

Kinetics of silver ion encapsulation as nanoparticles using *Vaccinium oxycoccos* plant extract for the efficient sensing of Cr(iii) ions & its biological assessment.

Introduction & Sensor Concept

Environmental Challenge
 Cr^{3+} is a significant concern in environmental monitoring and pharmaceutical wastewater management. Rapid, affordable, and field-deployable detection methods are needed to ensure water safety and reduce environmental risks.

Green Nanotechnology Solution
 This study presents a sustainable biosensor based on silver nanoparticles (AgNPs) synthesized using Cranberry plant extract. The plant extract acts as a natural reducing and stabilizing agent, eliminating the need for toxic chemical reagents.

Key Advantage
 AgNPs demonstrate remarkable structural stability, remaining functional for approximately 7-8 months, significantly longer than many conventional systems.

Sensor System

Sensor system is based on AgNPs synthesized from Cranberry. When Cr^{3+} ions are introduced into the solution, they interact with the polyphenols of AgNPs and induces nanoparticle aggregation, producing a visible color change that serves as the sensing signal.

Working of the Sensor

Optical response
 No Cr^{3+} → gold color
 Cr^{3+} → pink color

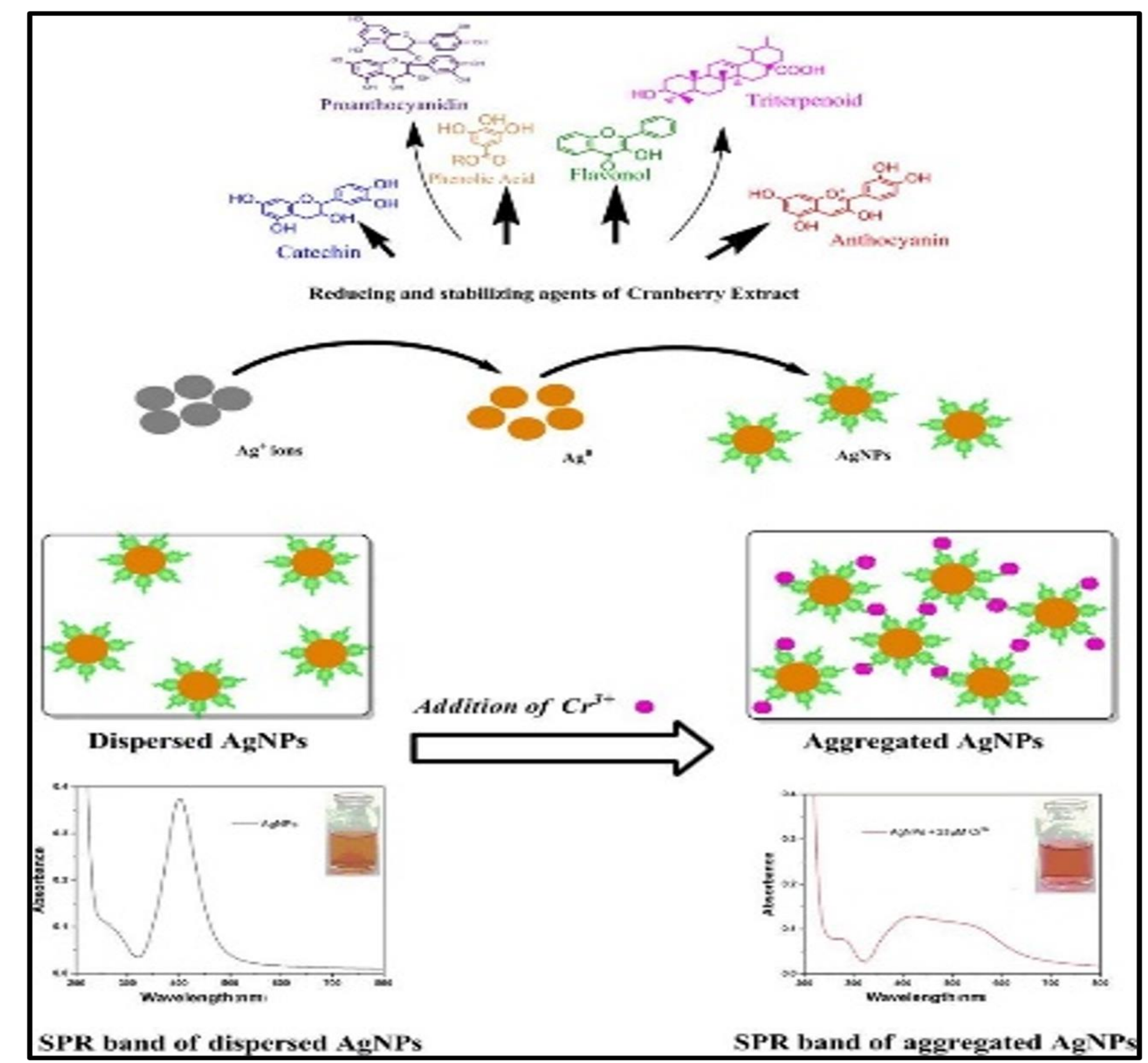
UV response
 No Cr^{3+} → UV peak at 520 nm
 Cr^{3+} → UV peak at 420 nm

