Universidade Federal do ABC

Antibacterial activity of nitric oxide (NO) releasing silver nanoparticles (AgNPs)

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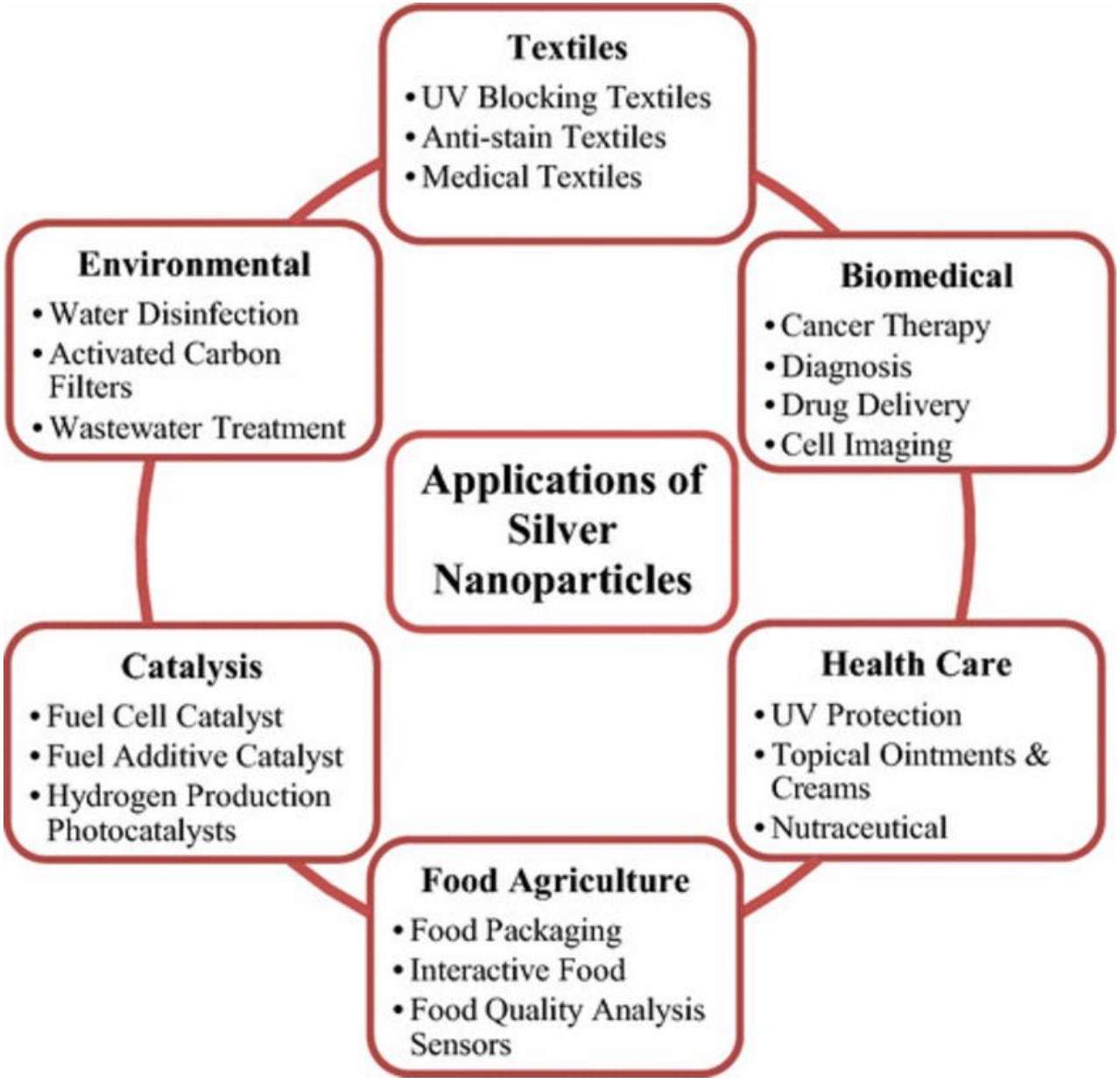
Silver nanoparticles (AgNPs)



Silver nanoparticles (AgNPs)


Nano silver beauty soap


Nano silver hair shampoo


Nano silver body cleanser


Nano silver facial mask sheet


Nano silver skin care line


Nano silver makeup line


Nano silver toothbrush


Nanosilver hair conditioner


Nano silver wash dish & laundry detergent


Nano silver toothpaste

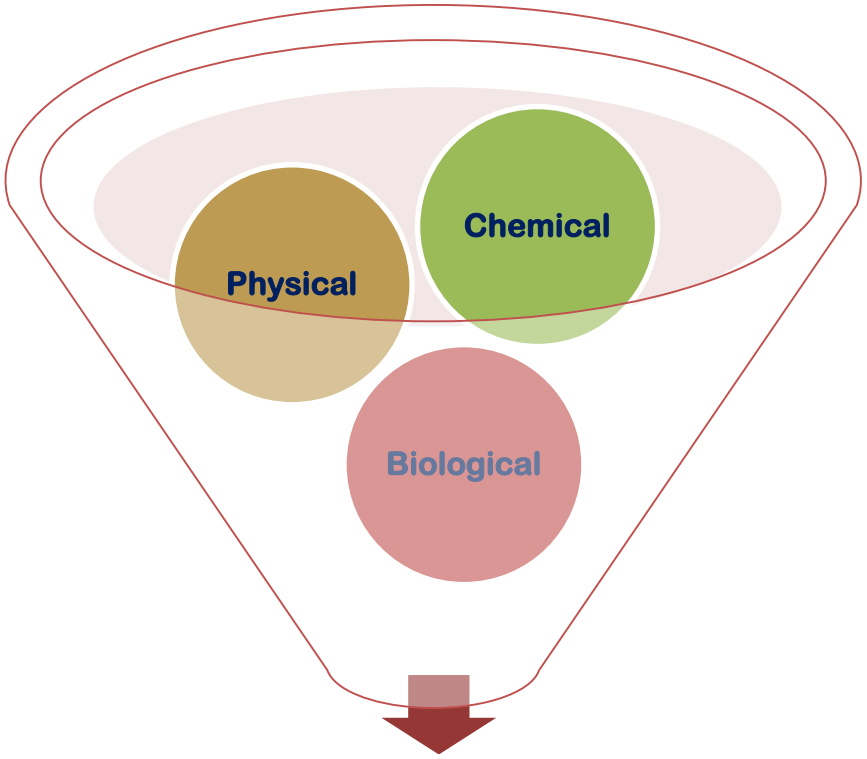

Nano silver hand sanitizer


Nano silver wet wipes


Nano silver disinfectant spray

Methods os synthesis of AgNPs

The most generalized methods for nanoparticle synthesis are chemical, physical and biological methods



