pH-driven biosynthesis of silver nanoparticle colloids from *Garcinia mangostana* L. (mangosteen) rind extract

UCSI University | Faculty of Engineering, Technology & Built Environment

UCSI-Cheras Low Carbon Innovation Hub Research Consortium

Min Kaung Htet Ko Ko[a], Dr Sum Jing Yao[a]

Department of Chemical and Petroleum Engineering, Faculty of Engineering, Technology and Built Environment, UCSI University

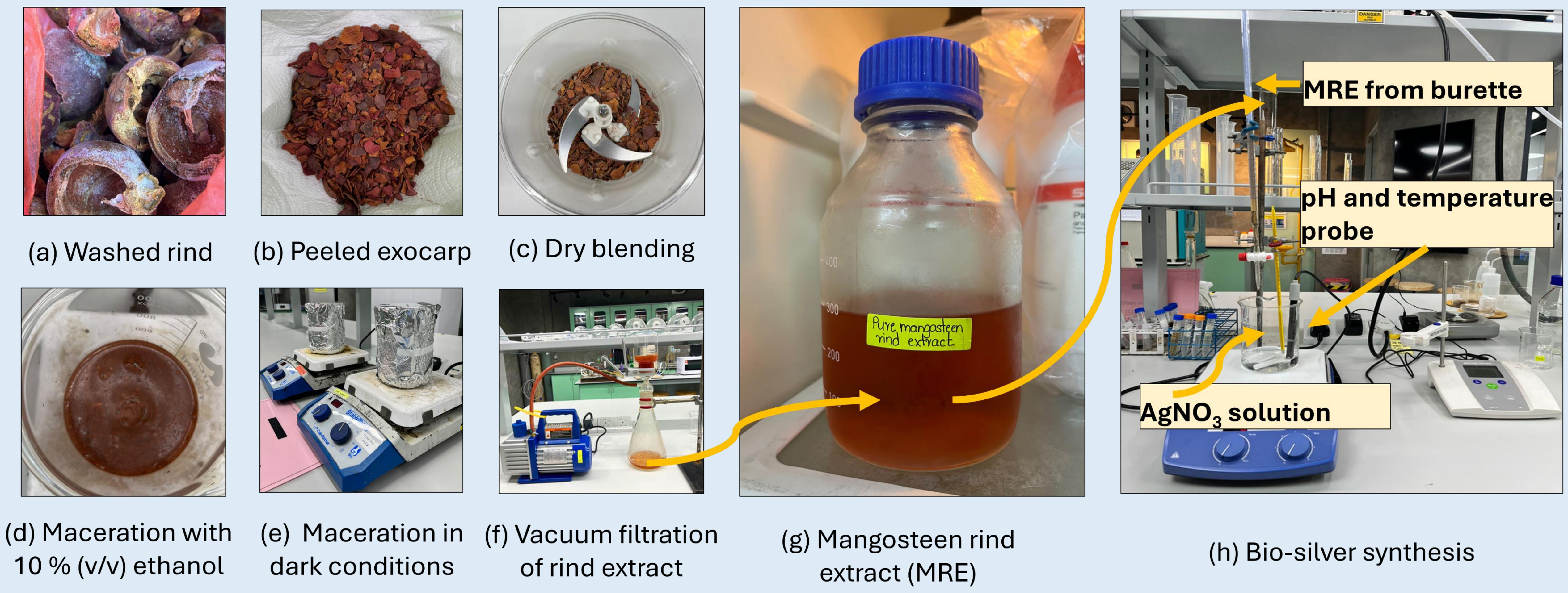
Priority Topic Area: **Responsible Production, Innovation and Industry**

1 – Problem statement and aim

Two-thirds of the mangosteen fruit is still disposed as **solid waste** when it contains valuable polyphenols such as anthocyanins and flavonoids [1]. This study aimed to **valorize** mangosteen rind for the biosynthesis of silver nanoparticle (AgNP) colloids with pH as the driving force. This study also elucidated the yield and stability of bio-silver which are underreported in literature. The bio-silver can be potentially applied in antibacterial ultrafiltration systems for the food and beverage **industry** in future.

2 – Methodology

As illustrated in Scheme 1, the biosynthesis of AgNP colloids was performed via a facile **one-pot method** reacting 5 mM $AgNO_3$ with mangosteen rind extract (9:1 v/v) upon stirring at 30 °C. 0.1 M NaOH was used to vary the pH of the medium to 8, 9, and 10, respectively.



