ISSN: 0975-8585

Research Journal of Pharmaceutical, Biological and Chemical Sciences

Effect of Talc Addition on the Properties of Polystyrene / Talc Composites.

Hachani Salah Eddine, and Meghezzi Ahmed*.

Laboratoire de Chimie Appliquée, Faculté des sciences exactes et des sciences de la nature et de la vie, Université de Biskra, B.P. 145, RP. 07000 Biskra, Algérie.

ABSTRACT

In this study, the polystyrene/talc composites were obtained by melting compounding using a single screw extruder. Our composites were characterized using different techniques in order to study the effect of talc incorporation on their properties. XRD results revealed that the PS/talc composites combine between the amorphous nature of polystyrene and the crystalline one of talc.The tensile test demonstrated that the mechanical properties were improved after talc addition with significant increasing in shore D hardness. DMA results show an improvement of polystyrene storage modulus after talc adding. The results of scanning electron microscopy (SEM) indicate a good dispersion and distribution of talc particles in the polystyrene matrix.

Keywords: polystyrene, talc, XRD, Tensile test, hardness shore D, DMA, SEM.

Corresponding author

ISSN: 0975-8585

INTRODUCTION

Nowadays, the thermoplastic composites represent an important class of materials because of their potential advantages such as lower process temperature, recyclability [1] and light weight [2]. These polymer composites have various applications in automotive [3], electrical insulation [3], and medical domain [4].One of the most useful and edible thermoplastic polymer is the polystyrene which has a chemical formula $(C_8H_8)_n$. It is an amorphous polymer, colorless and inexpensive. The polystyrene has different applications in all fields of daily life (food containers, kitchen appliances, audiovisual, toys, computers, drinking cups, packaging)[5].

The polystyrene is not used in the virgin state due to it poor mechanical properties and it bad resistance to surfactants[6]. As a reinforcement method to enhance the properties of the neat polystyrene, a lot of researches have been focused on polystyrene composites including metal oxides[7], carbon nanotubes[8] and glassfibers[9].

The addition of mineral fillers has been demonstrated to be an effective way to improve the mechanical properties of the polymer matrix for example Gauri S and al have reported good mechanical response by the addition of mica and talc to poly(butylene terephthalate)[10]. Luyt A.S also observed an amelioration of mechanical and thermal properties of polypropylene after wollastonite incorporation [11].

The talc is a mineral belongs to the phyllosilicate clays family. It presents a multiple advantages like; low cost, high thermal stability and the chemical inertness [12]. Talc is used in numerous industries; in plastics, paints and rubbers, cosmetics. It extends to pharmaceutical products [13]. The researchers were interested in the role of talc in thermoplastic polymers. The studies demonstrated that talc improves the mechanical properties of polypropylene. Moreover, the polymer crystallinity degree is increased suggesting that talc particles act as nucleating agents in semi-cristallin polymer crystallization [14]. Few researchers have studied the polystyrene/talc composite for example Anson Wong has studied the effects of extensional stresses on the foamability of polystyrene/talc composites blown with carbon dioxide [15].

The polystyrene composites can be elaborated by different techniques like the emulsion polymerization[16], solvent casting[17]. In this study the polystyrene/talc samples were prepared by extrusion using a single screw extruder. The objective of this study is to investigate the effect of talc incorporation on the properties of polystyrene/talc composite films.

The polystyrene/talc composites have been evaluated using the tensile test measurements and Shore D hardness. The polystyrene/talc composites crystalline state was studied using X-ray diffraction (XRD) technique. The polystyrene/talc composites were the subject of DMA analysis to assess the variations of the storage modulus. The morphology of the studied composites has been examined using scanning electron microscopy.

EXPERIMENTAL PART

Materials

The polymer used in this study is the polystyrene supplied by Total Petrochemicals Company, Spain, E-U. The natural talc was obtained from Turkish Omyatalc (Omya Madencilik AS). The polystyrene platelets were grinded using a commercial lab milling in order to improve the mixing between the polystyrene matrix and the talc particles to obtain homogenous films.