Methods of synthesis

Green Synthesis of AgNPs

Green Synthesis of AgNPs

1. Nature of solvent (Aqueous or water)

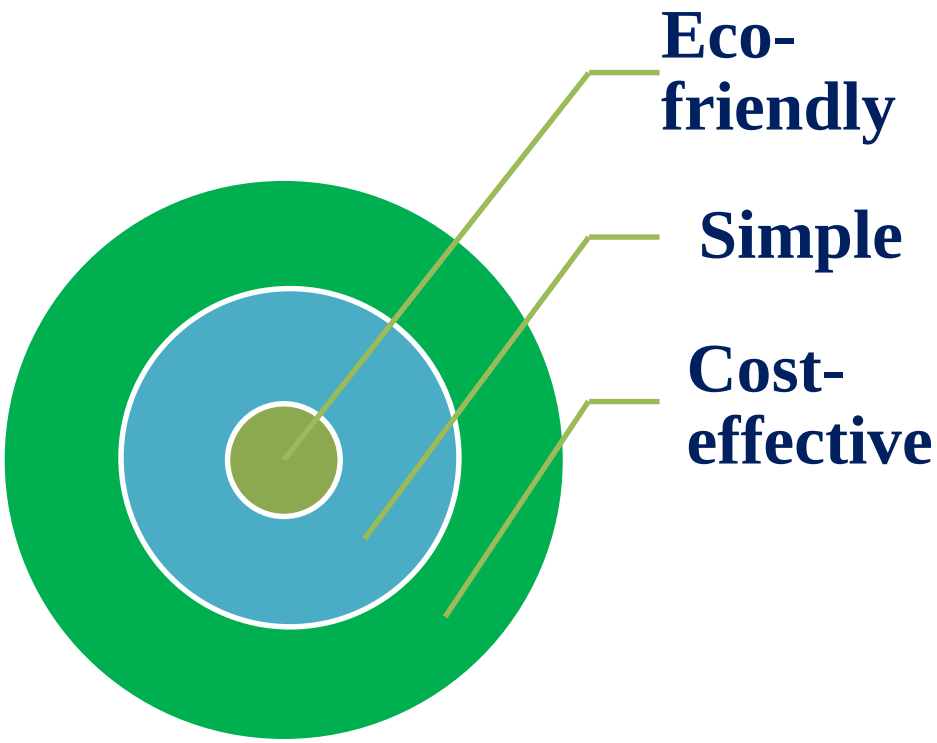
2. Simple procedure (No pressure, temperature maintenance and toxic chemicals)

3. Reducing and capping agents (Proteins or enzymes, polyphenols, alkaloids, flavonoids, saponins, phenols, essential oils and polyols)

