

Multimetallic nanohybrids as potential antimicrobial agents with extensive microbe coverage to be used in personal care products.

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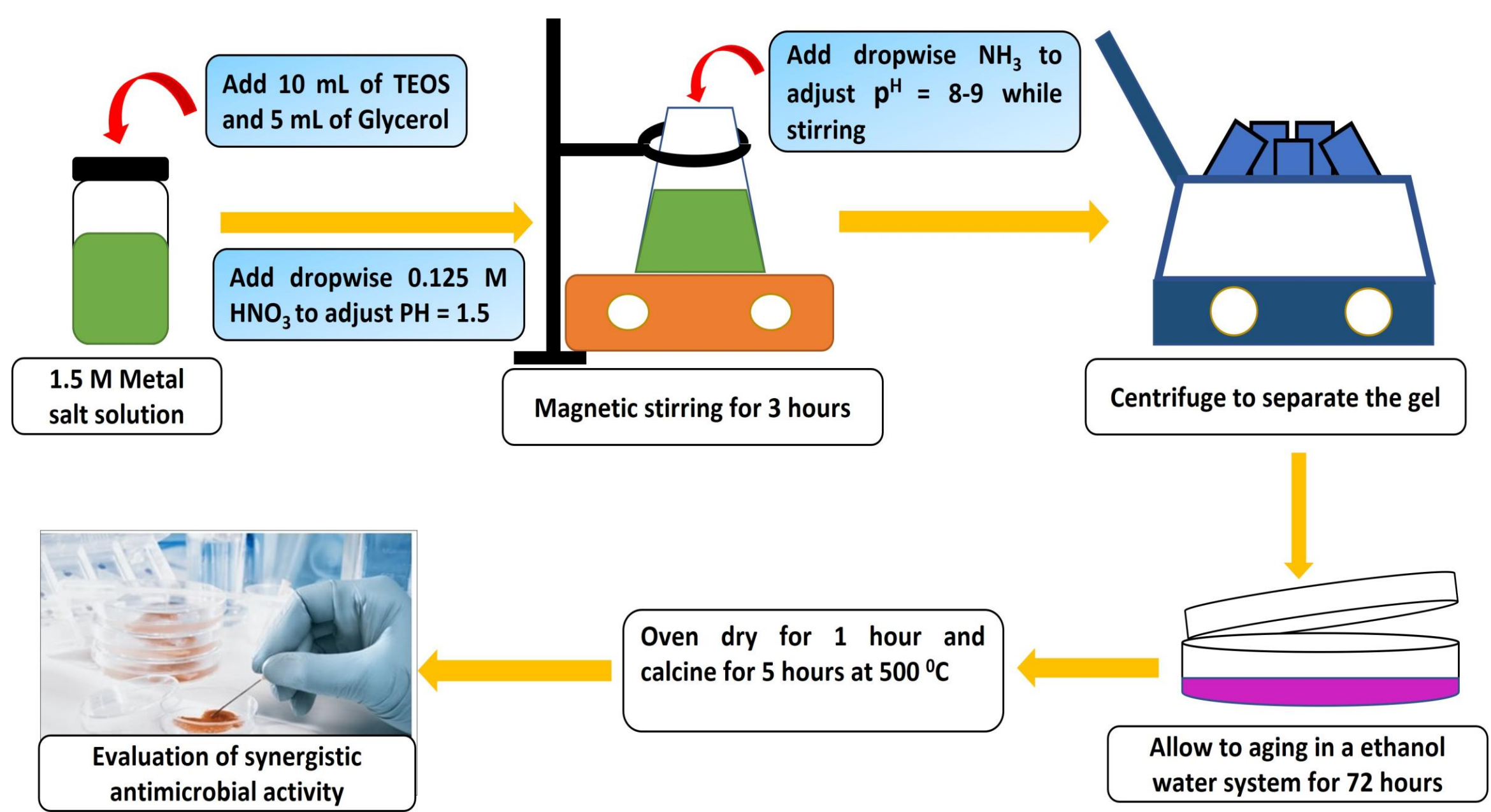
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Introduction