Film preparation

The polystyrene/talc composites films were obtained by extrusion process. Both of the polystyrene powder and the talc powder were mixed using a commercial mixer at room temperature. The final mixture of each formulation was extruded using Plasti-corder PLE 330 single screw extruder. The extrusion conditions were barrel temperature of 175 C° and screw speed of 30 r.p.m. The talc loadings were 0, 5, 10 and 15 % by weight.

Structural analyses

X-rays diffraction analysis

The phase identification of polystyrene and talc, the crystalline state investigation of the PS/talc composites, both were studied using X-rays diffraction technique. The XRD diffraction patterns were obtained using BrukerD8 ADVANCE diffractometer within 2θ varies from 10 to 90°. The studied samples were films except the talc which was powder.

Mechanical analysis

The tensile test for the studied samples was performed using Zwick Roell testing machine according to ASTM D 638. Five specimens were examined from each composite formulation and the five test results were averaged and then reported.

Shore D Hardness

The Shore D hardness of the studied samples was carried out using a commercial durometer according to ASTM D 2240. Four measurements were performed for each formulation and the hardness middle value was reported.

Dynamic Mechanical Analysis (DMA)

Dynamic mechanical properties of the polystyrene/talc composites were investigated using Metravib db 50 Tester. The storage modulus of each formulation is registered. The samples were heated from 40C° to 150C°at a constant heating rate of 10 C/minand a frequency of 1 Hz.

Scanning electron microscopy (SEM)

The morphology of the studied composites has been analyzed using a scanning electron microscope JEOL JSM-6335F FEG, the films have been coated with a gold thin layer to obtain good SEM micrographs.

RESULTS AND DISCUSSION

The XRD patterns of polystyrene, talc powder and polystyrene/talc composites at different talc loading level sare shown in Fig. 1. Regarding the polystyrene XRD pattern, we show that any crystalline peak appears, the polystyrene has a unique halo centered at 2θ= 19.68. This halo confirms the amorphous nature of polystyrene;a similar XRD pattern is reported by Peng Ding[18]. Looking to the XRD spectrum of talc we remark that the talc crystal phase has a principal peak that appears at 2θ= 29.79° and it corresponds to a d-spacing equal to 0.3 nm. The comparison between X-ray diffraction patterns of PS, PS/Talc composites and Talc, revealed that The PS/Talc system combines between the amorphous nature of polystyrene and the crystalline one of talc with diminution of polystyrene amorphous character and no alteration in crystal structure of talc. This combination brings more rigidity to the studied samples. This hypothesis is approved by the mechanical results.

The mechanical properties such as tensile strength and elongation at break are very important factors in composite materials industry and applications. Several researches have studied the tensile properties of the polymer matrix reinforced with different types of filler. The Figure 2 presents the variation of elongation at break values for the studied composites as function of talc content. We observe that the elongation at break increases with the increasing of talc content until 10 %. When the talc content increased to 15 %, samples failed but with higher elongation at break then the virgin polystyrene. These mechanical results indicate a good adherance between the polystyrene matrix and the talc particles. The same mechanical behavior is reported by Fengmei Yu who studied the effect of talc on the mechanical and thermal properties of polylactide [19].