4. Higher reducing potential

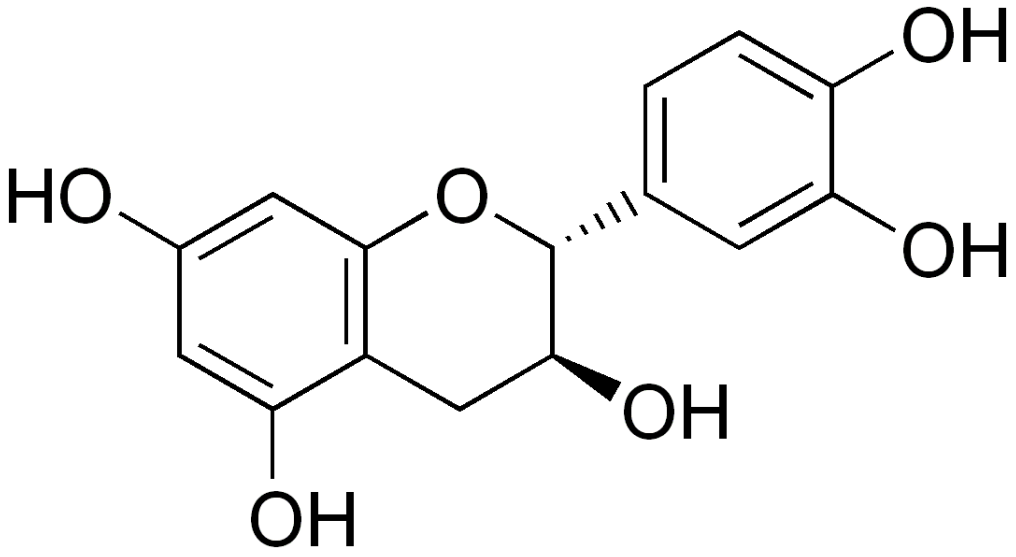
5. Zero contamination

6. Reduced or less environmental impact



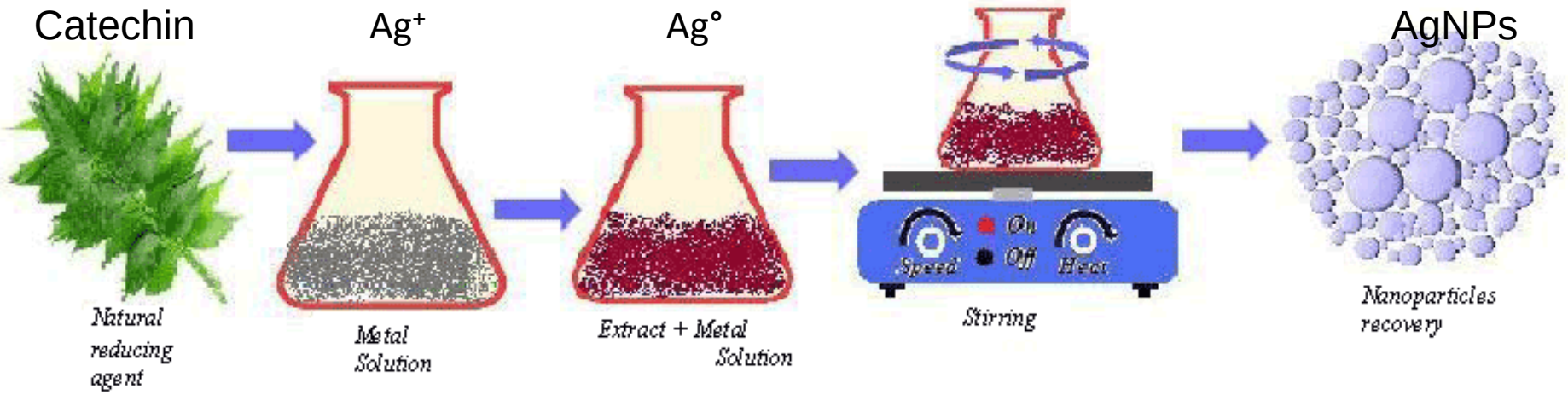
Green Synthesis of AgNPs

Green tea

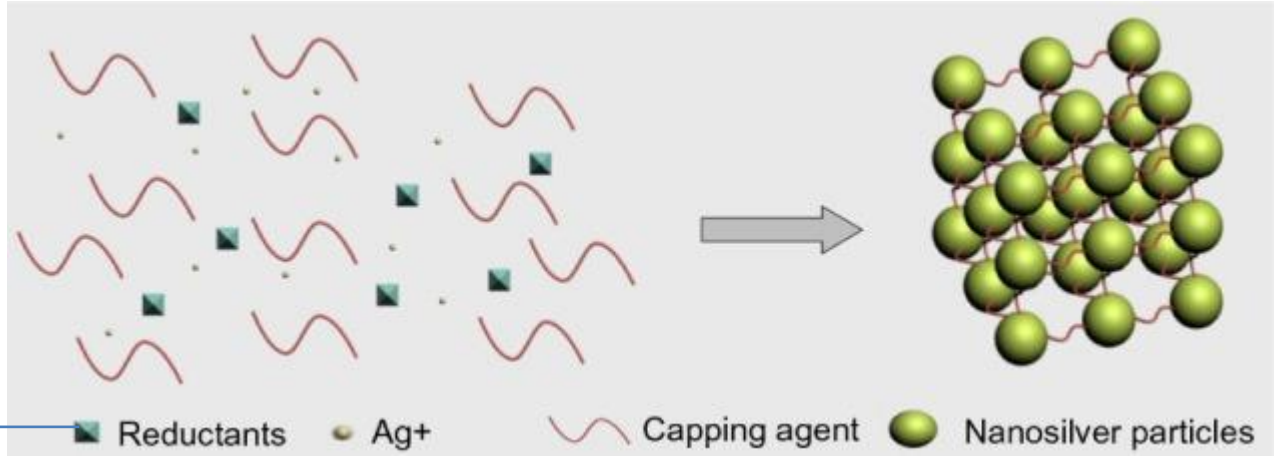


Catechin

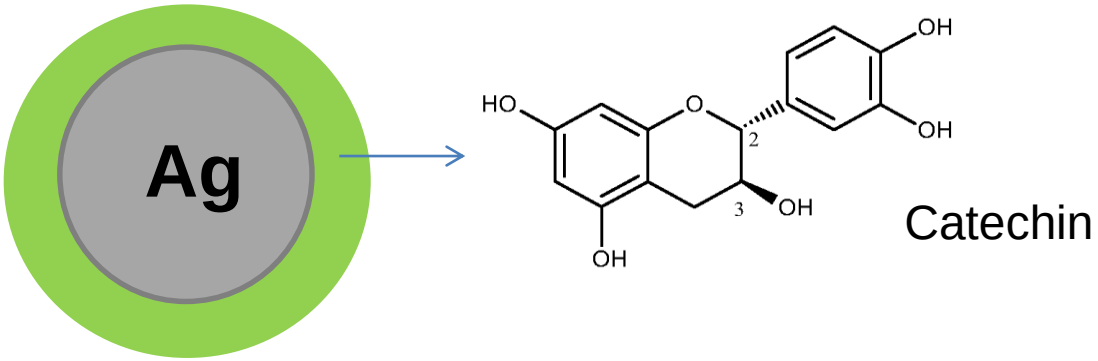
Synthesis of AgNPs by catechin



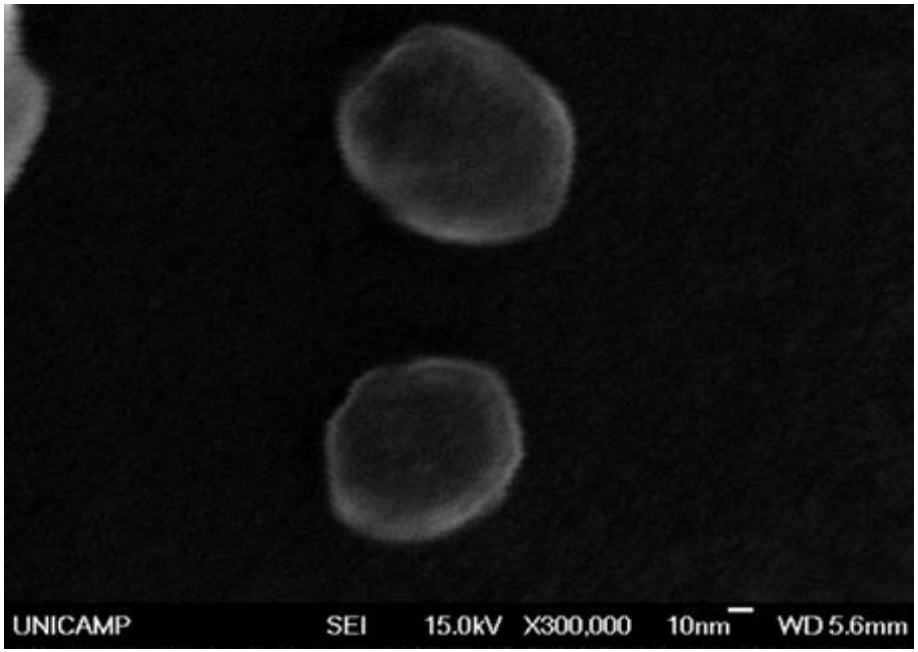
The rapid reaction between catechin and $AgNO_3$ was carried out at room temperature without the addition of surfactant or polymer as capping or reduction agents



