



HYBRID SYSTEMS OF CHLORAMPHENICOL WITH COBALT, NICKEL, ZINC FERRITE NANOPARTICLES: CRYOCHEMICAL SYNTHESIS AND PROPERTIES

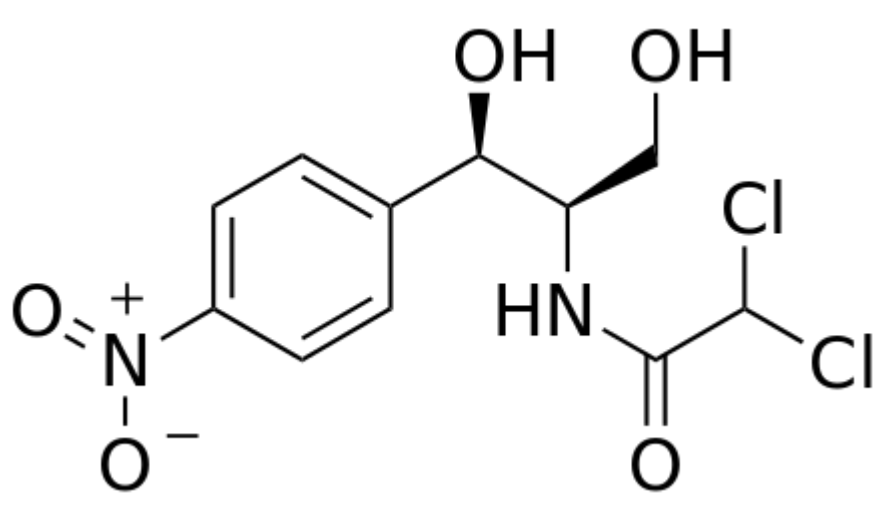
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Hybrid systems

Antibacterial drug chloramphenicol

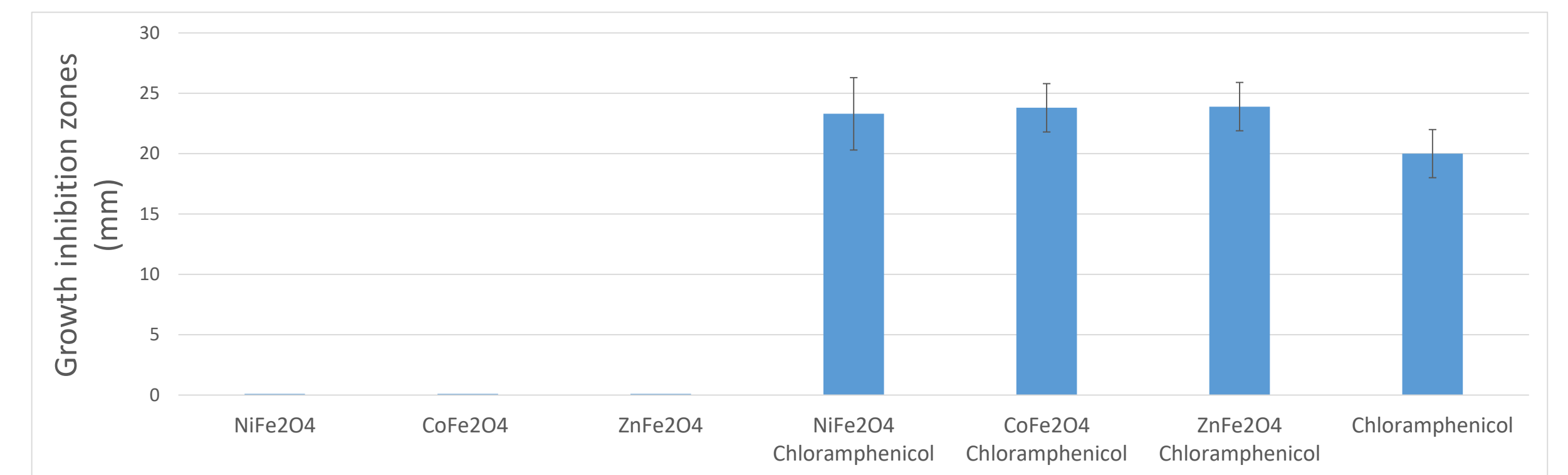


Ferrite nanoparticles

1. Controlled magnetic behavior;
2. Large specific surface area required for efficient drug loading;
3. Active against gram-positive and gram-negative bacterial strains.