ISSN: 0975-8585

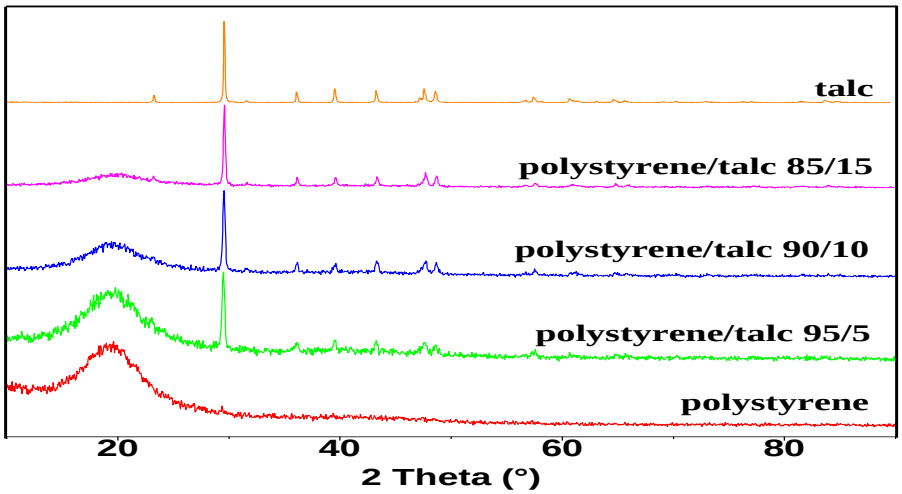


Figure 1: XRD patterns of polystyrene, talc and polystyrene/talc composites.

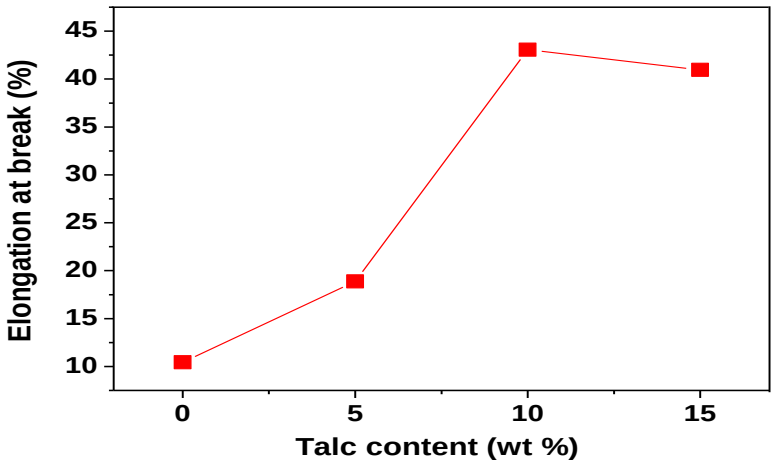
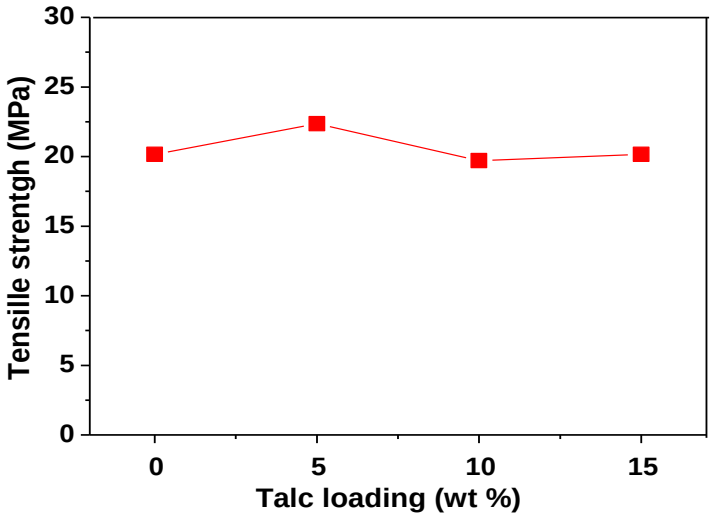


Figure 2: Elongation at break variations of polystyrene/talc composites as function of talc content.



ISSN: 0975-8585

Figure 3: Tensile strength variations of polystyrene/talc composites as function of talc loading.