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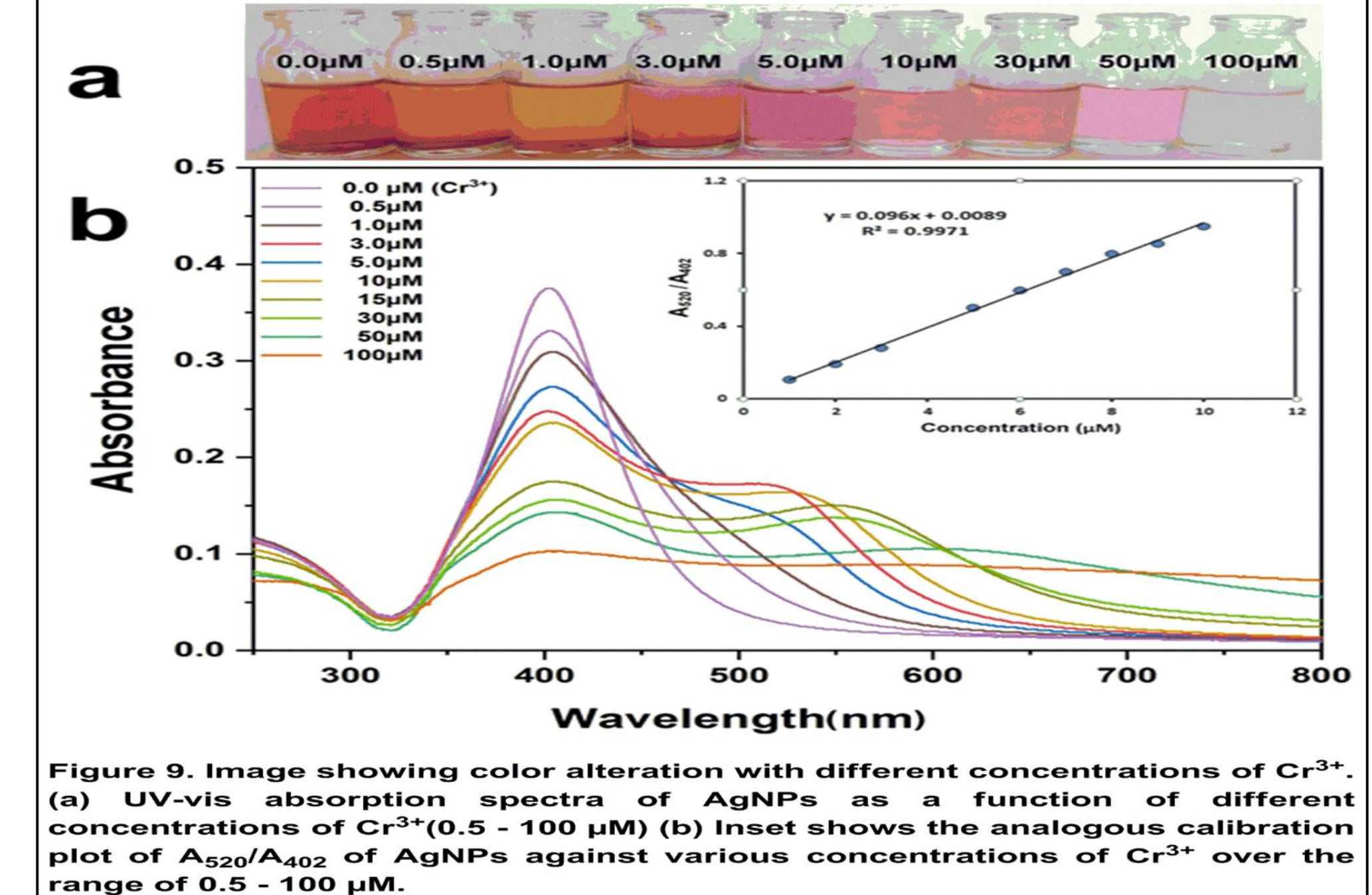
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Graphical Abstract



