Investigation of bacterial adsorption and antibacterial properties of silver-containing ferrite nanoparticles

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Abstract: Amine-functionalized silver-doped cobalt and nickel ferrite nanoparticles prepared by solvothermal method were analyzed against certain microorganisms. Our aim was to determine whether these materials are suitable for binding bacterial cells from liquid media and whether they exhibit antibacterial activity, thereby assessing their potential applicability in water purification.

Application of magnetic nanoparticles (MNP's)

- Biotechnology, catalysis, magnetic resonance imaging, wastewater treatment

Favorable properties of MNP's: $Ag/CoFe_2O_4$-NH_2, $Ag/NiFe_2O_4$-NH_2

- Solvothermal synthesis
- Silver core
- Transition-metal ferrite shell
- Amine-functionalized surface
- Superparamagnetic

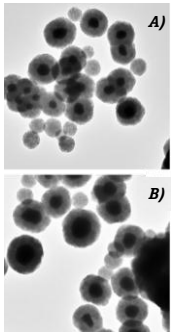

Figure 1
TEM images of core-shell structured MNP's
A) $Ag/CoFe_2O_4$-NH_2
B) $Ag/NiFe_2O_4$-NH_2

Benefits of water purification with MNP's

- Favorable composition and functionalized surface
- Adsorb microorganisms from contaminated liquid
- Electrostatic interaction

Model organism used – Fecal indicators in contaminated water

- Gram-negative: *Escherichia coli*
- Gram-positive: *Micrococcus luteus*

Preparation of bacterial suspension

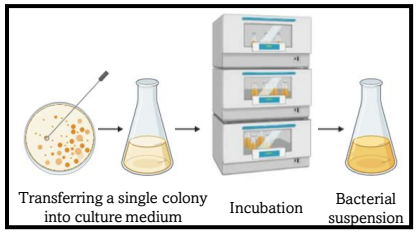

Figure 2 *Preparation of bacterial suspension*

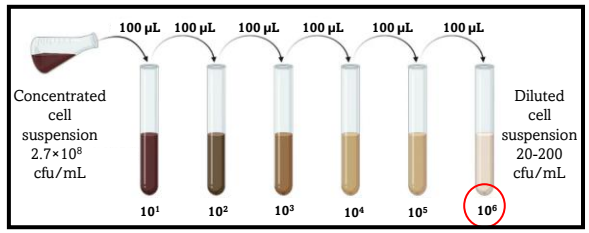

Figure 3 *Preparation of dilution series*

Antibacterial tests

- Spreading bacterial suspension on agar surface
- Applying the MNP dispersion droplets to be tested in different concentrations
- Incubation with the appropriate controls

Measurable inhibition zone around sample

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Sample has antibacterial activity

Tested MNP dispersion concentrations:
30 mg/mL, 3 mg/mL, 1 mg/mL, 0.5 mg/mL, 0.1 mg/mL

Determination of minimum inhibitory concentration (MIC)