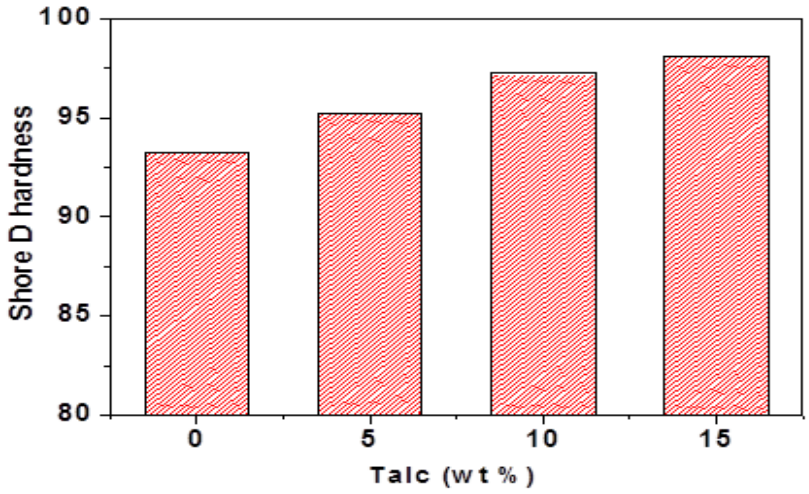


Figure 4: Shore D hardness changes of polystyrene composites as function of talc loading

The curve presented in the figure 3 shows the tensile strength variations for the studied composites as a function of talc loading levels. It is clearly evident from this curve that the addition of talc particles affected slightly the tensile strength of the polystyrene matrix.

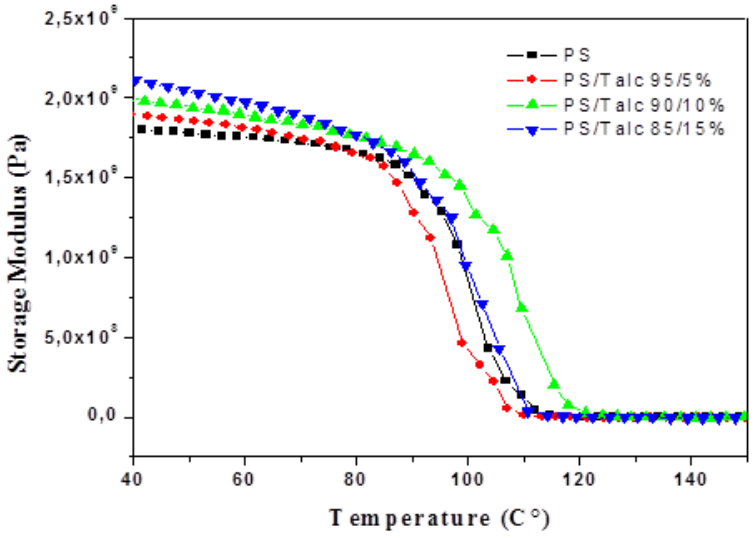


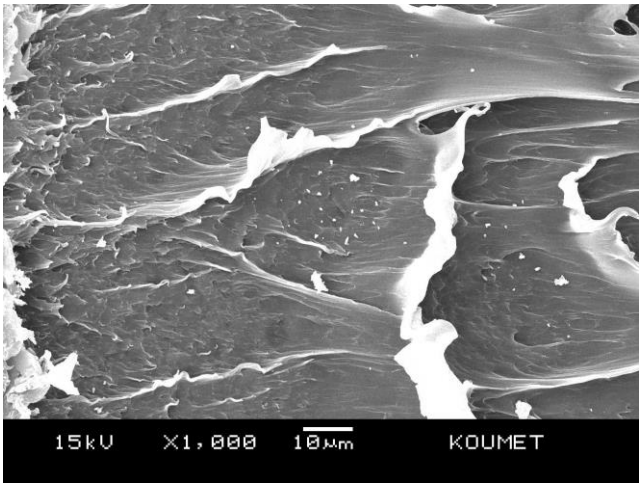
Figure 5: Storage modulus of neat PS and PS/talc composites as a function of temperature

The shore D hardness of thermoplastic polymers has been the subject of considerable researches; this test evaluates the polymer material's resistance to permanent indentation. The Shore D hardness values corresponding to both of the virgin polystyrene and it composites at different amount of talc are compared in fig 4. It can be seen that the shore hardness values increase with the increasing of talc content. This increase in shore D hardness could be attributed to the good filler particles dispersion into the matrix which restricts the polymer chains mobility and the matrix deformability[20].

