Solving Big Problems with Tiny Threads: Sustainable Nanotechnology Research

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Background

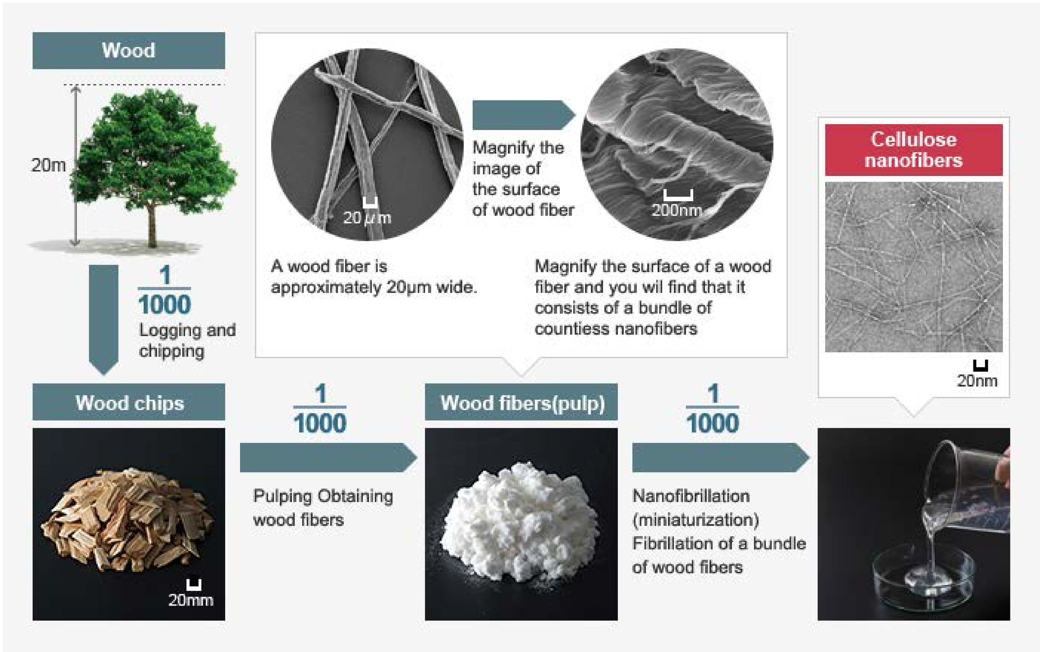
Cellulose is defined as an insoluble substance that is the main constituent of plant cell walls. Cellulose is a polysaccharide that consist of glucose (simple sugar) monomer chains. These cellulose fibers have been used to create nanoparticles; which are microscopic particles ranging between 10-100 x 10^{-9}.
Copper is known to have killed bacteria, yeast and viruses upon contact with the surface of Copper. Because of Coppers antimicrobial properties it has been studied and evaluated for use on surfaces people touch the most to try to reduce infections in public places such as hospitals.

Introduction

Cellulose is the most abundant and naturally occurring renewable polysaccharide, found as a primary make up of plants and natural fibers such as cotton (Dong, 2018).

Nanomaterials are of small size and offer high reactivity toward environmental contaminants, pollution detection and prevention, and water treatment. Nanoparticles can penetrate deeper and thus can treat wastewater effectively, which is generally not possible by conventional technologies. Challenges, such as textile dyes, have hazardous effects on the life of aquatic animals and human beings. Advances in nano-science and technology have led to the evolution of pollution control (Uddin, 2018).

Figure 1: *Trees are composed of wood fibers, which in turn are made of cellulose nanofibers, aggregations of cellulose molecules. Source: nipponpapergroup*



Cellulose nanofibers or CNF is the world's most advanced biomass material. It creates low environmental impact in its production and disposal. It is lightweight, is elastic, and presents high barrier properties with regard to oxygen and other gases (Uddin, 2018).

