

Development of photocatalytic poly(vinylidene fluoride - trifluoroethylene)/TiO₂ porous membranes

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INTRODUCTION

Photocatalysis has become an attractive process to remove contaminants from aquatic environments¹. Photocatalysis consists on the use of solar light to generate highly oxidizing species, most often the hydroxyl radical ($\bullet\text{OH}$), to destroy harmful compounds². Catalysts are required in this process and, due to its significant oxidizing properties under UV irradiation, TiO₂ is the most widely used photocatalyst [ref³=6]. One disadvantage of the UV/photocatalyst process is the fast recombination rate of the electron-hole pairs³. Doping the photocatalysts with other elements is an effective approach to overcome this problem[ref]. Nevertheless, one of the largest drawbacks of the use of photocatalyst particles is the recycling and reutilization of the nanoparticles, which is time consuming and requires expensive processes². In order to overcome this drawback, TiO₂ immobilization in several substrates (e.g. glass, zeolite, silica and ceramic) has been explored. This work reports the optimization and photocatalytic activity of poly(vinylidene fluoride - trifluoroethylene) (PVDF-TrFE)/TiO₂ nanocomposites.

EXPERIMENTAL/THEORETICAL STUDY

Nanoparticles (P25 Evonik®) were characterized by X-ray diffraction (XRD), transmission electron microscopy (TEM), UV-vis spectroscopy, dynamic light scattering (DLS) and Brunauer–Emmett–Teller (BET) analysis. Subsequently, nanocomposites of PVDF-TrFE with three different concentrations of TiO₂ nanoparticles (2,5; 5 and 7,5 wt.%) were produced by solvent casting. The microstructure of the nanocomposite was studied by scanning electron microscopy (SEM), porosity was estimated with a pycnometer and the optical properties were obtained by UV-vis spectroscopy. The photo degradation activity of the polymeric nanocomposites was assessed by immersing in a methylene blue solution (10⁻⁵ M) under UV-A light irradiation (365 nm; 5 mW/cm²). The absorbance of the methylene blue was monitored at intervals of 3 min, using a spectrophotometer (ScanSpec UV-Vis, ScanSci) in the range of 300–900 nm. The variation in methylene blue concentration was investigated by monitoring the maximum absorbance of this dye, at 662 nm.

RESULTS AND DISCUSSION

The nanoparticle observation by TEM, indicates an average nanoparticle size around 30 nm. Furthermore,

BET analysis on the TiO₂ nanoparticles revealed a surface area of 55 m²/g.

Highly porous membranes with a degree of porosity ranging from 70 to 80% were obtained independently of the filler content (Figure 1A). Further, TiO₂ nanoparticles were well dispersed and embedded within the polymer microstructure. No variations in the co-polymer phase were observed due to the presence of the nanofillers. Regarding the photocatalytic tests, all the produced nanocomposites completely degrade the dye, however, higher concentrations of TiO₂ allow for enhanced photodegradation performance.

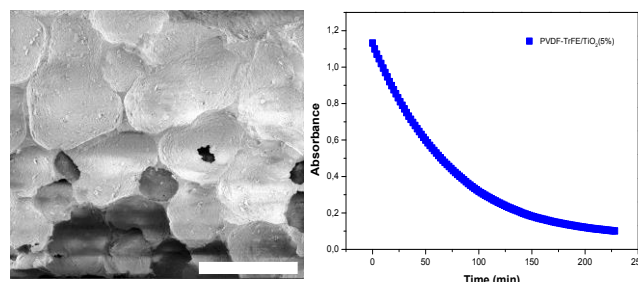


Fig. 1 **A**- SEM cross section micrographs of the porous nanocomposite membranes (PVDF-TrFE:TiO₂ (5%)); **B**- UV-vis absorbance decay as a function of time, measured at 662 nm, for the PVDF-TrFE:TiO₂(5%) nanocomposite immersed in a methylene blue solution (10⁻⁵ M) under UV-A irradiation f.

The produced nanocomposites allowed thus proper photocatalytic activity that is suitable for large-scale applications, due to the synergetic effect of the high degree of porosity and high surface area.

CONCLUSION

PVDF-TrFE/TO₂ nanocomposites were successfully prepared with suitable performance for re-usable applications. Photocatalytic membrane performance depends on both polymer and filler characteristics, such as degree of porosity and nanofiller content, allowing further optimization for specific applications.

REFERENCES

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