- Public health is greatly impacted by personal protective equipment (PPE) and personal hygiene products like sanitary napkins and diapers.
- Antimicrobial agents possess a potential to be incorporated into them to get secured against different pathogenic infections.
- Most affluent nations can afford them, whereas third-world nations face a number of obstacles in acquiring PPE and other personal hygiene products due to their inefficient supply, high prices, and the use of expensive and sophisticated manufacturing technologies. Therefore, regardless of socioeconomic factors, a constant and affordable supply of PPE and personal hygiene products for every person in the world is essential.
- Consequently, it is essential to develop new antimicrobial agents that are cost-effective for use in PPE and personal hygiene products.
- Nanotechnology, which has revolutionized several areas in health-related issues, possess an ability to act as an aid for this purpose.
- In this study, three types of metallic nanohybrids; silver (Ag), copper (Cu), and cobalt (Co) were doped into silica nanoparticles, combined, compared, and evaluated as antimicrobial agents based on their individual activity and synergistic activity.
- Hence, developed antimicrobial nanohybrids has the potential to incorporate in personal care products as emerging and cost effective agents to gain good health and well being by achieving sustained development goals.

Methodology



Characterization

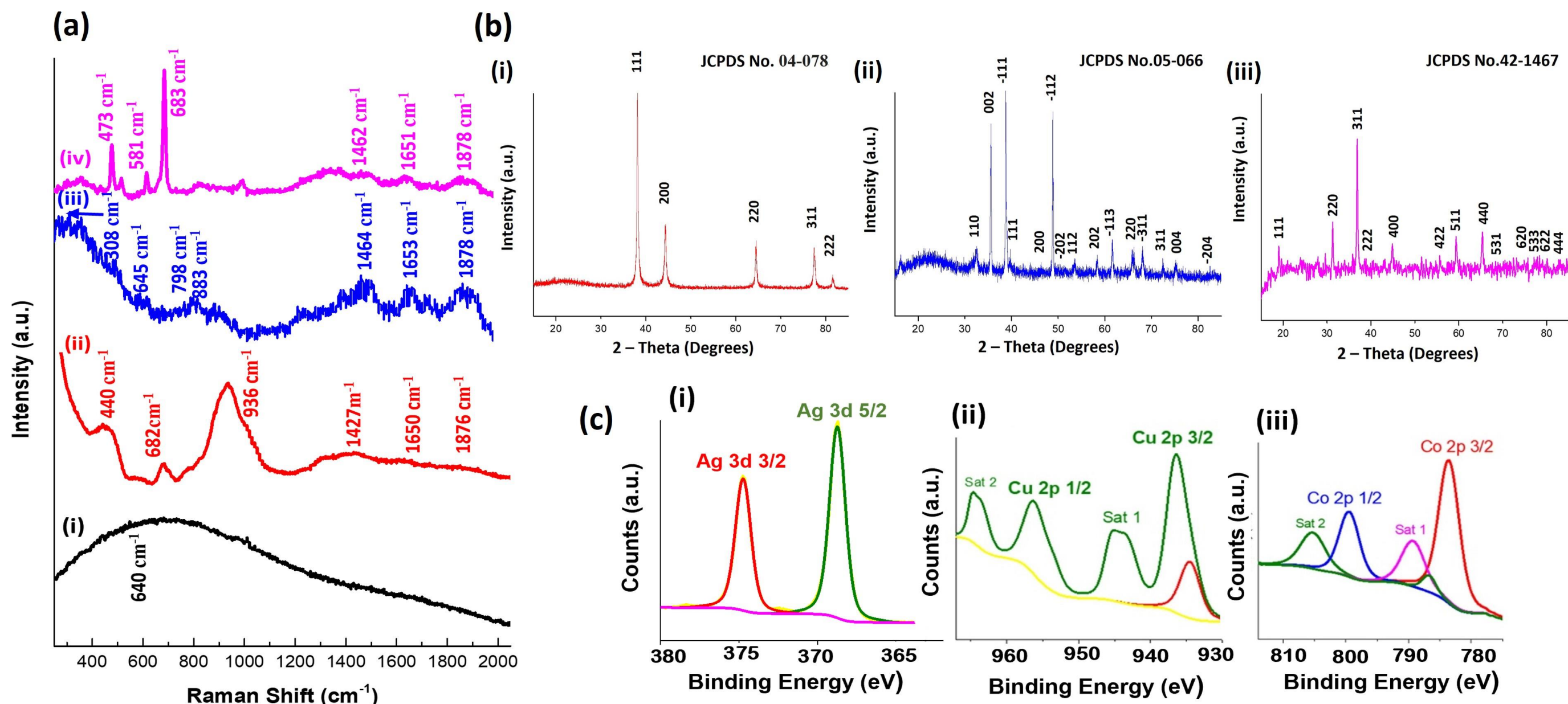


Figure 1: (a) Raman spectra of (i) SiNP, (ii) Ag doped SiNP, (iii) Cu doped SiNP, (iv) Co doped SiNP; (b) XRD spectra of (i) Ag doped SiNP, (ii) Cu doped SiNP, (iii) Co doped SiNP; (c) Deconvoluted high resolution XPS spectra of (i) Ag 3d state, (ii) Cu 2p state and (iii) Co 2p state of Ag, Cu, and Co doped SiNP respectively.