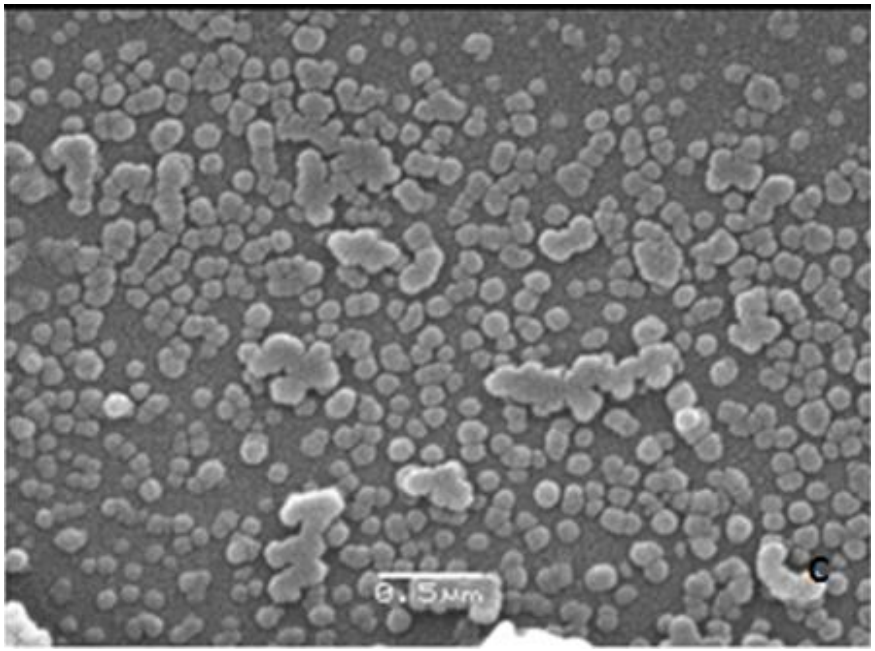
Catechin-AgNPs



Catechin

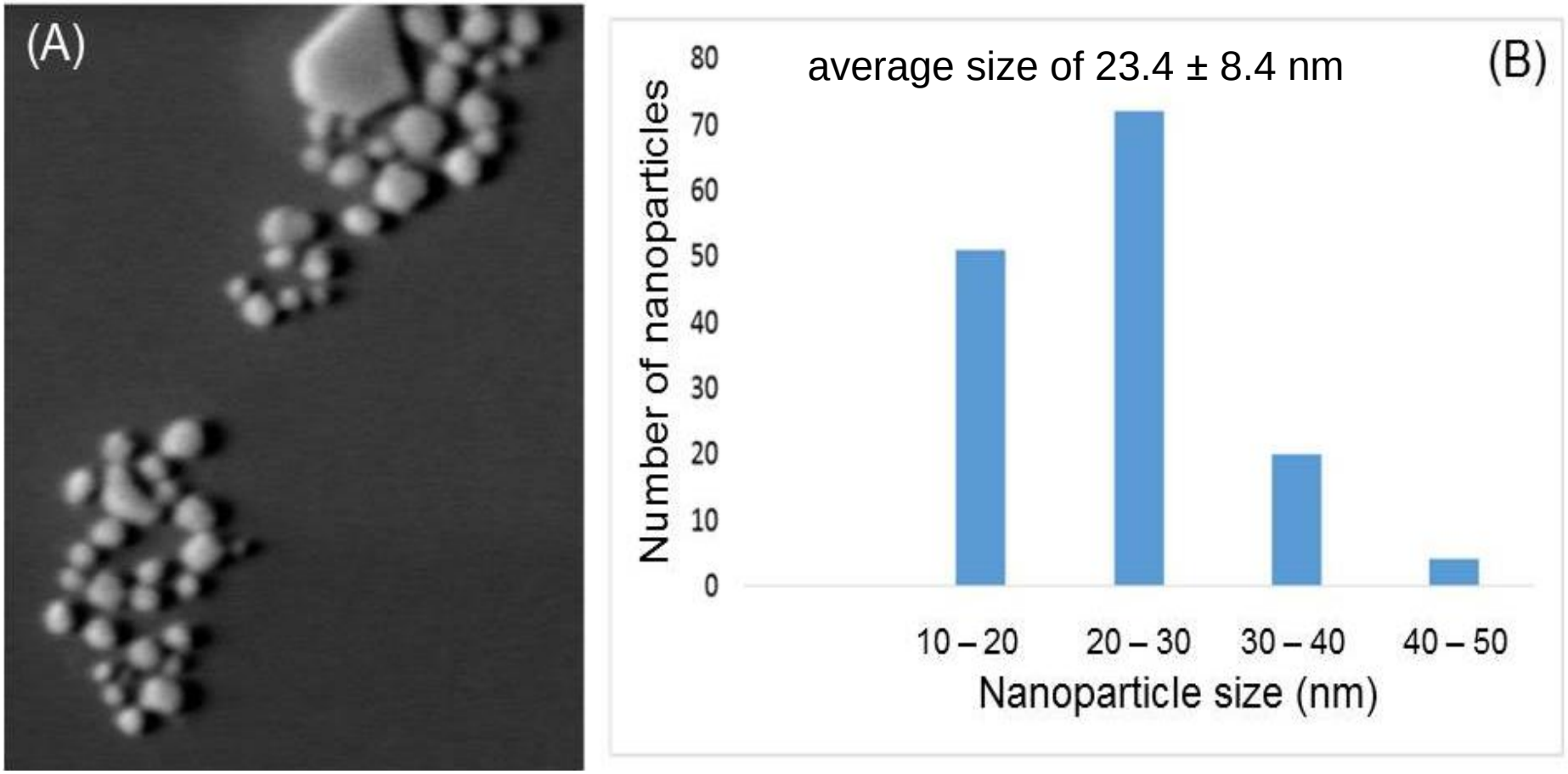


Transmission electron microscopy



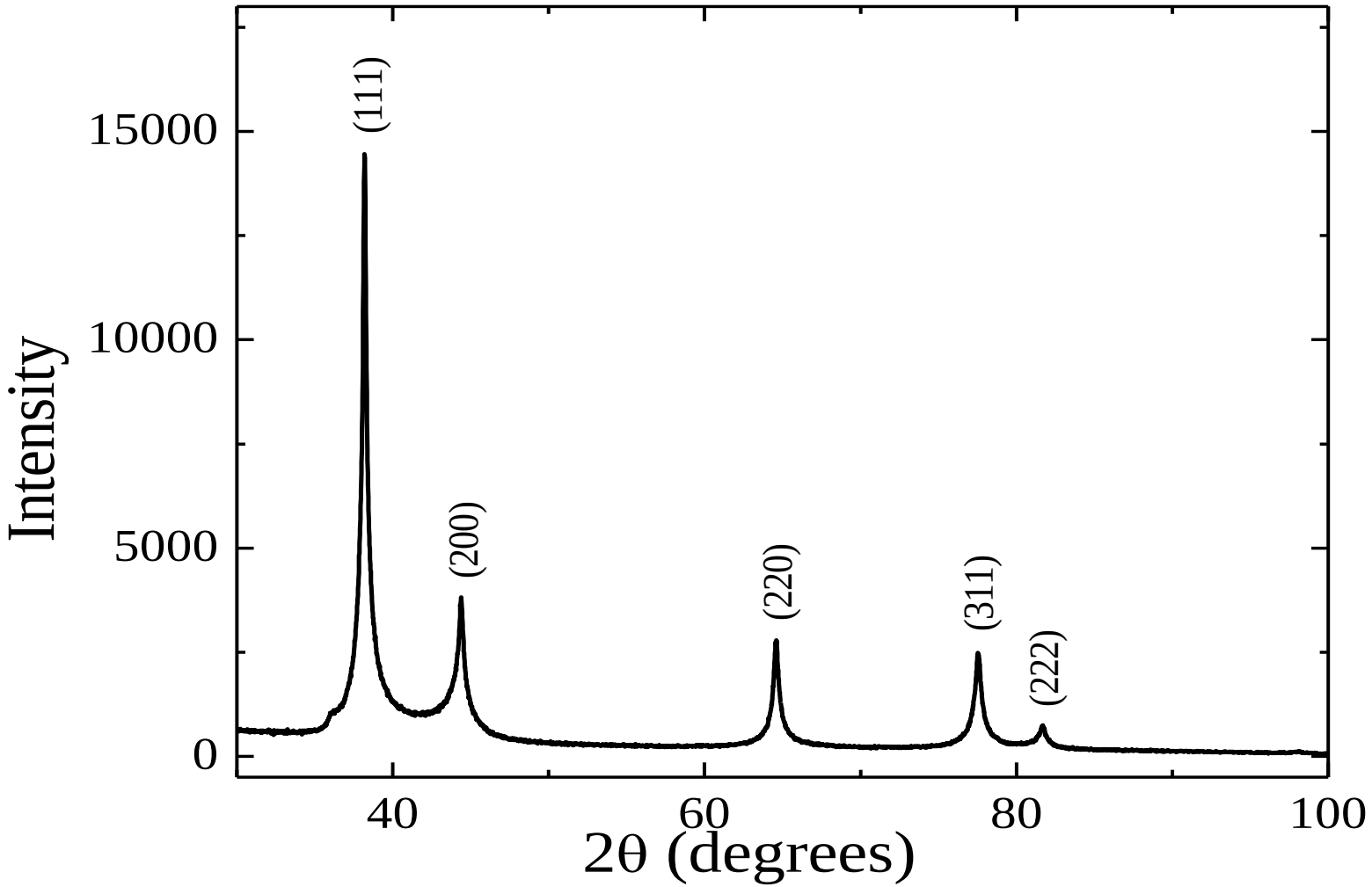
Scanning electron microscopy

