Fighting Back with Silver Nanoparticles

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Background

The increasingly alarming rate of which bacteria is becoming resistant to antibiotics is causing a desperate race to find an alternative source. Silver Cellulose NanoFibers (CNF) may just be the answer. Cellulose fibers come from plants that are processed into pulp. These nanomaterials are manufactured and used at a very small scale.Silver nanoparticles have unique properties that are being incorporated into products that utilize their high electrical conductivity, stability, and low sintering temperatures. Silver nanoparticles have major applications in the medical fields from diagnostics to serving as antimicrobial agents. An increasingly common application is their antimicrobial coatings, wound dressings, and biomedical devices which now contains silver nanoparticles that continuously release a low level of silver ions to provide protection against bacteria. Cellulose and silver nanoparticles have exciting characteristics and new combinations of both may lead to eco-friendly functional nanocomposites with unique properties.

Procedures

- Freeze dried cellulose nanofibrils were separated and suspended in deionized water to create a .5%, 2.5, and 5% cellulose solution
- The cellulose solution was left to mix overnight using a metal stirrer and then placed in a ultrasonic machine to further separate the cellulose fibers with the goal of the solution to become clear once again once all the cellulose had been dispersed.

Procedures (*continued*)

- The cellulose solution was characterized using the ultraviolet visible-spectroscopy which measures the amount of color that is able to be passed through a solution. The solution was also characterized using the Fourier transform InfraRed spectroscopy which measures the absorption of infrared radiation by the sample material versus wavelength. The infrared absorption bands identify molecular components and structures
- Using the .5% and 2.5% solution, we placed 1mL, 2mL, 3mL, and 4mL of the solution in well plates to make films via evaporation casting.
- The making of these films helped to create a baseline for the percent of CNF solutions that would be needed to make silver nitrate cellulose nanoparticle films and solutions.
- To create the silver nanoparticles we used the 5% CNF solution and added 1 molarity and 5 molarity of silver nitrate. Using two testing samples, we set one sample group in complete darkness to use as a control and the other in direct sunlight. We left both groups overnight and monitored their color change.
- Using the ultraviolet visible-spectroscopy and the InfraRed spectroscopy we characterized both
- We put both the AgNO3 cellulose gels (sunlight and complete darkness) and solutions (sunlight and complete darkness) on an Apgar plate that was already cultured with E coli bacteria and monitored to see if a zone of inhibition would develop indicating that the bacteria was being killed by the substances.

Results

- We have found that varying the concentration of the silver nitrate solutions determines if films or gels will form
- We were able to utilize the Infrared and UV-vis spectroscopy to determine base functional groups and characterizations. As well as determining the absorptions and predicting size of the nanoparticles
- Upon adding the silver nitrate to the cellulose solution, we were able to observe a change in color and consistency. The sample that was in direct sunlight and in complete darkness formed a gel within minutes of adding the silver nitrate. The sample that was in direct sunlight turned a dark brown color after leaving it overnight and the sample in complete darkness turned a dark orange.

  The apgar plate of e coli showed a small zone of inhibition for the solution and gel of AgNO3 that was in direct sunlight, but little to no zone for the samples that were in complete darkness.

Conclusions

- Silver nanoparticles using cellulose and silver nitrate were successfully formed
- Many of the cellulose solutions and the cellulose silver nitrate solutions were unable to produce a viable film, the most that was able to form was gels
- The zone of inhibition for both solutions and gels that were in direct sunlight and complete darkness, may have been larger if the substances would have been placed on the apgar plate shortly after the E-coli was prepared.

Classroom Application

Below are a few North Carolina Common Core State Standards that proved applicable during this research:

- Measurement of substances needed for titration: NC.5MD.1
- Understanding decimal place value: 5.NBT.A.1 and 2
- Adding and subtracting decimals in equations used to calculate molarity of a substance
- Compare cellulose fiber in its freeze dried state to the solution: 5.P.2.3
- Understanding of the water cycle, specifically evaporation, in the use of making films via evaporation casting: 5.P.2.1
- LNG ARTS: reading, comprehending, and referencing literature in order to develop a hypothesis
- LNG ARTS: knowledge of prefixes to help decode scientific lingo such as nanoparticles. Nano- small

Bibliography

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Future work will also include testing AgNO3 cellulose solutions with various bacteria to observe the nanoparticles antimicrobial properties.

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