- The characterization of synthesized nanohybrids was confirmed the successful synthesis of metal doped silica nanoparticles.
- Raman analysis corroborated the diagnostic peaks and peak shifts due to the doping of metals into silica nanoparticles.
- XRD analysis provided evidence for the successful formation of the metal oxide crystalline structures within the silanol network.
- Deconvoluted high resolution XPS spectra of metal doped SiNP confirmed the successful doping and electron configurations of each metal.

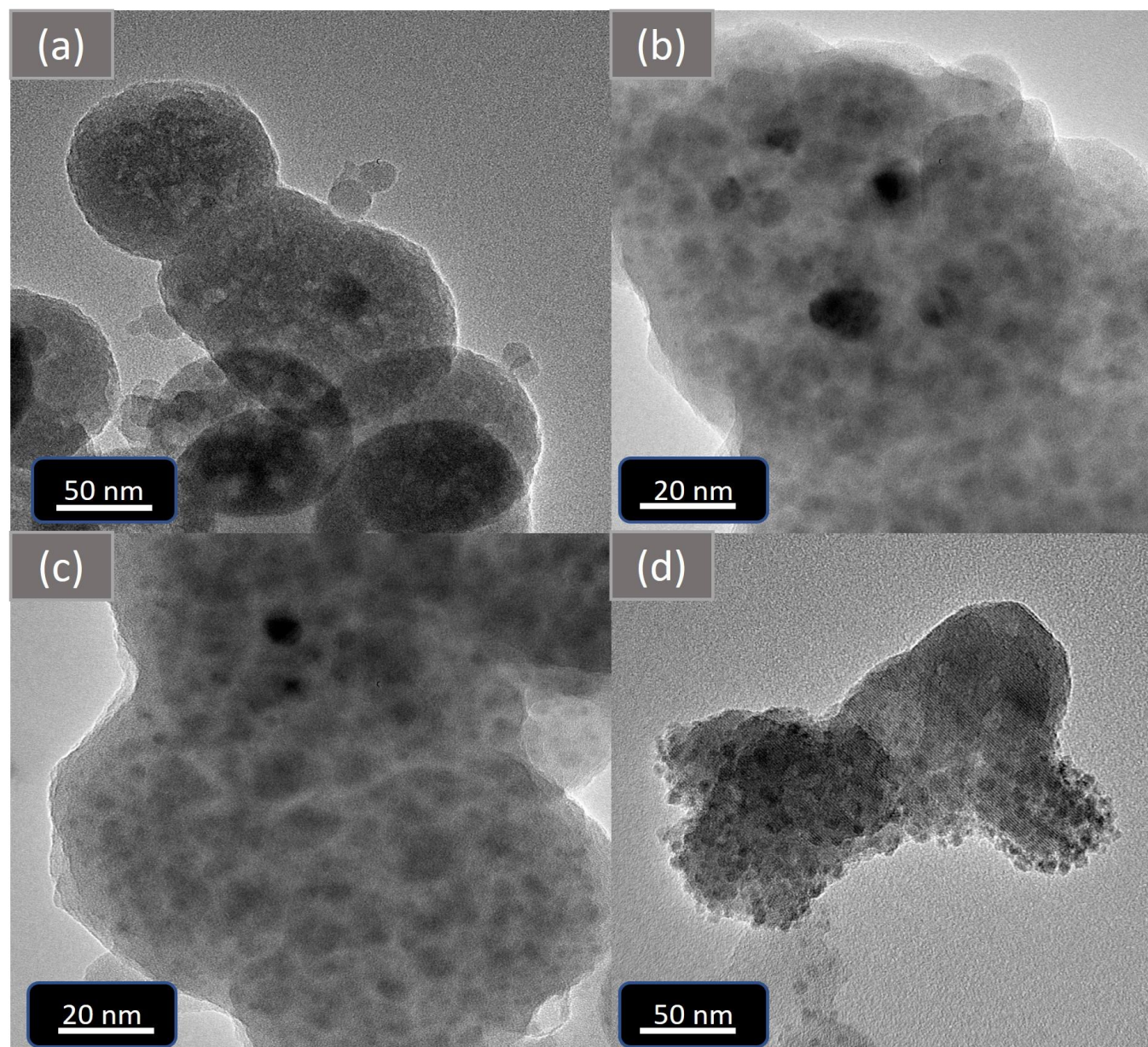


Figure 2: TEM imaging of (a) Silica nanoparticles, (b) Ag doped SiNP, (c) Cu doped SiNP, (d) Co doped SiNP.

- TEM imaging confirmed the spherical morphology of SiNP and successful doping of metal into the pores of SiNP.

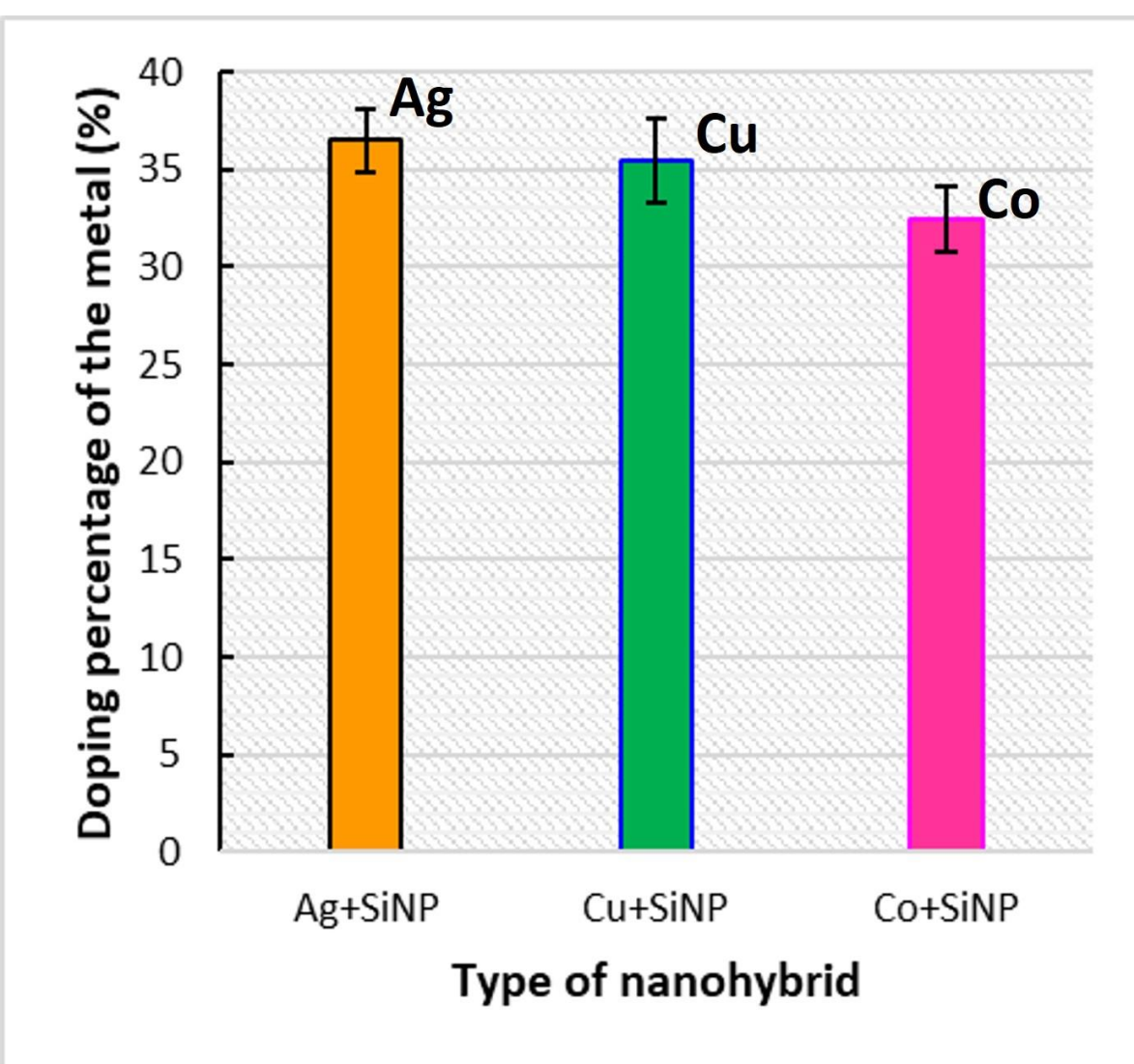


Figure 3: AAS analysis that confirms the doping percentages of each metal in synthesized monometallic nanohybrids.

