Synthesis and Characterization of $Zn_{0.85}Ni_{0.15}O(CA)_x$ Nanoparticles with Varying Amounts of Cinnamic Acid

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ABSTRACT

Antibiotics are important in medicine and are well-known as life-saving drugs. However, bacteria are becoming increasingly resistant to traditional antibiotics. One new class of potential antibacterial agents is metal oxides, such as zinc oxide. This project focuses on synthesizing and characterizing nickel-doped zinc oxide nanoparticles prepared with varying amounts of cinnamic acid (CA). Preliminary results show an increase in the antibacterial properties of $Zn_{0.85}Ni_{0.15}O(CA)_x$ nanoparticles capped with cinnamic acid. The nanoparticles were prepared by varying the cinnamic acid to metal ratio from 3:1 to 0.1:1 to understand how the CA to metal ratio alters the nanoparticle's physical and chemical properties. The materials were characterized by FT-IR, TGA, and X-ray powder diffraction (XRD). The materials were used to decolorize malachite green dye solutions under UV illumination to measure their photochemical activity.

HYPOTHESIS

$Zn_{0.85}Ni_{0.15}O(CA)_x$ nanoparticles capped with cinnamic acid will have increased antibacterial properties compared to $Zn_{0.85}Ni_{0.15}O$ nanoparticles without cinnamic acid.

PROCEDURE

Synthesis

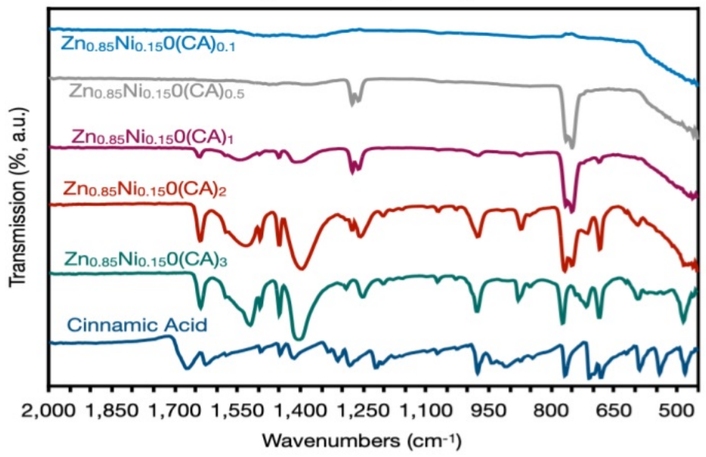
Zinc nitrate hexahydrate, nickel nitrate hexahydrate, and trans-cinnamic acid were dissolved in methanol and the $Zn_{0.85}Ni_{0.15}O(CA)_x$ nanoparticles were precipitated by the addition of NaOH at 65°C. The solid was isolated by centrifugation, washed with water and methanol, dried in vacuum overnight and then annealed under nitrogen at 200°C for 2 hours.

Characterization

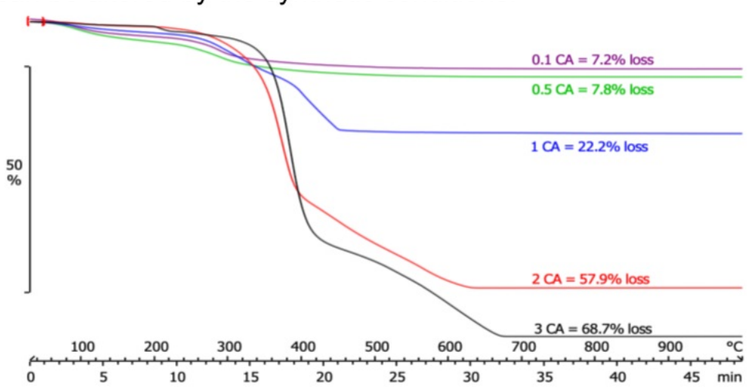
The nanoparticles were characterized by FT-IR to confirm the presence of CA on the particles, TGA to quantitatively determine the amount of CA bound to the nanoparticles, XRD to confirm structure type and purity and to calculate crystallite size using the Scherrer equation, and were used to photocatalytically degrade malachite green under UVA illumination. The first-order rate constant for each material was determined for the degradation of the dye.

