Influence of twin-screw extrusion processing conditions on the structure of nanocomposites and characterization by rheometry

T. Domenech, E. Peuvrel-Disdier, B. Vergnes

MINES ParisTech, Centre de Mise en Forme des Matériaux, UMR CNRS 7635

BP 207, 06904 Sophia Antipolis (France)

edith.disdier@mines-paristech.fr; bruno.vergnes@mines-paristech.fr

Nanocomposite materials received a lot of interest in the last years as promising high performance materials. However the fact that produced materials do not meet theoretical expectations makes that their industrial application is still limited. This is due to a lack of understanding of some fundamental questions related to the polymer nanocomposite technology. Despite recent progresses, open questions remain such as the nanofiller/matrix compatibilisation, the control of the filler dispersion of the nanocomposite under thermomechanical solicitations (processing conditions), the relationship between the level of filler dispersion and the mechanical properties. In this presentation, two of these points will be discussed. In a first part, the use of dynamic rheometry to probe the filler dispersion will be discussed. In a second part, the effect of processing parameters on the dispersion state will be investigated.

Nanocomposites are based on organomodified montmorillonite (OMMT) dispersed in an isotactic polypropylene (PP) matrix compatibilized by a polypropylene grafted with maleic anhydride (PP-g-MA). Nanocomposites are obtained using a ThermoFischer PTW24 co-rotating twin-screw extruder, by dilution of a masterbatch into the PP matrix down to the composition 85/10/5 wt% PP/PP-g-MA/OMMT. The effect of different extrusion parameters (feed rate, screw speed, barrel temperature for a fixed extrusion screw profile) on the final dispersion state is investigated. The nanocomposite structure is characterized by X-ray diffraction, scanning and transmission electronic microscopy (SEM and MET) and dynamic rheometry.

Dynamic rheometry is well adapted to probe the microstructure of nanocomposites. Depending on the nanoclay state (from intercalated to fully exfoliated), the rheological behavior lies between a liquid-like and a solid-like one. The solid-like behavior is associated to the presence of a 3D structure where the nanoclay platelets and tactoids form a more or less soft network. The complex viscosity curve of such a material is well fitted by a Carreau-Yasuda law with a yield stress. The yield stress is a good and unique indicator of the exfoliation state [1-2]. We will also see that the microstructure of these materials is not stable and evolves with time [3]. Sample preparation conditions are thus critical in order to properly characterize the microstructure when using the yield stress as a probing parameter to compare nanocomposites prepared in different conditions.

The effect of extrusion parameters such as screw speed, feed rate and barrel temperature on the nanocomposite structure will be examined in a second part. The nanocomposite structure appears to be controlled by the specific mechanical energy up to a critical value. Results will be discussed.

Authors thank Aleksey Drozdov from Danish Technological Institute, Taastrup, Denmark for gently providing the masterbatch. Financial support by the European Commission through project Nanotough-213436 is gratefully acknowledged.

References :

1. W. Lertwimolnun, B. Vergnes, *Polymer*, **46**, 3462 (2005).
2. B. Vergnes, *Intern. Polym. Proc.*, in press (2011).
3. R. Zouari, T. Domenech, B. Vergnes, E. Peuvrel-Disdier, Paper submitted to *J. Rheol.*