Extended Abstract

The Nanomechanical and Tribological Properties of Polyamide/Hydrotalcite Nanocomposites [†]

George Mihail Teodorescu, Zina Vuluga *, Mihai Cosmin Corobea, Cristian Andi Nicoale, Augusta Raluca Gabor, Nicoleta Levinta and Andreea Alexandra Mainea

National Institute for Research and Development in Chemistry and Petrochemistry-ICECHIM, 202 Spl. Independenței, 060021 Bucharest, Romania; georgemihail.teodorescu@yahoo.com (G.M.T.); mcorobea@yahoo.com (M.C.C.); ca_nicolae@yahoo.com (C.A.N.); raluca_gabor@yahoo.com (A.R.G.); nicoleta.levinta@yahoo.com (N.L.); andreea.maineadinu@yahoo.com (A.A.M.)

* Correspondence: zvuluga@yahoo.com

[†] Presented at the 15th International Symposium “Priorities of Chemistry for a Sustainable Development” PRIOCHEM, Bucharest, Romania, 30 October–1 November 2019.

Published: 15 October 2019

Keywords: bio-PA nanocomposites; LDH; nanoindentation; nanoscratching

In specific fields of the industry (e.g., aircraft and automotive industry), plastic materials with high performance (improved scratch resistance, fire resistance, thermal stability, and high mechanical properties) are required. In recent years, the interest in nanocomposites based on bio-polymers and nanofillers has grown, as they are a successful alternative to petroleum-based plastics. Both petroleum-based and bio-based polyamides (petro-based PA and bio-PA) are high performance materials that are highly attractive for specific applications. Good effects on improving flame retardancy and thermal stability had been found for polymer matrices containing modified layered double hydroxides (LDH) as nanofiller [1,2]. Usually, for uniform dispersion of nanofiller in the polymer matrix and obtaining homogeneous composites, different dispersion agents are added [3], and a nanoscratching technique can be used in order to measure a wide range of local mechanical properties (hardness, stiffness, reduced modulus, friction coefficient, roughness, etc.) for homogenous and heterogeneous materials [4]. In this study, the behavior in nanoindentation and nanoscratching of bio-PA/LDH nanocomposites, in comparison to petro-based PA/LDH nanocomposites, were studied. The nanomechanical and tribological properties were investigated and compared with dynamic-mechanical and thermal properties of nanocomposites. The dispersion of LDH in the polymer matrix as well as their interactions were explained based on both the results of the mechanical properties and the surface damage mechanism.

Two commercial polyamides (PA10.10 and PA6), layered double hydroxide (LDH), and ethylene bis(stearamide) (EBS) were used. PA nanocomposites with 5 wt. % of LDH and LDH treated with EBS were obtained in dynamical conditions by the melt processing method. The nanoindentation and nanoscratch tests were performed at room temperature on a TI Premier system (Hysitron Inc., Minneapolis, MN, USA) using a three-side pyramidal Berkovich tip. Thermal analyses were performed on the TH-Q 5000IR and DSC Q2000 (TA Instruments, New Castle, DE, USA). Dynamic mechanical analysis was performed using the DMA Q800 (TA Instrument).

The addition of LDH and EBS in both PA 10.10 and PA 6 led to changes of both rigidity and hardness as well as of the elastic behavior and scratch resistance of nanocomposites when compared to the neat polyamides. The results proved that there is a strong interaction between the nanofiller and the polymer matrix when EBS was used. The best results were obtained in the case of the nanocomposite based on PA10.10 and LDH treated with EBS (elastic modulus and hardness were higher by 20% compared with neat PA 10.10). Furthermore, this nanocomposite showed more resistance against deformation caused by normal loads but had smaller elastic recovery compared

with the nanocomposite based on PA and untreated LDH. The friction coefficient and the roughness of PA nanocomposites were higher than for neat PA.

The addition of hydrotalcite into polyamide should provide the nanocomposite materials with improved bulk and surface properties, which in turn can find applications in an industry that requires materials with high performances.

Acknowledgments: This work was supported by a grant of the Romanian Ministry of Research and Innovation, CCCDI-UEFISCDI, project number PN-III-P1-1.2-PCCDI-2017-0387/80PCCDI Tehnologii emergente pentru valorificarea industrială a structurilor 2 D (grafenice și nongrafenice) Acronym EMERG2Ind, within PNCDI III.

References

1. Lennerova, D.; Kovanda, F.; Brozek, J. Preparation of Mg-Al layered double hydroxide/polyamide 6 nanocomposites using Mg-Al-tuarete LDH as nanofiller. *Appl. Clay Sci.* **2015**, *114*, 265–272.
2. Hajibeygi, M.; Shabanian, M.; Khonakdar, H.A. Zn-Al LDH reinforced nanocomposites based on new polyamide containing imide group: From synthesis to properties. *Appl. Clay Sci.* **2015**, *113*, 256–264.
3. Ogunsona, E.O.; Codou, A.; Misra, M.; Mohanty, A.K. A critical review on the fabrication processes and performance polyamide biocomposites from a biofiller perspective. *Mater. Today Sustain.* **2019**, *5*, 100014.
4. Diez-Pascual, A.M.; Gomez-Fatou, M.A.; Ania, F.; Flores, A. Nanoindentation in polymer nanocomposites. *Prog. Mater. Sci.* **2015**, *6*, 71–94.

© 2019 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<http://creativecommons.org/licenses/by/4.0/>).