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2nd Generation Layered Silicates Nanocomposites with improved Mechanical and Electrical Properties

Volker Altstädt[1], Josef Breu[2]
[1]Department of Polymer Engineering, University of Bayreuth
Universitätsstraße 30, 95447 Bayreuth, Germany
altstaedt@uni-bayreuth.de
[2]Department of Inorganic Chemistry I, University of Bayreuth
Universitätsstraße 30, 95447 Bayreuth, Germany
josef.breu@uni-bayreuth.de

Extended Abstract

In this study a novel kind of reinforcing polymethylmethacrylate (PMMA) aas well as improving the electrical properties of polyetherimide (PEI) with a 2nd generation of layered silicates is shown. Layered silicates are used as nanofillers in polymers due to their ability to increase the mechanical strength as well as to improve flame retardancy [1] and barrier properties [2], respectively. The first studies about polymeric nanocomposites with layered silicates were published in the mid eighties of the last century and lead to the development of a nylon-6-montmorillonite nanocomposite which has been the first layered silicate nanocomposite to be commercialized [3]. Since these first studies about polymer/clay nanocomposites [4], a rapid development has brought further improvement of the overall properties of these materials. However, the potential of commercially available natural layered silicates seems to have reached its limitations due to small lateral dimensions and a high heterogeneity of surface charge. Processing via melt compounding results mostly in incomplete delamination of the tactoids, which further reduces the maximal possible aspect ratio and therefore the desired properties. Also the incorporation of commercially available natural organo-clay in PMMA by melt-compounding leads to an increase of the stiffness, but an unsatisfactory dispersion quality of the nanoclay in the PMMA matrix. This leads to an decrease in toughness. Therefore we developed a new kind of synthetic layered silicate and used them in an innovative transfer batch moulding process to create a PMMA-nanocomposite. With these synthetic layered silicates which have aspect ratios of up to 600, it was possible to significantly increase the young's modulus of about 55% and the fracture toughness of about 70 %, without any decrease in tensile strength. Furthermore analysis of the corresponding fracture surfaces by scanning electron microscopy show in case of the novel filler additional energy dissipating mechanisms like crack deflection, crack bridging as well as debonding effects with platelets pull-out leading to enhanced fracture toughness.

In addition to the improvement of the mechanical behavior, the layered silicates possess the ability to decrease the coefficient of thermal expansion (CTE) of the matrix material [5]. Therefore layered silicates provide the possibility of utilizing thermoplastic materials for applications which require a lower CTE. In electric devices e.g. substrate material has to have a CTE in the range of the copper foil (around 17 ppm/K) to avoid thermal stresses between materials. Therefore current studies are evaluating the effect of layered silicates on thermal and electrical properties of PEI.

References

[1] M. Schütz, et.al., "Intumescent-like behaviour of polystyrene clay nanocomposites," *Polymer*, vol. 52, pp. 3288-3294, 2011.
[2] D. Kunz, et.al., "Clay-Based Nanocomposite Coating for Flexible Optoelectronics Applying Commercial Polymers," *ACS Nano*, vol. 7, pp. 4275-4280, 2013.
[3] Q. Nguyen and D. Baird, "Preparation of Polymer-Clay Nanocomposites and Their Properties," *Advances in Polymer Technology*, vol. 25, pp. 270-285, 2006.
[4] A. Usuki, et.al., "Synthesis of nylon 6-clay hybrid; Journal of Materials Research," *Journal of Materials Research*, vol. 8, pp. 1179-1184, 1993.

[5] Y. Q. Rao and T. Blanton, “Polymer Nanocomposites with a Low Thermal Expansion Coefficient Macromolecules,” *Macromolecules*, vol. 41, pp. 935-941, 2008.