Nano Innovation 2022 Rome, 19-23 September Conference & Exhibition

Synthesis and characterizations of highly stable magnetite-silver (Fe_3O_4-Ag) nanohybrid for recyclable antibacterial materials

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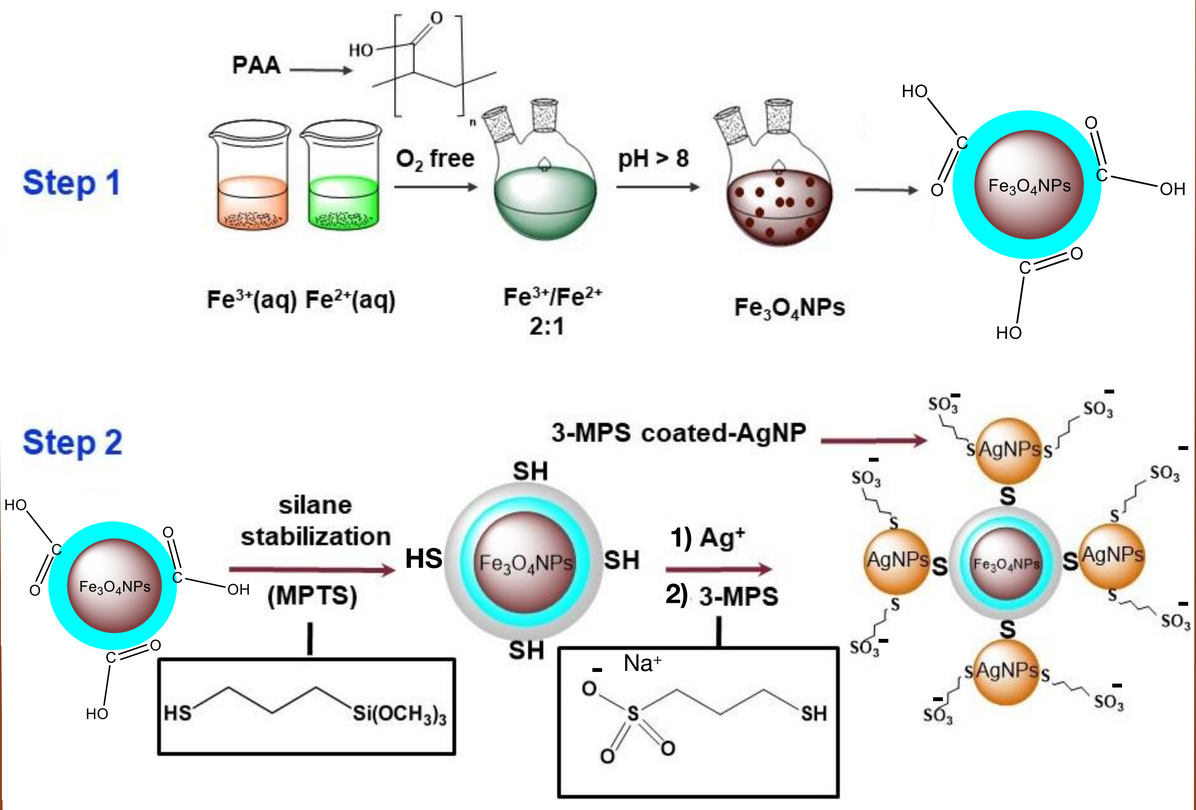
1. Introduction