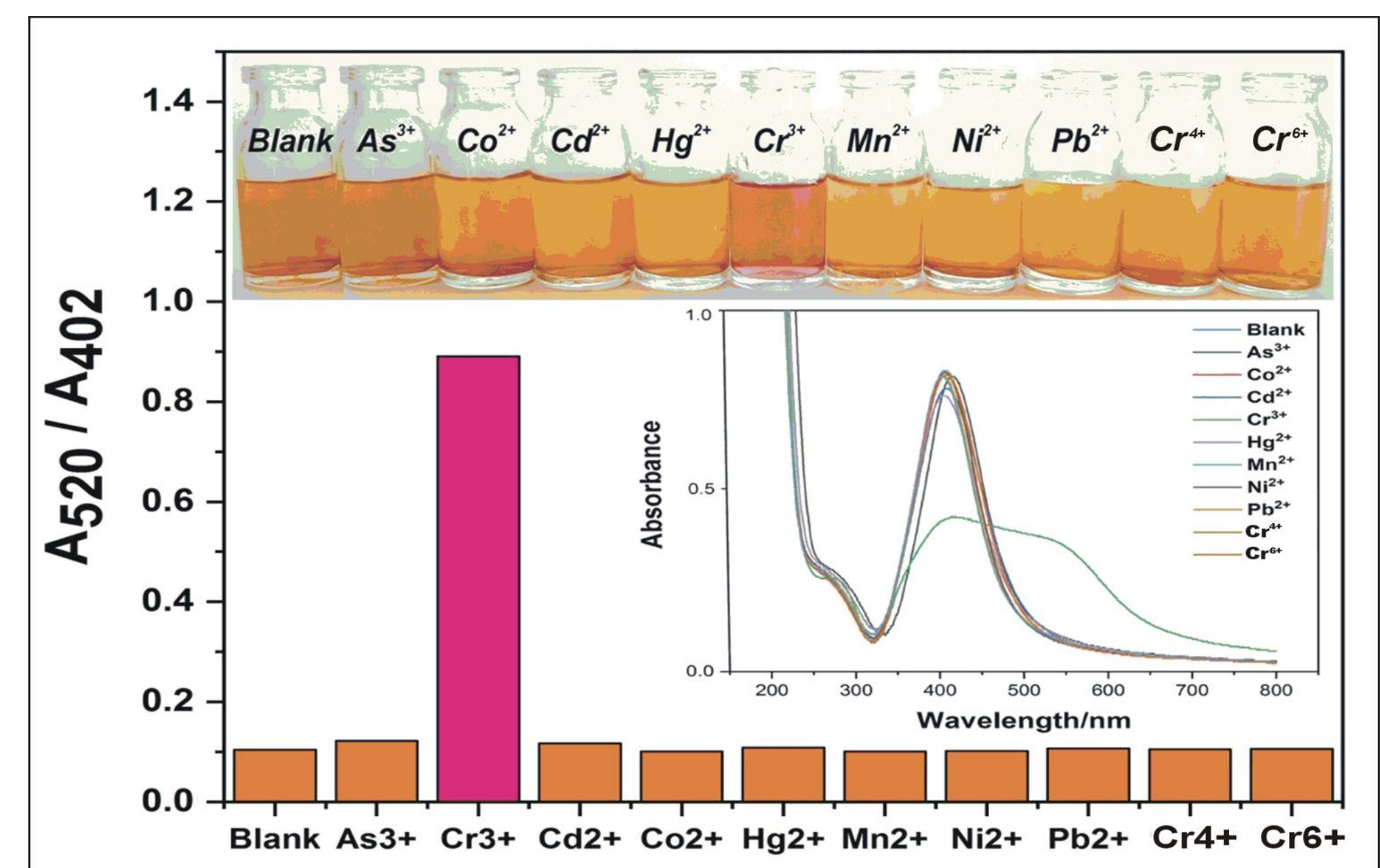
Detection Capability



Correlation Performance $R^2 = 0.997$
Linear Detection Range (0.5 μM – 100 μM Cr^{3+})

High Selectivity Toward Cr^{3+}

The AgNPs sensor maintained selective detection of Cr^{3+} even in the presence of competing ions, including:
 As^{3+} , Hg^{2+} , Pb^{2+} , Cd^{2+} , Co^{2+} , Sn^{2+} , Ni^{2+} , Mn^{2+} , and Cr^{6+}



