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Comparison of citric acid vs. ascorbic acid functionalized magnetic nanoparticles

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Abstract

Magnetic nanoparticles (MNPs) have attracted broad attention due to their potential biomedical applications, such as drug delivery and bio-imaging, as well as other applications involving materials separations and harvesting energy. Citric acid is a widely accepted coating material for MNPs; however, very few studies have focused on ascorbic acid coated MNPs. Here, citric acid and ascorbic acid coated iron oxide nanoparticles were synthesized to study the size distribution and stability. The nanoparticles were characterized by multiple techniques including dynamic light scattering, atomic force microscopy, and Fourier transform infrared spectroscopy. It was found that citric acid coated MNPs were more stable than ascorbic acid, but ascorbic acid could be a possible alternative coating material.

Objective

Synthesize and characterize magnetic nanoparticles to produce stable MNPs in solution with various coating materials

Methodology

Materials

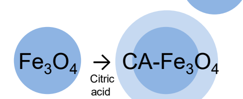
- Iron (II) chloride
- Iron (III) chloride
- Ammonium hydroxide
- Citric acid
- Ascorbic acid

Synthesis

- Performed reaction under fume hood in reactor with thermocouple-controlled temperature control set at 70°C with nitrogen gas purge
- Used mechanical stirring in place of magnetic stirring to reduce interference with the MNPs
- Separated MNPs with a strong magnet

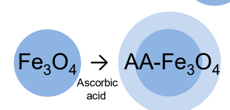
Synthesis of citric acid coated MNPs

$$FeCl_2 + 2FeCl_3 + 8NH_4OH \xrightarrow{70^\circ C} Fe_3O_4 + 4H_2O$$



Synthesis of ascorbic acid coated MNPs

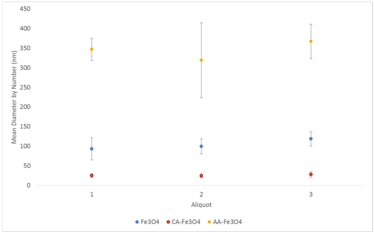
$$FeCl_2 + 2FeCl_3 + 8NH_4OH \xrightarrow{70^\circ C} Fe_3O_4 + 4H_2O$$



Results & Discussion

Dynamic Light Scattering (DLS)

Hydrodynamic diameter of the nanoparticles was measured by DLS. It was found that the uncoated Fe_3O_4 MNPs had a mean diameter by number of **103.67 nm.** With the citric acid coating, the mean number diameter decreased to **25.57 nm** with no change over time. While the ascorbic acid coated MNPs increased to **344.51 nm**. However, this high mean diameter number suggests possible aggregates throughout the AA-Fe_3O_4 solution.



Atomic Force Microscopy (AFM)

AFM was used to determine the size of the nanoparticles using height measurements as well as show the general particle distribution and the aggregation of the nanoparticles. In **Fig. 3**, the large heights suggest possible aggregates in the dried AA-Fe3O4 MNPs similar to the DLS results.

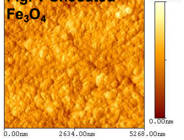


Fig. 1 Uncoated Fe_3O_4

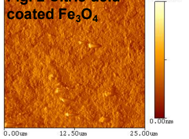


Fig. 2 Citric acid coated Fe_3O_4

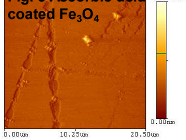
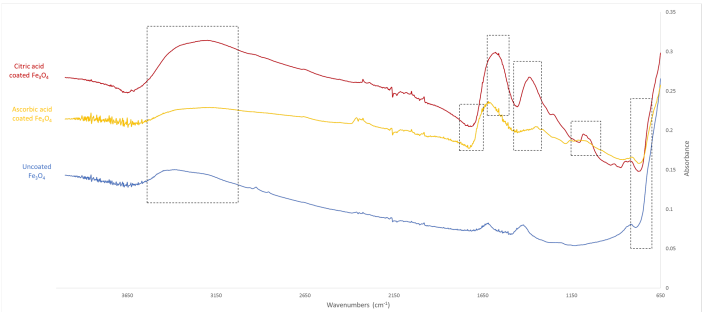


Fig. 3 Ascorbic acid coated Fe_3O_4

Fourier Transform Infrared Spectroscopy (FTIR)



In the FTIR spectra, the peaks in the range 3,600–3,100 cm^{-1} correspond to the different hydroxyl groups. The FTIR spectrum for CA-Fe_3O_4 and AA-Fe_3O_4 show strong peaks at ~1600 cm^{-1} due to the stretching vibrations of C=O from the COOH group. The neighboring peaks at ~1400 cm^{-1} can be assigned to the asymmetric stretching of CO from the COOH group. In addition, the low-intensity bands between 800 and 700 cm^{-1} can be attributed to the Fe-O stretching of Fe_3O_4.

Conclusions

Through several characterization methods, it was found that citric acid is a more successful coating material for MNPs. It proved to be more stable and smaller in diameter. In addition, time did not effect the stability of the citric acid coated MNPs. Ascorbic acid could be potential alternative, but due to aggregation, ascorbic acid coating material should be further investigated to improve the stability.

Future Work

- Attachment of fluorescent molecules due to electrostatic interaction
- Scaffolds for bone regeneration
- Analytical methods for determining chemical compounds
- Separating heavy metal nanoparticles
- Self-packing 3-D materials