

## MAKING ALL-POLYMER FIBRILLAR NANOCOMPOSITES

Kinga Jurczuk<sup>a</sup>, Pawel Michalak<sup>a</sup>, Justyna Krajenta<sup>a</sup>, Andrzej Galeski<sup>a</sup>

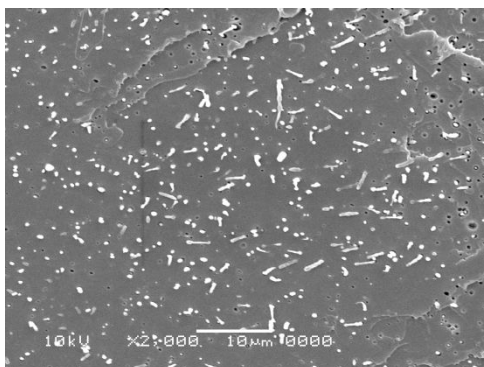
<sup>a</sup>Polymer Physics Department, Centre of Molecular and Macromolecular Studies,  
Polish Academy of Sciences, Sienkiewicza 112, 90-363 Lodz, Poland  
e-mail: kinsow@cbmm.lodz.pl

### ABSTRACT

Formation of all-polymer nanocomposites with nanofibrillar inclusions directly by compounding is a promising alternative to conventionally filled polymers with ready-made polymer fibers. Previously, we have shown that polytetrafluoroethylene (PTFE) nanofibers can be generated in situ by plastic deformation of chain-extended PTFE crystals through shearing during compounding with different thermoplastic polymers [1]. Now, we present how to apply this method to make the all-polymer nanocomposites containing nanofibers of other than PTFE crystalline polymers. For that purpose high density polyethylene powders (HDPE) were obtained either via controlled polymerization (temperature, pressure) or crystallization from dilute solution. HDPE synthesis was performed in toluene in the presence of methyl aluminoxane (MAO) and post-metallocene catalyst, so-called FI catalyst, i.e. fluorinated bis(phenoxy imine) titanium complex at the temperature of 10 °C and pressure of 1 bar under atmosphere of inert gas. Such polymerization conditions enabled to obtain HDPE with chain-extended crystals having melting temperature above 140 °C and degree of crystallinity of about 80 %.

HDPE with largely disentangled chains and chain-folded crystals was also obtained by dissolving HDPE in decalin at 2 % concentration and cooling the solution at the rate of 15 °C/h. The structure, thermal and rheological properties of HDPE powders were characterized by different experimental techniques (e.g. SEM, DSC, WAXS, rotational rheology, etc.). The all-polymer nanocomposites were produced by compounding of those HDPE powders with low density polyethylene (LDPE), atactic polystyrene (PS), and amorphous polylactide (PLA) at various processing conditions (temperature, shear rate, time of compounding) using a conical twin-screw mini-extruder. The compounding temperature was maintained below melting temperature of HDPE crystals. The morphology, thermal, and rheological properties of obtained all-polymer nanocomposites with HDPE nanofibers were examined. An exemplary SEM image of PLA nanocomposite containing 3 wt.% of HDPE nanofibers is presented in Fig.1.

The studies revealed that several factors such as type of HDPE powder, type and viscosity of polymer matrix, as well as shear rate and time of compounding are crucial for efficient deformation of HDPE crystals and affect the final morphology of the materials. If single HDPE crystals are sufficiently large, macromolecules disentangled while the deformation ratios and rates sufficiently large then the HDPE crystals were deformed to thin and strong nanofibers dispersed in the form of entangled network in the matrix of second polymer, which in turns drastically changes rheological and mechanical properties of the nanocomposites.



**Fig. 1:** SEM microphotograph of cryogenic fractured surface of PLA/HDPE/3.

### References

<sup>1</sup>Jurczuk, K.; Galeski, A.; Piorkowska, E. *Polymer* **2013**, 54, 4617.