Photo-Responsive Micro and Nano Helicoidal Fibers Obtained From Cellulose Liquid Crystals

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Helical nano- and microstructures which respond to external stimuli by changes in shape or size present many potential applications in actuators and biologically active materials [1]. Cellulose, along with polypeptides and DNA, belongs to a family of organic molecules that can form cholesteric liquid crystalline (LC) phases, where the direction of preferential molecular alignment rotates in a helical pattern [2]. Recently it was found that helical micro- and nano-helices can be obtained from cellulose liquid crystalline phases by the electrospinning technique (Fig.1) [3]. The twisting is on supramolecular scale, and is similar to what has been seen in other systems such as amyloid (polypeptide) nanofibrils [4] and cellulose from micrasterias denticulate [5]. By using different electrospinning collectors the fibers can be assembled into aligned membranes. We found that those membranes can spontaneously alter their shape and size as can be seen in Fig.1a and b. This motion can be stimulated by heat or light; for white light the response speed was found to be v = 0.06 cm/min, while for the UV light (λ=254 nm) no actuation response was registered. This macroscopic motion, and the underlying fiber contraction, appears to be generated by the rotation of the helical structures at the nano-scale, as presented in Fig.1c and d. The studies of these fibers, carried out by using POM, SEM, AFM and mechanical testing, indicate that the mechanism, which seems to lead to the curling and twisting at the nanoscale, is due to stimulated changes in the intrinsic curvature of fibers which is promoted by the processing conditions of the LC cellulose material. Future applications of these systems will be discussed.

References:

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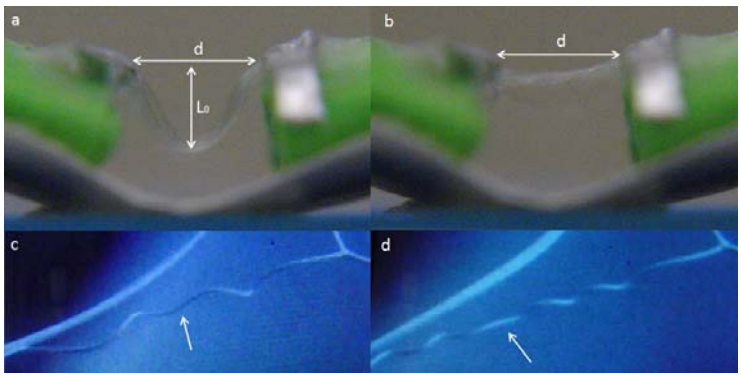

Figure 1 – Cellulose liquid crystalline electrospun materials. (a) and (b) represent the spontaneously membrane shape and size modification induced by light, (b) was recorded 175 min after (a); d = 4 mm. (c) and (d) Scanning electron microscopy (SEM) images; evolution of a microhelical structure. Electron beam irradiation at the arrow-pointed spot (photo (d) was taken 16 s after photo (c))