Reusability of Nanostructured Materials in the Degradation of Water Pollutants

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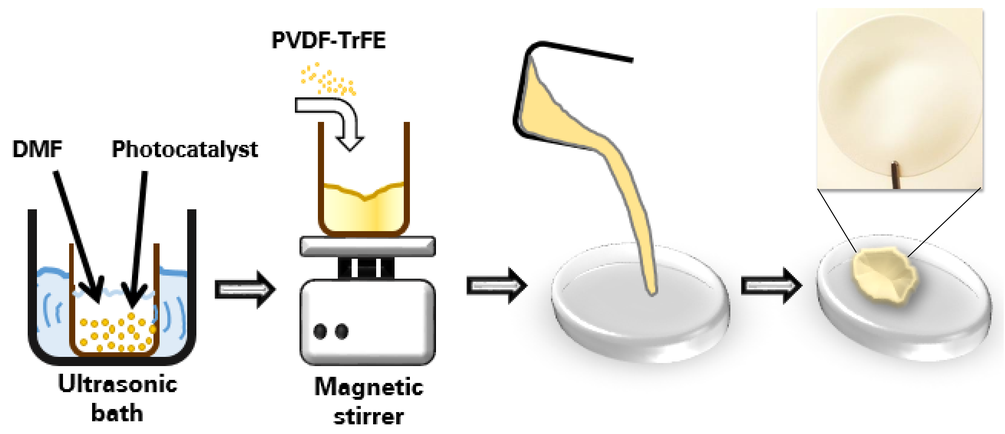
Introduction

Pharmaceuticals in the environment are of major public health concern due to their potential toxicity to humans and other living organisms [1]. When consumed, pharmaceuticals are excreted into the sewer network and reach the WWTP [2], [3], [4]. The inability of the WWTPs to effectively eliminate these pollutants makes it necessary to find alternative methods. Therefore, research on Advanced Oxidation Processes (AOPs) has been immense [5]. Among several AOPs, heterogeneous photocatalysis arises as a promising approach regarding water pollution mitigation as it only requires a source of energy and a photocatalyst [6], producing reactive hydroxyl radicals that degrade different organic contaminants in water.

The photocatalysts can be employed either in suspension or immobilized. Immobilized photocatalysts show an ease of recovery and great potential for reutilization [4], [7]. An efficient attachment of the photocatalyst to the substrate and a production method that does not reduce the efficiency of the catalytic properties are paramount for application. Polymers are good materials to immobilize the photocatalysts because of their high mechanic stability and durability [8].

In this work, 8 % wt. P25 TiO_2 nanoparticles were immobilized in PVDF-TrFE by solvent casting. One of the problems arising from the use of PVDF-TrFE is its low wettability which limits the interaction between the pollutant and the photocatalytic material. The nanocomposites were characterized by SEM/EDX, FTIR-ATR and contact angle, and their photocatalytic properties and reusability assessed on the degradation of four compounds: bisphenol A, ciprofloxacin, ibuprofen and methylene blue.

Figure 1: Scheme of the preparation method of the nanostructured materials



Aim of the project

Synthesis and reusability of nanostructured materials to use on the degradation of water pollutants via photocatalysis using TiO_2 and UV.

Methods

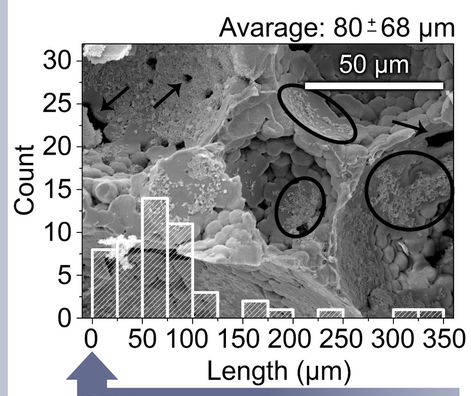
- 8 % wt. TiO_2 P25 immobilized in PVDF-TrFE (2.5 x 10 cm)
- 50 ml containing each pollutant were exposed for 5 hr to UV (365 nm) at 1.8–1.9 mW cm^{-2}
- Nanocomposites were reused 3 times
- The degradation of the pollutants was determined by the Langmuir-Hinshelwood model:

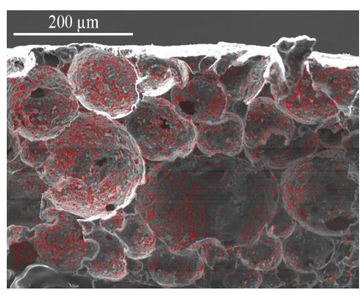
$$\ln \frac{C}{C_0} = -kt$$

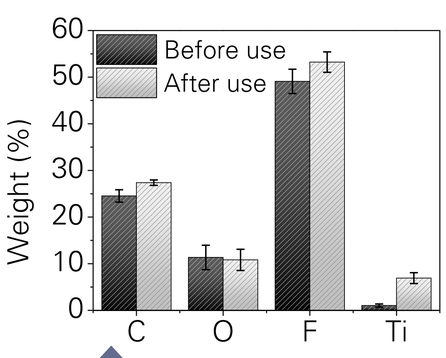
C_0 - initial concentration of the compound
C - concentration of the compound at time t