- AAS analysis confirmed the doped percentages of each metal into SiNP.

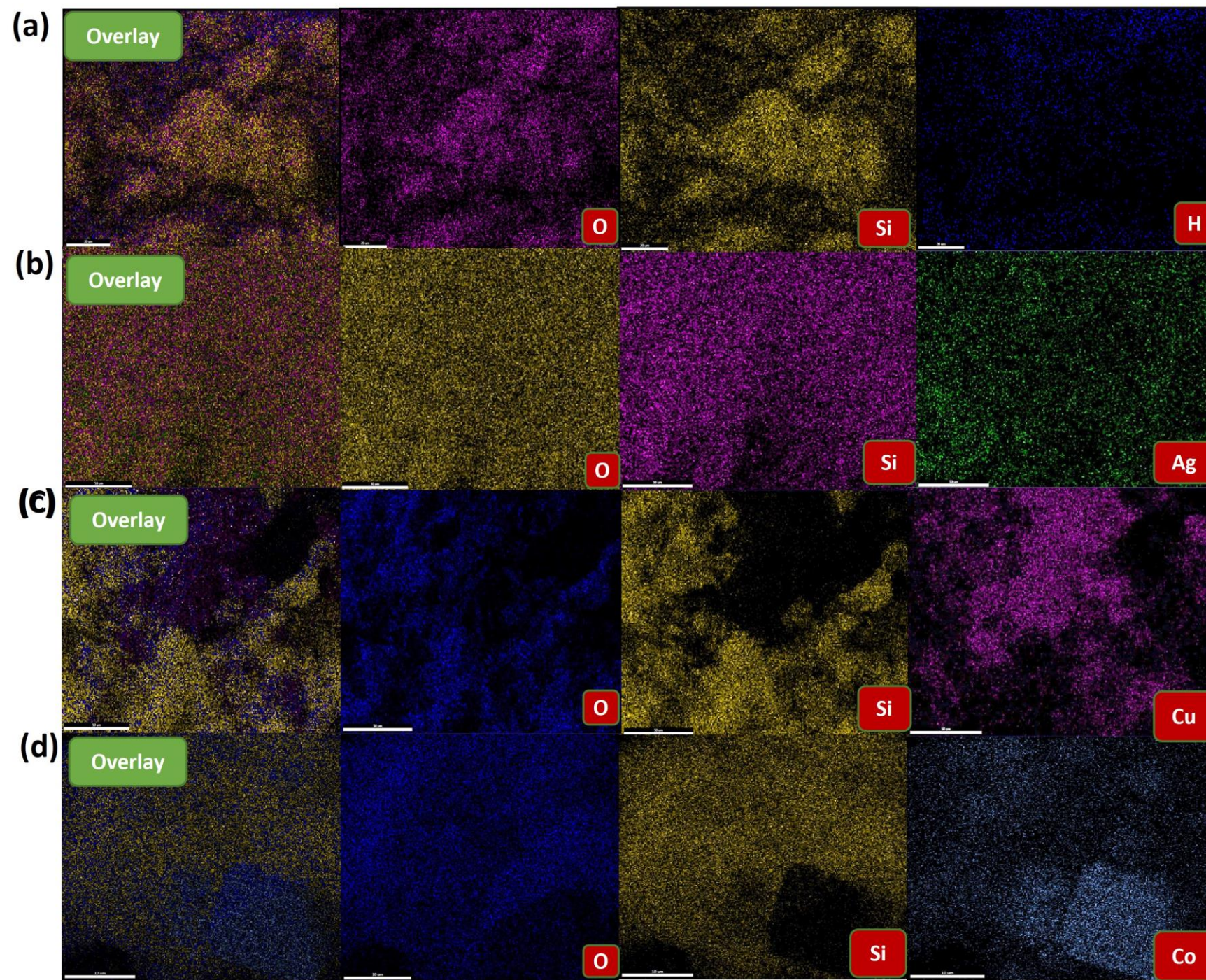


Figure 4: EDS mapping of (a) SiNP, (b) Ag doped SiNP, (c) Cu doped SiNP and (d) Co doped SiNP.