Antibacterial activity

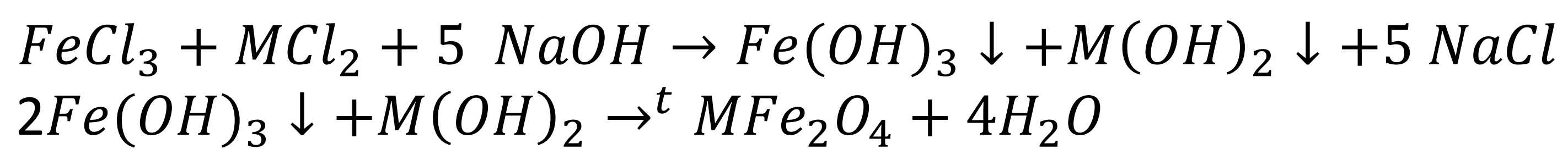
Disk diffusion test



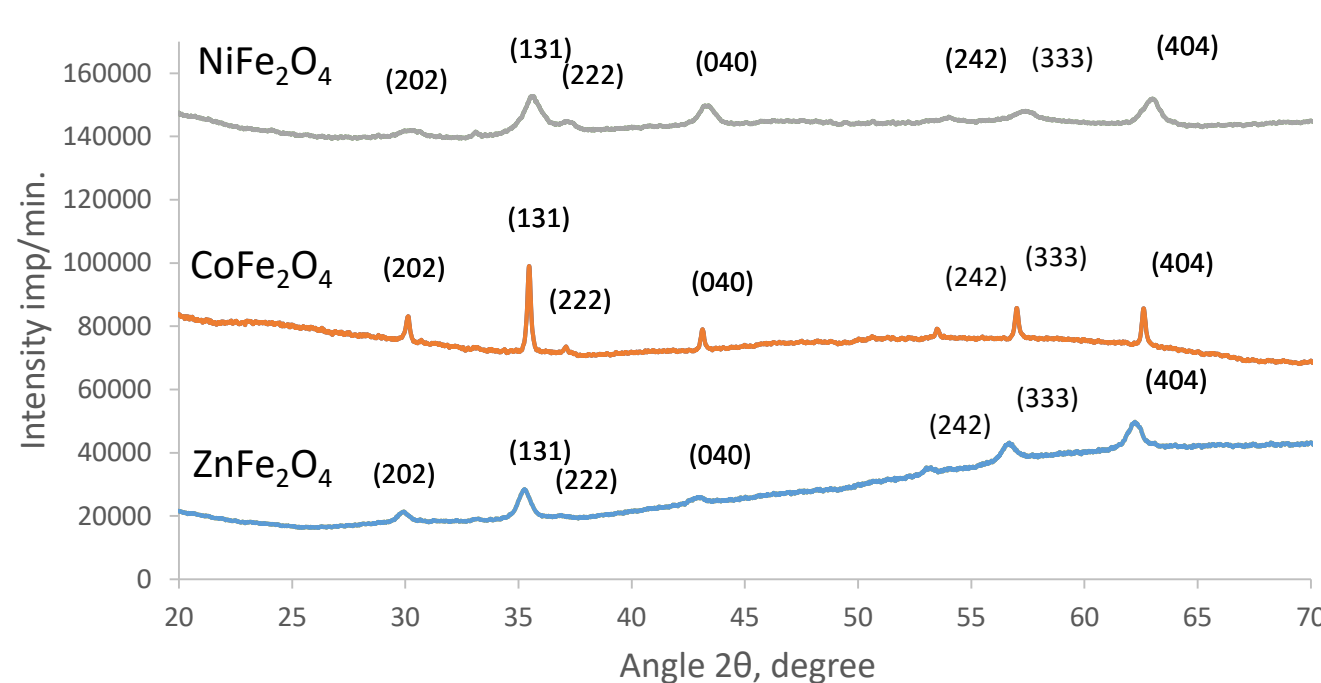
MIC value

Bacterium/parameters	E. coli	S. aureus
Reagent	MIC µg/ml	
Chloramphenicol	0,01	0,2
ZnFe ₂ O ₄ /Chloramphenicol	0,002	0,04
ZnFe ₂ O ₄	1	1

