Electrospun biodegradable polycaprolactone/poly(1,4-butylene adipate-co-polycaprolactam) hybrid scaffold for bone tissue engineering

T S Sampath Kumar* and Rajkamal Balu
Medical Materials Laboratory, Department of Metallurgical & Materials Engineering,
Indian Institute of Technology Madras, Chennai 600 036, India

Statement of Purpose: Polycaprolactone (PCL) is biodegradable polyester approved by US Food and Drug Administration as a compatible polymer with soft and hard tissues. However, limitations exist in using this polymer due to their poor degradation rate and with few cases of inflammation after certain period of time. These limitations may be overcome by forming polymer blends of PCL with other biodegradable polymers. In this work poly(1,4-butylene adipate-co-polycaprolactam) (PBA-PCL) a biodegradable semi-crystalline aliphatic polyester, has been blended with PCL to form a hybrid with improved degradation rate and surface wet ability. The blend has been electrospun to fabricate nanofiber scaffold that can be potentially applied in bone tissue engineering.

Methods: Nanofibers of PCL/PBA-PCL blend were electrospun from a solution containing PCL (15 Wt.%) and PBAPCL (20 Wt.%) using chloroform and 1,1,1,3,3,3-Hexafluoro-2-propanol (HFP) as solvents respectively. Morphology of fibers was observed by scanning electron microscopy (SEM) as well as structure, molecular interactions, thermal characteristics and water contact angle of blend fibers were characterized by X-ray diffraction (XRD), Fourier transform infrared spectroscopy (FT-IR), thermo gravimetric analysis (TGA) and contact angle meter. Enzymatic *in vitro* degradation study was performed for native polymer and blend using enzyme lipase. The blend mat was checked for bioactivity in simulated body fluid conditions and cell viability of blend mat was assayed by direct contact method. Human osteoblast cell culture studies were performed to demonstrate the tissue response to the blend and application of the material in bone tissue engineering.

Results: The PBAPCL solution was not electro spinnable as such. An addition of PCL solution to the ratio of 1:1 v/v to PBAPCL produced narrow distributed fibers (as shown in fig.1). Further increasing or decreasing the volumetric ratio to 3:1 or 1:3 showed widely distributed fibers with beads. The 1:1 hybrid was considered for further characterization.

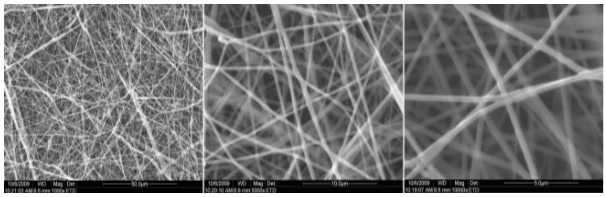

Fig.1. SEM micrograph of hybrid (1:1) fiber mat

The XRD studies showed the crystalline nature of the polymers and blend. The orthorombic crystal form of PCL with (110) and (200) diffraction peaks along with the broad diffraction peaks of semi-crystalline PBA-PCL were observed for the hybrid. FTIR confirmed molecular interaction of the blend with the shift from 600, 1123 and 1731 vibration bands of PBAPCL. The thermal stability of the blend was found to be between that of mother polymers with onset temperature degradation of hybrid less than that of PCL. Enzymatic degradation study with enzyme lipase from *Candida cylindraceae* has indicated a higher degradation rate for fibrous blend fiber than PCL mat as shown in Fig.2. The water contact angle measurements showed higher wetability of hybrid mat (80°) compared to that of PCL (92°).

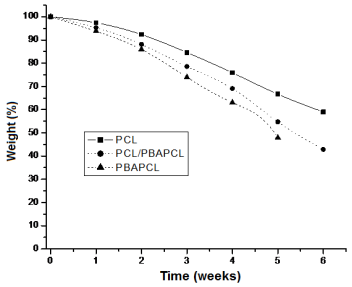

Fig.2. Enzymatic degradation profile of polymer films in phosphate buffer

The blend fiber mat showed to be bioactive with the formation of hydroxyapatite (Ca/P ratio 1.88) after immersion in simulated body fluid (SBF) for 2 weeks. MTT assay using mouse fibroblast L929 showed the hybrid mats to be non-cytotoxic. Cell culture study with osteoblast cell lines showed (Fig.3) the hybrid mats to be a positive scaffold for bone tissue engineering.

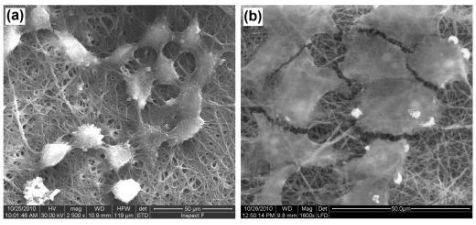

Fig.3. SEM micrograph of osteoblast cell response to hybrid scaffold after (a) 2 days (b) 4 days.

Conclusions: Consistent morphology nanofibers with a diameter of approximately 400 nm were electrospun from PCL/PBA-PCL (1:1) blend. The electrospun hybrid nano fiber mat showed to be a biodegradable and bioactive scaffold with good osteo tissue response and as a promising scaffold for bone tissue engineering.

Acknowledgement: This work is partially supported by Council for Scientific and Industrial Research (CSIR), Govt. of India.