Results and Discussion

Characterization of the TiO_2/PVDF-TrFE nanocomposites







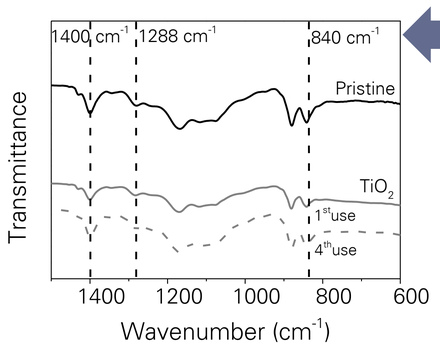
SEM images

Black arrows indicate pore interconnectivity (good water percolation) and black circles indicate the TiO_2 particles within the pores (good immobilization).

EDX mapping

All elements are attributed to the nanocomposite:
- C and F to the polymer.
- Ti and O to the nanoparticles.

Ti indicated by the red dots (good dispersion within the pores).
No loss of TiO_2 nanoparticles with use.

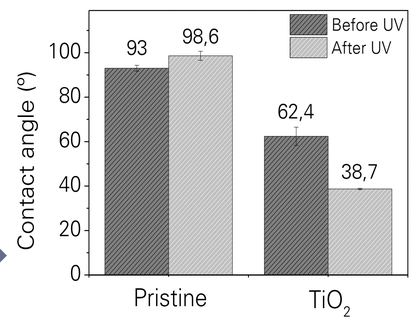


FTIR spectra

PVDF-TrFE crystallization in β–phase independent of the presence of TiO_2.
Chemical structure not affected after four uses for 20 h under UV.
PVDF–TrFE resistant to radiation.

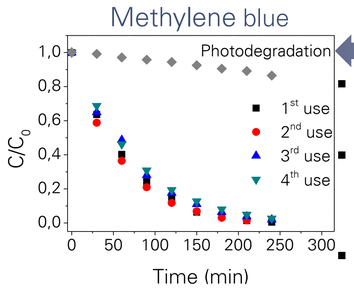
Contact angle

Adding TiO_2 increased the wettability of the polymer.



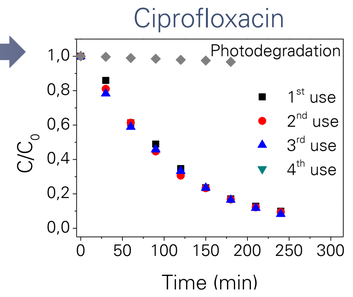
Photocatalytic activity of the TiO_2/PVDF-TrFE under UV

Methylene blue

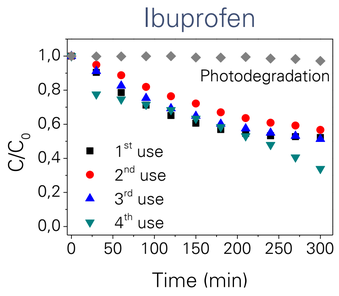


- Compounds photo stable.
- Complete degradation after 4h (under UV).
- No loss of efficiency.

Ciprofloxacin

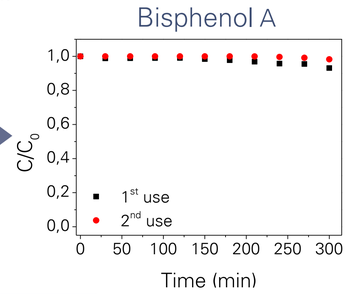


Ibuprofen



- Compound photo stable.
- 66 % degradation after the 4th use (5 h).
- Increase of the degradation rate due to initial higher adsorption.

Bisphenol A



- Low degradability. Recalcitrant compound.
- High concentration of the pollutant may lead to the saturation of the TiO_2 surface.

No loss of efficiency
Excellent reusability

Conclusions

- The produced nanocomposites exhibited a highly porous structure and the addition of TiO_2 increased the hydrophilicity of the nanocomposites.
- The polymeric structure was not affected by the addition of TiO_2 and it was kept intact after four uses (total time of 20 h) under UV.
- The tested compounds were totally or partially degraded by the produced material under UV, except bisphenol A, which is a recalcitrant compound.
- The reutilization of the nanocomposites showed no loss of efficiency. EDX confirmed the presence of the TiO_2 after 4 uses.
- These nanocomposites are a cost-effective nanomaterial for environmental remediation.

Acknowledgements

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complex nano materials

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