Electrospun Poly (2-Hydroxyethyl Methacrylate) as Non-fouling Scaffolds

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Statement of Purpose:

With the innovative applications of nanotechnology to medicine, the nano-featured synthetic matrix have promising implications in the basic studies of cell biology[1] and in applications for human organ regeneration and medical device design[2]. Well known to prevent protein attachment and cell adhesion[3], poly (2-hydroxyethyl methacrylate) (polyHEMA) serves in multiple biomedical applications, such as contact lens, drug delivery, and dental implants due to its satisfactory biocompatibility. PolyHEMA has been used as a dual-functional biocompatible material of preventing nonspecific protein adsorption and permitting chemical decoration with bio-functional signals. In this work, electrospinning process, a remarkably efficient, rapid and inexpensive approach to produce nanofibrous scaffolds, is used to fabricate non-woven, porous and nanofibrous polyHEMA scaffolds which possess morphological similarity to natural extracellular matrix (ECM) and high surface area to volume ratio and thus are promising candidates of tissue engineering scaffolds.

Methods:

In this work, polyHEMA was prepared by free radical polymerization and subsequently electrospun to generate fibrous scaffolds. Morphology, porosity and fiber diameters were examined by Scanning Electrical Microscope (SEM). Furthermore, electrospun polyHEMA fiber diameter and porosity were adjusted by changing solution concentrations and syringe injection flow rates systematically. To increase the fiber stability in water, electrospun fibers were thermally treated. Fiber stability in water was examined by weight loss measurement. Additionally, FTIR was applied to determine the structural changes before and after electrospun fibers were thermally treated. Fibrinogen adsorption on these fibers was measured by Enzyme-Linked Immunosorbent Assay (ELISA) to test the non-fouling property of the fibrous polyHEMA scaffolds.

Results:

To prepare low-fouling and biocompatible polymeric scaffolds for biomedical applications in nano-scale, the electrospinning approach was applied to fabricate polyHEMA nanofibers. Dynamic viscosities of polyHEMA solutions with different solutions were measured. A linear dependence relation between sample dynamic viscosity and polyHEMA concentration was observed. Confirmed by SEM (Fig.1), the average diameters and porosities of the electrospun fibers can be well controlled by adjusting electrospinning parameters, including solution concentration and syringe injection flow rate. Fiber diameters ranging from 270nm to 1.5μm were realized. The polyHEMA electrospun fiber

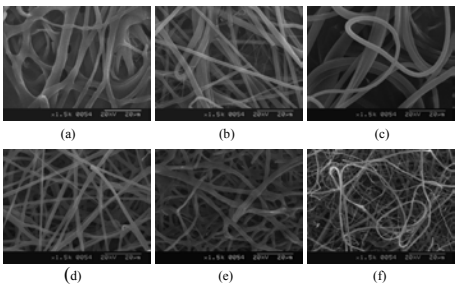

Figure 1 SEM micrographs of polyHEMA electrospun fibers with various polyHEMA syringe injection flow rate: (a) 80 μL/min; (b) 60 μL/min; (c) 40 μL/min; (d) 20 μL/min; (e) 10 μL/min; (f) 3.8 μL/min. Other electrospun parameters were fixed (polyHEMA concentration 15.7 wt. %; needle tip to collector distance 15 cm; high voltage 25 kV)

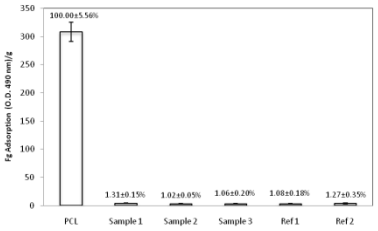

Figure 2 Human plasma fibrinogen adsorption on different fiber samples measured by ELISA, relative adsorption values (mean ± SD %) are shown on the top of each column. Ref 1: no fibrinogen exposed; Ref 2: polyHEMA 15.7 wt. % no fibrinogen and HRP anti-body exposed; Sample 1: polyHEMA 15.7 wt. %; Sample 2: polyHEMA 7.8 wt. %; Sample 3: polyHEMA 5.7 wt. % (66.7 % aqueous ethanol as solvent; other electrospinning parameters were Syringe injection flow rate 20 μL/min, needle tip to collector distance 15 cm, and high voltage 25 kV). Abbreviation: O. D., optical density.

solubility in water was changed considerably before and after thermal treatment procedure. The degree of thermal treatment and fiber water-stability were intimately associated to thermal treatment time. After thermal treatment for 24 h, the electrospun polyHEMA fibers possessed good water-stability, demonstrating that those fibers have a redeeming potential for applications in tissue engineering. ELISA was applied to determine human plasma fibrinogen adsorption on electrospun polyHEMA fibers. It is demonstrated that the electrospun polyHEMA nanofibers were highly resistant to protein adsorption (Fig.2). The low-fouling characteristic of the scaffolds is most possibly attributed to the "water barrier layer"[4] formed by the hydrophilic hydroxyl groups of polyHEMA.

Conclusions:

In our work, polyHEMA was electrospun into fiber forms successfully. The morphology and average fiber diameter were well controlled by systematically adjusting polyHEMA concentration and syringe injection flow rate. Fiber diameters ranging from 270nm to 1.5μm were realized. Most importantly, the electrospun polyHEMA scaffolds were highly resistant to human plasma fibrinogen adsorption, thus can serve as desirable scaffold materials for tissue engineering applications where low biofouling is required.

References:

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