AC 2012-5007: FROM MACROMOLECULE TO NANOFIBER: ELECTRO-SPINNING JUST THE TECHNIQUE FOR THE JOB

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Sonja Turner was a middle/high school science teacher for about 17 years. She is a graduate of Bennett College in Greensboro, N.C., where she completed her bachelor's in biology. She has attended many science education workshops and completed 12 hours of graduate level science courses. After being selected as a candidate to participate in the NSF-ERC Research Experience for Teachers Program on the campus of North Carolina A&T State University, she decided to enroll in graduate school full-time in the area of bioengineering. After completing her degree, it is her intent to help young people explore and develop a love for and a joy of exploring science.

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From Macromolecule to Nanofiber: Electrospinning Just the Technique for the Job

Abstract: Introducing middle/ high school-aged students to STEM based education can be very challenging for teachers in today's classrooms. Finding ways to bridge the gaps in knowledge between science, technology, engineering, and math is a desire most teachers have. Using unique ways to introduce information to their students through labs, and demonstrations, is a task providing teachers the opportunity to utilize their creativity. This demonstration is an example of ways in which teachers assists their students in making connections between advances in STEM and everyday life activities. This demonstration will also help students understand the importance of the collaboration between different disciplines. The technique discussed in this paper is one that is utilized by scientists and engineers to design new materials with new functionality that assists doctors in repairing tissue in the human body.

One particular macromolecule selected for this demonstration which grabs the eyes of youth and adults everywhere is sugar, also known as glucose. When this particular macromolecule is transformed into a fiber like material, called "cotton candy", there is a twinkle in the eyes of carnival goers everywhere. How is this macromolecule transformed into a stringy fibrous material that appears like a well spun spider web? Furthermore what does this have to do with engineers, scientists, and students' grades 6th-12th? Scientists have discovered that in order for these macromolecules to be used, and beneficial, they must be transformed into very small building blocks that go beyond the vision of the naked eye as well as what is viewed by using a light microscope. These polymers must be transformed to Nano (10^{-9} m) scale sized architecture in order for live cells to communicate. This communication can be very beneficial to all involved. The understanding of this concept and its benefits can have a profound effect on STEM education.

Objectives: To expose middle school and high school students to different techniques used by scientists, researchers, bioengineers and engineers that assist doctors and with cutting edge applications used in tissue regeneration, bone repair, and the coating of materials used human body repair. To help students understand the importance of different disciplines working together.

Macromolecules are very important to the existence of organisms. What are the benefits of using large molecule to produce fibers that measure on the Nano scale? This paper will describe how the transformation of a macromolecule can have profound benefits to living organisms and will serve to provide a visual example of the transformation of a macromolecule into a fibrous material.

Macromolecules assist living organisms with activities such as transformation of matter and energy into different forms, displaying responses to their environment, and displaying growth and reproduction. These activities and changes are dependent upon four main macromolecules: carbohydrates, lipids, proteins, and nucleic acids. Carbohydrates are the macromolecules that will be discussed in this paper.

The base elements of carbohydrates are Carbon(C), Hydrogen (H) and Oxygen (O). In carbohydrates, monomer units form monosaccharides or simple sugars. Monomers are single unit smaller, organic molecules. When two of these monosaccharides are linked by covalent bonds, a disaccharide is created. When several monosaccharides are bonded together a polysaccharide, or complex sugar, is created. Polysaccharides are the polymers of carbohydrates.

The processes living organisms perform require carbohydrates. These processes are naturally occurring and continuously happen as long as conditions are properly in place. These processes provide great benefits to living organisms. Due to extreme conditions and situations, damage and disruption to these processes can occur. When this disruption and damage occurs, scientists have explored methods that have proven to be beneficial and provide excellent treatment.

Scientists have found that using macromolecules to produce fibrous materials that measure on the Nano scale have great benefits for the human body. There are many organic and inorganic polymers that are beneficial to science and medicine. Glucose (sugar), proteins, cellulose, collagen, chitosan are just a few. These polymers, once turned into Nano fibers can assist in the healing of large burns and abrasions, transportation and release of drugs to tumors, the coating of screws used in healing broken bones, and the regeneration of tissue for the purpose of healing cartilage, blood vessels, lung tissue, and heart tissue.

The technique used to turn these macromolecules into Nano fibers is called electro spinning. Electro spinning is a highly versatile method used to process polymers into continuous fibers with diameters ranging from micrometers to a few nanometers [1]. It involves the use of electrical charge to draw very fine fibers from liquids. Solvents are used to assist in the breaking down of the solid pieces of a polymer into a liquid solution.

Using polymers to produce Nano fibers provide medical benefits as well as improvements in the uses of materials associated with energy, and building materials. Nano fibers allow for greater surface area coverage. This characteristic is very beneficial in the field of medicine.

Another technique used to produce fibers from macromolecules is known as forced drawing under heat. This technique has been used since the early 1900's in the production of cotton candy. It is a process by which macromolecules in a solution or melt are converted into fibers with the help of mechanical force. In heating, molecules become mobile. The mobility of the molecules and the contact with air causes the macromolecules to become fibers.

The process of turning macromolecules into fibers has many benefits. Medical uses, material production, energy, and pleasurable foods are all areas that highlight the profound uses of macromolecules turned into fibers/Nano fibers [2, 3].

Seeing is believing……. In order for middle/high school students to understand the concept of turning macromolecules into fibers, the actual making of cotton candy during a science class is an excellent way to get the point across. This procedure takes approximately 5-10 minutes, excluding clean-up, and is fairly easily. Using sugar, light corn syrup, water, vanilla flavoring, food coloring, vegetable baking spray, and a few classroom and kitchen items, students will be amazed how easy it is to go from macromolecule to fibrous materials in minutes all the while enjoying a wonderful treat.

To assess how well students understand the electro spinning technique and the collaboration between disciplines it takes to produce nano fibers, a vocabulary questionnaire will be given at the end of the demonstration. Students will, also, write a brief statement explaining how science, technology, engineering, and math play a role in the formation of Nano fibers and the electro spinning technique.

Acknowledgements: Development of this module is supported by Engineering Research Center-Revolutionizing Metallic Biomaterials (ERC-RMB) (NSF-0812348) at North Carolina A&T State University. Sonja Turner wants to acknowledge ERC-RMB's summer RET program, members of Bhattarai-Biomaterial research group (Graduate Student-Chris Mahoney and REU-Jeanette Delva) and Dr. Clinton Lee of NC A&T. Resources from websites: www.foodnetworkwebsite.com and www.Youtube.com.

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