Synthesis and characterization of nickel oxide-silver-antibiotic nanocomposites

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INTRODUCTION

Combination of nanotechnology and traditional antibiotic has been adopted as a promising tool to solve the problem raised by the antimicrobial resistance in the treatment of bacterial infectious diseases. Extensive research studies have revealed improved activity of nanoparticles when used in combination with antibiotics against various pathogenic microorganisms.

AIM of WORK

In the present work, nickel oxide-silver-antibiotic composites (antibiotics: sulfamethoxazole, norfloxacin) were synthesized and characterized by several techniques: X-ray diffraction (XRD), Fourier-transform infrared spectroscopy (FTIR), transmission electron microscopy (TEM), scanning electron microscopy (SEM), and UV-VIS spectroscopy. In future studies, the prepared composites will be evaluated for their antimicrobial activity against different pathogenic strains.

MATERIALS and METHODS

Nanocomposite components

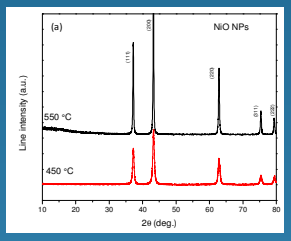
- Synthesis of NiO NPs: precipitation method using $Ni(NO_3)_2 \cdot 6H_2O$, $H_2C_2O_4 \cdot 2H_2O$; reaction temp. RT
- Synthesis of Ag nanoparticles: aqueous solutions of silver nitrate, $AgNO_3$ 10^{-3} M and trisodium citrate dihydrate, $Na_3C_6H_5O_7 \cdot 2H_2O$ 0.03 M (orange-brown mixtures). Reaction conditions: 90 °C, 20-25 min, under magnetic stirring. Ag-weight percent: 5 wt. % (sample 1) and 10 wt.% (sample 2).

Preparation of nickel oxide-silver-antibiotic composites

- The provenance of antibiotics used: sulfamethoxazole (Sigma-Aldrich), norfloxacin (AC Helcor Baia-Mare); the antibiotics were dissolved in ultrapure water to prepare aqueous solutions
- Mass ratio metal-based composite: antibiotic = 2: 1
- Reaction conditions: 24 h, RT, magnetic stirring.

EXPERIMENTAL DATA and RESULTS

XRD analysis



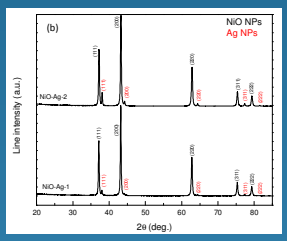
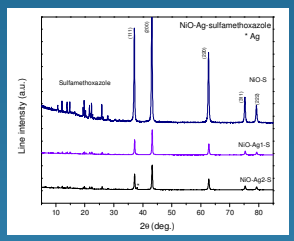


Figure 1. XRD spectra of: (a) NiO NPs after thermal treatment at 450 °C and 550 °C; (b) NiO-Ag nanocomposites with different amounts of Ag NPs.



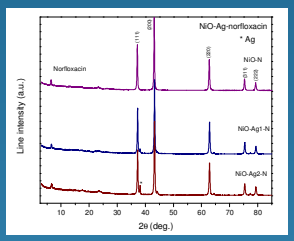


Figure 2. XRD spectra of NiO-Ag-antibiotic composites (antibiotic: sulfamethoxazole, norfloxacin).

- The average crystallite size of nanocomposite components (sample 1, sample 2) was calculated based on Scherrer's equation: (a) NiO NPs (30-34 nm), (b) Ag NPs (44-46 nm).

TEM and SEM analyses

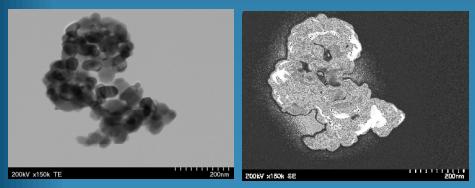


Figure 3. TEM and SEM images for NiO NPs after thermal treatment of precipitates at 550 °C.

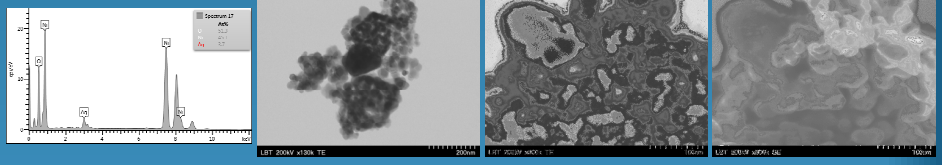


Figure 4. TEM and SEM images for NiO-Ag sample (2) and the EDX corresponding spectrum, over a selected area.

- Microscopy images reveal the presence of polyhedral shape NiO NPs with the average size around 30 nm.

FTIR analysis

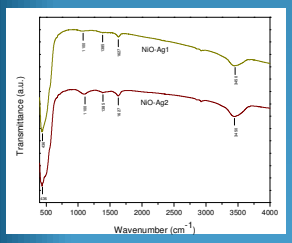


Figure 5. FTIR spectra of NiO-Ag nanocomposites.

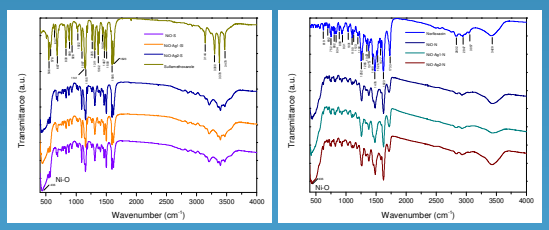


Figure 6. FTIR spectra of NiO-Ag-antibiotic nanocomposites.

- Ni-O stretching mode at 436 cm^{-1}, stretching vibration mode of H-O-H bond of adsorbed water at 3450 cm^{-1}, vibration mode of H_2O molecule at 1627 cm^{-1} [M.T. Ramesan, V. Santhi, Composite Interfaces 25(9) (2018) 725].

UV-VIS analysis

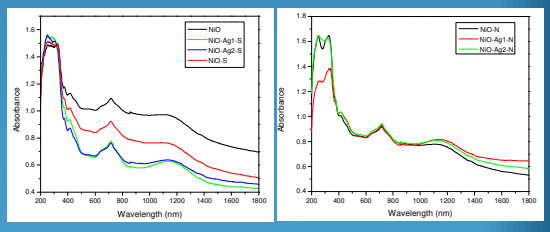


Figure 7. UV-VIS spectra of NiO-Ag-antibiotic nanocomposites (S: sulfamethoxazole, N: norfloxacin).

- The band gap Eg values: NiO (3.14 eV), NiO-Ag-antibiotic composites (in the range 3.1-3.25 eV).

CONCLUSIONS

- NiO-Ag-antibiotic nanocomposites were successfully prepared and analyzed by several characterization techniques (XRD, TEM/SEM, FTIR, UV-VIS).
- Analysis results confirm the formation of NiO NPs and Ag NPs with average size of about 30 nm and 45 nm, respectively.
- Future studies will be carried out in order to evaluate the antimicrobial potential of prepared NiO-Ag-antibiotic nanocomposites.

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