

## Rheological Behavior of Polypropylene/Organoclay Composites

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### INTRODUCTION

Polypropylene/organoclay nanocomposites with a compatibilizer were prepared by melt blending for thin film extrusion applications. The compatibilizers were maleic anhydride grafted polypropylene (PP-g-MA), which has narrow molar mass distribution and polar functional groups along the chain and PP-based wax (PPwax), which has wide molar mass distribution and is a swelling agent for clay. PPwax was chosen to be a new exfoliating agent, alternative to PP-g-MA. The type of compatibilizer and the concentrations of compatibilizer and organoclay were studied for their influence on the melt viscosity and moisture vapor permeation.

The relationship between rheological behavior and degree of exfoliation of organoclay was studied. The processability properties were determined by using a stress controlled rotational rheometer. The moisture permeation through the PP/organoclay thin films was studied by measuring the water vapor permeability.

### MATERIALS AND METHODS

The composites consisted of polypropylene, compatibilizer, and organoclay. The concentration of organoclay and compatibilizer varied and the amount of compatibilizer was subtracted from the polypropylene phase.

A commercial neat polypropylene matrix, HC205TF by Borealis Polymers Ltd., was blended with organomodified clay (Cloisite®15) and a compatibilizer: Maleic anhydride grafted polypropylene (PP-g-MA) from Borealis Polymers (BB125E) and polypropylene wax was from Clariant (TP LICOCENE PP 6102) Fine grain in a laboratory scale co-rotating twin-screw midi extruder (DSM) with a capacity of 16 cm<sup>3</sup> as presented in Table 1.

Dynamic rheological experiments were conducted utilising a stress controlled rotational rheometer (Rheometric Scientific SR-500) on compression-moulded plaques. Frequency sweeps at 210°C were performed following the stress sweeps, which were needed to locate the linear viscoelastic region. The measuring geometry was 25 mm cone and plate with a gap of 45 µm. All the rheological measurements were executed under nitrogen atmosphere.

The water vapor transition rate (WVT) was measured according to standard EN 96 using the desiccant method. The measurements were carried out in a test chamber and the bottom was filled with saturated KCl solution. The solution was stirred continuously. In this way the humidity in the chamber was kept constant at 86% at room temperature (22 °C).

## RESULTS AND DISCUSSION

### Rheological properties

Melt viscosities of the PP/nanoclay composites are plotted in Figure 1. Samples containing PP-g-MA compatibilizer and organoclay showed higher viscosities compared to the neat polypropylene matrix throughout the shear rates. The increase in viscosity is due to the exfoliated nanoclay structure formed with PP-g-MA. In this range of PP-g-MA and clay contents, the viscosity increase is proportional to the amount of additives.

Correspondingly, composites with PPwax compatibilizer exhibit lower viscosities in comparison to neat PP matrix. PPwax has a broad molar mass distribution, and the low molar mass fraction lowers the viscosity. Furthermore, PPwax is not able to exfoliate the clay as well as PP-g-MA but produces mainly only intercalated clay structures. In higher PPwax and clay contents the exfoliation is somewhat improved and there is no further decrease in viscosity despite the added low molecular weight fractions from the increased PPwax quotient.

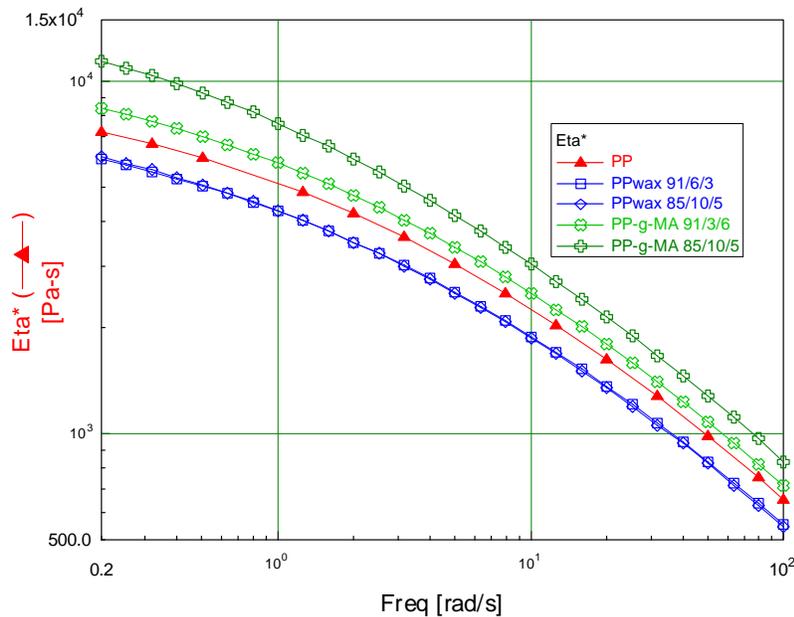


Figure 1. Effect of compatibilizer and clay contents on PP/PP-g-MA/nanoclay and PP/PPwax/nanoclay composites.

### Water vapor permeability

Water vapor diffusion was slower when PP-g-MA was used as compatibilizer than when PPwax was the compatibilizer due to the different nanostructure of the organoclay. Water vapor transition rate and the permeability are presented in Table 1. Exfoliated structure of the organoclay hinders the diffusion of water whereas the

intercalated structure absorbs water. The amount of water weight the PP/PP-g-MA/organoclay samples increased with the concentrations of the compatibilizer and organoclay, whereas the amount of water weight on the PP/PPwax/organoclay samples decreased when the concentrations of the compatibilizer and organoclay increased, as expected.

Table 1. Calculated slopes of the lines ( $\Delta m/\Delta t$ ), water vapor transition rate (WVT), average permeability (P) of the studied PP and PP/organoclay nanocomposites

Sample	Ratio	$\Delta m/\Delta t$ (mg/h)	WVT (mg/h*m <sup>2</sup> )	P (10 <sup>-12</sup> g/Pa*s*m)
PP	100	1.10	210	4.1
+PP-g-MA/organoclay	91/6/3	1.30	240	4.6
+PP-g-MA/organoclay	85/10/5	1.83	340	7.0
+PPwax/organoclay	91/6/3	2.57	490	9.0
+PPwax/organoclay	85/10/5	1.47	280	5.3

#### SUMMARY

- ❖ PP-g-MA enhanced the exfoliation of the organoclay more than PP-based wax.
- ❖ Melt viscosities decreased as the concentration of the organoclay and PP-based wax increased but remained unchanged as the concentration of the organoclay and PP-g-MA increased.
- ❖ Exfoliated organoclay sheets absorbed less moisture than intercalated organoclays

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