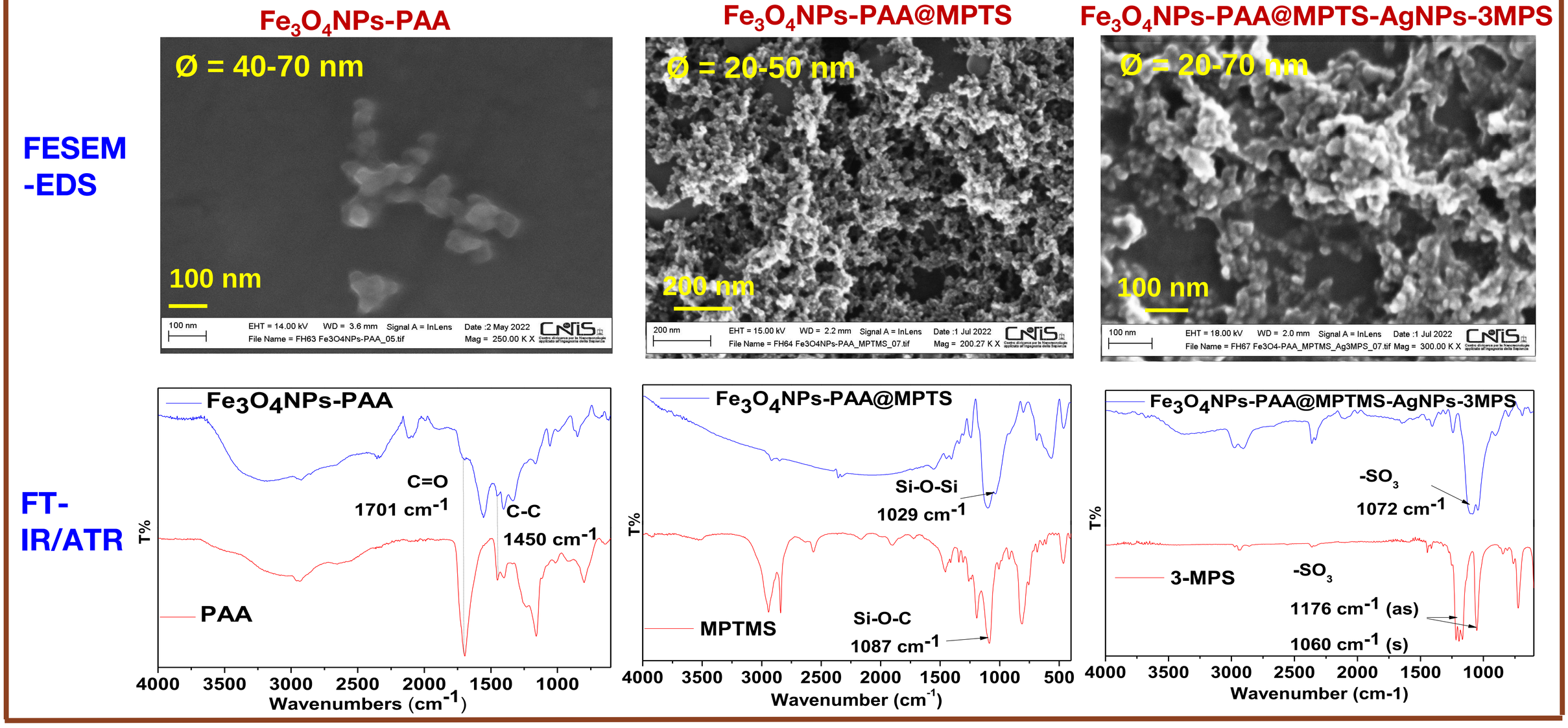
Due to their excellent antimicrobial activity, silver nanoparticles are considered as promising candidates against resistant pathogens. For such biological applications, it is of great importance to separate these nanoparticles from the surrounding media to prevent the potential contamination or aggregation. The Fe_3O_4 nanoparticles (Fe_3O_4NPs) are the mostly used magnetic materials in such fields, due to their biocompatibility, well-known chemistry/synthesis methods, and high surface area which allows to load many antibacterial agents on their surface [1].

In this research, highly stable silver nanoparticles, AgNPs-3MPS (3-MPS: 3-mercapto-1-propanesulfonate) were chemically decorated on the surface of silane-functionalized Fe_3O_4NPs. The (3-mercaptopropyl)trimethoxysilane (MPTS) was used for the silane functionalization to provide the free –SH groups on the Fe_3O_4NPs suitable for the chemical conjugation of AgNPs-3MPS with the magnetite surface. The Fe_3O_4NPs were synthesized by a co-precipitation of Fe(II) and Fe(III) ions in the presence of polyacrylic acid (PAA) as coating agent, followed by the surface silanization using a sol-gel method. Then AgNPs-3MPS were prepared *in situ* (reducing agent: $NaBH_4$) and directly attached to the free –SH groups of Fe_3O_4NPs-PAA@MPTS forming the final nanohybrid. The stability, size, morphology, and chemical composition of both Fe_3O_4-PAA@MPTS and nanohybrid were evaluated by FT-IR/ATR, FESEM-EDS, DLS characterizations.

2. Synthesis of nanohybrid



3. Characterizations



4. Discussion

The FESEM results show that all these three nanostructures have grain-like morphology with an approximate size range of 20-70 nm, for the main distributions. The EDS elemental analyses confirmed the presence of Si and Ag in the Fe_3O_4NPs-PAA@MPTMS and nanohybrid, respectively which show the successful salinization and silver decoration around the Fe_3O_4NPs-PAA. During the stepwise surface functionalization, vibrational spectra change in each step which can be an indication of the surface modification of the nanoparticles for each step. As can be seen in the FT-IR/ATR figures, there are main characteristic bands, assigned to the PAA, MPTS, and 3-MPS, for the sequential steps of synthesis. Also, these nanostructures showed colloidal stability in water up to 70 hours (1 mg/mL concentration). The ζ-potentials values of these three nanosystems are within the range of -22 to -30 mV, with the hydrodynamic size range of 255 nm (for Fe_3O_4NPs-PAA) to 326 nm (for the nanohybrid).

5. Conclusions and Perspectives

The results shown here provided some information about the surface characteristics, colloidal properties, solid state morphology and size, chemical structure of these three nanostructures, which can be a good indication of successful synthesis process. However, more studies should be conducted to obtain more insight on the structure of these nanoparticles, including XPS analysis (for surface chemical evaluations), VSM (to study the magnetic properties), ICP (to quantify the amount of Ag in the nanohybrid), colloidal stability in culture media such as LB of PBS^- (to gain insight on the stability) and finally conclude the antibacterial properties of the nanoparticles to investigate their potential biological applications.

6. Reference

[1] A. B. Shatan, K. Venclíková, B. A. Zasońska, V. Patsula, O. Pop-Georgievski, E. Petrovský, D. Horák, Pharm. Res. 2019, 36, 147.