3D printed photocatalysts against liquid laundry detergents

Nikolaos Rafail Vrithias
Institute of Electronic Structure and Laser, Foundation for Research & Technology-Hellas, N. Plastira 100
Department of Materials Science and Technology, University of Crete, 70013 Heraklion, Greece

Maria Sevastaki
Institute of Electronic Structure and Laser, Foundation for Research & Technology-Hellas, N. Plastira 100
Department of Chemistry, University of Crete, 71003 Heraklion, Crete, Greece

George Kenanakis
Institute of Electronic Structure and Laser, Foundation for Research & Technology-Hellas, N. Plastira 100

The last few years, there is an increasing research interest concerning the degradation of large amount pollutants in waste water, using semiconductor photocatalysts such as ZnO and TiO_2 under solar or artificial light. There are plenty of powder photocatalysts, having encouraging results, although there is a difficulty in their reuse [1]. Moreover, there are several experiments performed, employing stabilized photocatalysts in the form of thin films or nanostructures on various substrates, which offer reusability, while in most cases their dimensions cannot exceed some tens of mm [2].

A different approach, which has not be studied until now, is the synthesis of large scale and 3-dimensional photocatalytic samples/devices in the order of cm or tens of cm [3]. In this case, the active material could be either dispersed within, or located on the surface of device 3D scaffold. Following this approach, we fabricated 3D printed photocatalytic samples, for every day and large scale applications. In this work we chose the Fused Deposition Modeling (FDM) technique, which allows us to fabricate 3D samples with complex geometries in large scale (~20x20x20 cm^3) with a spatial resolution of approximately 100 μm in z-axis and 11 μm in x and y.

In this work, ZnO and/or TiO_2 nano-powders were mixed with ABS or HDPE in several v/v concentrations reaching a maximum of 20% v/v and forwarded to a "Noztek Pro" (Noztek, Shoreham, West Sussex, UK) high temperature extruder, in order to be transformed to cylindrical filaments with a diameter of 1.75 ± 0.15 mm, suitable for 3D-printing, and several 3D geometries were fabricated by means of a dual-extrusion FDM-type 3D printer (Makerbot Replicator 2X; MakerBot Industries, Brooklyn, NY, USA).

The photocatalytic activity of the 3D printed samples was quantified by means of the decolorization of methylene blue (MB), and a typical Liquid Laundry Detergent (Dixan) in aqueous solutions. The decolorization of the above aqueous solutions was monitored by UV–Vis spectroscopy in absorption mode, while their degradation was checked by Raman spectroscopy, under UV illumination.

It is evidently shown that the 3D architectures result in a significant photocatalytic ability, due to their increased active surface area reaching an efficiency of ~ 95% after 60 min of UV irradiation (even ~ 85% in only 20 min) under UV irradiation, offering a novel low-cost alternative way for fabricating large-scale photocatalysts, suitable for practical applications.

References

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