Disinfection Efficiency of Selected Photocatalysts on *E. coli* Indigenous to WWTP

I. Zammit[a], R. Cucciniello[b], V. Vaiano[c], D. Sannino[c], A. Proto[b], L. Rizzo[a]*

a: Department of Civil Engineering, University of Salerno, 84084 Fisciano, SA, Italy. b: Department of Chemistry and Biology, University of Salerno, 84084 Fisciano, SA, Italy
c: Department of Industrial Engineering, University of Salerno, 84084 Fisciano, SA, Italy *Corresponding author: L.rizzo@unisa.it

Introduction

Advanced oxidation processes, such as is heterogeneous photocatalysis, are processes that rely on the generation of reactive oxygen species for the degradation of chemical and biological contaminants.

In order to design an effective heterogeneous photocatalytic reactor for advanced treatment of urban wastewater, the disinfection efficiency of a number of photocatalysts are studied herein. This work forms part of the ANSWER project (www.answer-itn.eu) which deals with antibiotic resistance in wastewater reuse applications.

Methods

The ZnO based catalysts were synthesised via the hydroxide ion hydrolysis of zinc nitrate followed by calcination at 300 °C. For the cerium doped ZnO catalysts, the corresponding quantity of cerium nitrate to achieve Ce:Zn atom ratios of 0.0025 (Ce-DL), 0.0051 (Ce-DM), 0.0101 (Ce-DH) was added prior to the precipitation of Zn^{2+}.

The composite of graphene oxide ZnO (GO-ZnO) was produced in-house. GO was produced via the modified Hummer's method and combined with ZnO via a hydrothermal method as per [1]. TiO_2-P25 by Evonik was purchased and used as is.

Secondary effluent of an urban WWTP in Salerno was collected and *E. coli* were isolated on TBX agar. The isolate was used in all disinfection experiments. The various catalysts were tested at a concentration of 0.1 g/L under constant stirring and illuminated by a 125 W UVA (λ_{max}=365 nm) lamp placed at a distance of 28 cm from the base of the open reactor of 18 cm diameter using 500 mL of 0.85% NaCl solution and an *E. coli* concentration in the 10^6 $CFUmL^{-1}$ range. Prior to each measurement the catalyst and bacterial suspension were equilibrated in the dark for 60 min.

The synthesised catalysts were characterised by XRD, Raman & UV-VIS DRS. The GO and the GO-ZnO composite were additionally characterised by FT-IR. For all catalysts the specific surface area (SSA) was measured by BET.

