Aspirin-loaded poly (ethylene terephthalate)/carbon nanotubes nanofibers used for vascular engineering applications potentially

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ABSTRACT

Deficient cell proliferation on vascular grafts can cause coronary thrombosis and despite all recent innovations in vascular tissue engineering, fabricating novel materials with superior hemocompatibility remains a challenge. In this work, poly (ethylene terephthalate) (PET)/carboxylated multi-walled carbon nanotubes (CMWCNT) nanofibers were prepared via electrospinning. The results showed that the optimum value of CMWCNT content was 1% which in turn the average diameter of nanofibers, electrical conductivity and water contact angle were obtained 188 nm, 4.47×10^{-9}, and 120º, respectively. To assess the hemocompatibility of the PET/CMWCNT1% nanofibers, aspirin (2 wt. % per polymer weight) as an anticoagulant drug was used and outcomes revealed that the blood platelets adhesion spreading was less than that of sample without the drug.

INTRODUCTION

Nowadays, electrospun polymeric nanofibers have received a great deal of attention for vascular tissue engineering uses. Despite a series of merits for these scaffolds such as great mechanical strength and tunable properties, there is one major demerit which is blood coagulation. Many reports have been published to offer ways of overcoming this shortcoming.[1]

In this regard, various natural and synthetic polymers are used as scaffolds in vascular tissue engineering, which one of them is poly(ethylene terephthalate) (PET). This polymer is a semi-crystalline polyester with relatively low density, biodegradable, good solubility, cost-effective, and high mechanical properties. As a result, it has been considered for the construction of tissue-engineered blood vessels. Thanks to the mentioned benefits, nanofibrous PET have been used in many researches and their properties have been studied. Pezzoli et al. [2] showed that electrospun PET could be a promising material for small caliber vascular graft applications owing to its mechanical properties, biocompatibility, and nanofibrous structure that mimic the morphology of natural extracellular matrix. Carboxylated multi-walled carbon nanotubes (CMWCNTs) are also proved to be a great candidate for improving conductivity and hydrophilicity of nanofibrous polymers and as a result, improving their hemocompatibility. [3] Aspirin (ASA), which is the most frequently used antiplatelet drug for stroke prevention, is also proved to decrease platelet adhesion in vascular scaffolds.[4]

This study aims to investigate the effect of CMWCNT on physical and hemocompatibility properties of electrospun PET scaffolds. In this regard, ASA is also employed as an anticoagulant drug to evaluate drug release in samples with and without the nanotubes besides the hemocompatibility.

MATERIALS & METHODS

PET (weight average molecular weight of 24000 Da) was supplied from Shahid Tondgooyan Petrochemical Co., (Iran). ASA was purchased from Temad Co. (Iran). Dichloromethane (DCM) and trifluoroacetic acid (TFA) were provided from Merck (Germany).

To prepare PET nanofibers, a mixture of 1: 1 by volume of DCM and TFA was used as a solvent and a predetermined amount of PET was added to 10 mL of the solvent, and stirred at room temperature for 40 min until a polymer solution with concentration of 10 wt. % was attained. In the following, a specific amount of CMWCNTs (10 mg) were inserted in TFA (5 mL) and ultrasound for 10 min and then PET granules with concentration mentioned above was added to the CMWCNTs solution. The mixture was stirred for 24 h and DCM (5 mL) was gradually added to the solution until a homogenous solution was obtained for electrospinning process. To prepare ASA-loaded PET nanofibrous sample, 20 mg of the drug powder were weighed and added to the PET/CMWCNT solution prepared earlier. The operation conditions of the electrospinning device (model eSpinner NF-CO EN/II, Asian Nanostructures Technology Co., Tehran, Iran) for the preparation of the samples were as follows: the applied voltage of15 kV, the distance between the syringe needle and the collector of 15 cm and the solution flow rate of 0.8 mL/h, eventually the samples were collected on sterile aluminum foils.

– Morphological studies

To observe the morphology of PET, and PET/CMWCNTs nanofibers, a scanning electron microscopy (SEM, AIS 2100, Ser4on technologies, South Korea) was utilized with 300000 X magnification.

– Electrical conductivity

An electrometer (610 Solid state, Keithley Instruments Co., OH, United States) with a wide range of resistances from 100 to 10^{14} Ω was employed to measure the electrical conductivity of the PET and PET/CMWCNT nanofibrous samples with a two-point probe.

– Water contact angle measurements

To measure the hydrophilicity of the PET nanofibers in presence and absence of CMWCNTs, they were cut in dimensions of 2×2 cm, and the water contact angle was measured by using a goniometer (Model G10, Kruss Inc., Germany). For each sample, 3 measurements were done and the average was reported.

