NEW CERAMIC TILE APPLICATIONS: DEVELOPMENT OF A PHOTOCATALYTIC REACTOR FOR WASTEWATER TREATMENT

I. Tormos[(1)], M.C. Bordes[(2)], J.M. Cabedo [(1)],J. Marro[(1)], J. G. Berlanga[(1)], E. Sánchez[(2)], C. Gil[(3)]

[(1)] Sociedad Fomento Agrícola Castellonense, S.A (FACSA), Castellón. España.

[(2)] Instituto de Tecnología Cerámica (ITC). Universitat Jaume I. Castellón. España.

[(3)] KEROS Cerámica, S.A. Nules (Castellón). España.

1. INTRODUCTION

Heterogeneous photocatalysis is an advanced oxidation process based on the generation of hydroxyl radicals (•OH) by incident ultraviolet radiation on a photocatalyst (TiO_2). These radicals have a high oxidising power and are able to degrade and mineralise a great number of organic pollutants and to inactivate a great number of microorganisms in aqueous systems.

Numerous studies are available in which tertiary wastewater treatment systems based on photocatalytic technology have been developed. Ceramics are materials with a chemical resistance and durability that make them suitable for use as a photocatalytic substrate in this type of system. This study was undertaken to obtain decontaminating ceramic tiles by applying a nanometric sol-gel coating of titanium dioxide (TiO_2) on the ceramic substrate. Using the resulting photocatalytic ceramic tiles, a reactor for wastewater decontamination and disinfection was developed.

The decontaminating capability of the developed system was evaluated by treating a wastewater treatment plant (WWTP) effluent that contained the pesticide Imazalil as main pollutant.

2. EXPERIMENTAL

Decontaminating ceramic tiles were obtained on a pre-industrial scale by applying a commercial nanometric coating of titanium dioxide (TiO_2) on a porcelain tile body. The pieces were obtained by spraying and firing in a laboratory kiln at a peak temperature of 600 ºC. The methodology of obtaining the tiles was optimised by testing 3 different methods that combined: a single spraying and firing stage (M1); double spraying with a single firing stage (M2); and double spraying and firing (M3).

The photocatalytic properties of the ceramic tiles were characterised by monitoring the degradation of an aqueous solution of 5 mg/L of methylene blue (MB) in contact with the photocatalytic coating, on exposure to UV radiation in an exposure chamber.

The decontaminating capability of the system was evaluated by treating a wastewater treatment plant (WWTP) effluent. A photocatalytic reactor was designed for this purpose, based on the ceramic tiles obtained (Figure 1). The design consisted of an annular reactor with a 7 L capacity, consisting of a mercury vapour UVB lamp, located on the cylinder axis, surrounded by a structure that held the photocatalytic ceramic tiles. The parameters used to evaluate the decontaminating capability were the reduction in Imazalil concentration and total organic carbon (TOC) in the water, after 6-minute treatment with UV radiation in the reactor.

***Figure 1**. Photocatalytic reactor.*

3. RESULTS

The photocatalytic tiles obtained by the 3 methods combining the firing and spraying stages were characterised, determining their photocatalytic activity. In addition, a test was conducted with a tile body without the photocatalyst to evaluate the photolysis undergone by methylene blue under UV radiation.

The results show that the reduction in the organic colorant concentration was much more pronounced in the coated tiles than in the blank tile, evidencing their photocatalytic activity.

The photocatalytic activity constants obtained on fitting the experimental data to the kinetic equation indicated that the optimum method was by double spraying of the coating with a single firing stage.

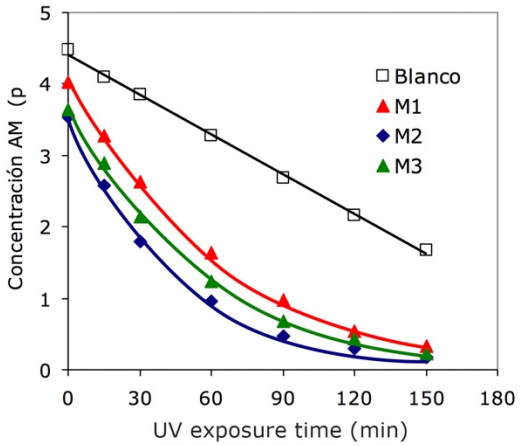

Figure 2. *Variation of MB concentration with UV exposure time.*

The decontaminating capability of the developed tiles (M2) was evaluated in the reactor designed for this purpose by treating a wastewater treatment plant (WWTP) effluent that contained Imazalil as main pollutant in a concentration of 3.5 mg/L.

The results obtained indicated that, though the photolysis effect was very pronounced, the photocatalytic degradation gave rise to almost complete removal of Imazalil. In addition, the reduction in TOC showed that the photocatalytic reaction not only degraded the pollutant but also produced its partial mineralisation.

Sample	Reduction of Imazalil (%)	Reduction of COT (%)
Blanh	74	9
M2	91	21

Table 1. *Reduction (%) of Imazalil and of (TOC) of the wastewater, after 6-minute treatment in the reactor.*

4. CONCLUSIONS

Photocatalytic ceramic tiles were developed by applying a commercial sol-gel coating of TiO_2. The photocatalytic activity of the developed tiles allowed the optimum conditions for obtaining photocatalytic tiles to be established.

The decontaminating capability of the system was evaluated by treating a wastewater treatment plant (WWTP) effluent. A photocatalytic reactor was specially designed for this purpose, based on the ceramic tiles obtained. The study conducted in this photoreactor showed the degradation and even partial mineralisation of the pollutants present in the wastewater.

A hitherto unknown system was thus obtained, based on ceramic tiles, whose use as tertiary wastewater treatment allows, in addition to other applications, non-degradable compounds in a conventional biological treatment to be removed.

ACKNOWLEDGEMENTS

This study was funded by the European Union through the European Regional Development Fund (ERDF) and by the Spanish Ministry of Economy and Competitiveness under the National Plan for Scientific Research, Development, and Technology Transfer 2008-2011, National Programme of Public–Private Cooperation – sub-programme INNPACTO (IPT-2012-0165-420000).

REFERENCES

[1] A. Fujishima, X. Zhang, D.A. Tryk, Heterogeneous photocatalysis: from water photolysis to applications in environmental cleanup, Int. J. Hydrog. Energy 32 (2007) 2664–2672.

[2] L. Prieto-Rodriguez, S. Miralles-Cuevas, I. Oller, P. Fernández-Ibáñez, A. Agüera, J. Blanco, S. Malato, Optimization of mild solar TiO_2 photocatalysis as a tertiary treatment for municipal wastewater treatment plant effluents, Appl. Catal. B: Environ. 128 (2012) 119–125.

[3] A. Houas, H. Lachleb, M. Ksibi, M. E. Elaloui, C. Guillard, J.M. Herrmann, Photocatalytic degradation pathway of methylene blue in water. Appl. Catal. B: Environ. 31, 145-157 (2001).