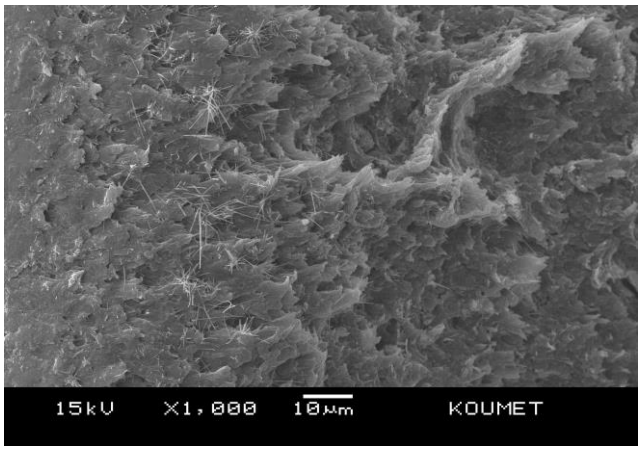
The dynamic mechanical analysis is an effective technique to study the properties of the polymeric materials such as relaxation mechanisms, compatibility of polymer blends, damping properties [21]. The storage modulus is useful to evaluate the mechanical properties of a polymeric material due to it high sensitivity to the structural changes. This modulus is considered as the elastic response of the polymeric material to the deformation [22]. The figure 5 shows the storage modulus variations corresponding to both of the neat polystyrene and it composites reinforced with different loading levels of talc as a function of temperature. From the curve it is observed that the storage modulus of the polystyrene is enhanced after the

addition of the different loading proportions of talc, this is for all temperatures lower than the polystyrene's softening point. The reinforcement of talc particles could be attributed to two main factors; the first is to the well dispersion of talc particles into the polystyrene matrix, the second is the good interaction between these particles and the polystyrene matrix. Similar behavior is observed by Zvonimir Matusinovic and coworkers; they reported an increase in polystyrene's storage modulus after the incorporation of molybdenum disulfide [23].

The scanning electron microscopy (SEM) is very commonly used as a tool for the microstructural characterization of the polymer composites. This technique provides useful information of the state of the distribution and the dispersion of the filler in the polymer matrix which allows understanding the final properties of the prepared composites. It is well known that poor dispersion and distribution of the filler in the polymer matrix leads to degrade the properties of elaborated composites [24]. The dispersion and the distribution of the talc particles in the polystyrene matrix were analyzed by SEM. The micrographs of the polystyrene samples reinforced with 5 and 10% of talc are shown in figure 6 (A and B). The observed morphology in this figure shows good dispersion and distribution of the talc particles in the polystyrene matrix, no agglomerate was observed.



A



B

Figure 6: SEM micrographs; (A) polystyrene reinforced 5% of talc, (B) polystyrene reinforced 10% of talc.

CONCLUSION

This paper investigates the effect of talc particles incorporation at different loading levels on the properties of polystyrene/talc composites. The XRD declared that the polystyrene/talc presented simultaneously the amorphous nature of polystyrene and crystalline structure of talc. The tensile test indicates that the addition of different talc proportions to the polystyrene matrix affected slightly the tensile strength of the studied samples. Contrariwise it enhances significantly the elongation at break of the polystyrene

composites compared to the elongation value of the pure polystyrene. The shore D hardness values higher with the increasing of talc content which made the polystyrene matrix less deformable. The DMA results demonstrated that the stiffness of the polystyrene is quietly enhanced after talc adding. A good morphology presented bythe studied samples was observed by SEM.

