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Effects of High Energy Radiation on Mechanical Properties of PP/EPDM Nanocomposite

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Abstract. Nanocomposites are the materials that are created by introducing nanoparticulates that always referred to as filler into the matrix. Blends of polypropylene (PP)/ethylene propylene diene monomer (EPDM)/Montmorillonite (MMT) were treated by compatibilizer MAPP and irradiation of electron beam. The effects on mechanical properties for both samples were compared with the untreated nanocomposites. Because each samples used different portion of clay loading, the effects of clay loading on mechanical properties is also observed. The sample is characterized by using Transmission Electron Microscope (TEM), X-Ray Diffraction (XRD), tensile test and impact test.

Introduction

In the recent decades, polymer-layered inorganic nanocomposites have experienced an important development over the past 10 years across the world. Nanocomposites are particle-filled polymers for which at least one dimension of the dispersed particles is in the nanometer range which have superior physical properties such as thermal, mechanical and barrier properties or some new properties comparing to the original polymer/filler composites [1].

Electron beam is stream of electrons (as from a betatron) generated by heat (thermionic emission), bombardment of charged atoms or particles (secondary electron emission), or strong electric fields (field emission). Electron beam cross-linking is a good alternative instead of cross-linking by chemical agents. It is especially true for blends or multimaterials [2]. When polymers are crosslinked, the molecular movement is severely impeded, making the polymer stable against heat. The main effects of an electron beam irradiation are chain scission, oxidation and increase of unsaturation, depending on the dose rate and the oxygen content in the exposure environment [3].

The purpose of this paper is to produce PP/EPDM nanocomposites using organically modified montmorillonite (OMMT). Two types of modification have been done on the nanocomposites using maleic anhydride polypropylene (MAPP) and irradiation using electron beam (EB) and compared with non-treated nanocomposites. The effect of nanoclay loading from 0 to 8% by weight on mechanical properties of the nanocomposites was also investigated. The structure of the nanocomposites was studied using X-ray diffraction (XRD) and transmission electron microscope (TEM).

Experimental

The polymer blends used as matrix is blending of polypropylene (with density of 0.92 g/cm3) which are supplied by Polypropylene Malaysia Sdn Bhd and ethylene propylene diene monomer, EPDM (with density of 0.87 g/cm3) from Centre West Industrial Supplies Sdn Bhd. The PP:EPDM ratio used was 70:30. The clay (with density of 1.00 g/cm3) used is 1.31PS grades that is containing silane modification which was supplied by Nanocor Inc. The compatibilizer used was maleic anhydride polypropylene, MAPP (with density of 0.95 g/cm3) from Aldrich Chemical Co. USA. The weight of MAPP used was 3%.

In this research, three types of nanocomposites samples were prepared. Firstly, was the untreated samples contain of PP/EPDM with 0, 2, 4, 6, 8 wt.% clay loading. Secondly, was sample with compatibilizer agent (PP/EPDM/MAPP with 0-8 wt.% clay loading). The third sample was the irradiation samples (PP/EPDM with 0-8 wt.% clay loading). All samples were prepared in internal mixer using Banburry blade rotor at temperature of 180 °C and the rotor speed of 40 rpm for 10 minutes by direct mixing. Compression moulding was used to compress the mixing samples into a sheet of 1 mm thickness. The samples were then cut according to ASTM D412.

For irradiation samples, radiation was done after the compression moulding process. Samples were exposed to irradiation dose of 100 kGy. While for the samples with compatibilizer, the MAPP was added during mixing process. The samples were then characterized for its tensile properties. The small part of tensile test samples was used for XRD. The sample was put in position of the sample holder. The speed used for XRD was 2°/min with the angle from 10° to 80° for 30 minutes. Nanocomposites were viewed by transmission electron Microscope (TEM) by having the nanocomposite thin-sectioned using a Reichert-Jung Cryo-Ultracut at 25 °C. Sections were examined with a Philips CM-12 TEM.

Results and Discussion

Tensile Test. Tensile test was done to observe the effects in strength of nanocomposite when treated by compatibilizer agent and radiation of electron beam. Both were compared with the untreated nanocomposite and also compared with the clay composition. The compatibilizer added is MAPP at 3% by weight and the irradiation dose is 100 kGy. The result is summarized in the Table 1 and Fig. 1 below.