Sample A - pure MRE (pH 3.89)
Sample B - pure NaOH
Sample C - MRE (pH 8.0)
Sample D - MRE (pH 9.0)
Sample E - MRE (pH 10.0)

UV-VIS analysis ▶ *SPR*
Hydrodynamic particle size/ Z-average (nm)
Zeta potential (mV)
FTIR

Scheme 1. Preparation of rind extract via maceration of mangosteen exocarp with 10% (v/v) ethanol and bio-silver synthesis

3 – Results and discussion

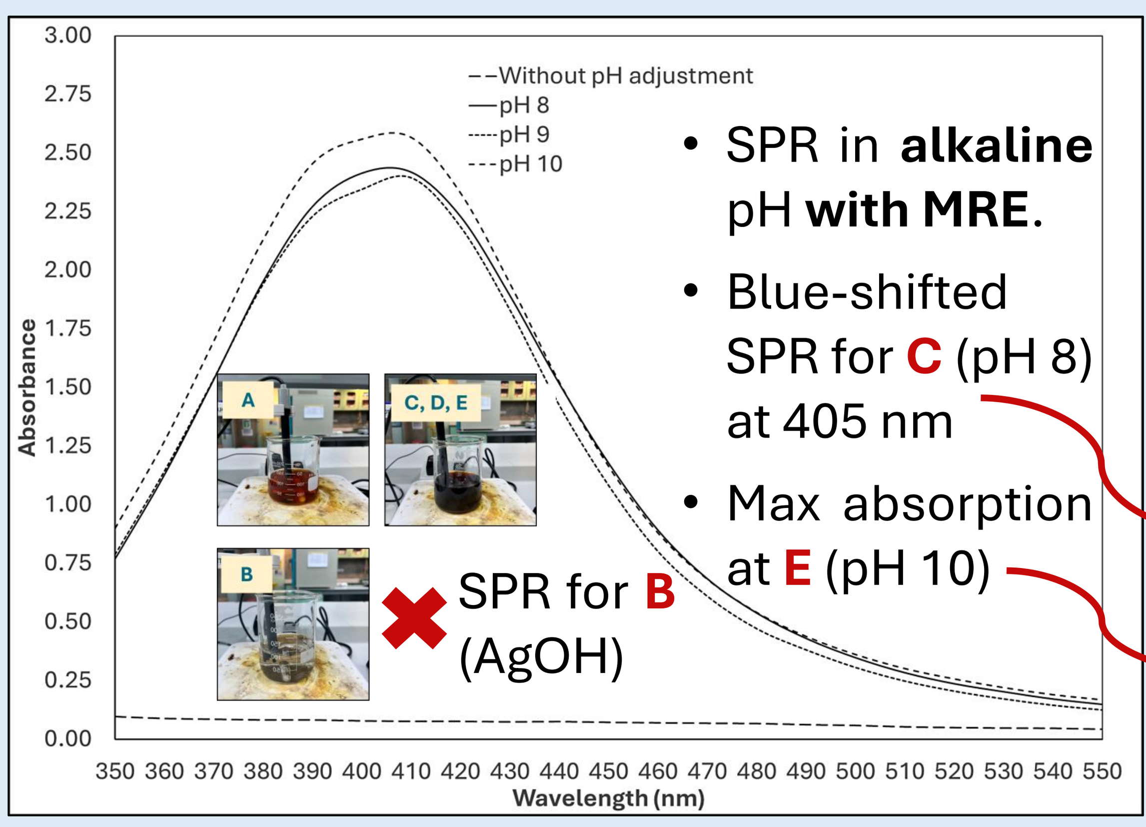


Figure 1. Surface plasmon resonance (SPR)

Table 1. Size and stability of MRE/AgNP colloids

	Z-average (nm)	PDI	ζ (mV)
pH 3.89 (A)	1015.50±12.50	0.44±0.07	-10.41±1.39
pH 8 (C)	128.67±0.58	0.41±0.01	-39.57±0.42
pH 9 (D)	199.07±1.20	0.50±0.03	-25.57±0.09
pH 10 (E)	200.27±2.84	0.39±0.01	-30.97±0.33

Table 2. Yield of MRE/AgNP colloids

	Yield (mg/mL)
pH 3.89 (A)	0.32±0.13
pH 8 (C)	0.47±0.14
pH 9 (D)	0.55±0.03
pH 10 (E)	0.73±0.16

- Ionic strength > steric hinderance at high pH leading to bigger sizes (**agglomeration**)
- **Smallest** hydrodynamic particle size and **best stability** (most negative ζ) at pH 8 (**C**) due to enhanced steric repulsion of bioactive compounds
- **Highest yield** at pH 10 (**E**) due to abundance of **–OH** groups which accelerated the reduction of Ag^+ to Ag^0 thus increasing AgNP nucleation [2]

- Metallic **Ag** bond for all samples at 409.04 (1) and 475.06 cm^{-1} (3)
- N-O symmetry of $AgNO_3$ at 1057.77 cm^{-1} (5) disappeared in Samples **A**, **C**, **D**, and **E** signifying **bio-reduction** by MRE
- Chelation of Ag^+ ions with –OH (13) from carboxylic acids in mangosteen rind at **alkaline pH**
- Broadening of 957.30 (4) and 1174.02 (6) cm^{-1} at **C** (pH 8) signified **bond formation** between Ag^+ and C-N, C-O-C, C-OH moieties of flavonoids and terpenoids in MRE [3]
- **Capping** interactions by C-N (8) and C=O (9) groups were most pronounced at **E** (pH 10) (increased ζ from D to E in Table 1)