The goal of this work is to understand the interaction between CNF and metal ions or charged molecules in solution. Research activities will include studies aimed at characterizing the removal of metal ions and charged molecules from solution as well as characterization of solid films.

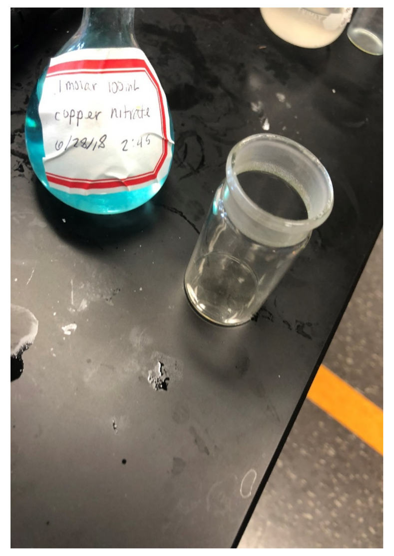
Procedure

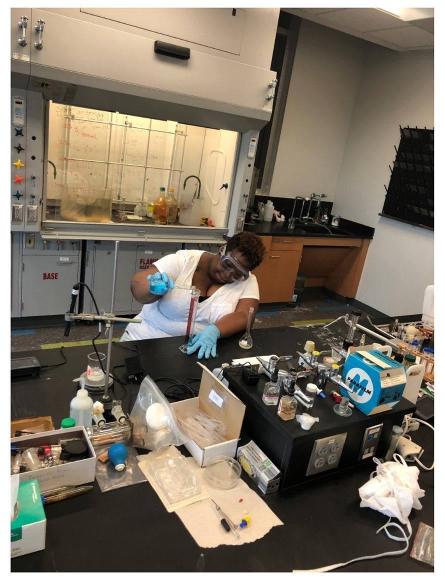
1% CNF (Cellulose Nanofibral) Solution
1. 1g of CNF_s was dissolved in 80-90mL of DI H_2O

0.1M Copper Film
1. Combine 25mL of 1% CNF Solution with 25mL of 0.1M $Cu(NO_3)_2$ (Copper Nitrate)
- The solution immediately became a sort of jelly solution upon combination.
- Solution was placed on the stirrer for a few seconds then poured on to a vacuum filtration system to suction out leftover solution; a gel was left which we will sit over night to dry into a film to be tested.

0.001M Copper Nanofiber Film
1. Clean flask with 10mL of Concentrated HNO_3 (Nitric Acid) and Deionized Water
- Place the flask in Ultrasonic Water Bath
1. Add 96mL of DI (deionized) H_2O to the flask
2. Place clean flask in a Circulating water bath at 90°C
3. Add 12mL of CNF Solution
4. Add 2mL of $Cu(NO_3)_2$
5. Add 15drops of 1M $C_6H_8O_6$ (Ascorbic Acid (Vitamin C)) Solution as a reduction agent
- Ascorbic Acid had to be made from the following
1. Add 8.8g Ascorbic acid to 50mL DI H_20
- During the addition of the addition of the 1M $C_6H_8O_6$, we observed a color change from a clear → a brownish hue → a full pink color solution with visible particles inside.
1. The solution was removed from the water bath and allowed to cool, this was done to allow the flask to be held.

The vacuum filtration system was set up and the contents of the flask was poured to allow leftover solution to be pulled out, due to the amount of nanoparticles the flask was left overnight on the filtration system to pull out excess solution and allowed to dry.





