

Mechanical Properties of PE, PP, Surlyn and EVA/Clay Nanocomposites for packaging films

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Abstract: The article deals with the preparation, properties and the usage of polymer barrier films. The problem of exfoliation and dispersion of the filler in the polymer matrix and mechanical properties of barrier films is discussed. This problem is connected with the use of nanofiller either in the polymer matrix or on the surface of prepared films. Together the evaluating comparison of used nanofillers is done. Polypropylene, polyethylene, EVA copolymer and Surlyn were used like polymer matrices. Organically modified montmorillonite (Cloisite 93A, 30B, 10A, Dellite 67) were used like nanofillers. Morphology (TEM, XRD) and mechanical properties were observed.

Keywords: nanocomposites, nanofillers, clays, montmorillonite, polymers, mechanical properties,

PACS: 82.35.Np Nanoparticles in polymers

INTRODUCTION

A new trend in chemical engineering is the development of new technologies and new types of active nanocomposites contain as the active ingredient nanomaterials. Such materials, especially packaging films are still on the market in limited quantities. Goal is to develop new technologies and materials that help to eliminate causes problems of production and technical limits of current commercial materials. Nanocomposites -, significantly affects their structure. Polymers with improved properties must have some degree of polarity, the resistance against gases (polar groups that enable the polymer to absorb moisture from the surrounding environment), good interaction between chains and a high glass transition temperature. To compare the improved properties of nanocomposites used for example of mechanical resistance, exfoliation, determination or comparison of morphology and more [1- 4].

Nanocomposites are materials comprising a polymer matrix, a nanofiller. To obtain nanocomposite with the required properties, especially in case of nonpolar ones it is necessary to apply a modification of clay nanofiller leading to the "organofilization" of filler. Nanocomposites differ from traditional plastic composites by providing improvements with minimal impact on density and do it without processing penalty. This article builds on our research in the area of packaging films. In this section, the mechanical properties of polyethylene, polypropylene, EVA and Surlyn nanocomposites are studied [5, 6].

This article is focused on the preparation and comparison of polymer nanocomposites supposed to be used in the packaging industry.

EXPERIMENTAL

The polymer matrix used as carrier materials were Polyethylene (Borealis RB 707 CF fy Borealis AG) and Polyethylen (Bralen RB 03-23, fy Slovnaft Petrochemicalis Bratislava), EVA (Ultra FL 00218) and Surlyn A (8940). To increase compatibility between the polymer matrix and the filler was used for maleinized PP polypropylene (PP - MA) Exxelor PO 1015 K 1,909,201 1 3 EXXON and PE maleinized polyethylene (PE - Ma) AMPLIFY GR 216

Were used organically modified montmorillonites with tradenames Cloisite 93A, 30B, 10A (fa Southern Clay Products, Inc.), and Dellite 67G (fa Laviosa Chimica Mineraria S. p A.).

Polymers with the fillers (mass fraction 5 %) were compounded in a twin screw extruder ZE Berstдорff 25, screw diameter was 2 x 28 mm and a L / D ratio of 38 The temperature of the individual heating zones and the extrusion head was set at 210 ° C for PP and PE, 160 ° C for EVA and 200 ° C for the Surlyn A rotation speed was 15 per minute. The extruded wire was cooled in a water bath and then transferred using a knife mill back to granulate the unit Scherr SGS - 50E. On the laboratory blow line TVR - C9S - 7EX (UTB) connected to the extruder single screw unit Brabender OHG Duisburg were prepared from granules blown film. From the prepared granules were pressed plates of dimension 125 x 125 x 2 mm. The temperature for molding the PP and PE was 210 ° C, 150 ° C for EVA and for Surlyn 220 ° C. The pressing time was 3 minutes for all the polymers and the cooling period was from 7 to 15 minutes. To prepare the solution for deposition of the filler onto the surface of the polymer matrix was used a solvent consisting of ethyl acetate and ethanol, which is a normal part of the polymer printing inks used for printing on transparencies. 150 g of solvent was added 10 wt% (15 g), polyvinyl butyral (PVB) and 5 wt% (7.5 g) nanofiller. The solution was prepared separately for nanofiller Cloisite 93A and for Dellite 67.

The structure was studied using an URD-6 Diffractometer in the reflection mode in the range from 0.8000 to 11.9870 ° 2 θ at a voltage of 40 kV and 30 mA with a step size of 0.0263 °. The dispersion of the clays in polymer matrix and nanostructures were observed through microscopic investigations.

Samples of 40 x 20 mm made from molded plates were sent to the IMC Prague, where it was performed TEM. As samples were used ultrathin sections prepared on special Ultra - cryomikrotomu LEICA at -100 ° C, temperature of the knife - 50 ° C and a thickness of about 50 nm. Transmission electron microscopy was performed on a JEM 200 CX at an accelerated voltage of 100 kV.

Tensile tests were measured at the Faculty of Technology in UTB Demo Room ALPHA Technologies Ltd. On tensile testing machine TENSOMETR 2000. EN ISO 527-3 (64 0604) was used the speed of the tearing 2 - initial speed was 1 mm / min to the module 2%, then the speed was increased to 100 mm / min until rupture. For tensile tensile strength, elongation et break, tensile-Chor modulus and yield stress were measured and evaluated.

RESULT AND DISCUSSION

Polymer/clay nanocomposites have been studied for longer period as materials possible used in packaging industry. Therefore, this work is particularly interested in the mechanical properties. Table 1 and 2 presents the mechanical properties of polymers with nanofillers and the inside surface of the polymeric matrix.

