Influence of filler and/or ZnO-coating on the physical properties of Poly(lactic acid)/TiO_2 bionanocomposites

A.A. Barmpaki[a*], E.E. Zavvou[a], M.A. Botzakaki[a], N.J. Xanthopoulos[a], A. Giannakas[b], C.E Salmas[c], P.K. Karahaliou[a], P. Svarnas[d], A. Ladavos[e] and C.A. Krontiras[a]

[a] *Department of Physics, University of Patras, 26504 Patras, Greece*
[b] *Department of Food Science and Technology, University of Patras, 30100 Agrinio, Greece*
[c] *Department of Material Science and Engineering, University of Ioannina, 45110 Ioannina, Greece*
[d] *Department of Electrical & Computer Engineering, University of Patras, 26504, Patras, Greece*
[e] *Department of Business Administration of Food and Agricultural Enterprises, University of Patras, 30100 Agrinio, Greece*

Poly(lactic acid) (PLA) has been extensively employed as an alternative to traditional petroleum-based polymers in a wide range of applications [1-3]. Implementation of bionanocomposites, exploiting PLA as the matrix and a variety of organic or inorganic materials as nanofillers, results in the enhancement of the polymer physical properties [4]. Among the wide family of nanofillers, titanium dioxide (TiO_2), an inert and low-cost inorganic nanoinclusion, is an excellent candidate for the production of such nanocomposite systems [5]. In this work, PLA/TiO_2 bionanocomposites were prepared via twin-screw extrusion, in a wide range of filler content (1, 3, 5, 7 and 10 wt%), and were hot-pressed and quenched in liquid nitrogen, forming amorphous films. Scanning Electron Microscopy studies revealed good dispersion of the nanoparticles within the polymer matrix. Both the glass transition and the melting behavior appear rather independent on the addition of TiO_2 content, while the cold crystallization is strongly affected, as revealed by Differential Scanning Calorimetry. A mild improvement of the thermal stability of nanocomposites upon increasing filler content was obtained through Thermogravimetric Analysis. Water Vapor Transmission studies indicate a small decrease of Water Vapor Transmission Rate (WVTR) with increasing TiO_2 content. Contact angle and surface energy measurements suggest that the wettability of the bionanocomposites remains unaffected. Finally, Zinc oxide (ZnO), a material with antibacterial properties [6], was deposited via Atomic Layer Deposition onto the amorphous samples. The barrier and surface properties of the coated specimens were studied and evaluated in comparison to the uncoated ones.

Acknowledgements
Authors acknowledge Dr. V. Drakopoulos and Dr. E. Mystiridou, Prof. N. Bouropoulos for their assistance in SEM experiments and TGA experiments, respectively. C. Drivas and Prof. S. Kennou are also acknowledged for XPS analysis. The present work was financially supported by the «Andreas Mentzelopoulos Foundation».

References

[1] Di Lorenzo M.L. & Androsch R., Advances in Polymer Science. Springer, Cham, Switzerland, 282, 2018.
[2] Jamshidian M. et. al. Compr. Rev. Food Sci. **9**, 552-571 (2010).
[3] Zavvou E. et al. J Polym Res 29, 284 (2022).
[4] Rhim J.-W. et al., Progress in Polymer Science **38**, 1629– 1652 (2013).
[5] Kassem M. et al. Materials **12**, 3659 (2019).
[6] Sirelkhatim A. et al. Nano-Micro Lett. **7**, 219–242 (2015).

* a.barmpaki@upnet.gr