DEVELOPING NEW ECOLOGICAL MATERIAL WITH APPLICATIONS IN CONSTRUCTION INDUSTRY AND POLLUTION REDUCTION

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Abstract
The photocatalytic activity of TiO_2 incorporated foam glass obtained from glass waste from household activities with $CaCO_3$ waste from the marble industry samples was studied by evaluating their ability to degrade organic pollutants in aqueous solutions under the action of simulated solar radiation and using UV-VIS spectroscopy as a simple method to monitor dye concentrations over time. Organic dye has been selected as the reference substance for degradation experiments because the dyes are stable at high temperatures and light and are reported as a major source of pollution, especially for the aquatic environment generated by effluents, mostly in textile industry. Given the characteristics of glass foam combined with current requirements in environmental protection to develop smart materials to combat climate change caused by environmental pollution, this study aimed to expand the application potential of cellular glass by functionalizing it with a material with properties photocatalytic in order to degrade various pollutants in the atmosphere.

Introduction

Cellular glass is a material that presents an interesting combination of properties of interest that makes it a valuable and future material in the field of construction. The study focused on broadening the application potential of cellular materials by functionalizing them with material that have photocatalytic properties in order to degrade some pollutants. In this regard, the materials were activated with TiO_2 photocatalyst [1]. The material with embedded TiO_2 was subjected to photocatalytic studies and their ability to degrade pollutants under the action of simulated solar radiation was evaluated. A Methylene Blue (MB) dye was selected as the reference substance to be degraded. Activation of cellular glass to obtain photocatalytic properties was achieved by depositing in its volume. Cellular glass was obtained by capitalizing on household glass waste as a base material and $CaCO_3$ waste. The characterization of activated cell glass was performed by investigating the properties using the following analysis techniques: Raman spectroscopy), SEM-EDAX, X-ray diffraction, thermogravimetric analysis, UV-VIS spectroscopy, confocal 3D laser scanning microscopy and photocatalytic activity.

Experimental

Cellular glass was obtained by exploiting glass waste from household activities as a basic material and CaCO3 waste (5%) from the marble industry as a foaming agent. The glass and marble waste were ground and passed through a sieving system until a powder granulation of 0.036 mm was obtained.

Next, the glass, marble and 1% photoactive compound TiO2 powders were mixed together with a few drops of ethylene glycol in an Agate mortar for homogenization and introduced into the press to obtain pills of different sizes.

The TiO2 photoactive material was obtained by sol-gel method from Titanium isopropoxide. The pellets were subjected to two heat treatment: the first a gentle at 200° C for 2 h and the strong heat treatment at 850°C for 30 minutes. The heat treatment at 850°C was performed in a SNOL-type furnace with a heating rate of 5°C/minute for 30 minutes. During the heat treatment, CO2 bubbles resulted from the thermal decomposition process of CaCO3, the generated gas leading to the formation of pores in the obtained pills and implicitly to the formation of cell glass.

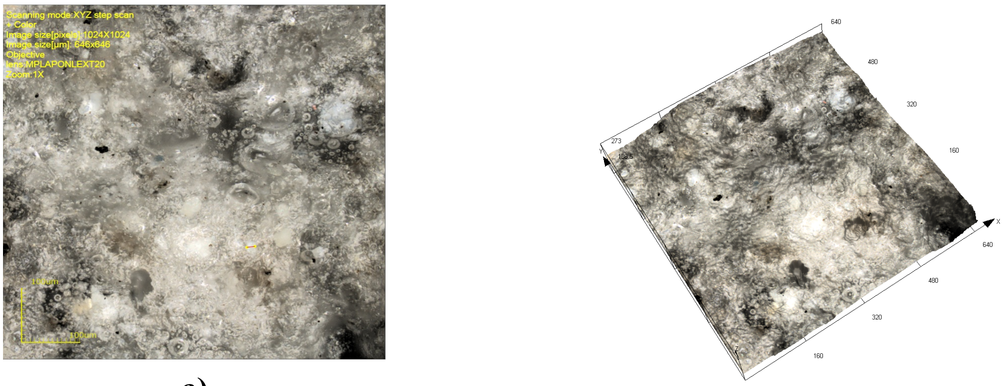
In order to introduce the photoactive compound in the volume of the cell glass, the sol-gel synthesis was applied as a method of obtaining it. Thus TiO_2 nanoparticles in concentration of 1% were introduced from the beginning of the synthesis together with glass waste, $CaCO_3$ (powder) and ethylene glycol, to which two heat treatments were applied: 200° C for 2 h and 850°C for 30 minutes.

To determine the photocatalytic activity the same equipment was used as in ours previouse paper [2] but instead of Rhodamine B as dye, we used this time Methylene Blue while adsorption-desorption balance between the sample and the dye was 12H. The simulated solar radiation consisted of ultraviolet radiation with a measured irradiance power of 1.11 mW cm^{-2} and visible field radiation with a measured power of 840 W m^{-2}. In order to identify and understand the factors and how they influence the results obtained in photocatalytic studies 1 cm diameter cell glass activated with 1% TiO_2 was immersed in aqueous solution of MB, followed by exposure for 2 hours to simulated solar radiation, using different concentrations of solutions. Thus, in table 1 are presented the working conditions and the results obtained for different concentrations of Methylene Blue.