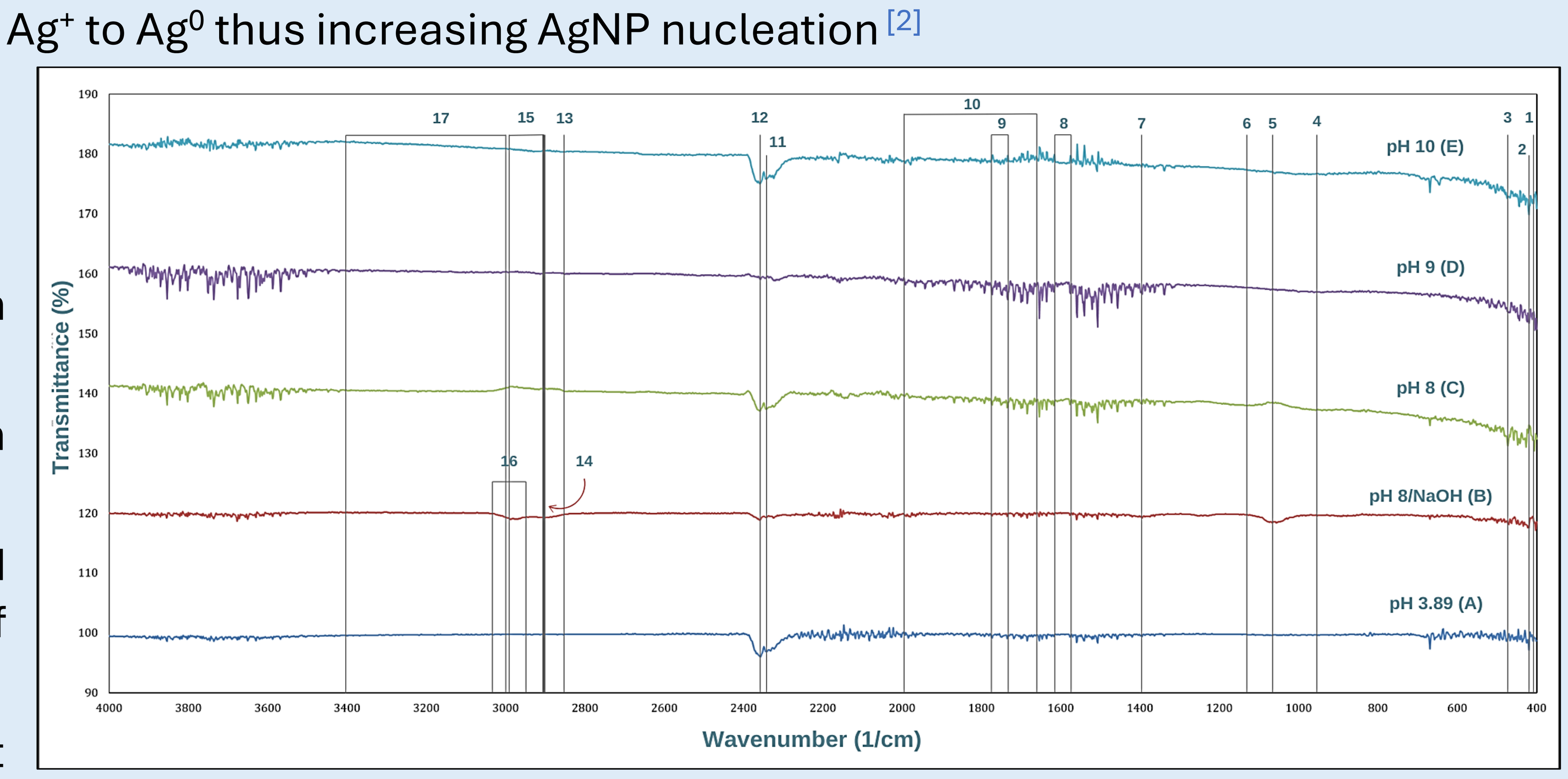


Figure 2. IR Spectra of Samples A-E

4 – Benefits to society

Repurposed mangosteen waste acts as a **sustainable bio-reductant** for the green synthesis of AgNP colloids which can serve as antibacterial agents in fabricating low-fouling ultrafiltration membranes for the food and beverage industry. Additionally, valorizing mangosteen rind lowers the environmental footprint of disposing mangosteen waste in Malaysia and Southeast Asia.

5 – Conclusion and next steps

pH 8 is recommended as the optimum pH for a future feasibility study on using bio-silver in an **antibacterial ultrafiltration membrane** for concentrating anthocyanins in fruit extracts.

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References/Acknowledgements

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[2] R. Zong, X. Wang, S. Shi, and Y. Zhu, "Kinetically controlled seed-mediated growth of narrow dispersed silver nanoparticles up to 120 nm: secondary nucleation, size focusing, and Ostwald ripening," Physical Chemistry Chemical Physics, vol. 16, no. 9, pp. 4236–4241, 2014.
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