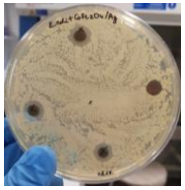


Figure 4

Escherichia coli
MIC = 0.5 mg/mL

Figure 5

Micrococcus luteus
MIC = 3 mg/mL

Adsorption tests implementation

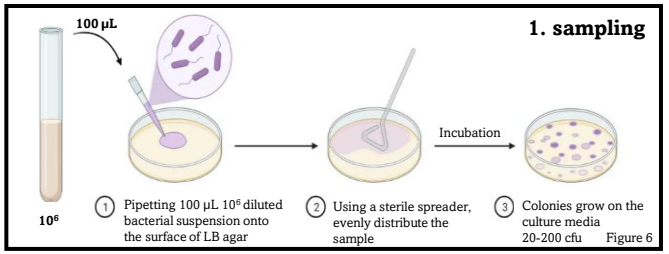


Figure 6

Initial cell number

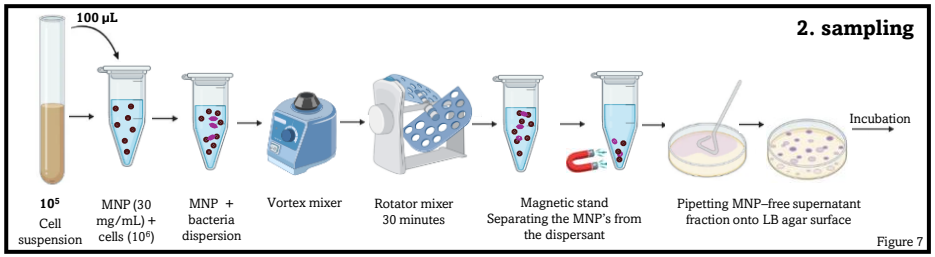


Figure 7

Cell number after adsorption

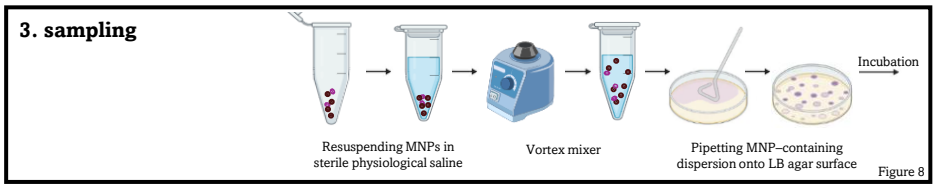
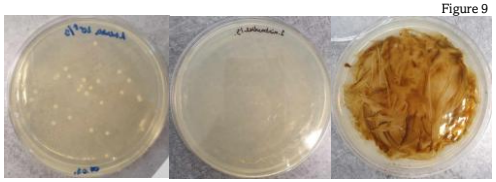


Figure 8

Pellet cell number

Adsorption test results

Figure 9



Initial cell concentration (before adsorption) | *Supernatant cell concentration (after adsorption)* | *Pellet cell concentration*

Escherichia coli *bdl: below detection limit*

MNP concentration [mg/mL]		Initial cell concentration [cfu/mL]	Supernatant cell concentration [cfu/mL]	Pellet cell concentration [cfu/mL]
$Ag/CoFe_2O_4$-NH_2	30	1.5×10^8	0	0
$Ag/NiFe_2O_4$-NH_2		5.6×10^8	0	0
$Ag/CoFe_2O_4$-NH_2	0.5	7.2×10^8	bdl	bdl
$Ag/NiFe_2O_4$-NH_2		5.2×10^8	0	0
$Ag/CoFe_2O_4$-NH_2	0.1	1.2×10^8	bdl	bdl
$Ag/NiFe_2O_4$-NH_2		4.8×10^8	0	0

Table 1

Micrococcus luteus

MNP concentration [mg/mL]		Initial cell concentration [cfu/mL]	Supernatant cell concentration [cfu/mL]	Pellet cell concentration [cfu/mL]
$Ag/CoFe_2O_4$-NH_2	30	3.2×10^8	0	0
$Ag/NiFe_2O_4$-NH_2		3.2×10^8	0	0
$Ag/CoFe_2O_4$-NH_2	3	2.7×10^8	0	0
$Ag/NiFe_2O_4$-NH_2		2.7×10^8	0	0
$Ag/CoFe_2O_4$-NH_2	1	2.7×10^8	0	0
$Ag/NiFe_2O_4$-NH_2		2.7×10^8	0	0

Table 2

Summary

Antibacterial properties (due to silver content) + Adsorptive properties (due to functionalized surface)

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Capture & Destroy

- Based on the results so far, it can be concluded that these MNP's are able to bind pathogenic microorganisms due to their structure and functionalized surface.
- As a result of the silver content, they also destroy the bacterial cells.
- We don't need to invest more energy to the elimination of the adsorbed microorganisms
- Following process optimization, these magnetic nanoparticles with antibacterial and adsorption properties may be promising candidates for the development of new types of water purification technologies.