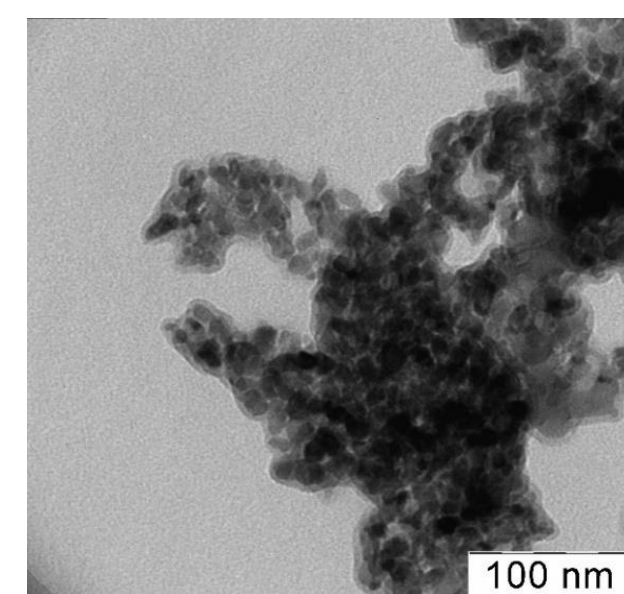
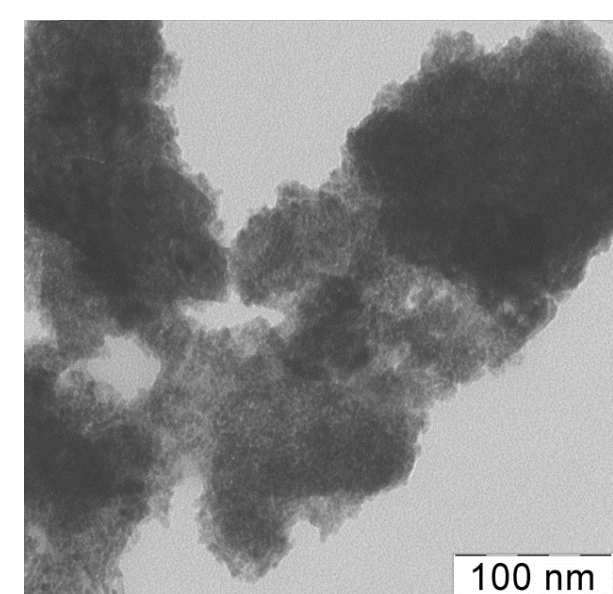
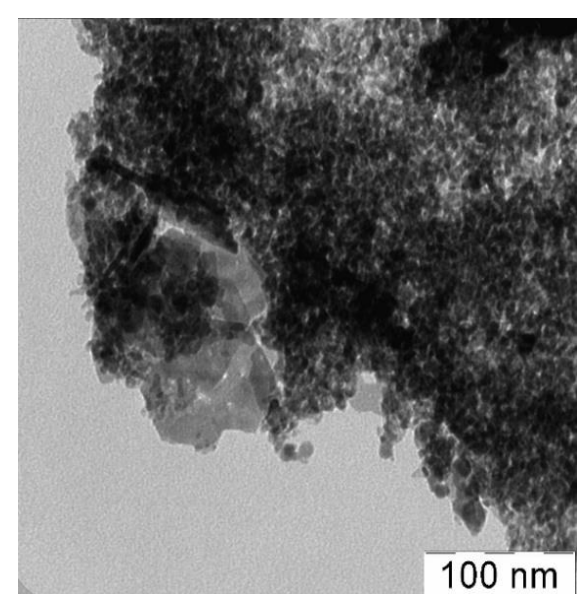
Ferrites



M = Zn, Ni, Co t = 300°C (Zn), 600°C (Ni, Co)



Sample	S _{sp} , m ² /g	d _{cp} , nm
NiFe ₂ O ₄	111	10
CoFe ₂ O ₄	229	5
ZnFe ₂ O ₄	221	5