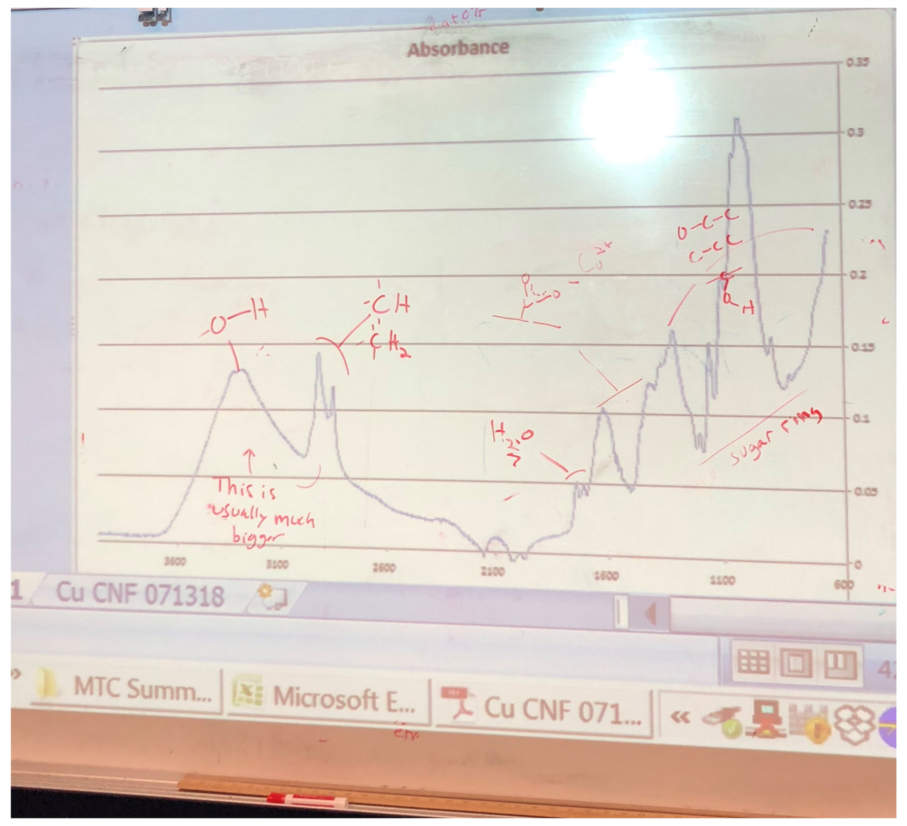
Results

The peaks between 1600 and 1400 tells you how the copper and cellulose are interacting. What we are seeing is the copper sticking to the fibers. The copper can stick to one fiber and apparently stick to two fibers. The idea is once you start sticking fibers together, if you stick enough of them together it makes a gel or network (from one dimensional to 3-dimensional network). The peaks between 3600 and 3100 are the OH groups (not sure why the OH group is smaller the hydrocarbon molecule). The bump between 3100 and 2600 are carbon hydrogen bonds. 1400 and 600 are several atoms (show us the rings that make up the glucose nets).

Figure 2: Suspension

Figure 3: *Copper nanoparticle cellulose nanofiber composite. The chemistry was taking place at the surface of the fibers. .*

Figure 4: *What this tells us is that the cellulose is there, some of it is in the form of the carboxyl group. Most of the light is making it through the sample. The absorbance is pretty reasonable.*



Conclusions

We are sure that we have made a reduced form of Cu, either (Cu metal nanoparticles or Cu_2O nanoparticle). We are sure that the Cu is binding to the cellulose particles based on observations. Further testing will need to be done in order to confirm our observations.

Further Research

Further research using nanoparticles with an emphasis on using copper and cellulose will open other questions such as, will this be more cost efficient in treating wastewater. Will this able to remove more pathogens and what issues could arise from the use of these cu nanofibers. Why does the film change in the light, is it the thickness of the film or the density of where the copper ended up?

References

1. Uddin, M. K., & Rehman, Z. U. (2018). Application of Nanomaterials in the Remediation of Textile Effluents from Aqueous Solutions. *ResearchGate*, 135-161. doi:10.1002/9781119459804.ch4
2. Dong, H., Snyder, J. F., Williams, K. S., & Andzelm, J. W. (2013). Cation-Induced Hydrogels of Cellulose Nanofibrils with Tunable Moduli. *Bio Macromolecules*, 3338-3345. Retrieved July 6, 2018, from pubs.acs.org/Biomac.
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