Fabrication of structured micro and nanofibers by coaxial electrospinning.

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Electrified coaxial jets [1], with diameters in the micro and nanometric size range, emerging from the tip of electrified conical menisci of two co-flowing liquids, is a consolidated platform for the production of nanofibers with inner structure, in a process so-called coaxial electrospinning or co-electrospinning [2, 3]. In contrast to other multi-step template based procedures, the EHD methodology is much more simple and general since, firstly, a solid template is needless and, secondly, the process is seldom affected by the chemistry of the liquids. This gentle process allows selecting the liquid precursors depending on the application or activity sought for the nanofibers. Here, we review different types of interesting couplings of different materials obtained by this EHD technique: (1) nanofibers of biocompatible polymers encapsulating liquids in the form of beads [4], (2) Nanofibers of hydrophobic polymers encapsulating water (3), spinning nanofibers of alginate and (4) in-fiber encapsulation of active microgels [5].

In (1), we use co-electrospinning of a hydrophilic polymer solution outside and a regular liquid (non polymeric) inside for in-fiber encapsulation. The resulting fibers present beads, filled with the inner liquid, regularly distributed along the fibers; the size of the beads is rather uniform, although might become bi-modal depending on the operating conditions. Both, bead size and bead-to-bead separation can be controlled within a certain range by (mainly) adjusting the flow rates of both fluids through the spinneret. In (2) we use the same approach, but with a hydrophobic polymer to encapsulate water solutions. Aside of encapsulation, this process could also be useful for producing fibers with controlled axial anisotropies (composition) in the micron and submicron regime. Finally in (3), we take advantage of the template effect of the outer liquid, a PVP or a PEO solution in this case, to spin fibers of alginate, a bio-polymer which cannot be drawn into fibers by itself; the coaxial nanofibers of PEO (outside) and alginate (inside) are exposed to the alginate crosslinker which, after dissolving the shell, produces alginate nanofibers. Encapsulating in fibers, particles that may change their dimensions in response to the adequate external stimuli represents an important approach on the researching of new intelligent materials. In (4), these active particles are monodispersed microgels of N-isopropylacrylamide co-polymerized with acrylic acid that can notably change their diameter from ~0.3 to ~2.0 microns, depending on the pH and on the temperature of the liquid phase in which they are suspended.

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[5] I.G. Loscertales et al., Book of abstracts Mat. Res. Soc. Fall Meeting, 2006, Coaxial electrospinning for nanostructured advanced materials.