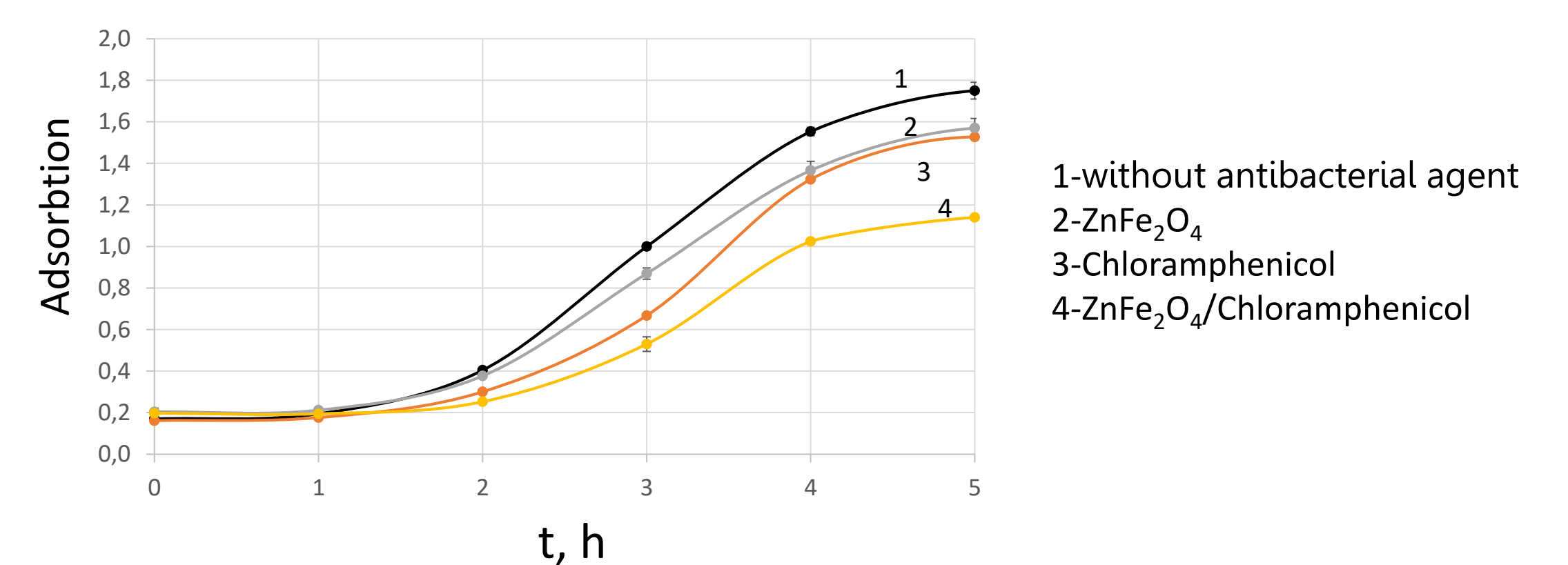


TEM micrograph CoFe₂O₄

TEM micrograph ZnFe₂O₄

TEM micrograph NiFe₂O₄

S. aureus growth curves



K_i value

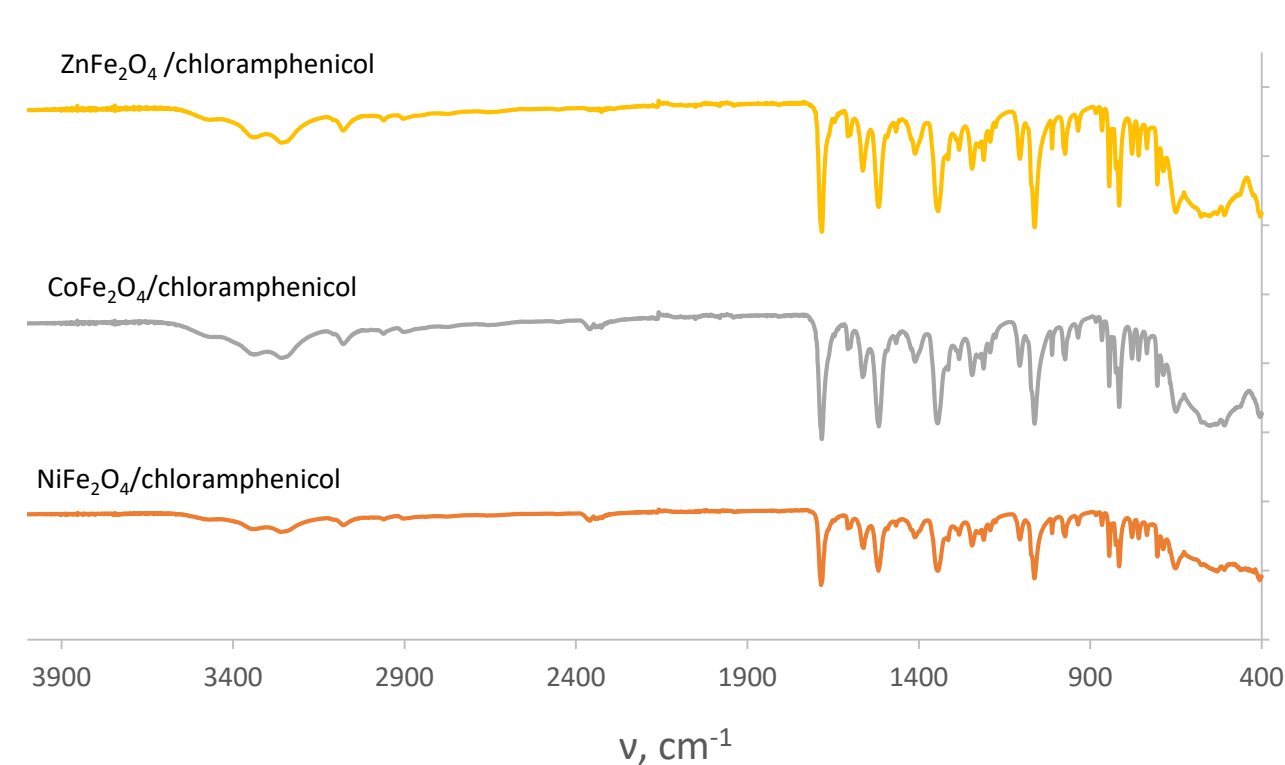
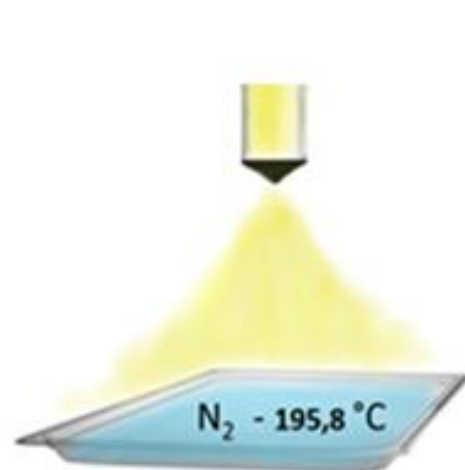
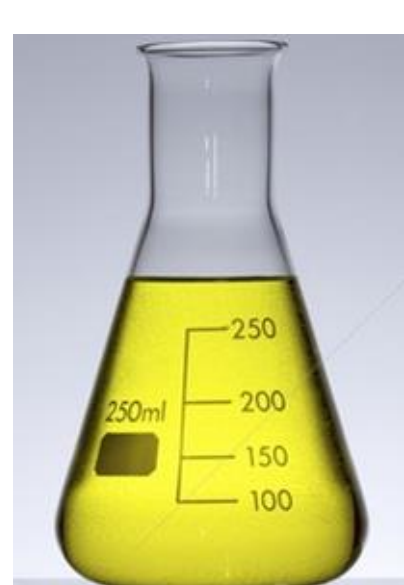
Bacterial strain	E. coli	S. aureus
Reagent	K _i µg	
Chloramphenicol	10	7
ZnFe ₂ O ₄ /Chloramphenicol	0,08	1
ZnFe ₂ O ₄	1057	2267

Ferrite/chloramphenicol hybrid systems

Preparation of an aqueous solution of chloramphenicol (0.4 mass%) + ferrite sol (0.1 mass%)

