Oral Presentation

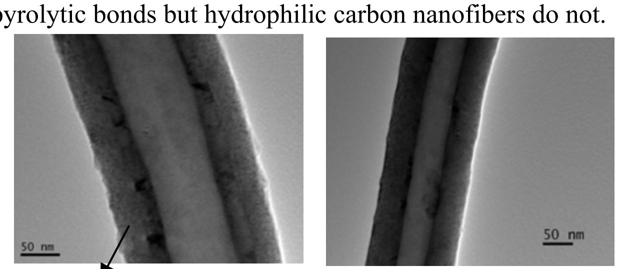
The Study of Different Carbon Nanofiber Surface Energy on Macrophage Functions

Young Wook Chun and Thomas J. Webster
Division of Engineering and Orthopaedics, Brown University, Providence, RI02917

Statement of Purpose: Purified carbon nanotubes or nanofibers (with toxic catalytic particles removed) have been considered as novel materials for drug delivery applications and for generating artificial organs more efficiently due to their unique surface features. Traditionally, the surface chemistry of carbon nanotubes has been modified through various functionalization strategies to increase biocompatibility. Importantly, modulating the intrinsic material surface energy of carbon nanotubes or nanofibers (without functionalization, thus, establishing permanent, non degradable chemical and physical surface properties) can potentially reduce an immune response mediated by macrophages. Herein, preliminary results of the characterization of different surface energy carbon nanofibers on macrophage functions while keeping their nanoscale surface roughness is reported.

Methods: All carbon nanofibers (hydrophobic and hydrophilic) obtained from Applied Sciences, Inc. (Cedarville, OH) were cleaned by deionized water. While hydrophobic carbon nanofibers were dissolved by chloroform and sonicated, hydrophilic carbon nanofibers were soluble in ethanol and were also sonicated for better dispersion. Hydrophobic carbon nanofibers were placed on glass discs, but polyurethane was used to enhance the attachment of hydrophilic carbon nanofibers before placing hydrophilic carbon nanofibers on glass discs. TIB186 macrophages (ATCC) were used since they generally are present 24 hours after bone implantation [1]. Proliferation test with TIB186 macrophages were conducted after a 48 hour initial seeding in RPMI (recommended by manufacturer). Glass was used as a control.

Results: TEM images showed the difference between hydrophobic and hydrophilic carbon nanofibers (Fig. 1a and 1b, respectively). Hydrophobic carbon nanofibers have outer layers composed of hydrocarbons such as pyrolytic bonds but hydrophilic carbon nanofibers do not.

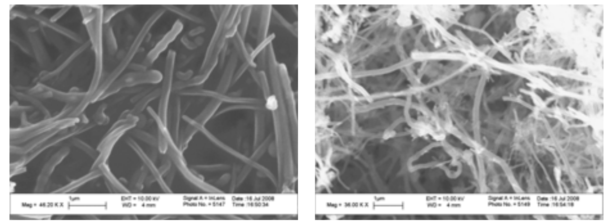


Outer layer

(a) Hydrophobic (b) Hydrophilic

Fig 1. TEM images of (a) hydrophobic and (b) hydrophilic carbon nanofibers with deionized water.

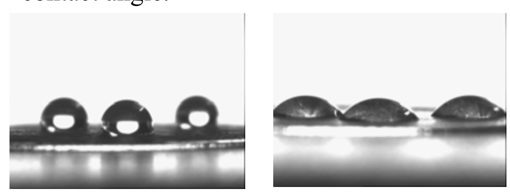
However, the films of those carbon nanofibers did not have different surface roughness or features at the nanoscale according to SEM images (Fig. 2a and 2b). As expected, there is a difference in contact angle analysis between hydrophobic (Fig. 3a) and hydrophilic carbon nanofibers (Fig. 3b). This is due to the existence of the outer layers of hydrophobic carbon nanofibers.



(a) Hydrophobic (b) Hydrophilic

Fig. 2. SEM images of (a) hydrophobic carbon nanofibers and (b) hydrophilic carbon nanofibers.

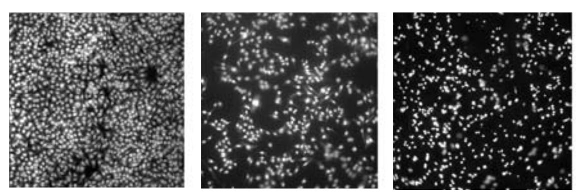
Specifically, hydrophobic carbon nanofibers had a 130° contact angle while hydrophilic carbon nanofibers had a 60° contact angle.



(a) Hydrophobic (b) Hydrophilic

Fig. 3. Contact angle images of (a) hydrophobic and (b) hydrophilic carbon nanofibers.

Macrophage density on these carbon nanofibers was determined after 48 hours (Fig. 4). The density of macrophages on hydrophobic carbon nanofibers was higher than that on hydrophilic carbon nanofibers.



(a) Glass (b) Hydrophobic (c) Hydrophilic

Fig. 4. Macrophage density on (a) glass (control), (b) hydrophobic carbon nanofibers and (c) hydrophilic carbon nanofibers.

Conclusions: This study demonstrated that carbon nanofiber surface energy mediated macrophages responses differently. Such results continue to provide promise for the use of hydrophilic carbon nanofibers as implantable devices.

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Reference: [1] Luciana P *et al*. Titanium particles and surface-bound LPS activate different pathways in IC-21 macrophges. 2006. *J Biomed Mater Res* Part B: Appl Biomater 79B:66-73