RESULTS

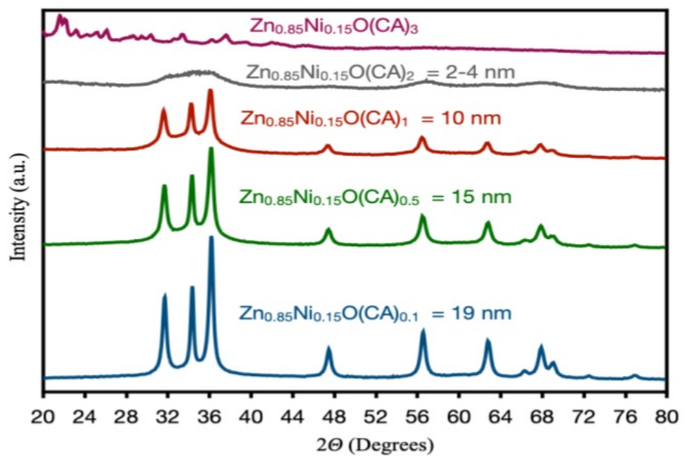
FT-IR (Fourier Transform Infrared spectroscopy) - was used to confirm that cinnamic acid is bound to the nanoparticles and the amount can be changed during the synthesis.



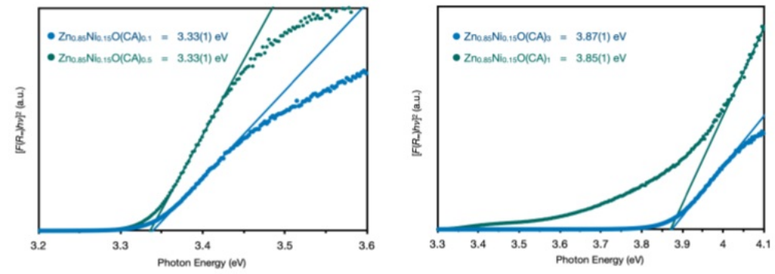
TGA (Thermogravimetric analysis) - used to determine the amount of cinnamic acid (CA) on particles. The amount of CA can be altered by the synthetic conditions.



X-Ray Powder Diffraction - was used to confirms structure type and to calculate average particle size. Particle size decreases with increasing amounts of cinnamic acid.

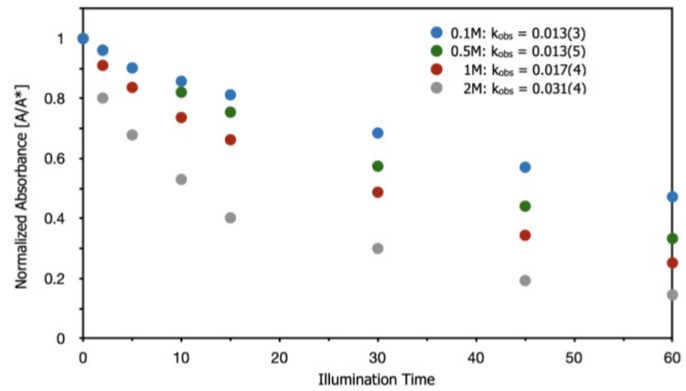


Optical Band gap - was measured for each material by diffuse reflectance. It measures where each material starts absorbing light.



Photodegradation - each material was used to degrade an organic dye (malachite green) under UV light and the first-order rate constants were determined.

Rate = k_{obs}[Dye]



CONCLUSIONS & FUTURE WORK

- Cinnamic acid was successfully added to the nanoparticles.
- The amount of cinnamic acid increases with stoichiometry.
- 3 CA : 1 metal did not produce the zinc oxide structure.
- The optical band gap increases with 1:1 stoichiometry.
- The photodegradation rate constants increase with increasing amounts of cinnamic acid.
- Antibacterial studies will be done at BSU in the future.

ACKNOWLEDGEMENTS

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