Catechin-AgNPs



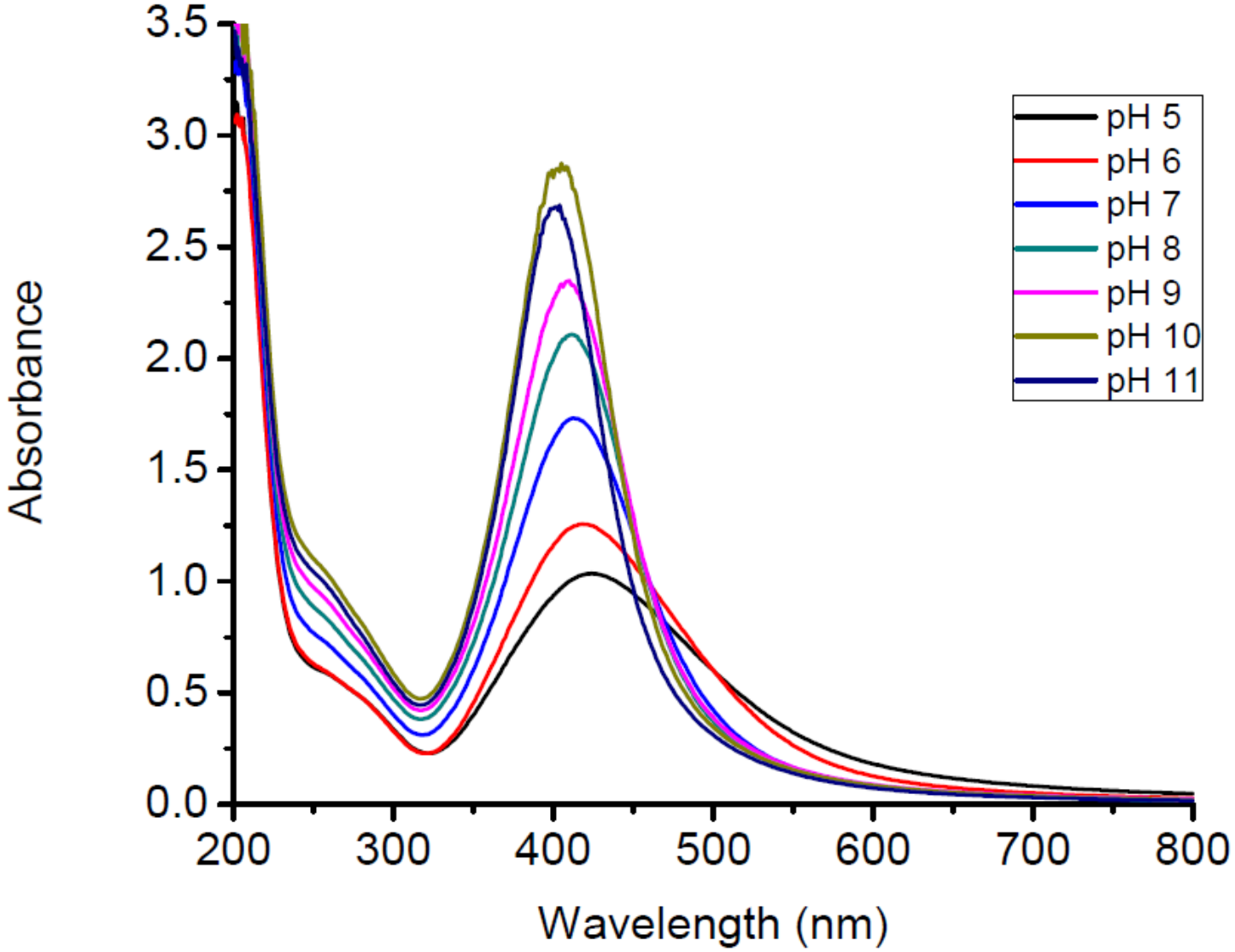
Field-emission scanning electron microscopy (STEM) of catechin-AgNPs (A) and their corresponding size distribution at solid state (B)

