

# POLYOLEFIN/CLAY NANOCOMPOSITES: COMPARING MECHANICAL AND BARRIER PROPERTIES

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## ABSTRACT

Polyolefin/clay nanocomposites were filled by the series of commercial filler Nanofil. Maleated polyolefins were used for better compatibility between polymer matrix and filler. The morphology and properties were evaluated. The properties of nanocomposites were tested by using mechanical tests and barrier properties. The results of PE/clay nanocomposites showed that the mechanical and barrier properties were not higher than the virgin polymer. However, polyethylene contained filler Nanofil 9 had better mechanical properties in compare with the virgin polymer. PP/clay nanocomposites had higher mechanical properties for both used concentration and PP/Nanofil 9 and 3000 had better barrier properties than the virgin PP.

## 1 INTRODUCTION

Nanotechnology is a science which studies preparation, properties and applications of nanocomposites. The nanotechnology has been started at 90 years of last century. Screw extruder, twin screw extruder can be used for the preparation of nanocomposites. The mechanical properties, barrier properties were measured and compared with the pure polymer matrix. The comparison of nanocomposites and the virgin polymer matrix (polyethylene, polypropylene and so one) showed better properties of prepared nanocomposites [1-4]. The application of nanocomposites is very variable: automotive, food packaging, aerospace and so one.

## 2 MATERIALS

Two different polymer matrixes were used. The first type of polymer matrix was polyethylene DOWLEX 2035 E. Maleated polyethylene AMPLIFY GR 216 was used for a better compatibility between polymer matrix and filler. Both types of polyethylene were produced by Dow Chemical Company, Belgium. The second type of polymer matrix was polypropylene MOSTEN 52.412 from company Chemopetrol Litvinov, Czech Republic. Maleated polypropylene EXXELOR PO 1015 was used as a compatibilizer for the polypropylene matrix. The characteristic of both polymer matrixes shows Tab. 1. The series of nanofillers Nanofil (Nanofil 5, Nanofil 8, Nanofil 9 and Nanofil 3000) were produced by company Südchemie, Germany.

	Melt Flow Index	Density
	[g/10 min]	[g/cm <sup>3</sup> ]
<b>Polyethylene DOWLEX 2035 E</b>	6.0	0.919
<b>Maleated polyethylene AMPLIFY GR 216</b>	1.25	0.916
<b>Polypropylene MOSTEN 52.412</b>	3.2	0.907
<b>Maleated polypropylene EXXELOR 1015</b>	22.0	0.900

Table 1.Characteristic of used polymeric materials

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### 3 PREPARATION OF POLYOLEFIN/CLAY NANOCOMPOSITES

All blends of nanocomposites were prepared by using a screw extruder KO BUSS. The link of extrusion was comprised by screw extruder, which had as the first part the calender; water bath and granulating device. The calender was heated by heating zones. The homogenization and the transport of materials were caused by screw. The conditions of preparation of PE/clay nanocomposites were following: temperatures of heating zones were 110, 150, 160, 170, 190 and 190 °C; the speed of screw was 67 rpm and speed of kneader was 280 rpm. The conditions of PP/clay nanocomposites were following: 155, 1165, 170 and 180 °C; speed of screw was 65 rpm and speed of kneader was 270 rpm.

The desks for study of morphology and mechanical properties were prepared by compression moulding. The temperature of moulding of PE and PP samples were 180°C for 8 min.

The films for barrier properties were prepared on extrusion link. The link comprised from a screw extruder Brabender, extrusion wide slotted head, cooling calender and retracting device. The conditions of extrusion for PE/clay film were following: the temperatures were 110, 150, 160, 170, 190 and 190°C; speed of screw was 40 rpm and speed of retract was 2.8 rpm. The conditions of extrusion for PP/clay film were following: the temperatures were 150, 210, 230, 230, 230 and 230°C; speed of screw was 35 rpm and speed of retract was 3.2 rpm. The thickness of both films was 0.05 mm.

### 4 CHARACTERIZATION OF POLYOLEFIN/CLAY NANOCOMPOSITES

The morphology was evaluated by X-ray diffraction and transmission electron microscopy (TEM). The X-ray diffraction was measured by using diffractometer URD at Tomas Bata University in Zlin, Czech Republic. The reflection mode was 3-30 2 $\theta$  with steep 0.5 s and the stamina was 5 s. TEM pictures were obtained Macromolecular Chemistry AS CR, v.v.i., Prague, Czech Republic. Samples were prepared on ultracryomicrotome LEICA ULTRACUT UTC. Samples were measured by JEM (JOEL) at 100 kV. The mechanical properties were measured on device T 200 Alpha Technologies. The moving clamp was 60 mm and speed of displacement was 25 mm/min. Barrier properties were measured for O<sub>2</sub> and CO<sub>2</sub> according to the norm CSN 64 0115-B at 25°C. The measurement was provided by Institute of Testing and Certification, a.s. Zlin, Czech Republic. The conditions of measurement were following: the temperature/ the relative humidity/ the time were 23°C/45 %/ 48 hours.

### 5 RESULTS AND DISCUSSION

The X-ray diffraction and TEM pictures showed that the level of intercalation of filler was not perfect because the agglomerates of filler are visible from X-ray pattern as a peak. Fig. 1 presented X-ray pattern of a) PE and b) PP nanocomposites.