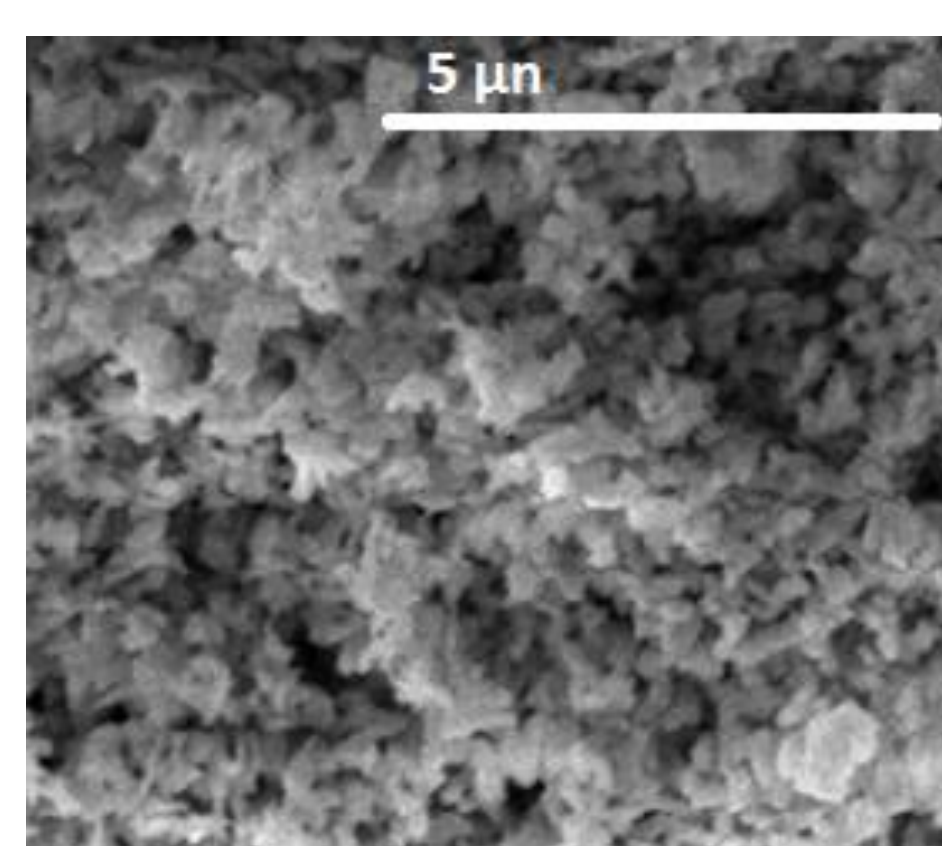
Rapid freezing

Cryogenic sublimation drying (24 hours)