Fig. 1 - Inactivation Kinetics

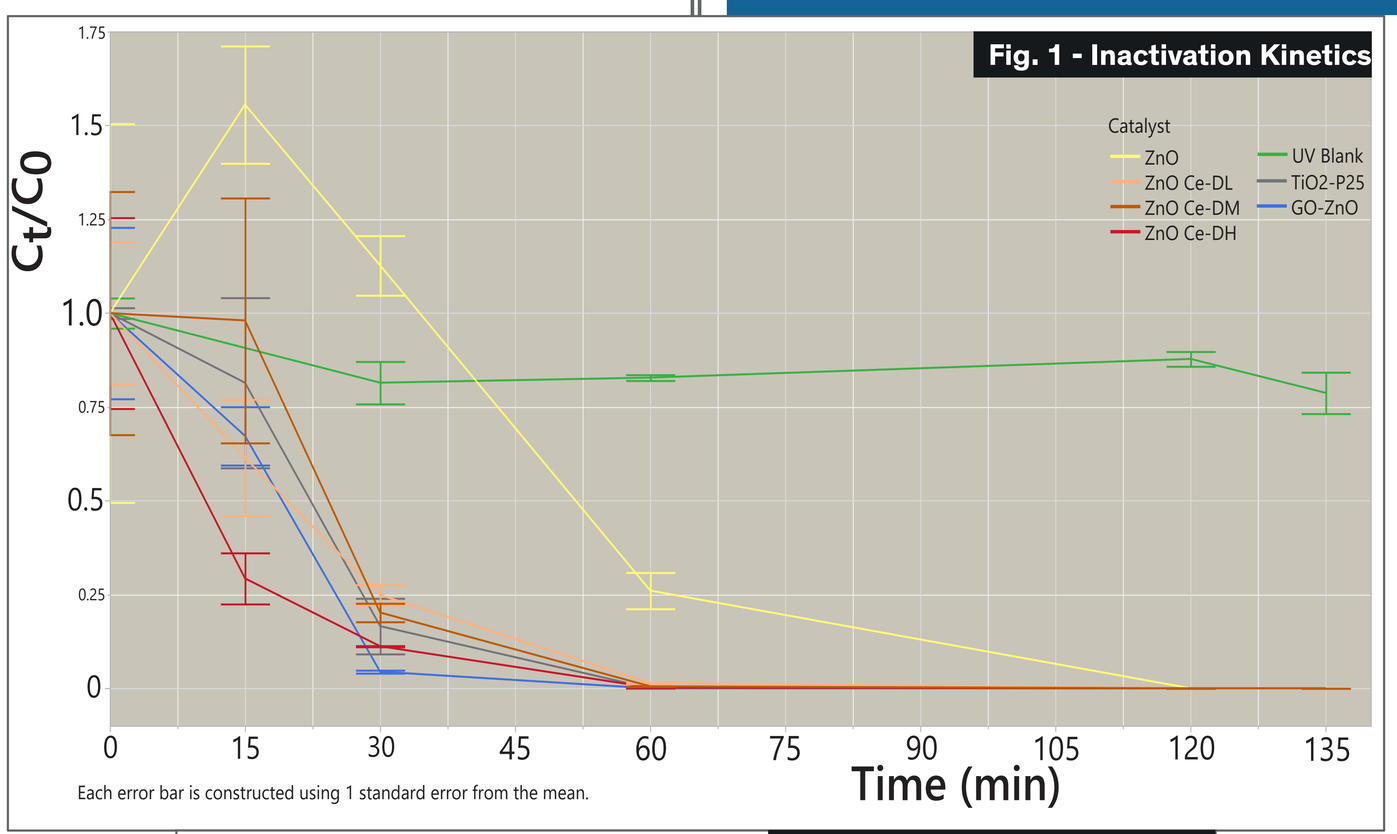
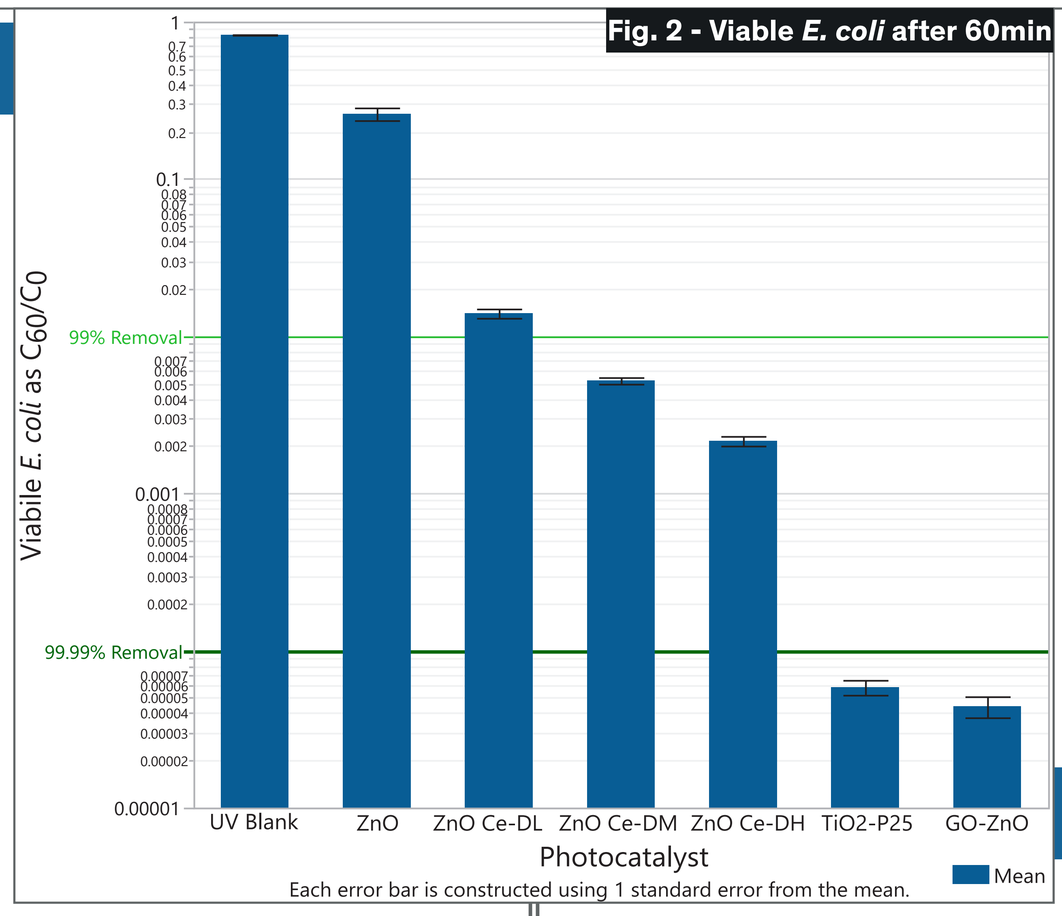


Fig. 2 - Viable *E. coli* after 60min



Results

Figure 1 shows the full kinetics of inactivation as measured by triplicate plate count on TBX agar. *Figure 2* shows inactivation after 60 min of UV treatment with GO-ZnO being the best performing catalyst.

Doping of the ZnO with cerium substantially improved the performance of the catalyst over the undoped ZnO.

Additionally a higher activity was measured with higher Ce doping, ZnO Ce-DH i.e. the highest doping being the most effective. TiO_2-P25 and notably GO-ZnO, with more than 99.99% inactivation after 60 min of treatment, showed the highest activity.

Future Work

The doping level of Ce doping will be further investigated with respect to bacterial inactivation efficacy in order to find the optimum.

In the effort to better design a macro-scale supported photocatalytic reactor a number of catalysts will be compared in the supported form, both in simple matrices and more complex such as is real wastewater.

References

1. Wu, D., et al., *Mechanistic study of the visible-light-driven photocatalytic inactivation of bacteria by graphene oxide–zinc oxide composite.* Applied Surface Science, 2015. **358, Part A**: p. 137-145.

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