- EDS mapping showed the chemical composition of each metallic nanohybrid and their homogenous distribution all over the sample.

Radical Scavenging Activity

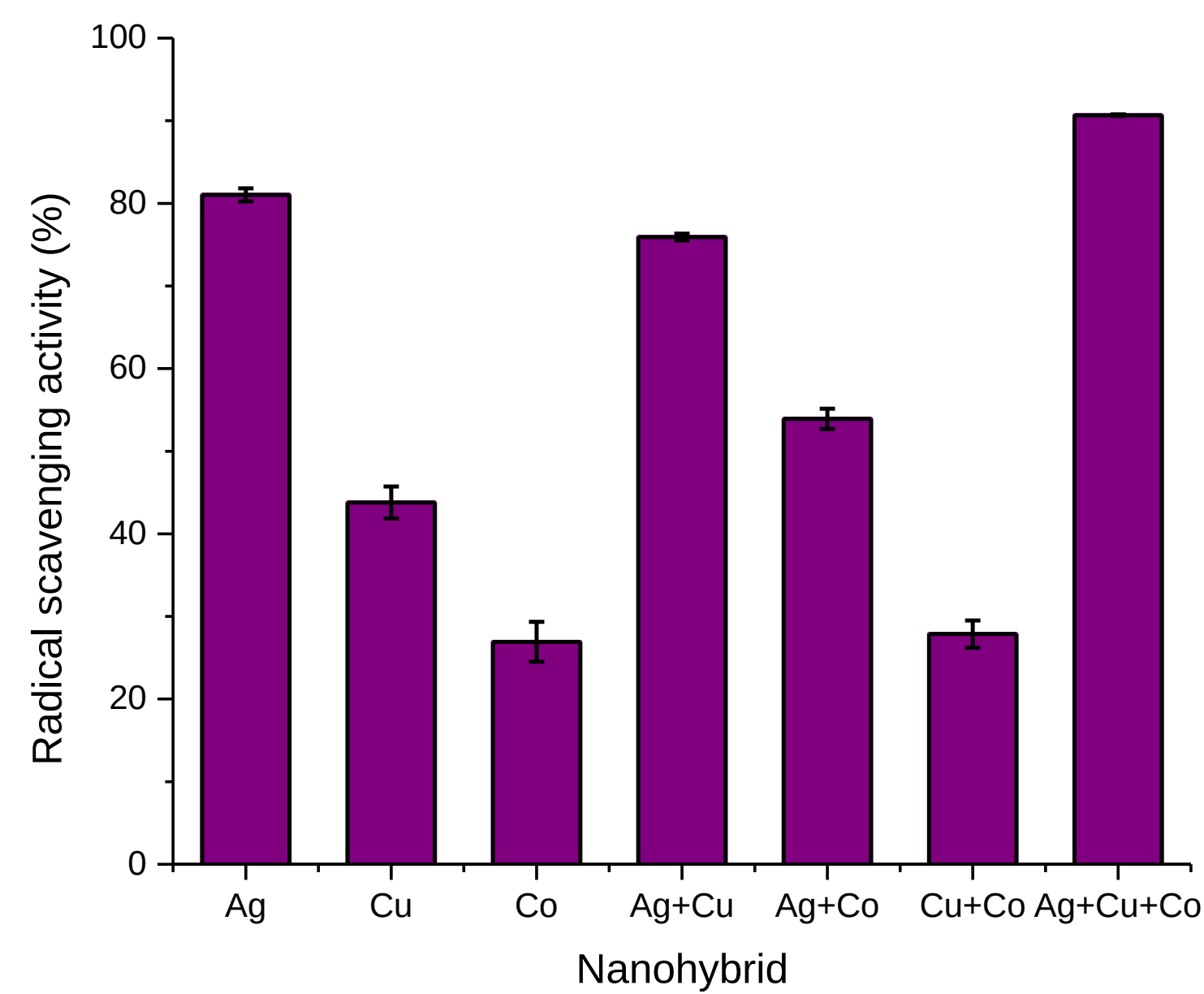


Figure 5: The radical scavenging activity of metallic nanohybrids by DPPH assay.

- DPPH assay confirmed the highest radical scavenging activity by trimetallic nanohybrid.