Catechin-AgNPs



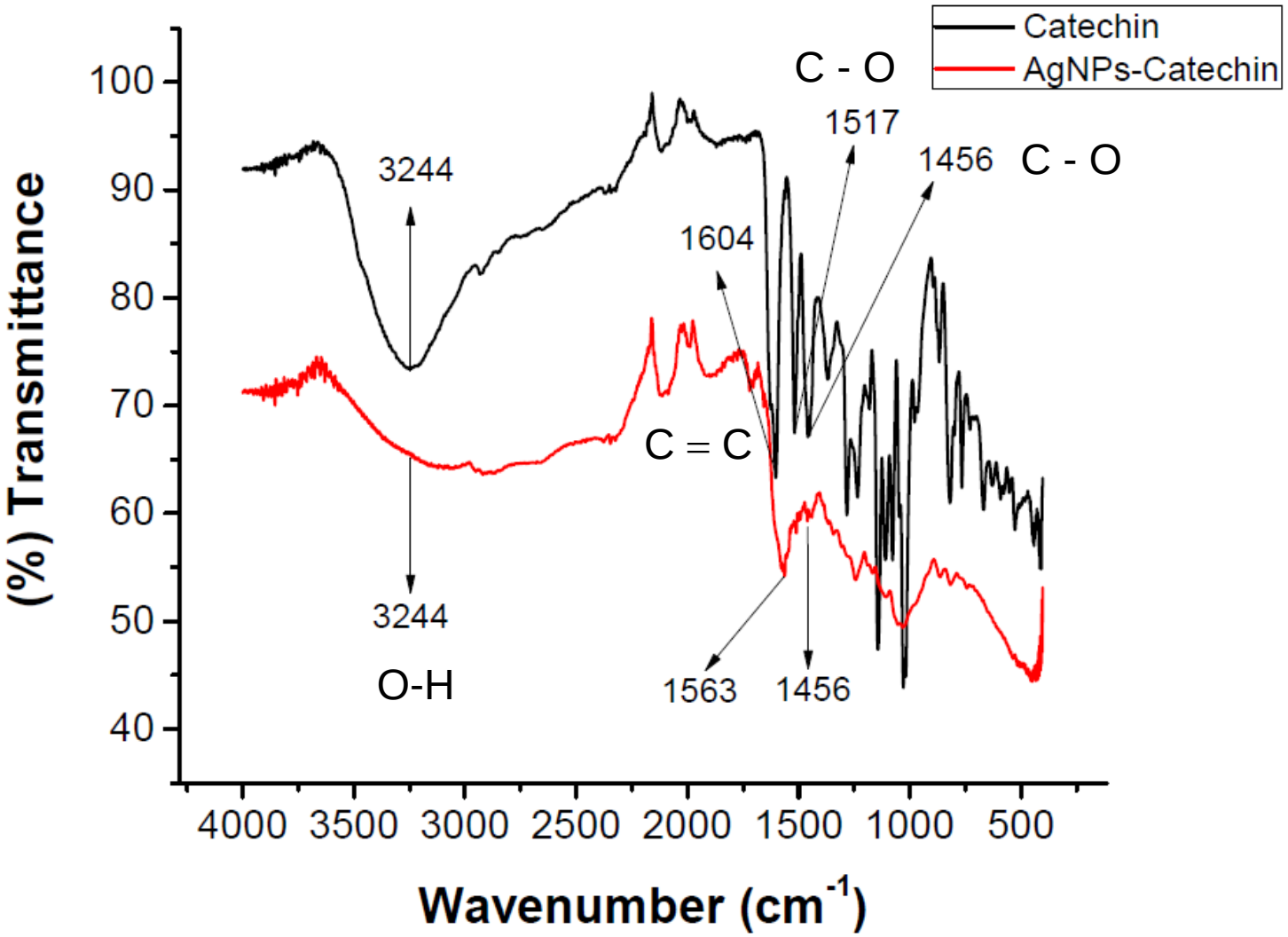
XDR patter of catechin-AgNPs

Catechin-AgNPs



Plasmonic absorbantion bands of catechin-AgNPs at different pHs

Catechin-AgNPs



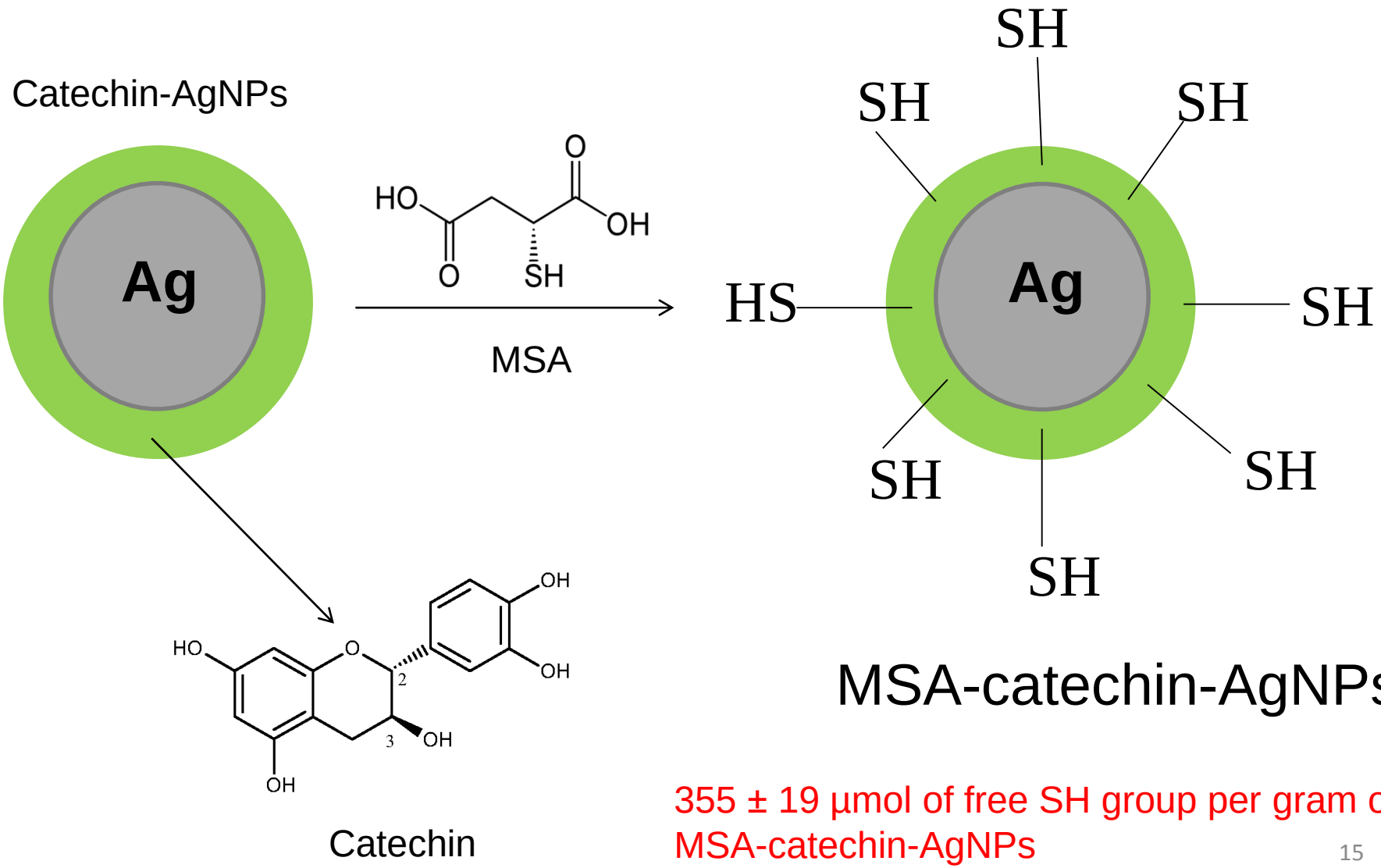
FTIR spectra of catechin and catechin-AgNPs

Catechin-AgNPs

Dynamic light scattering (DLS) measurements

- Hydrodynamic size = 44 nm,
- PDI = 0.21
- zeta potential = – 35.9 mV

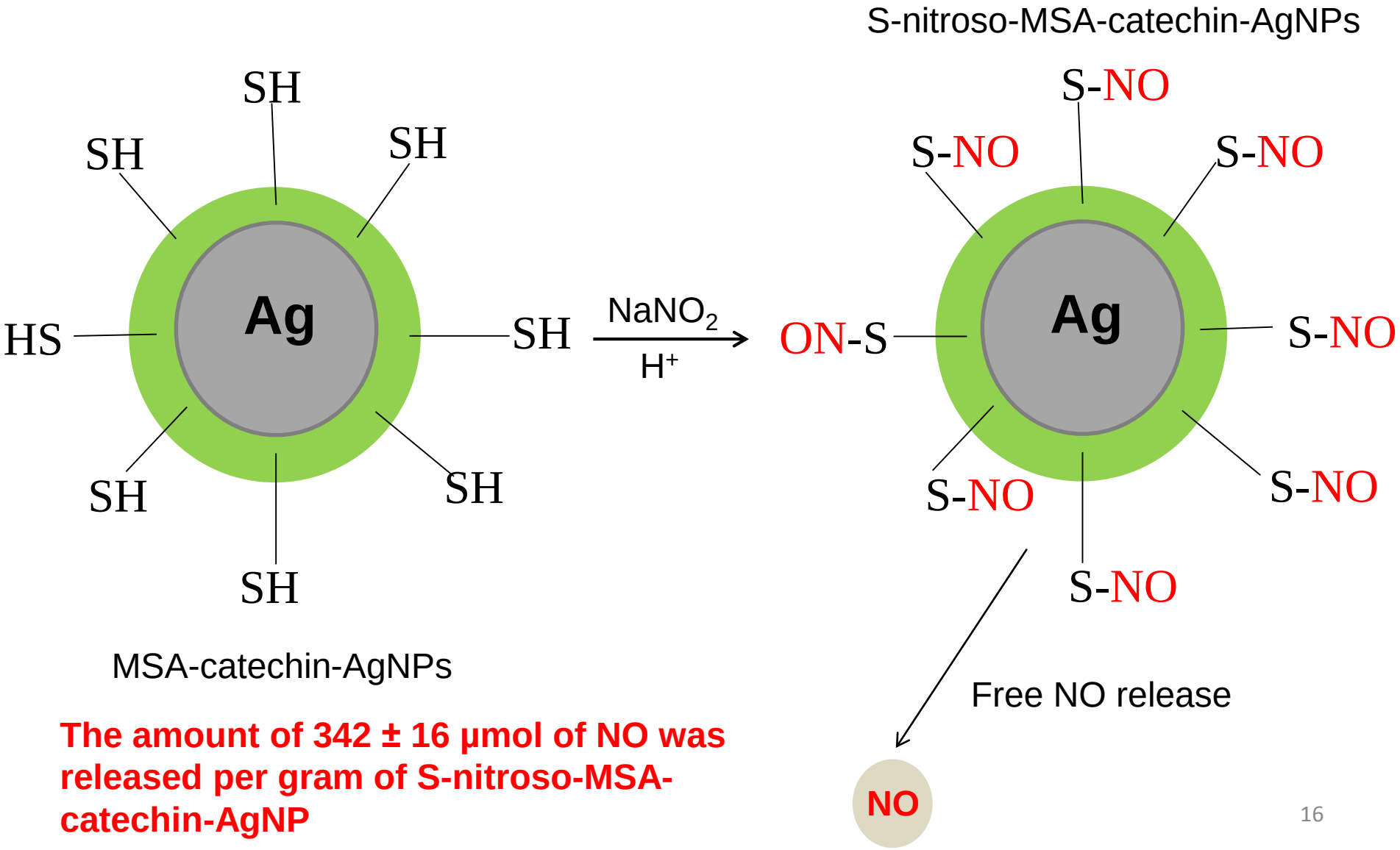
Functionalization of catechin-AgNPs with MSA leading to MSA-catechin-AgNPs



355 ± 19 µmol of free SH group per gram of MSA-catechin-AgNPs

Nitrosation of MSA-catechin-AgNPs leading to the formation of S-nitroso-MSA-catechin-AgNPs

Patent deposited BR102015015357



The amount of 342 ± 16 µmol of NO was released per gram of S-nitroso-MSA-catechin-AgNP

Why NO?

