Development of a conductive biopolymer-clay-graphene composite film

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Carbon nanotubes (MWCNTs) have been used to prepare several nanocomposites due to their conductive properties that give rise to improved applications in different fields [1,2]. However, MWCNTs are too expensive for the industrial applications. Then naturally occurring graphite, processed as graphene nanoplatelets (GNP), emerges as an alternative material for introducing conductivity into nanocomposites. Recently, we have found that clay-GNP mixtures may produce stable water dispersions in particular using sepiolite fibrous clay by sonomechanical treatment. Moreover, doping these systems with MWCNTs significantly enhances their electrical conductivity [3]. The particular microporosity of the sepiolite component allows interactions with biopolymers, opening the way to functional materials for advanced applications due to their inherent conductivity afforded by GNP and MWCNTs.
This work reports the preparation of functional nanocomposites by assembly clay-GNP hybrids with structural different polymers (alginate, gelatin, and polyvinyl alcohol). The alginate-based composites were the most interesting, being important the addition of the alginate only after the ultrasonic dispersion of the GNP and sepiolite. The dispersions lead to polymer-clay-GNP composites with enhanced mechanical properties. The in-plane conductivity of the films is always higher than through-plane conductivity because of the high tendency of graphene nanoplatelets to lie flat due to its 2D crystal organization. The doping of the composites with a very small amount of MWCNTs results in a significant increase of the electrical conductivity. Values of 2500 S m^{-1} and 0.05 S m^{-1} are achieved for in-plane and through-plane electrical conductivities, respectively for alginate-based composites. In conclusion, small amounts of MWCNTs together with GNP-clay systems can be used as nanofillers in the preparation of conductive composites, maintaining the mechanical properties, at low cost. The biopolymer-clay-graphene composite films could be of great interest for diverse applications, such as food packaging.

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References

[1] V. Singh, D. Joung, L. Zhai, S. Das, S. I. Khondaker, S. Seal, Progress in Materials Science **56**, 1178 (2011).
[2] R. M. Frazier, D. T. Daly, R. P. Swatloski, K. W. Hathcock, C. R. South, Recent Patents in Nanotechnology **3**, 164 (2009).
[3] E. Ruiz-Hitzky, M.M.C. Sobral, A. Gómez-Avilés, C. Nunes, C. Ruiz-García, P. Ferreira, P. Aranda, Advanced Functional Materials, *in press*.

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