

Development of Separation Devices/Media for Biomolecule Separations

The current projects involve developing separation devices/media for nanometer scale separations. New types of separation devices are needed to provide greater selectivity and efficiency of biomolecule separations.

Magnetic Nanoparticles

Magnetite nanoparticles are synthesized by using iron (II) chloride tetrahydrate and iron (III) chloride hexahydrate in a 1:2 (mass/mass) ratio. In order to synthesize the magnetite nanoparticles without aggregation, a microemulsion method is being developed using dioctyl sulfosuccinate sodium salt (AOT) to act as a reverse micelle to encapsulate and allow non-aggregated magnetite nanoparticles to be coated (Fig. 1).

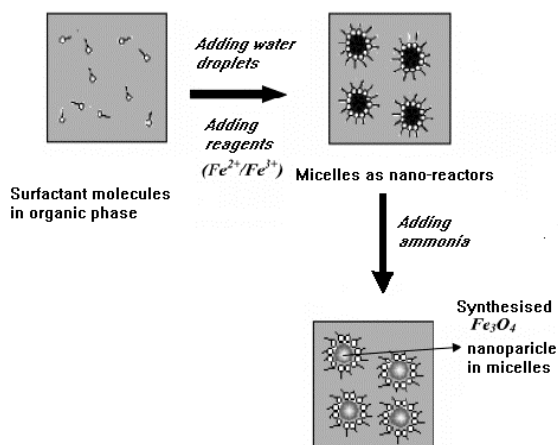


Figure 1. Schematic of Magnetite Formation

To ensure that the particles do not aggregate after synthesis, a silica surface coating, 3-aminopropyltrimethoxysilane (APTMS), is used. The amine group can be further reacted to attach biomaterial to the surface of the magnetite. We intend to attach biotin in order to study the Biotin/Streptavidin complex interaction, as described in the schematic of the surface modification in Figure 2.

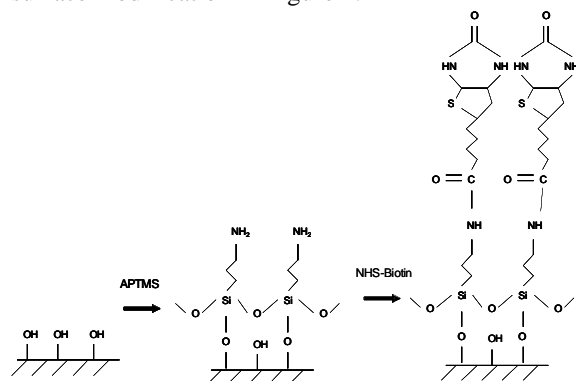


Figure 2. Schematic of surface modification

The synthesized particles displayed magnetic properties when an external magnet was applied and the particles were well dispersed in water (Fig. 3) with an average diameter of 26nm.

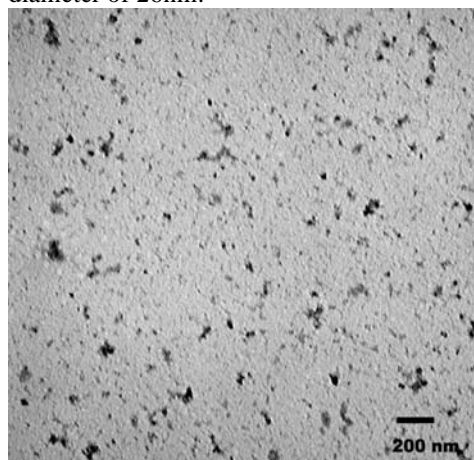


Figure 3. TEM image of the APTMS-coated magnetite particles.

Efforts are currently being made to pack these particles into a microcolumn.

Development of a Quartz Microfluidic Separation Device

The goal is to fabricate a quartz microfluidic device for the separation of biomolecules. Microchannels are currently being fabricated via laser ablation. The channels (Fig. 4) present a surface roughness, so coating procedures are being developed.