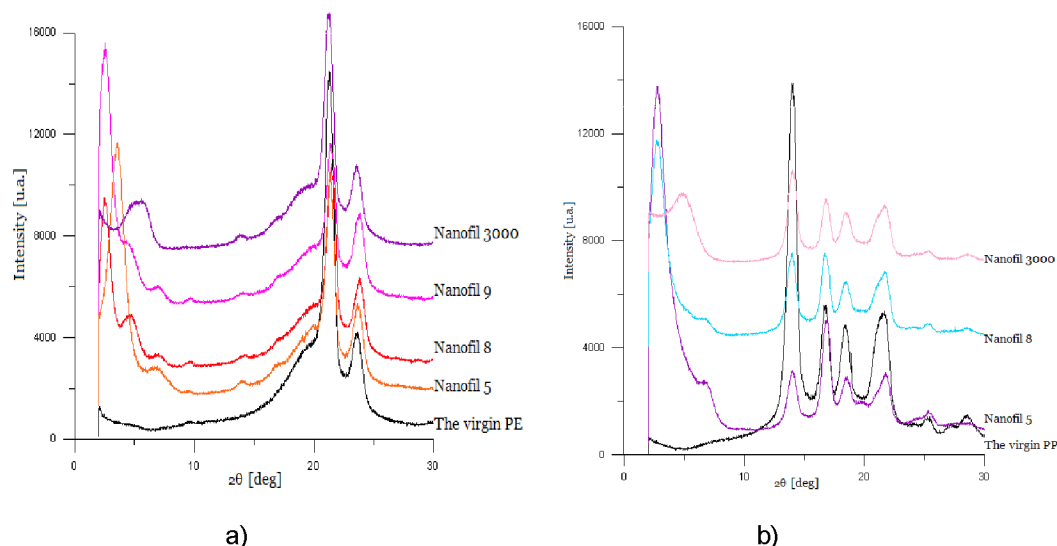


Fig. 1 X-ray pattern of prepared nanocomposites a) PE/3 wt.% of filler, b) PP/3 wt. % of filler

As can be seen from TEM pictures both types of prepared nanocomposites contained agglomerates of fillers (Fig. 2). The situation is the same for both types of polymer matrixes.

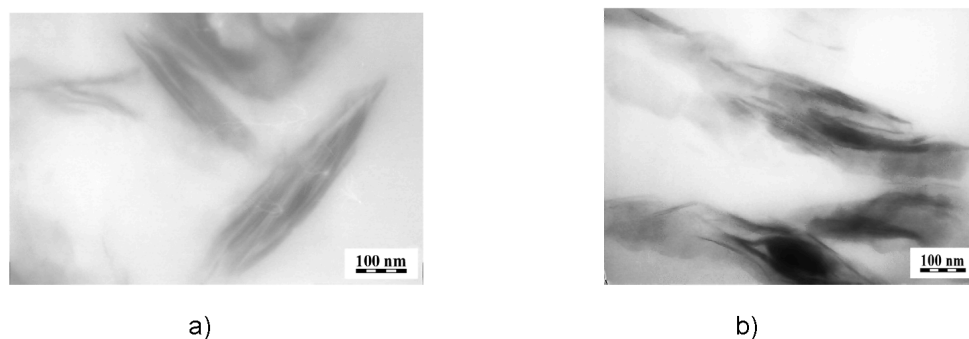


Fig. 2 a) PE matrix contained 5 wt. % of Nanofil 5, b) PP matrix filled by 5 wt. % of Nanofil 5

The Tab. 2 presents results of mechanical and barrier properties of PE/ clay nanocomposites containing 3 wt. % filler. As can be seen, the maximum of tensile strength was measured for PE/ 3 wt. % of Nanofil 9. However, all prepared nanocomposites had lower tensile strength than the virgin PE. The barrier properties of prepared films were better than the virgin polyethylene. The results of barrier properties showed that the dispergation and the intercalation of filler were not perfect.

PE/clay nanocomposites			
	Tensile strength (MPa)	$Q_{O_2}$ ( $m^2 \cdot Pa^{-1} \cdot s^{-1}$ )	$Q_{CO_2}$ ( $m^2 \cdot Pa^{-1} \cdot s^{-1}$ )
<b>The virgin PE</b>	14.725	$2.97 \cdot 10^{-17}$	$9.39 \cdot 10^{-17}$
<b>Nanofil 5</b>	14.196	$5.12 \cdot 10^{-17}$	$1.48 \cdot 10^{-17}$
<b>Nanofil 8</b>	3.393	$5.11 \cdot 10^{-17}$	$1.10 \cdot 10^{-16}$
<b>Nanofil 9</b>	14.828	$8.81 \cdot 10^{-17}$	$1.71 \cdot 10^{-16}$
<b>Nanofil 3000</b>	12.459	$7.72 \cdot 10^{-17}$	$1.68 \cdot 10^{-16}$

Table 2 Properties of PE nanocomposites contained 3 wt. % of filler

## 6 CONCLUSIONS

This work studies and compares two prepared nanocomposites: PE/clay and PP/clay nanocomposites. The results from morphology supported the results of mechanical and barrier properties. PE/clay nanocomposites had lower mechanical and barrier properties in compare with the virgin PE matrix, however, only PE/Nanofil 9 had better mechanical properties than the virgin PE. The different situation was obtained for polypropylene matrix. The mechanical properties of PP/clay nanocomposites are better for both used concentration of filler, only PP filled by Nanofil 8 had very lower mechanical properties in compare with the pure PP. The barrier properties were different too, because some nanocomposites with Nanofil 9 and Nanofil 3000 had lower permeability than the virgin PP.

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