Development of superparamagnetic nanocomposite: The effect of nanoparticles dispersion and matrix structure on magnetic properties.

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Polymer nanocomposites with response under magnetic field application were obtained by dispersion of magnetic nanoparticles in polymer matrices by extrusion, which is the preferred industrial method for polymer compounding and processing [1]. These nanostructured materials are expected to have a wide application range since the polymer technology allows components fabrications with diverse forms and mechanical properties. Applications in fields of sensors [2], magnetic storage [3], electromagnetic absorption and magnetic yielding [4] are usual. Ferromagnetic nanoparticles are very difficult to process, suffering from problems such as sticking of the particles at metallic components of the mixing machine, and to disperse due to their permanent magnetic moment causing strong particle-particle interactions. Superparamagnetic nanoparticles were used instead having the advantage that the thermal energy and the associated thermal fluctuations of the particles at process conditions supersedes the magnetic interparticle interaction but maintaining closely the high magnetic moment of their ferromagnetic counterparts. The superparamagnetic particles were magnetite, synthesised in a wet-chemical process and concentrated to a slurry to be used in the extrusion process. Two different types of polymer matrices were used: 1) an amorphous thermoplastic elastomer SEBS characterised by cylindrical phase morphology of the polystyrene blocks in the ethylene-co butylene phase and 2) a semicrystalline engineering thermoplastic PPS. The nanocomposites were prepared by melt-extrusion of Fe_3O_4 superparamagnetic nanoparticles with the polymer matrices using a twin-screw microextruder [5].
The nanocomposites were characterized by transmission electron microscopy (TEM) and thermal gravimetric analysis (TGA). Magnetic properties were evaluated by means of hysteresis curves, ZFC/FC curves and AC magnetic susceptibility measurements in superconducting quantum interference device (SQUID) and quantum design physical properties measurement system **(**PPMS**)** magnetometer. Results showed that with a small content of nanoparticles (<1,5wt%) a global magnetic response from the composite is achieved. The dispersion of nanoparticles was found to be affected by the matrix used. Contrary to the expectations, the lowest blocking temperature was obtained with the rigid matrix (PPS, having a Tg of 90°C) instead of the flexible one (SEBS with a Tg of the soft phase of –55°C). This effect is attributed to the cylindrical/micellar structure of SEBS that induces "depletion interaction" between superparamagnetic nanoparticles causing aggregation [6] and will be discussed in more detail. Our findings have general implication on the design of nanoparticles polymer composites and its processing for dedicated purposes.

References:

[1] MR Bockstaller, RA Mickiewicz, EL Thomas, Adv Mater. 17 (2005) 1331-1349.
[2] K Singh, A Ohlan, RK Kotnala, AK Bakhshi, SK Dhawan, Mater.Chem.Phys. 112 (2008) 651-658.
[3] J Jeong, S Shin, S Lee, J Kim, J Magn Magn Mater. 286 (2005) 5-9.

[4] NA Buznikov, IT Iakubov, AL Rakhmanov, AO Sboychakov, J Magn Magn Mater. 293 (2005) 938-946.
[5] G Kickelbick, Progress in Polymer Science. 28 (2003) 83-114.
[6] B Heck, P Arends, M Ganter, J Kressler, B Stuhn, Macromolecules. 30 (1997) 4559-4566.

Figures:

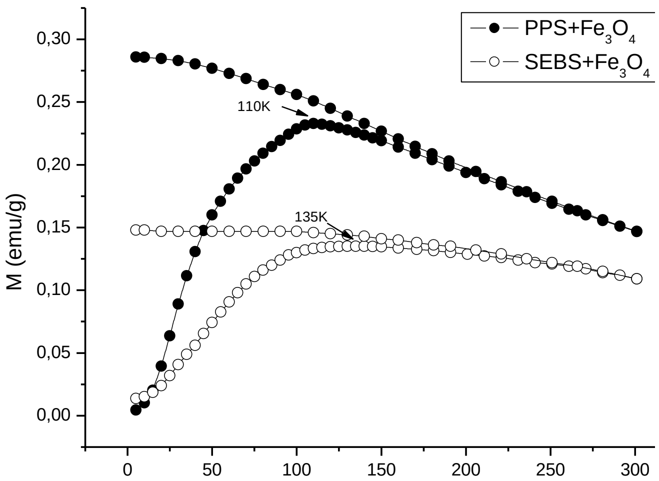
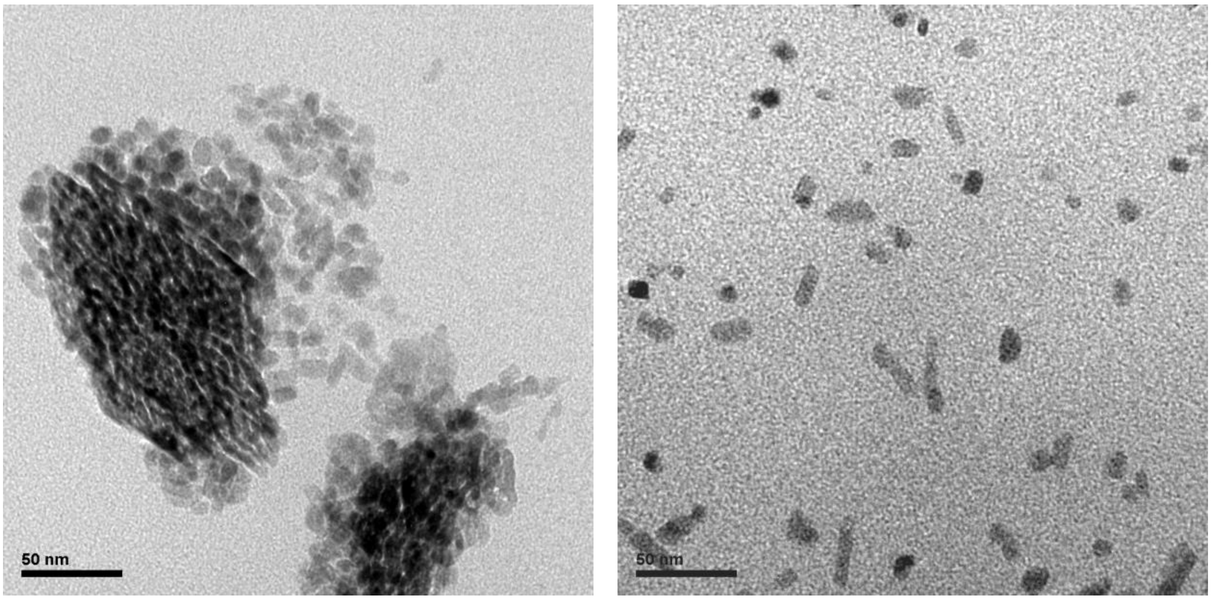


Figure 1. Comparison between the ZFC/FC curves for SEBS+Fe_3O_4 nanocomposite and PPS+Fe_3O_4 nanocomposite.



a **b**

Figure 2. Dispersion analysis by TEM images. a) SEBS+Fe_3O_4 nanocomposite. b) PPS+Fe_3O_4 nanocomposite.