Synergistic Antimicrobial Activity

Table 1: The evaluated MIC and MBC values for trimetallic nanohybrid against selected microorganisms

Nanohybrid	<i>S. aureus</i>		<i>S. pneumoniae</i>		MRSA		<i>E. coli</i>		<i>K. pneumoniae</i>		<i>P. aeruginosa</i>		<i>C. albicans</i>	
	MIC	MBC	MIC	MBC	MIC	MBC	MIC	MBC	MIC	MBC	MIC	MBC	MIC	MBC
Ag doped SiNP+Cu doped SiNP+ Co doped SiNP	24.50	49.00	24.50	97.00	24.50	97.00	24.50	97.00	49.00	197.00	49.00	197.00	12.25	12.25

Table 2: Synergistic antibacterial activity of the trimetallic nanohybrid against selected microorganisms by FICI; S=Synergistic, A=Antagonist .

Metallic nanohybrid	<i>S. aureus</i>		<i>S. pneumoniae</i>		MRSA		<i>E. coli</i>		<i>K. pneumoniae</i>		<i>P. aeruginosa</i>		<i>C. albicans</i>	
	FICI	Activity	FICI	Activity	FICI	Activity	FICI	Activity	FICI	Activity	FICI	Activity	FICI	Activity
Ag doped SiNP+Cu doped SiNP+Co doped SiNP	0.40	S	0.33	S	0.89	S	0.31	S	0.51	S	0.51	S	0.56	S

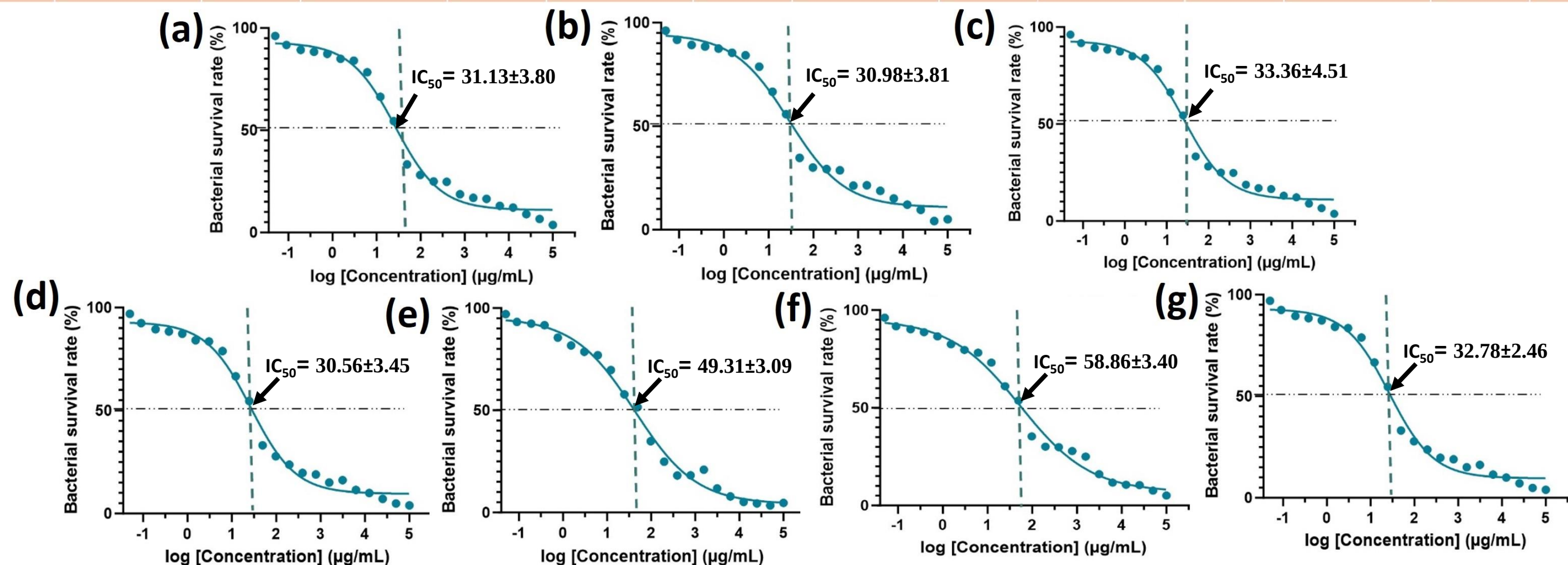


Figure 6: The IC₅₀ graphs of trimetallic nanohybrid; (a) *Staphylococcus aureus*, (b) *Streptococcus pneumoniae*, (c) MRSA, (d) *E. coli*, (e) *Klebsiella pneumoniae*, (f) *Pseudomonas aeruginosa*, (g) *Candida albicans*.