Table 1: The data obtained from tensile test

Clay composition (wt%)	Without MAPP (MPa)	stdev	With MAPP (MPa)	stdev	Radiation (MPa)	stdev
0	16.743	0.686	16.993	0.283	17.313	0.141
2	14.890	0.257	17.248	0.754	15.115	0.590
4	14.060	0.287	18.261	0.446	13.895	0.349
6	13.120	0.447	16.880	0.553	14.121	0.280
8	12.959	0.077	15.397	0.202	12.896	0.663

From the Fig. 1, the tensile strength of the studied nanocomposites with addition of compatibilizer agent, MAPP is higher than the untreated and irradiation nanocomposites. The untreated and irradiated composites show a decreasing trend in tensile strength. However, it is noted that irradiated composite give slightly better tensile strength than untreated composite. It is known that the effects of the applied treatment on the properties of the polymer blends depend both on the exposure type and on the composition of the blends [3]. Thus, improvement in radiated nanocomposites is also associated with the composition of the blends. Introduction of compatibilizer agent showed an increase in tensile strength. The improvement in strength by MAPP is larger as compared to the irradiated composite. Increasing in tensile strength can be attributed to the improved dispersion of clay by the addition of compatibilizer [4].

Clay composition in the samples also plays an important role as it has limit in improving the tensile strength. From the graph of untreated and irradiation, both show that the tensile strength decreases as the clay content increases. However, the radiated composite at 6 wt.% showed an increase in strength before it decreased again. This trend may occur due to the agglomeration of clay particle and poor dispersion of clay in the nanocomposite system. For composite treated by MAPP, it shows an increasing in tensile strength with maximum clay composition of 4 wt% and then decreases at higher clay content. Thus, the 4 wt% of clay content is the optimum value. It can be attributed to the better dispersion of nanoclay. The enhancement in tensile strength is directly attributed to the dispersion of nanosilicate layers in the matrix and strong interaction between matrix and clay, and the lower tensile strength can be attributed to inevitable aggregation of the silicate layers in high clay content [5].

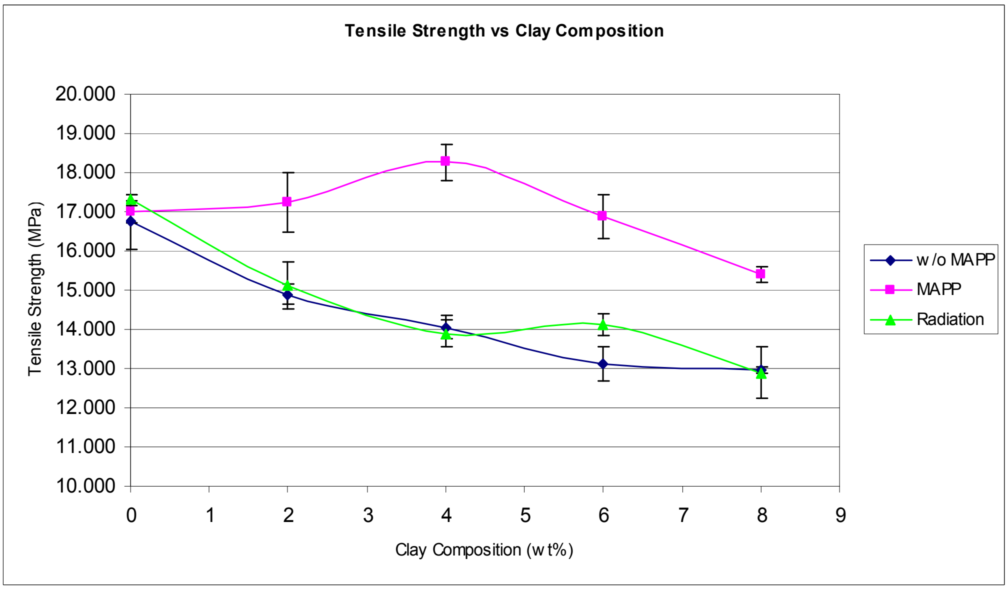


Fig. 1: Effects of clay composition on tensile strength of nanocomposites

X-ray Diffraction (XRD). XRD is an effective way to characterize the formation of a nanocomposite. In an immiscible mixture, the gallery height of clay, in terms of its d-spacing should be virtually identical to that of the pristine clay; if a nanocomposite is formed, the d-spacing must increase [5]. By using XRD, we can evaluate the clay dispersion by two possible cases, if a peak is seen at larger d-spacing than in the pristine clay, that indicating an intercalated structure. If no peak is seen, that may indicate either an exfoliated structure or disordering of the clay layers. Figs. 2(a-d) below show the XRD pattern of nanocomposites for untreated samples, with MAPP and irradiated by electron beam. All samples of nanocomposites show a slight shift in peak towards the left and increase in d-spacing. Thus it can be indicated that the structure of nanocomposite is intercalated.