Sample	Colorant concentrations	Conditions used	Adsorbtion Efficiency	Total Removal of Methylene Blue after Adsorbtion and Photocatalysis
Foam glass with 1% TiO_2	20 ml MB solution, concentration 2.5 mg L^{-1}	12h without stirring + 20 minutes stirring before exposure to radiation	66.82%	86.34%
Foam glass with 1%TiO_2	20 ml MB solution, concentration 5 mg L^{-1}	12 h + 20 minutes stirring before exposure to radiation	28.44%	64.51%

Results and discussion

In the Figures 1 with 20X and 2 at 10X magnification by associating 2D images with 3D ones, the deposition of TiO_2 particles is also confirmed outside the pores of the foam glass.



a) b)

Figure 1. (a) - 2D image of glass foam with 1% TiO_2 (b) 3D image of glass foam with 1% TiO_2 performed at 20X magnification

The surface roughness value at the scale of 20x was calculated on an area of 393289 µm², surface of 545240 µm² and volume of 914 µm³ as 4.23 µm.

[redacted]

a) [redacted] b)

Figure 2. (a) - 2D image of glass foam with 1% TiO_2 (b) 3D image of glass foam with 1% TiO_2 performed at 10X magnification

For the figure recorded at 10X the surface roughness value was 6.066 µm and calculated on an area of 1625368 µm², surface of 3025017 µm² and volume of 178 µm³.

Thus, considering the simplicity of monitoring the concentration of organic dye in aqueous solutions using UV-VIS spectroscopy but also their stability, photocatalytic studies were performed using Methylene Blue (MB) in different concentrations.

The adsorption and photoactivity of the as-prepared foam glass activated with TiO_2 photocatalytst was tested by the degradation of Methylene Blue (MB) under sunlight radiation at two concentrations of Methylene Blue 2.5 mg/L in figure 3 a) and 5 mg/L in figure 3b).

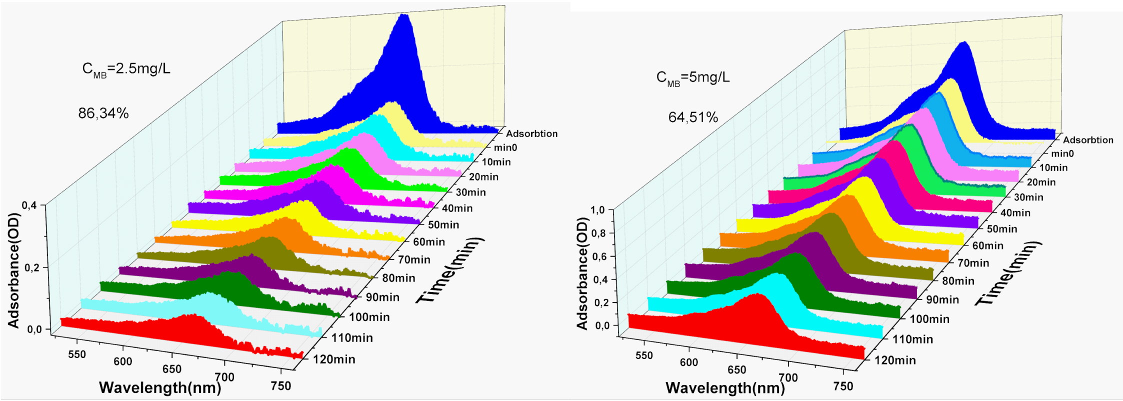


Figure 3. Photocatalytic activity in time of foam glass with 1% TiO_2 at 2.5 mg/L and 5 mg/L concentration of MB

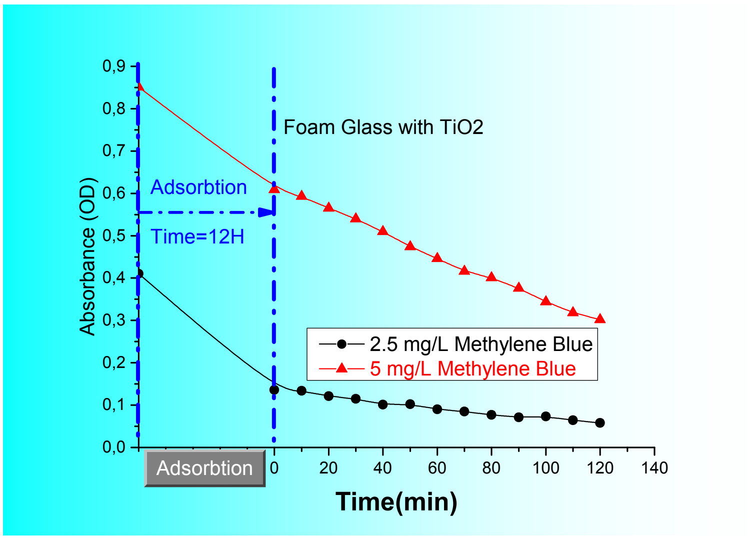


Figure 4. Figure 1. Removal of MB from aqueous solution by: TiO_2 activated cellular glass at 2.5 mg/L (marked with black), and 5 mg/L (marked with red) during adsorption and visible-light exposure

The new photocatalyst was able to reduce the concentration of MB by 88.34% where the initial concentration was 2.5 mg/L and 64.51% where the initial concentration was 5 mg/L.

Conclusion

The photocatalytic efficiency was evaluated by monitoring the discolouration of Methylene Blue applied to the surface of the foam glass obtained by capitalizing on household glass waste as a base material and CaCO3 waste which were then exposed to artificial solar simulator. The adsorption and photoactivity of the as-prepared foam glass activated with TiO_2 photocatalyst was tested at two concentrations of Methylene Blue with great efficiency of dye removal in both cases 88.34% and 64.51% which demonstrates that the ability of the tested samples to remove the dye by adsorption and degradation during photocatalysis is influenced by the solution concentration. Given the characteristics of glass foam combined with current requirements in environmental protection to develop smart materials to combat climate change caused by environmental pollution, this study proved that functionalized glass with TiO_2 can be used as a construction material with photocatalytic properties in order to degrade various pollutants in the atmosphere with great efficiency rate.

Acknowledgements

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