Biological Roles of NO

REGULATORY

pM | ---------- | μM

DELETERIOUS

mM

Regulatory

Vascular Tone

Neurotransmission

Bronchodilator

Immune System

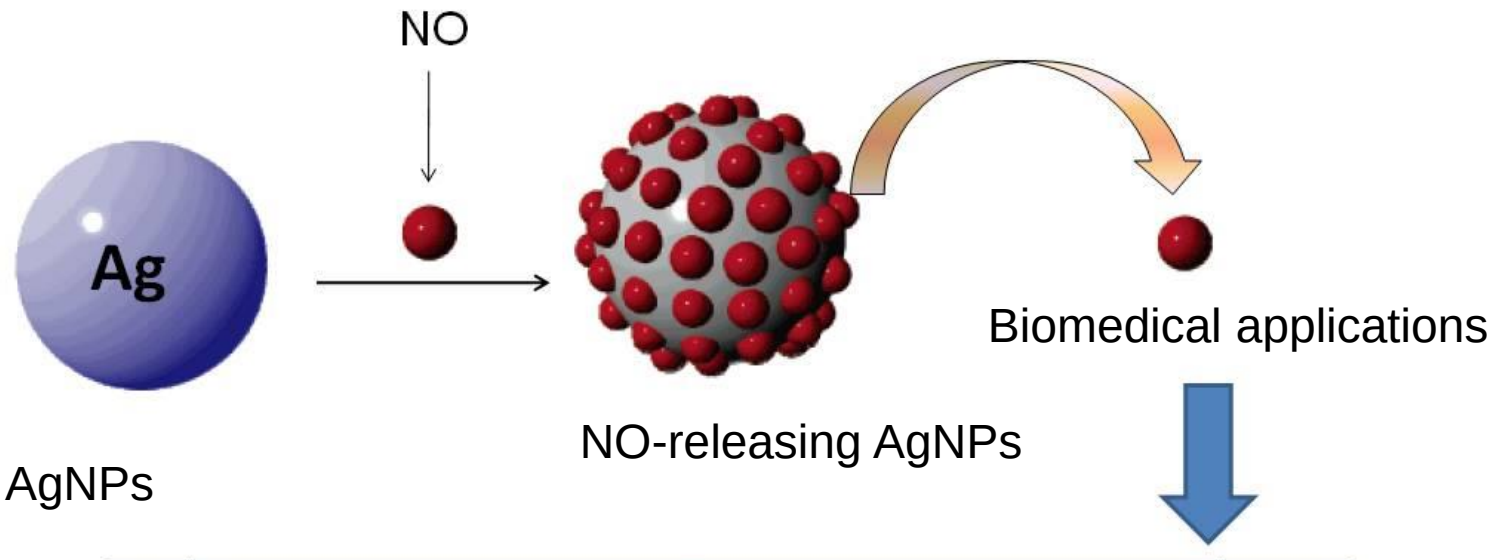
Inhibition of platelet adhesion and aggregation

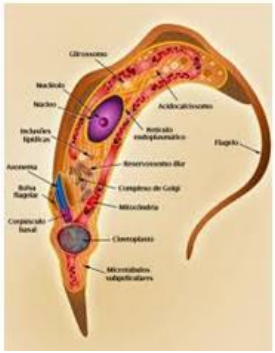
Wound healing

Deleterious

Inactivation of enzymes and DNA

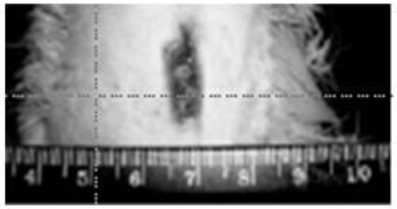
Nitric Oxide (NO)





Against parasites

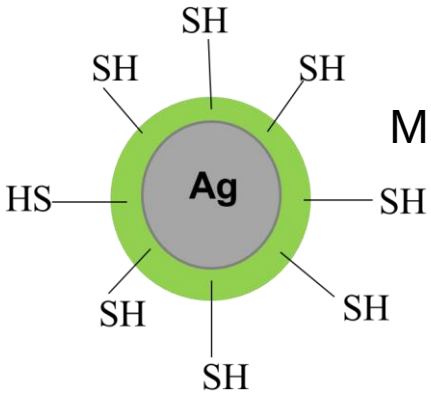
Anti-bacterial effects



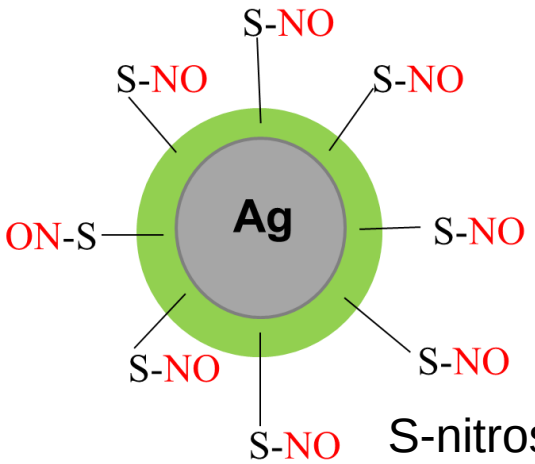
Wound healing

Antibacterial activities of the synthesized NPs

Catechin-AgNPs



MSA-catechin-AgNPs



S-nitroso-MSA-catechin NPs

Pseudomonas aeruginosa (ATCC 27853)

Staphylococcus aureus (ATCC 29213)

Klebsiella pneumoniae (ATCC 700603)

Salmonella enterica (ATCC 14028)

Escherichia coli (ATCC 35218)

Antibacterial activities of the synthesized NPs

MIC values (µg/mL) for different bacterial strains incubated for 24 h

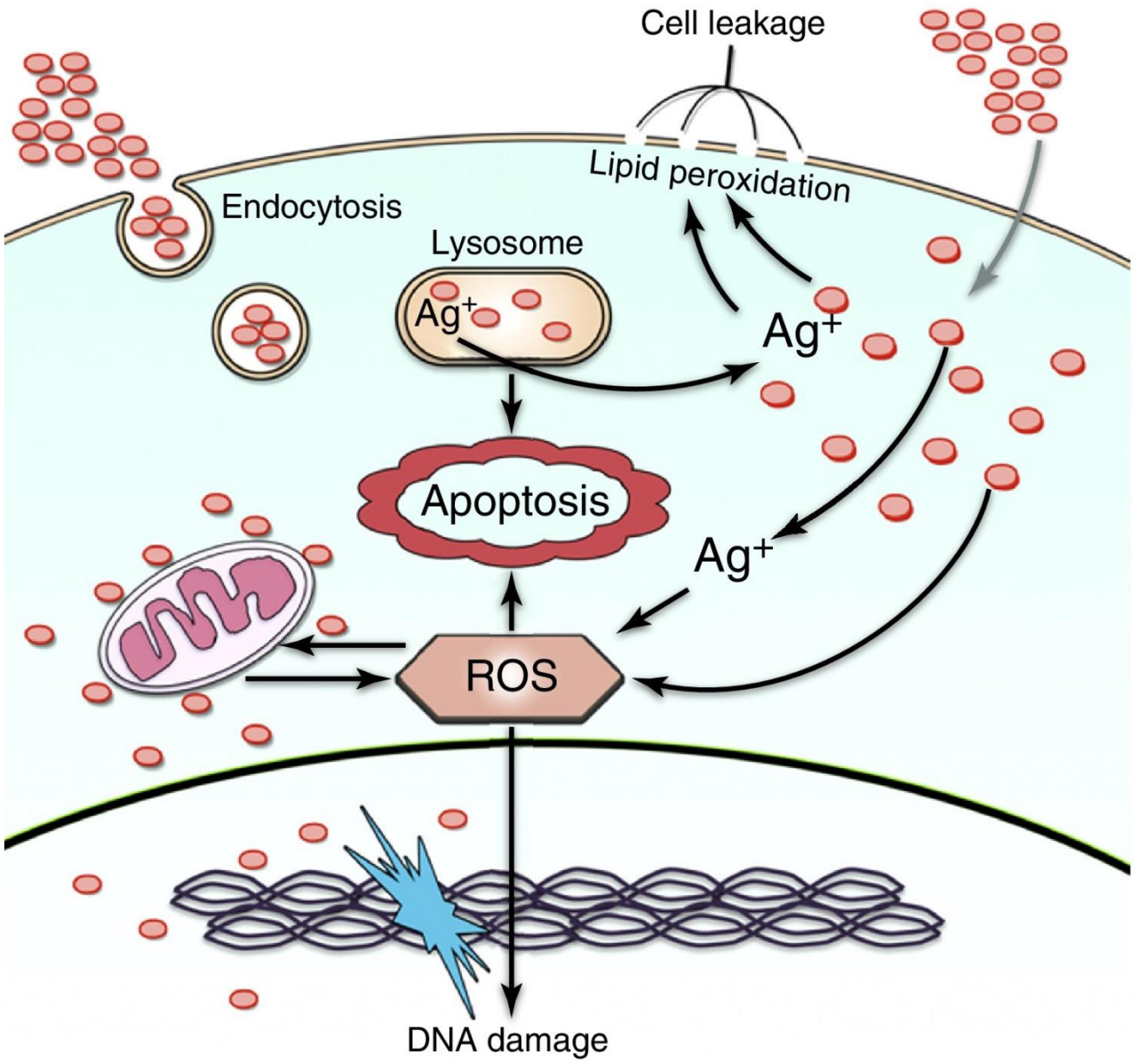
Bacterial strain	Catechin-AgNPs	MSA-catechin-AgNPs	S-nitroso-MSA-catechin-AgNPs
Pseudomonas aeruginosa	62	125	3
Staphylococcus aureus	500	250	125
Klebsiella pneumoniae	1000	250	125
Salmonella enterica	62	250	125
Escherichia coli	62	250	125

