Fabrication of Functional Conductive Nanofibers composed of $\alpha,\omega$-bi-DNP-poly(2-methoxystyrene), polystyrene including single walled carbon nanotubes for studying material-cell interactions and Gold Nanoparticle/Synthetic Functional Polymer Nanofibers for Nanobiosensors

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Objectives

• Electrospinning of electro-active functionalized nanofibers and determination of their binding capacity with IgE

• Characterization of electrospun nanofibers made up of PVA and AuNPs
Introduction
Nanofibers and their uses

• Air filtration systems.
• Catalysts – surface for enzymes to be immobilized on
• In medicine for artificial organ components, tissue engineering, implant materials, drug delivery, wound dressing, medical textile materials...
• Textile manufacturing (potentially producing non-woven garments via fiber electrospinning)
Introduction cont’d

• Composites- potential for manufacture of long fiber composites

• Application limited by quantity due to inability to make large amount of products in reasonable time

• Cost effective way to make wound dressings, medical implants and scaffolds for human tissues
What is nanotechnology?

- This is the understanding and manipulation of matter on an atomic and molecular scale.
- Dimensions between 1 and 100 nanometers.
- Unusual physical, chemical and biological properties emerge at the nanoscale.
Examples of Nanomaterials

Buckyball (spherical fullerene) and Carbon nanotubes
What is a polymer?

- Giant macromolecule composed of several repeating structural units
- Typical connection is by covalent bonds
- It is naturally occurring, and mostly synthetic
Formation of Polystyrene

many styrene \rightarrow \text{polymerization} \rightarrow \text{polystyrene}
Experimental

Synthesis of $\alpha,\omega$ bi[2,4 DNP-caproic][poly(ethylene oxide)-b-poly(2-methoxystyrene)-b-poly(ethylene oxide)]

CDNP-PEO-P2MS-PEO-CDNP

(hence referred to as P2MS)
Synthesis of Gold nanoparticles

• Liquid-Liquid interface
• One-step method

One-step method involves:

Tween-80 + KAuCl4 → Gold nanoparticles
Preparation of Polymer Composite A.

- DNP-functionalized block co-polymer + PS + SWNT in organic solvent gives composite
- Polymers have different composition:
  1:1 P2MS to PS (20 wt%)
  1:2 P2MS to PS (10:20 wt%)
  2:1 P2MS to PS (20:10 wt%)
  1 wt% SWCNTs was used

Solvents used: Chlorobenzene and DMF
Preparation of Polymer Composite B.

- PVA + AuNPs in ethanol gives polymer composite
- Mixture stirred and heated at 40 degrees celcius
Set Up for Electrospinning

Electrospinning Process

Solution properties
- Concentration/viscosity
- Dielectric properties
- Surface tension

Controlled variables
- Voltage/electric field/jet charge density
- Hydrostatic pressure in the capillary
- Tip-to-collector distance
- Feed rate

Ambient parameters
- Temperature
- Humidity
- Air velocity

KD Scientific Infusion Syringe Pump KDS 100
Trek Model 664 Component High Voltage Amplifier/Supply System
Electrospinning Set Up for Aligned Fibers
RESULTS

Optical Microscope Images

P2MS/PS/CNT nanofibers 1:1 in DMF X500

P2MS/PS/CNT fibers 1:1 in DMF X1000
RESULTS cont’d

Optical Microscope Images

P2MS/PS/CNT nanofibers 1:1 in C6H5Cl X 200

P2MS/PS/CNT nanofibers 1:1 in C6H5Cl X 1000
Optical Microscope Images

P2MS/PS/CNT nanofibers 1:2 in DMF X 100

P2MS/PS/CNT nanofibers in DMF X 500
Optical Microscope Images

P2MS/PS/CNT nanofibers 1:2 in C6H5Cl X 200

P2MS/PS/CNT nanofibers 1:2 in C6H5Cl X 1000
Optical Microscope Images – control for experiment

Non-functionalized polymer composite

Non-functionalized polymer composite
SEM Images

Functionalized nanofibers at \( X \ 1500 \)

Functionalized nanofibers showing bead on a string structure
Binding Studies with FITC-IgE

Nanofibers electrospun in C6H5Cl

Nanofibers electrospun in DMF
TEM Images

AuNPs/Interface synthesis

PVA/AuNPs Composite
U-Vis: Time evolution of the Absorbance peak of Au nano-clusters/nano-particles during the chemical reaction

Time evolution of the refractive index
SEM Images

21 wt% PVA w/0.05mM AuNPs at 17.5kV for 30 mins. ITO/Plastic

21 wt% PVA w/0.05mM AuNPs at 17.5kV for 30 mins on Aluminum
AFM Images

DNP functionalized nanofibers in C6H5Cl

Profile of the same nanofibers
AFM Images

3-D view

Image of nanofiber spun in DMF. Note the close resemblance to human hair.
Discussion

• Molecular weight
• Viscosity
• Flow rate
• Working Distance
• Voltage
Conclusion

• Successful binding of polymer to IgE—an indication of use in biological applications

• Synthesis of AuNPs was achieved and its composite with PVA was electrospun on different substrates (FTO glass, ITO/plastic glass, Aluminum, etc)
Future Work

Electrical Conductivity Measurement of

1. Free nanowires

2. Nanofibers bound to anti-DNP IgE

Alignment of nanofibers during electrospinning
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Acknowledgement

- The authors gratefully acknowledge the support of the studies by NIH/NIGMS MBRS/RISE Grant # 5R25G0M60414, Nanobiotechnology Center (NBTC) at Cornell University, an STC program of NSF under agreement No. ECS-9876771 and NSF HRD-0630456
- Bakari Hassan of Morehouse College
- Jereme Doss – Ph.D Candidate, Clark Atlanta University
- Ian Stubbs
- Kierra Wright