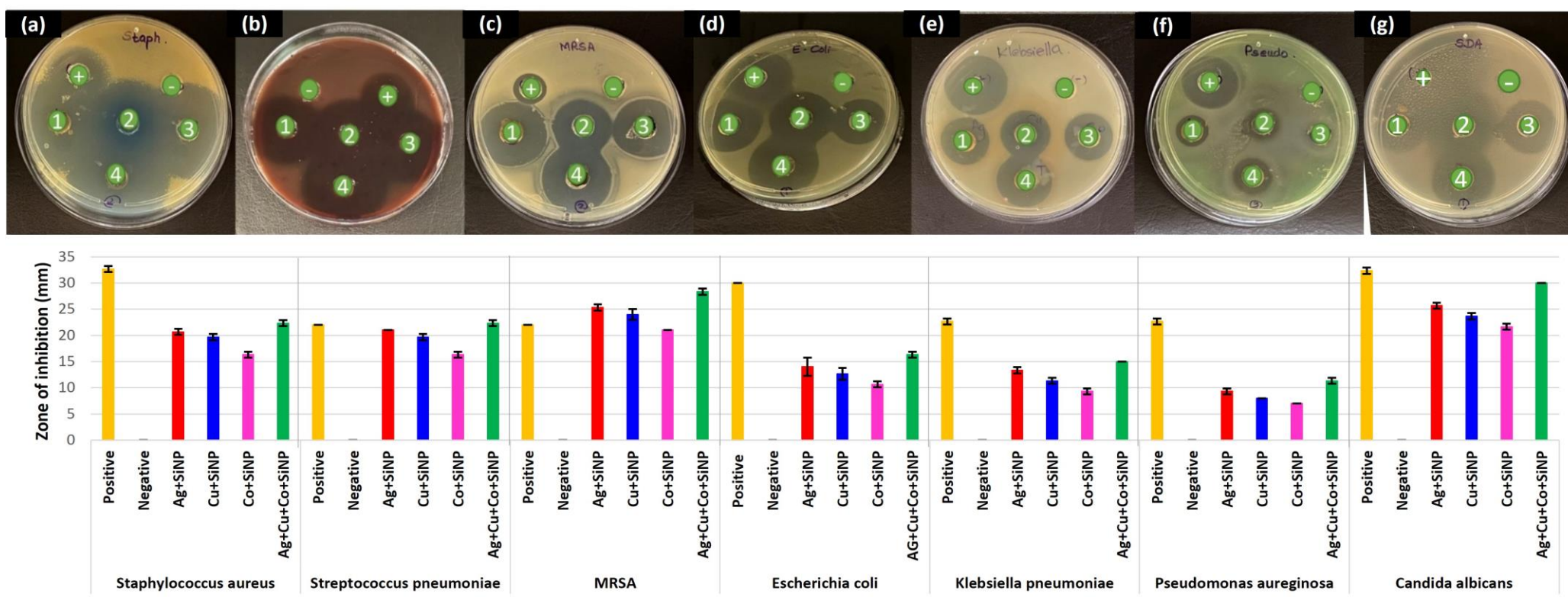


Figure 7: Zones of inhibition of ATCC strains of (a) *Staphylococcus aureus*, (b) *Streptococcus pneumoniae*, (c) MRSA, (d) *Escherichia coli*, (e) *Klebsiella pneumoniae*, (f) *Pseudomonas aeruginosa*, (g) *Candida albicans* (+) Positive control, (-) Negative control, (1) Ag doped SiNP, (2) Cu doped SiNP, (3) Co doped SiNP and (4) Ag doped SiNP+ Cu doped SiNP+ Co doped SiNP; (Each well contains 100 µl from each dispersion of metallic nanohybrid that has the concentration of 100mg/ml).

Acknowledgement

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Conclusion

- It was demonstrated that the synthesized multimetallic nanohybrid has the best antimicrobial synergy.
- It possesses a significant potential as an emerging and cost-effective antimicrobial agent with extensive microbe coverage.
- In addition, it was demonstrated that it could be utilized in PPE and personal hygiene products.

References

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