Pollutants removal in aqueous solutions with geopolymers: a PhotoFenton case

Stefano Savino [1*], Marina Clausi [2], Michele Casiello [1], Immacolata Tommasi [1], Caterina Fusco [3], Daniela Pinto [2], Lucia D'Accolti [1]

1 – University of Bari "Aldo Moro", Chemistry Department, via Orabona 4, 70125 Bari, Italy
2 – University of Bari "Aldo Moro", Dipartimento di Scienze della Terra e Geoambientali, via Orabona 4, 70125 Bari, Italy
2 – CNR—Istituto di Chimica dei Composti Organometallici (ICCOM), Bari Section, via Orabona 4, 70126 Bari, Italy

*e-mail address: stefano.savino@uniba.it

Abstract

Environmental pollution is a serious threat to human health and the natural environment and has aroused widespread concern. One of the most effective processes in the removal of pollutants from wastewater is the Fenton reaction. This process is based on the production of highly reactive •OH radicals due to the rapid reaction between iron ions and hydrogen peroxide under acidic conditions [1]. The hydroxyl radical has a high oxidation potential of E°(•OH/H2O) = 2.8 V/SHE at acidic pH, so they are extremely reactive and non-selective oxidizing agent towards organic contaminants in wastewater.

In order to avoid the drawbacks of a standard Fenton reaction, a solar photoFenton has been tested working at neutral pH in water in the removal of refractory pollutants. Concerning the catalyst, a heterogeneous system was experimented, impregnating porous metakaolin-based geopolymers, obtained by using hydrogen peroxide as foaming agent and vegetable oil in different ratios [2], with iron working as photocatalyst.

Sample preparation

Porous geopolymers were obtained by mixing a commercial kaolin, heat-treated at 700°C for 1 hours, and a solution formed by sodium hydroxide (NaOH) and sodium silicate (Na_2SiO_3). Hydrogen peroxide H_2O_2 (3 wt%), added in different ratios (1-5wt%), was used as pore foaming agent. Geopolymers, cured at 85°C and 100% R.H for 8 hours, are characterized by the following molar ratios: SiO_2/Al_2O_3=3.6, Na_2O/SiO_2=0.3, H_2O/Na_2O=12, Al_2O_3/Na_2O=1. Samples were labelled as GP_1HO, GP_5HO.

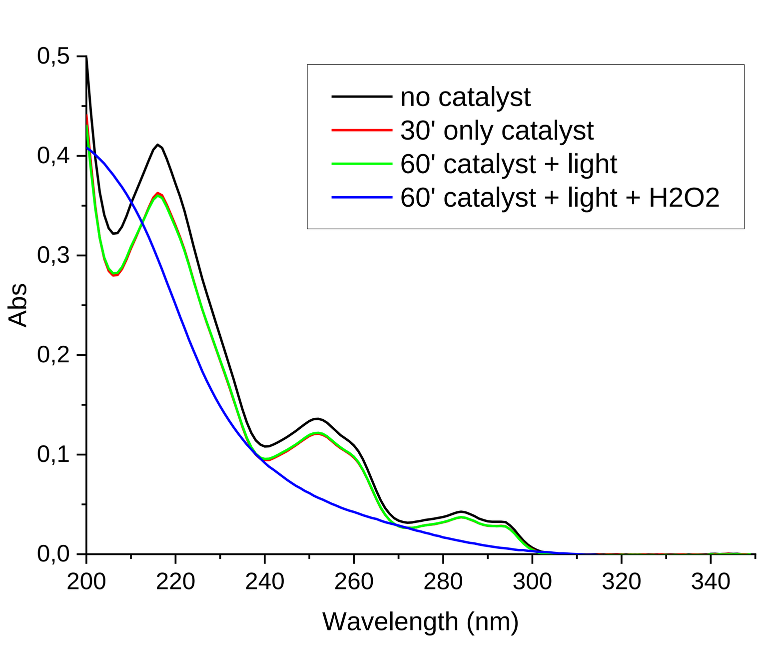
Stereo microscope analyses

Impregnation with $FeSO_4$ for 24h and section analysis

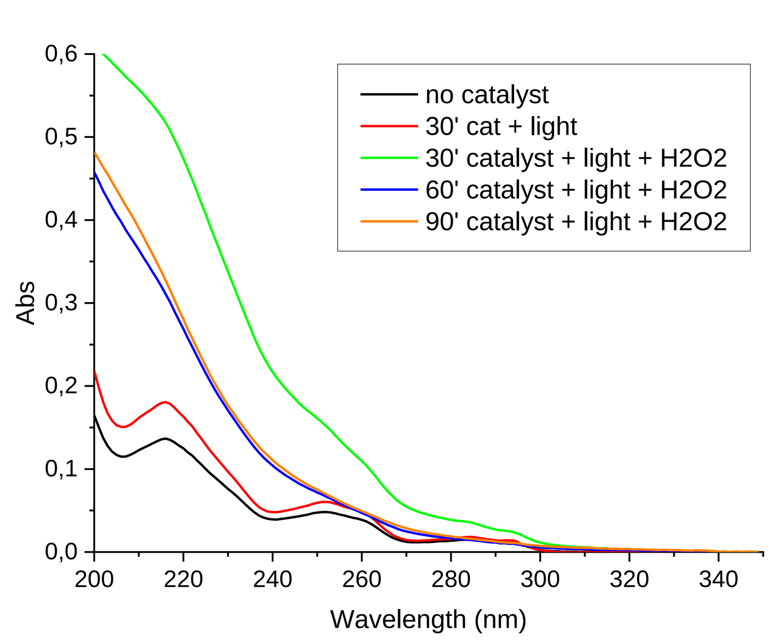
Experimental

Experiments were performed in a photoreactor with the catalyst soaked in a solution of benzothiazole ($0.74 \cdot 10^{-6}$M) under stirring. After the reaction, the catalyst was regenerated using a solution of hydroxylamine hydrochloride.