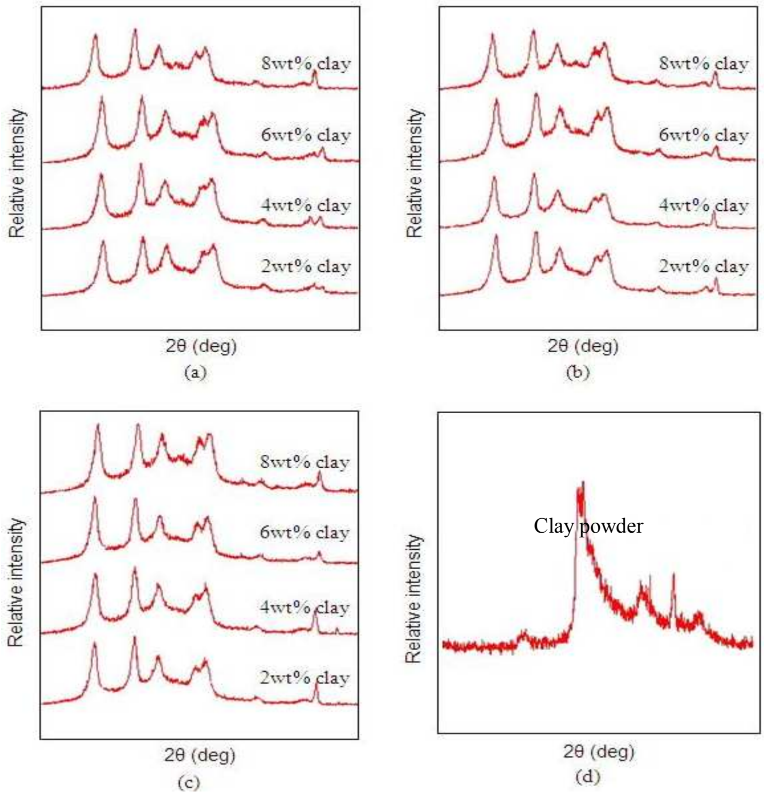
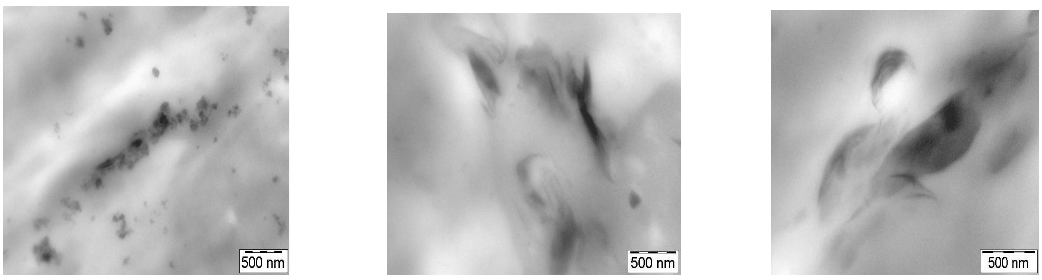


Fig. 2: XRD patterns of samples (a) without MAPP (b) with MAPP (c) radiation (d) clay powder

Transmission Electron Microscope (TEM). X-ray diffraction only provides a partial picture about the distribution of nanoclay in disordered-intercalated polymer nanocomposite [6]. Thus, to confirm the complete characterization of nanocomposites morphology requires microscopic investigation that can be done by using TEM. The images of TEM in Figs. 3(a-c) show that clay is intercalated in all samples. This may occur due to agglomeration of the clay. Other than that, the processing parameters also play an important role in clay distribution. These intercalated samples happen due to low rotor speed during the mixing of materials.



(a) (b) (c)

Fig. 3: TEM images of nanocomposites (a) without MAPP (b) with MAPP (c) radiation.

Conclusion. As conclusion, from the tensile tests, it was found that the present of MAPP as a compatibilizer agent has improved tensile properties of nanocomposites than the electron beam radiated coposites and untreated nanocomposites. The clay loading also affect the mechanical properties of nanocomposites. The optimum value for clay loading is at 4 wt%. By using XRD and TEM it is showed that the dispersion of nanoclay is intercalated. Thus intercalated clay will substantially reduce the mechanical properties.

References

[1] C. Yibing: J. Mater. Sci. Vol. 42 (2007), p. 5785.

[2] M. F., Vallat: Nuclear Instruments and Methods in Physics Research (B) Vol. 236, (2005), p. 141.

[3] M., Pascu: Materials Chemistry and Physics Vol. 80 (2003), p. 548.

[4] Sung Hun Ryu and Young-Wook Chang: Polymer Bulletin Vol. 55 (2005), p.385.

[5] Seyed Javad Ahmadi, Y., Yuang and L., Wei: Iranian Polymer Journal Vol. 13 (2004), p. 415.

[6] H., Acharya and S. K., Srivastava: Macromolecular Research Vol. 14, No. 2 (2006), p. 132.

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