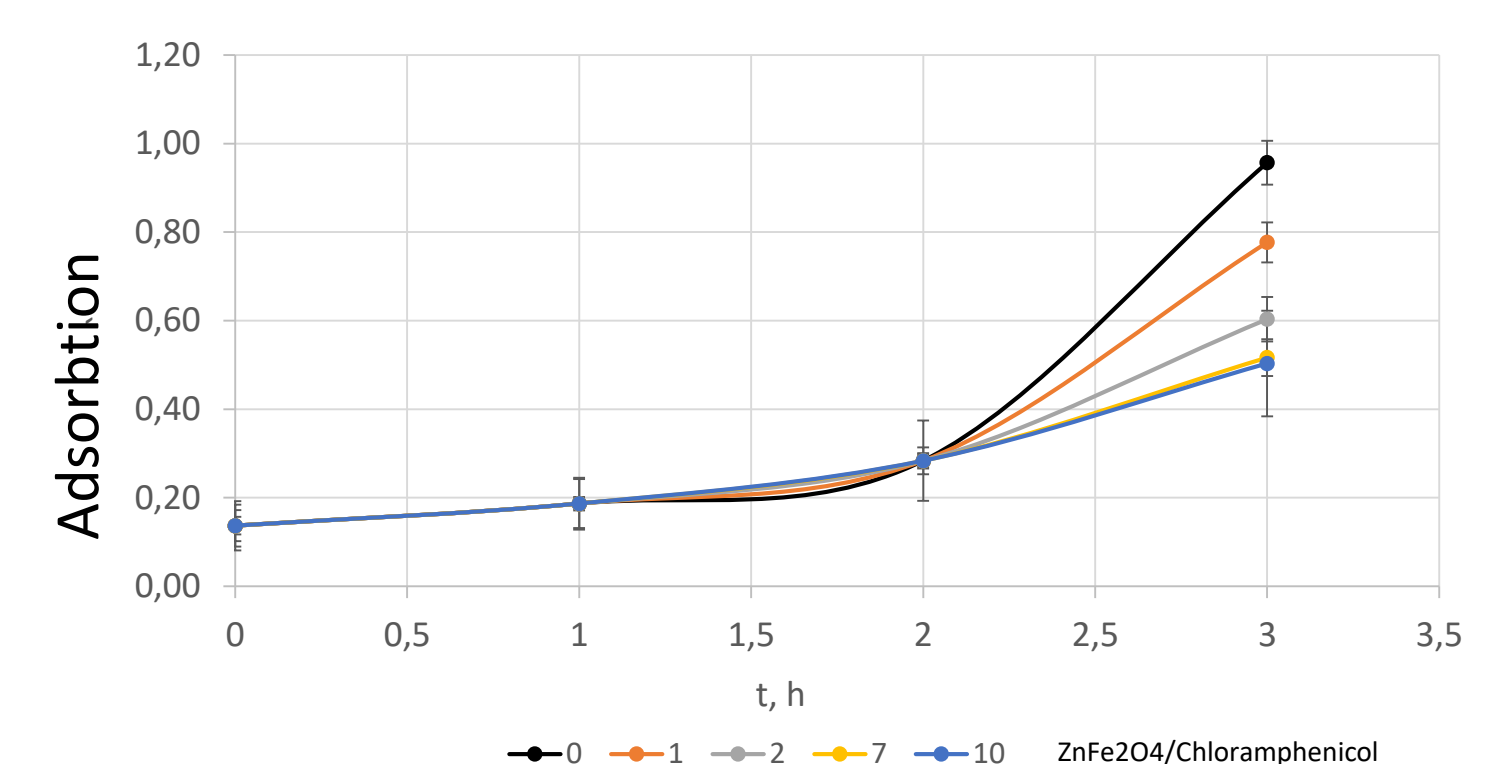


Sample	S _{sp} , m ² /g	d _{cp} , nm
ZnFe ₂ O ₄ / chloramphenicol	17	237
CoFe ₂ O ₄ / chloramphenicol	22	184
NiFe ₂ O ₄ chloramphenicol	23	171

ν, cm ⁻¹	Structural fragment
3500-3200	Chloramphenicol
3300-3200	Stretching vibrations of NH, stretching vibrations of adsorbed water, stretching vibrations of OH
3077	Stretching vibrations of the CH group
1683	Amide I - stretching vibrations of CO
1600	Aromatic ring bending vibrations
1563	Amide 2 - composite frequencies of deformation vibrations N-H and C-N
1516	NO ₂ stretching vibrations are asymmetric
1342	NO ₂ stretching vibrations are symmetrical
1283	C-O-H bending vibrations
1162	C-O-H bending vibrations
778	C-Cl stretching vibrations
Zinc ferrite	
530	Stretching vibrations of the oxygen-metal bond (metal is located at octahedral positions)
400	Stretching vibrations of the oxygen-iron bond (metal is located at tetrahedral positions)
Cobalt ferrite	
540	Stretching vibrations of the Fe ³⁺ -O ²⁻ bond, in which Fe ³⁺ ions are located in octahedral positions
400	Stretching vibrations of the Fe ³⁺ -O ²⁻ bond, in which the Fe ³⁺ ions are in tetrahedral positions
Nickel ferrite	
551	Oscillations of the oxygen-metal bond located at octahedral sites
401	Stretching vibrations of the Fe ³⁺ -O ²⁻ bond, in which Fe ³⁺ ions are in tetrahedral voids



SEM micrograph of ZnFe₂O₄/chloramphenicol



Conclusions

1. By means of low-temperature technologies, hybrid systems of zinc, nickel, cobalt ferrites with chloramphenicol were obtained. The systems are particles of a drug substance with a size of 50-300 nm in which nanoparticles of ferrites with an average size of 4-11 nm are incorporated. The composition and morphology of the systems and their precursors were confirmed by means FTIR and UV spectroscopy, X-ray analysis, PEM and SEM microscopy.
2. The disk-diffusion method, MIC and K_i values for the obtained systems showed the synergetic enhancement of the antibacterial activity of the systems in comparison with constituent components (magnetic particles and chloramphenicol)