Characterization

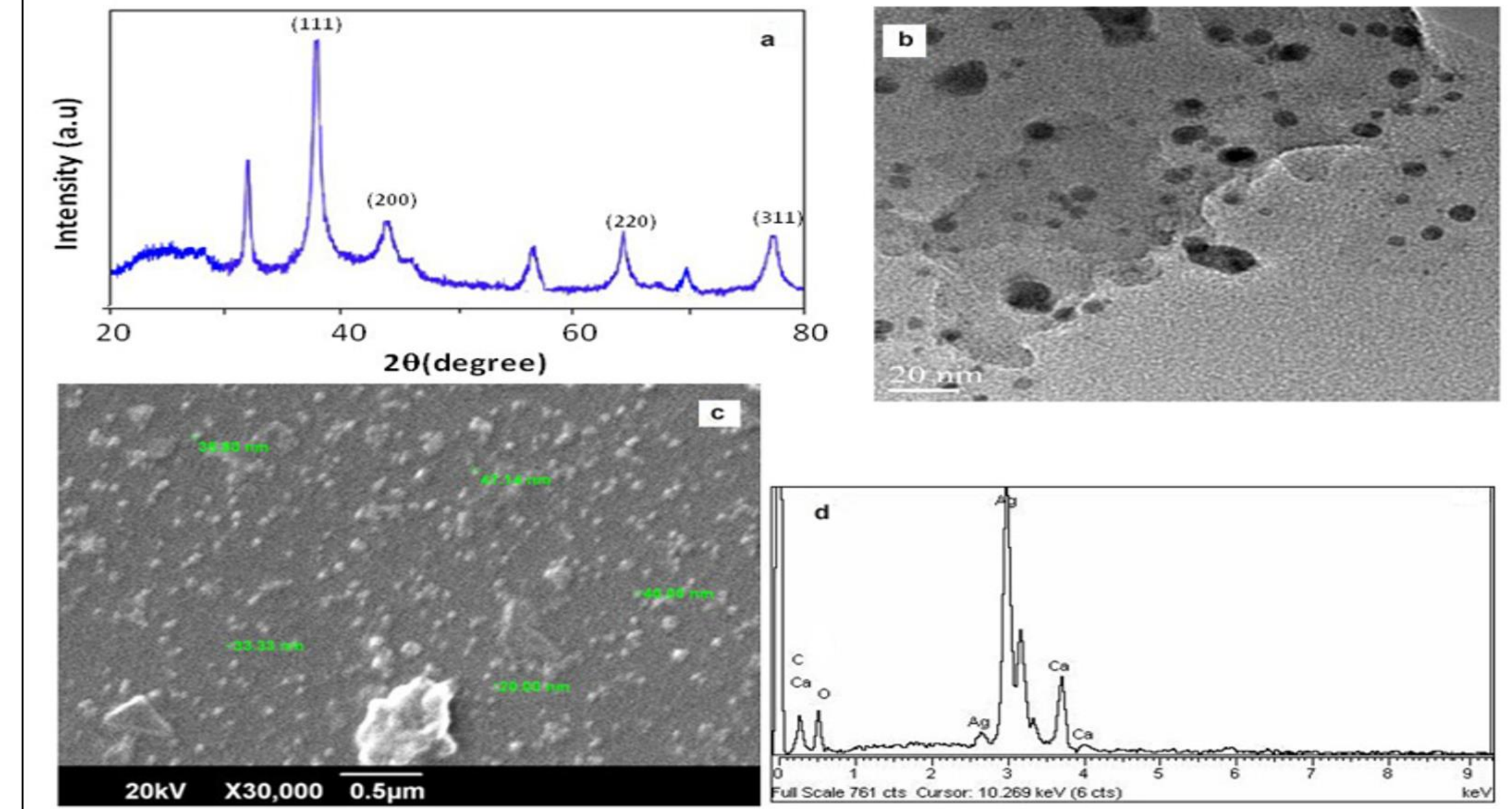


Figure 1. The schematic characterization of the synthesized AgNPs at room temperature using aqueous extract of Cranberry powder. (a) X-Ray diffraction pattern (b) TEM image (c) SEM image (d) EDX spectrum.

Key Points

- Green synthesis using *Cranberry* extract.
- Stable AgNPs with 7-8 month shelf life.
- Visual yellow-to-pink colorimetric detection.
- Detection range of 0.5-100 μM Cr^{3+} .
- Excellent linearity ($R^2 = 0.997$).
- Pseudo-second-order aggregation kinetics.
- High selectivity against multiple interfering metal ions.

Conclusion

In conclusion, the extract of *Vaccinium oxycoccos* was successfully used to synthesize AgNPs that function as an effective colorimetric biosensor for Cr^{3+} detection. The sensor exhibited a high correlation coefficient ($R^2 = 0.997$) and a detection range of 0.5-100 μM . Detection is based on the complexation of Cr^{3+} ions with polyphenolic capping agents on AgNPs, causing nanoparticle aggregation and observable color changes. Spectroscopic analysis confirmed the role of hydroxyl and carbonyl groups in nanoparticle synthesis and sensing. Kinetic studies supported a pseudo-second-order reaction mechanism. The sensor also demonstrated good recovery in real water samples, highlighting its potential for environmental, pharmaceutical, and healthcare monitoring as a simple, eco-friendly, and efficient analytical tool.

References:

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➤ Smitha, S. L., Nissamudeen, K. M., Philip, D., & Gopchandran, K. G. (2008). Studies on surface plasmon resonance and photoluminescence of silver nanoparticles. *Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy*, 71(1), 186-190.