In the table 1, it is possible to see the effect of fillers on tensile strength, tensile modulus and elongation. As it can be see, the values of net PP, PE and Surlyn are higher than the same materials enriched by fillers. Especially PP samples with fillers show significantly lower tensile strength. It can be assumed that the presence of filler in samples, compared to the net ones, has not a significant effect on tensile strength. However interesting is the fact that filled Surlyn had lower tensile strength, despite the fact that according to X-ray and TEM achieves the highest degree of exfoliation. Tensile modulus values were higher in samples filled with PE and Surlyn [7-10].

TABLE 1. Tensile tests - filler within the polymer matrix

Composition	Stress at break (MPa)	Elongation at break (%)	Yield stress (MPa)	Tensile modulus (MPa)
PP/93A	8,601	601,08	22,34	307,67
PP/67	8,657	619,08	21,01	313,97
PP	28,592	948,48	20,32	320,57
PE/10A	13,323	862,04	9,76	142,37

PE/30B	13,261	833,74	10,08	145,74
PE	15,903	790,30	9,73	117,37
EVA/93	20,580	1171,00	0,00	42,15
EVA/67	20,071	1112,10	0,00	38,60
EVA	19,51	1173,40	0,00	26,92
SRL/93	22,65	461,94	13,72	206,67
SRL/67	23,14	449,78	13,36	206,97
SRL	30,45	555,94	12,75	167,85
SRL/93	22,65	461,94	13,72	206,67
SRL/67	23,14	449,78	13,36	206,97

TABLE 2. Tensile tests - filler on the surface of the polymer matrix

Composition	Stress at break (MPa)	Elongation at break (%)	Tensile modulus (MPa)
EVA/93	16,58	1189,80	40,07
EVA/67	17,49	1254,30	34,26
EVA	19,51	1173,40	26,917
SRL/93	26,25	736,10	197,69
SRL/67	27,09	565,27	192,77
SRL	30,45	555,94	167,85

In the table 2, we can see that the filler material surface showed almost the same values as the pure material. The problem was that during tensile tests with the deposition of filler on the surface began to tear sooner than the blades.

The surface layer tore already at 12% elongation in almost all cases. Changing the properties in the case of the filler on the surface of the polymer matrix may also be caused by disruption of the surface of the blades during the deposition of filler (solvent effect). Tensile modulus at EVA filler surface and Surlyn with the filler surface slightly improved. The same fact was also observed for the filler within the polymer matrix. As shown by mechanical testing - the filler achieves a high degree of exfoliation, there is no difference in the imposition of filler - in a polymer matrix or at the surface [9-11, 13].

The exfoliation was very successful for Surlyn as it comes from results of TEM analysis. In Figure 1 it can be seen comparison of the distribution of nanofiller in a matrix of EVA and Surlyn. Distribution in both cases is about the same, but images suggest that in the case of EVA matrix the exfoliation is worse [11-14].

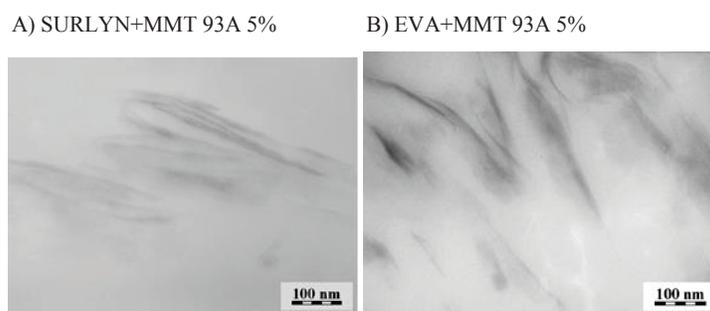


FIGURE 1. TEM Pictures of Surlyn a EVA Nanocomposites

Best results in X-ray diffraction can be observed Surlyn, where curves of both filled materials are compared with pure sample and they are almost identical, with no peaks. It can be stated that only filled Surlyn probably occurred highest grade of exfoliation when comparing the prepared samples [13-15].

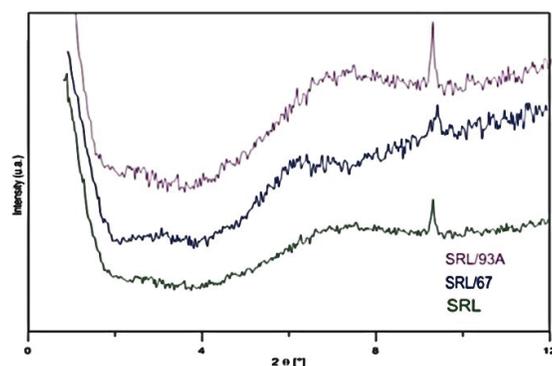


FIGURE 2. XRD Surlyn nanofillers, pure Surlyn, surlyn +MMT 93A 5% and surlyn + MMT 67 5%

CONCLUSION

Comparison of mechanical properties and exfoliation of the nanofiller in the polymer matrix was observed. Platelets of montmorillonite overlapped and may cause deterioration of the desired properties. The goal of the production of polymer nanocomposites is to achieve the full exfoliation. Important is the observation that nanofillers within the polymer matrix or on the surface of the polymer matrix mechanics affect polymer properties. We can say that good exfoliation of fillers can improve mechanical properties of nanocomposites. Nevertheless, the degree of exfoliation and orientation of the platelets is the most critical parameter .

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