Imprinted nanotextured scaffolds for cell guiding and migration

Binh Duong, Ming Su.
Department of Biomedical Engineering, Worcester Polytechnic Institute, Worcester, MA 01605

Statement of Purpose: The biomimetic design of a cell-material interface is significantly crucial in many biomedical applications, such as engineered tissues,[1] implantable medical devices,[2] and drug-delivery systems.[3] Achieving a proper attachment and alignment of cells on delivery substrate is, therefore, a critical requirement to successful delivery, integration, and therapeutic restoration of function. One of the key factors that contributes greatly to the adhesion, proliferation, migration, differentiation and apoptosis of a cell is surface topography. In efforts to mimic the natural extracellular matrix (ECM) scaffold in tissues, various techniques have been utilized to fabricate micro-nano-topographic surfaces, such as electron beam lithography (EBL),[4] nanocontact printing(nCP),[5] dip-pen nanolithography[6] or nanoimprint lithography(NIL).[7] A common drawback in these methods is the fact that a thin coating of ECM or collagen is required on the generated structures (not biomaterials) in order for cell to adhere. Here, we present a facile method called spin-on nanoprinting (SNAP) to print large area, well-ordered polyacrylonitrile nanostructures, which can highly facilitate cell adhesion and alignment without utilizing ECM coating.

Methods: Preparation of printing medium involves dissolving 8wt% of polyacrylontrile (PAN) in a solvent like dimethylformamide (DMF). This solution is heated at 150°C for 2 hours under constant stirring to partially cyclize (stabilize) PAN. Steps involved in the precursor printing are illustrated in Fig. 1a. The master mold was spin-coated with a thin layer of PAN. The film was then cured at 150°C before transferred onto a substrate. Scanning electron microscopy was employed to characterized imprinted structures and adhesion of cells on the structures. Cytotoxicity, proliferation assays were carried out to evaluate biocompatibility and cell populations on PAN surface in comparison with common petri-dish surface.

Results: As shown in Fig. 1b and c, density and distribution of cells on petri-dish surface and planar PAN film are almost identical. The adhesion and growth of cells on the films were assessed up to 3 days. After 72 hours, the cell population on the planar PAN films were found to be about 85% compared that on the petri-dish surface. Fig. 1d reveals that the cells aligned along the nanoridges. Cytotoxicity assay shown in Fig. 1e confirms that the PAN films are biocompatible with the cell viability are almost the same on both petri-dish surface and PAN films.

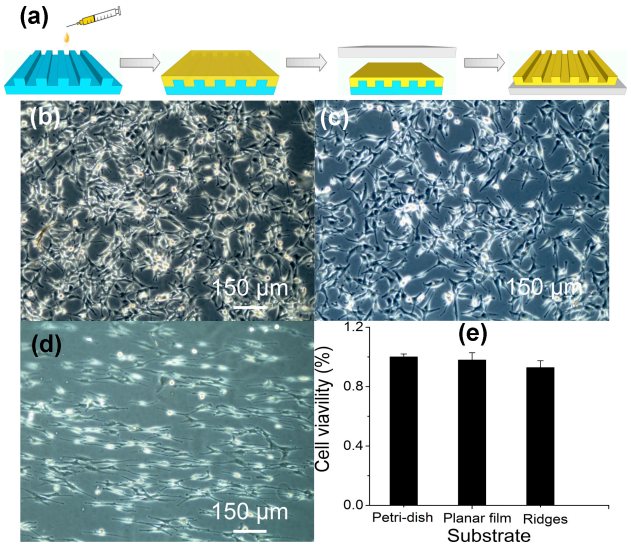

Figure 1. (a) Step involving in printing PAN nanopatterns. (b), (c) and (d) Optical microscope images of cells on petri-dish, planar PAN films and PAN nanoridges, respectively. (d) MTT test on cytotoxicity of PAN film compared to petri-dish surface

Conclusions: We presented a novel method to print highly order nanoridges using spin-on nanoprinting technique. By using this cell-nanostructured platform, cells adhesion and alignment were evaluated. This technique can be a viable technique for the fabrication of nanostructures to study cell guiding and migration for tissue engineering.

References:

1. Hahn, M.S., Adv. Mater. 2006; 18:2679-2684
2.Ingber, D. E. Tissue Eng. 2006; 12:3265-3283
3. Venkatesh, S. Expert Opin. Drug Delivery 2005; 2:1085-1096
4. Lim, J. Y. Tissue Eng. 2007; 13: 1879-1891
5. Lehnert, D. J. Cell Sci. 2004; 117:41-52
6. Lee, K. Science 2002; 295:1702-1705
7. Yim, E. K. Biomaterials 2005; 26:5405-5413