FROM NANOFIBRILS TO SINGLE POLYMER NANOCOMPOSITES

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Introduction

A basic problem in the science and technology of composites is the poor adhesion between matrix and reinforcement arising from their different chemical compositions. This can be improved significantly by the preparation of *single polymer composites* (SPC), as suggested by Capiati *et al.* [1]. Further, Ward *et al.* patented the "hot compaction" technology where only *one constituent* is used [2]. Karger-Kocsis explored the use of polymorphism for the preparation of SPCs from polypropylene (PP) applying the "*two constituent*" approach [e.g. 3]. In the present study attempts to apply these two approaches for the preparation of SPCs, using completely different starting materials as reinforcement, the *polymer nanofibrils,* are undertaken. Such a possibility is offered by, (i) the concept of polymer-polymer nanofibrillar composites, [4] and, (ii) the opportunity to isolate neat nanofibrils through selective dissolution of the second blend component.

Experimental

Materials and Sample Preparation

The neat poly(ethylene terephthalate) (PET) nanofibrils were prepared from textile yarn comprised of filaments of diameter 30 μm manufactured from a PP/PET = 80/20 (by wt) blend [4]. The yarn was then knitted and subjected to extraction by boiling xylene for the removal of the PP. The residue of PET nanofibrils (with diameters of 50-150 nm) is shown on the scanning electron microscope (SEM) micrograph in Fig.1a. They were then sandwiched between two PET films and compression molded at 120°C (the two constituent approach). For the preparation of SPCs using the one constituent approach the neat PET nanofibrils were subjected to hot compaction at 225°C for 5 min, at 35 MPa.

Methods of characterization

An SEM (Philips XL30S instrument) with an acceleration voltage of 5 kV was used for study of the cryofractured (in liquid N_2) surfaces.

An Instron 5567 machine equipped with a load cell interface (model SN-1000N), gauge length of 50 mm and crosshead speed of 7.5 mm/min was used for the tensile testing. The testing was carried out according to ASTM D882 on 15 mm wide strips at room temperature; five specimens were averaged for each sample.

Results and Discussion

In Fig. 1 the SEM micrographs of the starting material and the final SPCs are summarized. It is quite evident that neat PET nanofibrils were isolated, Fig. 1a, from which composite materials were prepared by applying the two typical for SPCs approaches, Fig. 1b and c.

The mechanical tests also confirmed that a composite material has been produced, as suggested by the SEM observations, since a clear reinforcing effect was observed. For the SPCs prepared according to the two constituent approach, Fig. 1b, the improvements of the tensile modulus and the tensile strength are between 40 and 140%.

The next step of this study was to manufacture SPCs *starting from nanofibrils only* following the protocol described above. After the hot compaction a thin (~5 μm) film was produced with a smooth surface and a quite different bulk structure as can be seen in Fig. 1c.

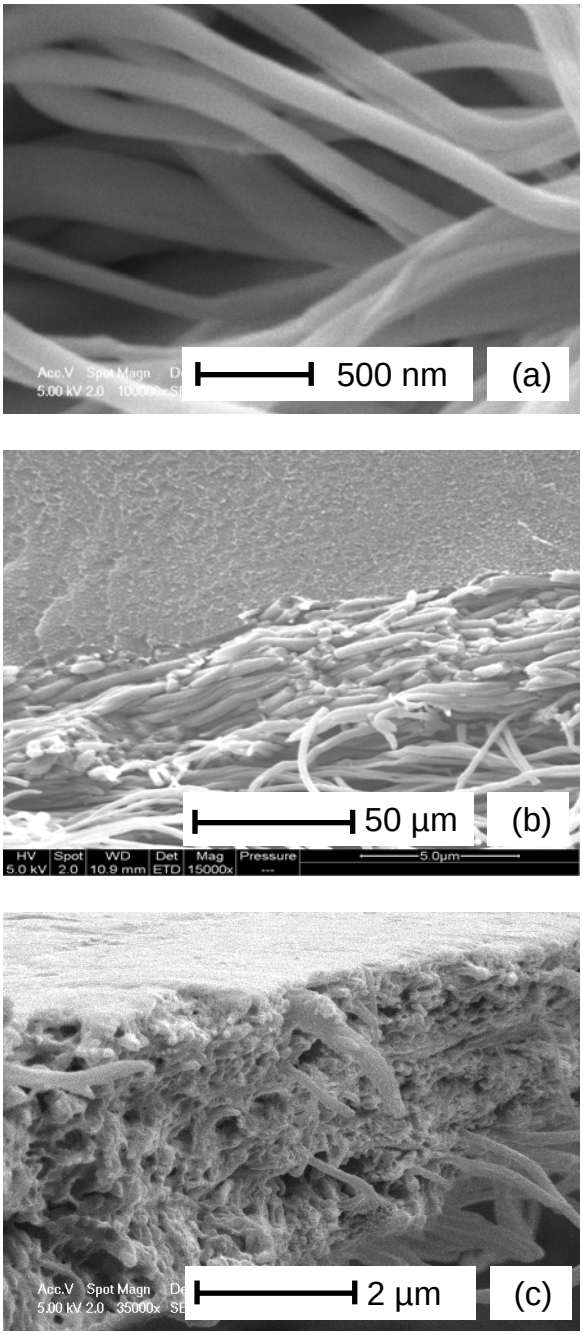

Fig. 1 SEM micrographs of parallel aligned PET nanofibrils prepared from PP/PET = 80/20 (by wt) textile filaments via selective extraction of PP: a) before hot compaction, b) cryofracture of PET nanofibrillar SPC prepared by the two constituent approach, c) the same but prepared by the one constituent approach.

The new PET nanofibrillar SPCs are characterized by an average modulus value of 6.85 GPa and a maximum of 10.57 GPa thus surpassing all previous SPCs based on PET and approaching even the stiffness of the glass fiber reinforced PET composite (with an *E* modulus of 11 GPa for 40 wt% glass [5]). Quite similar is the situation with the tensile strength where improvements of at least 300% are achieved in contrast to all other SPCs found in the literature including the PET/glass fiber composite, for which the improvement is 100 -150% [5].

Conclusion

A technique for the manufacture of nanofibrillar SPCs with superior mechanical properties is suggested. The final nanocomposite was prepared starting from nano-sized material only, a case which seems to be very rare if not unique.

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