Implementation Of Photocatalytic Surfaces In 3D Printing Materials And Polyester Fabric Using Easily Impregnation Methods

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Novel photoactive materials using 3D printing materials such as polylactic acid (PLA) as a support material for titanium dioxide (PLA-TiO_2), and fabrics of polyester (P) with TiO_2 (P-TiO_2), were prepared in this work using a simple and easy-to-apply impregnation method such as the spray. The self-cleaning properties of PLA-TiO_2 and P-TiO_2 were evaluated in the photocatalytic removal of methyl orange and methylene blue dyes. The PLA-TiO_2 and P-TiO_2 were characterized by FTIR, SEM, and EDX to determine the characteristics of the coating. It was found that the spray method allows the impregnation of TiO_2 on the materials and its distribution on the surfaces of the PLA and P materials was homogeneous. Photodegradation tests indicate that decolorization was achieved for both types of dyes, following first-order degradation kinetics.

Introduction

Cleaning process of surfaces (fabrics and plates) requires water to keep them clean, which generated a variety of liquid contaminants which are discharged directly into the environment. Therefore, the importance of generating processes that are environmentally friendly and that lead to the reduction of the polluting effects generated by these processes. Self cleaning processes seek to clean surface without using water or detergents that contaminate water sources.

This study proposes the development of photoactive materials that are functionalized with titanium dioxide (TiO_2) as 3D printing materials and fabrics. The materials include PLA plates and P fabrics, which will be provided with optical and catalytic properties, allowing their use in self cleaning processes. To prepare the coatings on PLA and P materials, easy and accessible pretreatment techniques were used to modify the surface material. They were coated with TiO_2 by spray method. The dyes methyl orange and methylene blue to simulate stains onto surface. The PLA-TiO_2 and P-TiO_2 were characterized by characterized by FTIR, SEM, EDX.

Material and Methods

Material Pretreatment

Plates of polylactic acid (PLA) 3 cm x 3 cm were printed on a 3D printer with a thickness of 1 mm. In the case of polyester fabrics (P), a finished polyester ready for commercial use was employed, and samples of 3 cm x 3 cm were cut. Both materials were provided by a local industry. The PLA and P materials were washed to remove the impurities introduced during materials fabrication. In the washing process, a small amount of soap diluted in distilled water was used to promote clean and eliminate any dirt or contaminants present on the materials. Later, several washes of samples with deionized water in ultrasonic bath for periods of 30 min ensuring the removal of any impurities or soap residues. Finally, samples were dried (45°C, 5 h).

Photocatalyst impregnation

The photocatalyst impregnation was carried out using the spray process. A dispersion of the photocatalyst (20 mg/L) with 70% ethanol was prepared. For impregnation, the TiO_2 dispersion is sprayed uniformly on the surface of material from a distance of 10 cm. The samples were impregnated on one side and they were dried (45°C, 1 h). The process of spraying and drying is repeated 6 times, until the desired film is achieved.

Characterization materials and photocatalytic evaluation

PLA-TiO_2 and P-TiO_2 were characterized by Fourier transform infrared (FTIR), Scanning electron

microscopy (SEM), and surface elemental composition analysis (EDX).

The photocatalytic activity of PLA-TiO_2 and P-TiO_2 was evaluated in the degradation of the dyes methyl orange and methylene blue. For this, 0.5 mL of dye is added to the sample surface and it is irradiated under UV radiation at different times. After exposure to light, the samples were washed by adding 5 mL of distilled water. The solution is filtered to remove TiO_2 particles, and colorant concentration determination was carried out by ultraviolet spectrophotometry. The optimal wavelength for reading the methyl orange was 465 nm. In the case of methylene blue dye, the optimal wavelength was 665 nm.

Results and Discussion

Morphological and compositional properties

The compositional characterization by FTIR of the P-TiO_2 and PLA-TiO_2 samples shows the presence of bands between 800 and 500 cm^{-1}. They are related to the TiO_2 impregnated into the materials. Confirming its support on the surface of P and PLA. Additionally, the functional groups corresponding to polyester [1] and polylactic acid [2] are observed in the infrared spectra.

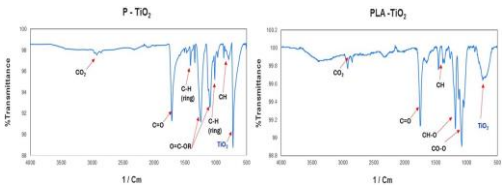

Figure 1. FTIR **(left)** P-TiO_2 and **(right)** PLA-TiO_2

The results of SEM and EDX analysis indicate that the spray method implemented allows the impregnation of TiO_2 on the P and PLA plates, achieving a uniform distribution of the photocatalyst.

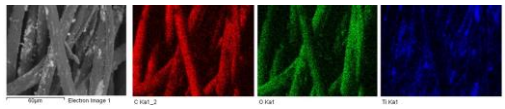

Figure 2. SEM and EDX of PLA-TiO_2

Photocatalytic evaluation

The photocatalytic evaluation indicates that both materials (PLA-TiO_2 and P-TiO_2) can eliminate methylene blue and methyl orange dyes, finding that at 9 h the greatest degradation of the dyes was achieved for P-TiO_2 (Figure 3a). In the case of PLA-TiO_2, a degradation up to 100% of methyl orange was observed after 5 h of irradiation (Figure 3b). On the other hand, in some materials a hydrophobic behavior is initially observed when the dye is added, being necessary to wait a period of 5 min for the dye drop distribute over the entire surface of the material (Graphical Illustration).

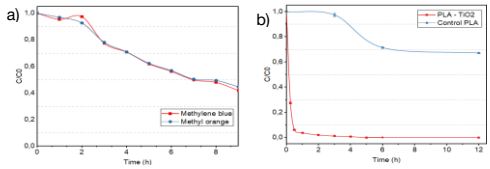

Figure 3. Concentration vs. time during dyes degradation of methyl orange and methylene blue.

Conclusions

The results obtained from the characterization and photocatalytic tests indicate that the supported materials (PLA-TiO_2 and P-TiO_2) are promising as they are obtained by a simple impregnation method. Moreover, their potential use in the production of materials with different 3D shapes and applications as clothing. The elimination of methyl orange and methylene blue dyes on the photoactive surface materials was achieved under UV irradiation.

Acknowledgments

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