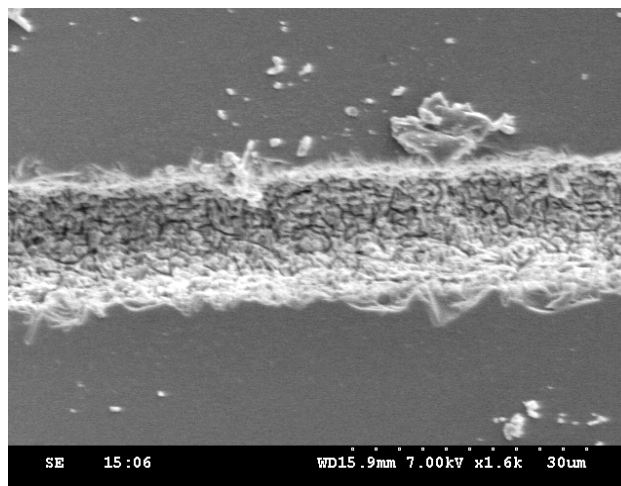


Figure 4. SEM image of the channel fabricated via laser ablation.

Coring of a Microchannel using SU8

A specific microfluidic channel design is used to create the cored channel. By using two materials with different viscosities, a cored channel is created. The coring fluid is silicone oil and the fluid that is cored is SU8. Various flow rates are used to optimize the shape of the cored channel and the cross sectional dimensions of the cored SU8. Figure 5 shows an SEM of the cross section of a cored channel. By using SU8, the cored channel is easily crosslinked using UV radiation, so the coring will remain. The advantage of the SU8 cored channel is that after crosslinking, the channel is resistant to most acids and bases used. Further studies on the size of the cross section based on flow rate are underway, and the devices will be used to separate biomolecules.

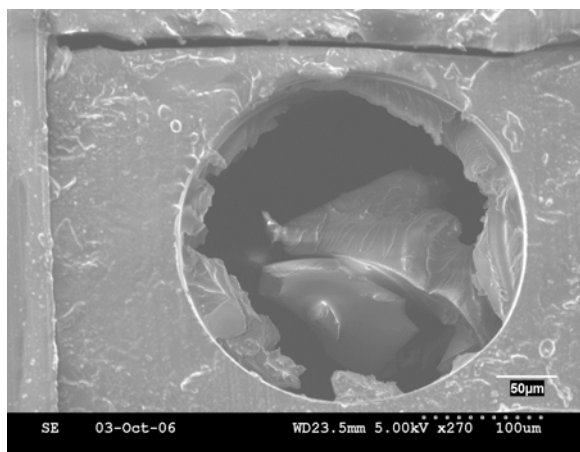


Figure 5. SEM image of an SU8 cored channel.

Development of Electrospun Carbon Micro/Nanofibers

Carbon nanofibers are fabricated by electrospinning a negative photoresist material (SU8). The electrospun fibers have diameters ranging from 300 nm to 1 μm, based upon the electrospinning parameters. An example of the fibers is shown Figure 6. To create the carbon nanofibers from SU8, a piece of silicon is used as the collector plate. After the fibers are spun, the silicon piece is transferred to a tube furnace for pyrolysis. The fibers are processed by flowing a forming gas mixture over the sample for the duration of the pyrolysis. The temperature processing range is 200-1000 °C, and the optimum pyrolysis conditions for the electrospun SU8 fibers are currently under study.

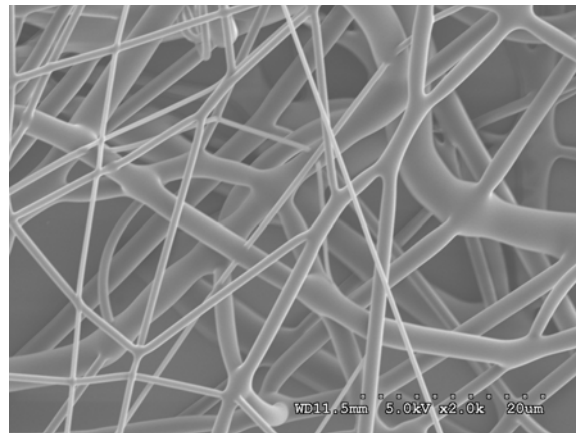


Figure 6. Electrospun SU8 fibers.

Publications:

1. Hae Woon Choi, Burr Zimmerman, Jeremy Steach, Susan Olesik, Jeffrey Chalmers, Jim Lee, David Farson, "Femtosecond laser micromachining of dielectric materials for biomedical applications", *Journal of Micromechanics and Microengineering*, accepted.
2. Jeremy Steach and Susan Olesik, "Electrospinning and Pyrolysis of SU8 Negative Photoresist," *Polymer*, submitted.