– Hemocompatibility assessments

In view of platelet adhesion, the hecocompatibility of the nanofibrous samples including PET/ASA and PET/ASA/CMWCNTs was evaluated. The protocol used for this test was reported by Jaganathan and co-workers. [5]

RESULTS

– Morphological studies

Figure 1 (a, b) show that the sample containing 10% PET and 1% CMWCNT is the optimal sample. These fibers have a narrow diameter distribution and are entirely smooth and without any bead.

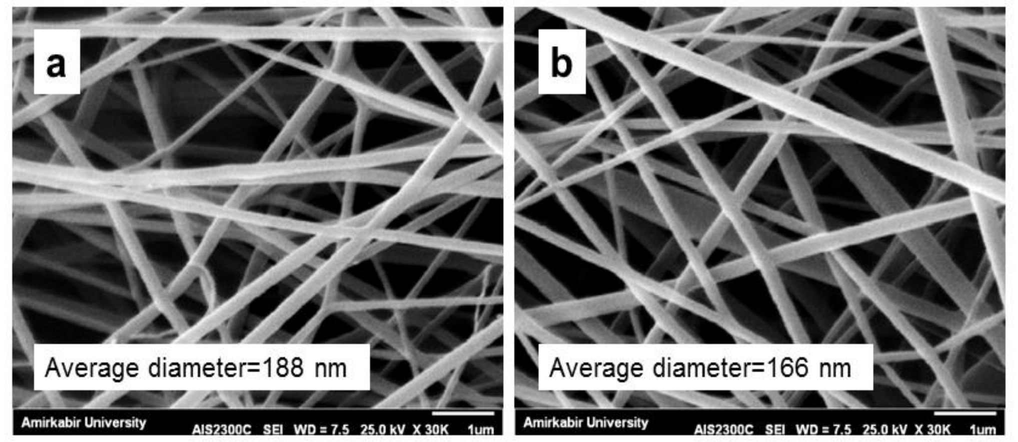

Figure 1. SEM images of a) PET and b) PET/CMWCNT nanofibers

– Conductivity and water contact angle measurements

Conductivity and contact angle tests were performed to investigate the effect of nanoparticles on these properties and results are shown in Table 1. It was observed that the addition of carbon nanotubes has a significant effect on increasing the conductivity of the polymer film; Carbon nanotubes, thanks to their high aspect ratio, can connect and form a conductive network quickly. Also, the contact angle test results indicate the positive effect of nanoparticles in increasing the hydrophilicity of the sample.

Table 1. Conductivity and water contact angle measurements results

	PET	PET/CMWCNT
Conductivity (S/cm)	3.45×10^{-16}	4.47×10^{-9}
Water contact angle (º)	136	120

– Hemocompatibility analyses

The SEM images of the platelet adhesion test (Figure 2) show that blood platelets activated in contact with PET have maintained their spherical shape in the presence of ASA and CMWCNTs, which indicated a decrease in adhesion in these scaffolds.

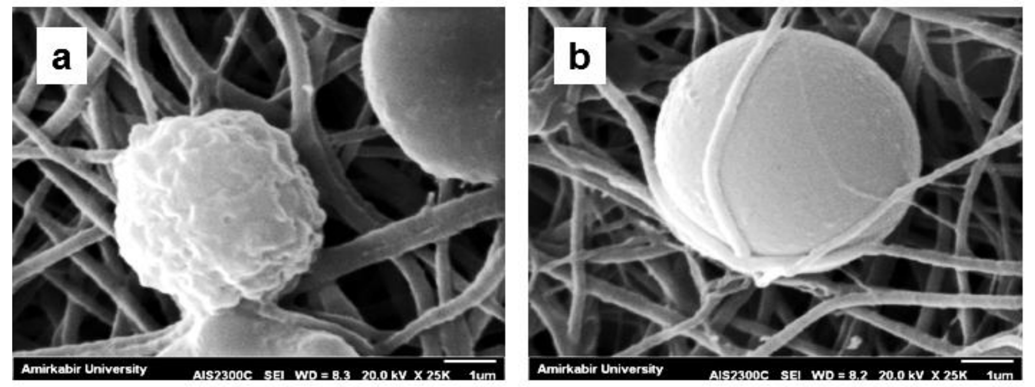

Figure 2. Platelet adhesion onto the surface of a) PET+ASA and b) PET/CMWCNT+ASA nanofibers

CONCLUSIONS

In this effort, nanofibers containing 10% of PET and 1% of CMWCNT and 2% of ASA were prepared, and different properties were measured. The results obtained from this study showed that nanofibers containing CMWCNTs had higher conductivity and hydrophilicity compared to neat PET nanofibers. The addition of CMWCNT also made these nanofibers more blood compatible and reduced platelet adhesion in contact with them.

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