark by the reaction with a trapped electron and the oxygen dissolved in water in order to create the superoxide anion.

Various methods are being developed to control the amount of these oxygen vacancies. The degradation of nitro blue tetrazolium, which has an affinity for the superoxide anion, confirms the activity of the catalyst in the dark.