REFERENCES

[1] Hassan M. EL-Dessouky, Carl A. Lawrence. Composites Part B 2013; 50 : 91–97.
[2] G. Schinner, J. Brandt, H. Richter. J Thermoplastic Composite Mater 1996; 9(3):239-245.
[3] Chokri Cherif, Sybille Krzywinski, Huangmei Lin, Christian Schulz, Georg Haasemann. Procedia Mater Sci 2013; 2:111–129.
[4] Timo O Närhi, John A Jansen, Tiina Jaakkola, Anja de Ruijter, Jaana Rich, Jukka Seppälä, Antti Yli-Urpo. Biomater 2003; 24(10):1697–1704.
[5] S M Pawde, Sanmesh S Parab. Prama J Physics 2008; 70(5): 935-948.
[6] Myer Kutz. Handbook of Materials Selection. John Wiley & Sons,2002;pp338.
[7] Jui Hung Chen, Chu-Yun Cheng, Wen-Yen Chiu, Chia-Fen Lee, Nai-Yun Liang. European Poly J 2008; 44: 3271–3279.
[8] Archana S. Patole, Shashikant P. Patole, Ji-Beom Yoo, Jeong-Ho An, Tae-Ho Kim. Poly Eng Sci 2013; 53(6):1327–1336.
[9] Quanyao Zhu , Fei Wu, Qing Yang, Jun Wang, Wen Chen. J Wuhan Univ Technol-Mater Sci Ed 2010; 25(5): 780-784.
[10] Gauri S Deshmukh, DR Peshwe, SU Pathak, JD Ek. J Polym Res 2011;18:1081–1090.
[11] AS Luyt, MD Dramicanin, Z Antic, V Djokovic. Polymer Testing 2009; 28(3):348-356.
[12] Bahri ERSOY, Sedef DİKMEN, Ahmet YILDIZ, Remzi GÖREN, Ömer ELİTOK. Turkish J Earth Sci 2013;22: 632-644.
[13] Francesco Dellisanti, Giovanni Valdrè, Mario Mondonico. App Clay Sci 2009; 42: 398–404.
[14] Castillo, L, Barbosa, S, Capiati N. J App Poly Sci 2012;126: 1763–1772.
[15] Anson Wong, Chul B. Park. Chem Eng Sci 2012;75:49–62.
[16] K Zhang, W Wu, H Meng, K Guo, JF Chen. Powder Technol 2009; 190(3): 393–400.
[17] O Bera, et al. Thermochimica Acta 2011; 515(1–2):1–5.
[18] Peng Ding, Baojun Qu. J Coll Interf Sci 2005; 291:13–18.
[19] Fengmei Yu, Tao Liu, Xiuli Zhao, Xuejiang Yu, Ai Lu, Jianhua Wang. J App Poly Sci 2012;125(2):99–109.
[20] A. Hamma, M. Kaci. Mohd Ishak, A. Pegoretti. Composites: Part A 2014; 56: 328–335.
[21] Luciana Castillo, Olivia Lopez, Cintia Lopez, Noemi Zaritzky, M. Alejandra Garcia, Silvia Barbosa, Marcelo Villar. Carbohydr Poly 2013;95:664– 674.
[22] Y. Xu, S. Kawata, K. Hosoi, T. Kawai, S. Kuroda. eXPRESS Poly Lett 2009; 3(10): 657–664.
[23] Zvonimir Matusinovic, Ruchi Shukla, E. Manias, Charles G. Hogshead, Charles A. Wilkie. Poly Degrad Stab 2012;97(12):2481–2486.
[24] Wenzhong Tang.Molecular Dynamics Simulations of Carbon Nanotubes in Liquid Flow. ProQuest, 2007;pp7.