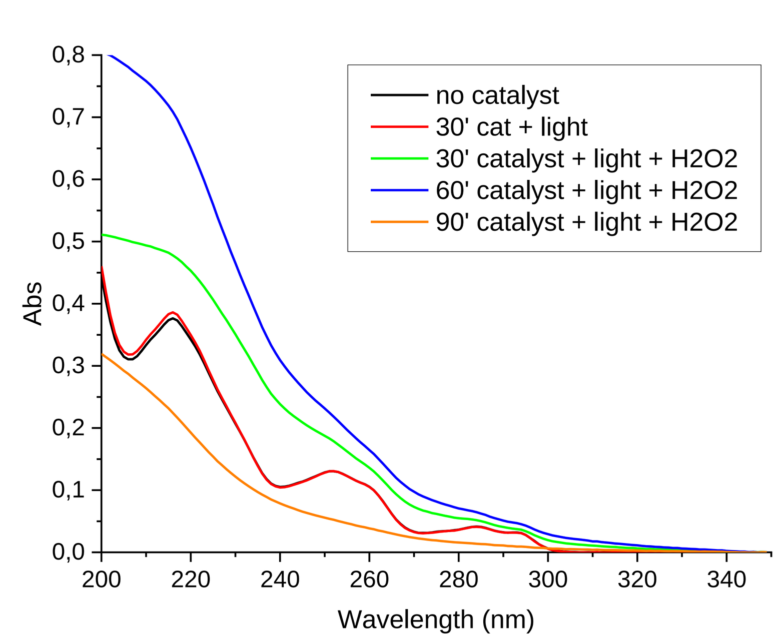
GP_1HO I Cycle



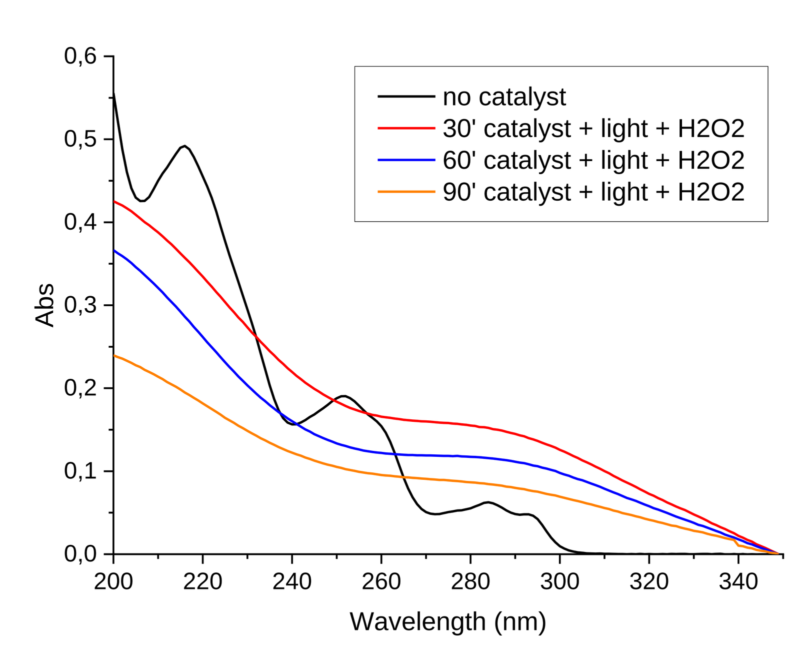
GP_1HO II Cycle



GP_1HO III Cycle



GP_5HO I Cycle



Conclusions

It is possible to highlight that the photocatalytic system based on functionalized geopolymers is very efficient in breaking down pollutants from water. Preliminary tests also show that this system is reusable for at least three times.
In conclusion, it appears clear that the system we tested is very promising but further studies on real systems are needed.

References:

[1] Girón-Navarro, R., Martínez-Miranda, V., Teutli-Sequeira, E. A., Linares-Hernández, I., Martínez-Cienfuegos, I. G., Sánchez-Pozos, M., & Santoyo-Tepole, F. (2023). A solar photoFenton process with calcium peroxide from eggshell and ferrioxalate complexes for the degradation of the commercial herbicide 2,4-D in water. Journal of Photochemistry and Photobiology A: Chemistry, 438, 114550.

[2] Bai, C., Franchin, G., Elsayed, H., Conte, A., & Colombo, P. (2016). High strength metakaolin-based geopolymer foams with variable macroporous structure. Journal of the European Ceramic Society, 36(16), 4243-4249.