Antibacterial activities of the synthesized AgNPs

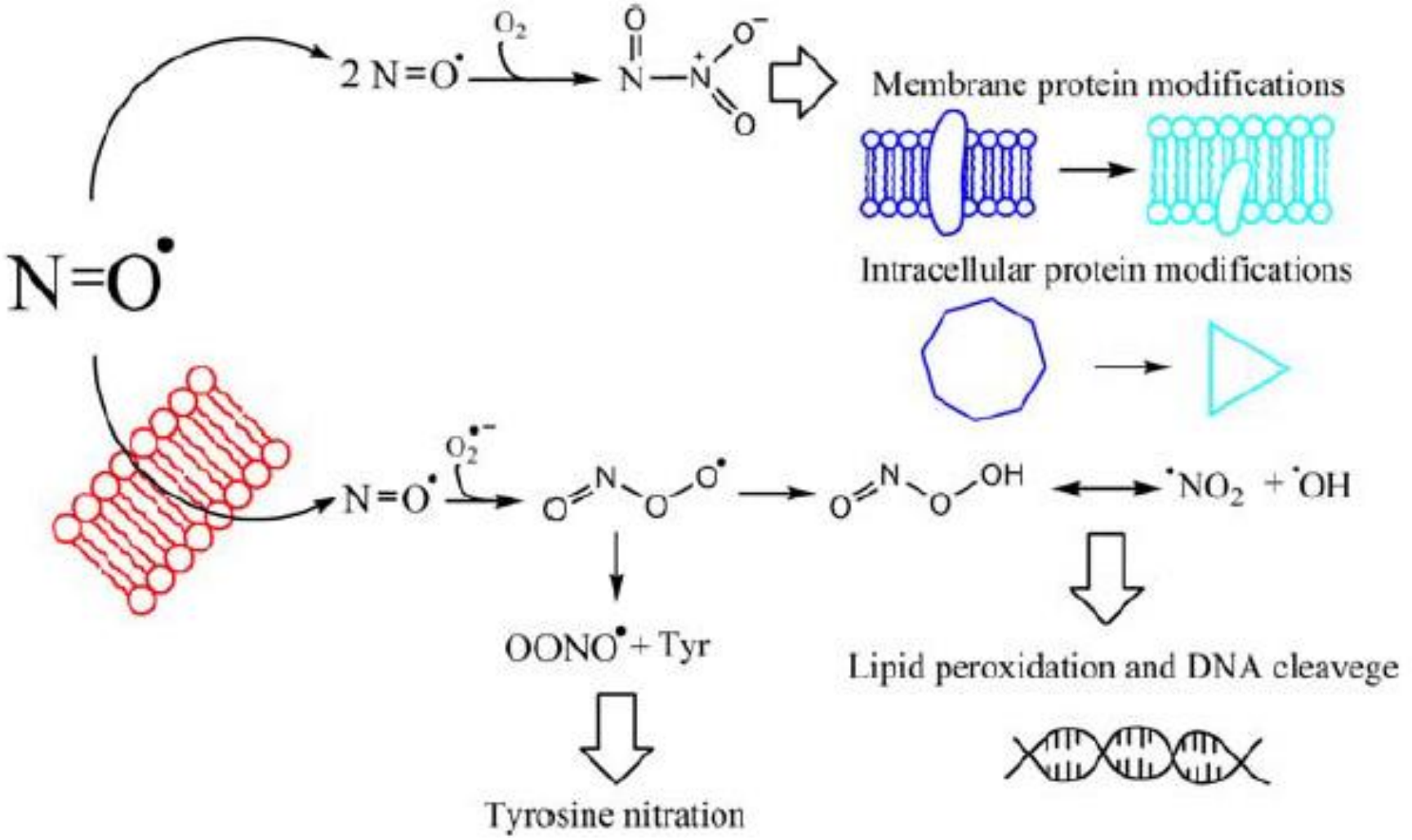
Minimum bactericidal concentration (MBC) values (µg/mL)

Bacterial strain	Catechin-AgNPs	MSA-catechin-AgNPs	S-nitroso-MSA-catechin-AgNPs
Pseudomonas aeruginosa	62	250	6
Staphylococcus aureus	500	500	125
Klebsiella pneumoniae	1000	500	125
Salmonella enterica	125	500	125
Escherichia coli	125	500	125

Antibacterial activities of the synthesized AgNPs



Antibacterial activities of NO



Conclusions

- ✓ AgNPs were synthesized by catechin, the main product of green tea extract
- ✓ Catechin acts a capping agent on the surface of AgNP, avoiding nanoparticle oxidation and/or aggregation
- ✓ The obtained nanoparticles were characterized by different techniques, which indicate the formation of AgNP core coated with catechin
- ✓ The surface of catechin-AgNPs was functionalized with MSA, a low molecular weight thiol containing molecule, leading to the formation of MSA-catechin-AgNPs.
- ✓ Free thiol groups on the surface of MSA-catechin-AgNPs were nitrosated leading to the formation of S-nitroso-MSA-catechin-AgNPs, which act as spontaneous NO donor

Conclusions

- ✓ The antibacterial activities of catechin-AgNPs, MSA-catechin-AgNPs and S-nitroso-MSA-catechin-AgNPs were demonstrated towards different bacterial strains
- ✓ All tested nanoparticles demonstrated antibacterial effects, as assayed by the determination of MIC and MBC values
- ✓ In most of the cases, NO-releasing nanoparticles enhanced the antibacterial effect of catechin-AgNPs.
- ✓ These results highlight the promising uses of NO-releasing AgNPs against resistant bacteria in several biomedical applications

Collaborators and Financial Support

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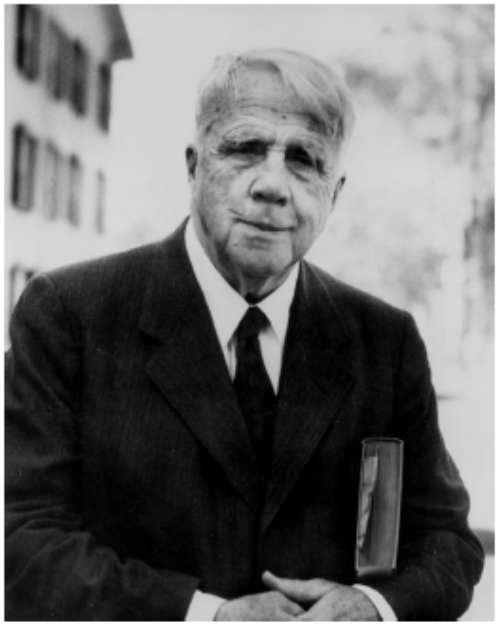
Green is less travelled…

Two roads diverged in a wood, and I took the one less traveled by, And that has made all the difference.

"The Road Not Taken"

Robert Frost



Robert Frost
(1874 – 1963)

Thank you for your attention