ALGINATE-MEDIATED SYNTHESIS OF HETERO-SHAPED SILVER NANOPARTICLES AND THEIR HYDROGEN-PEROXIDE SENSING ABILITY

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Introduction

Silver nanoparticles have been the focus of extensive research for many decades due to their unique physical, chemical and electrical properties, which make them suitable for diverse applications. Among the synthesis techniques for silver nanoparticles, green synthesis protocols, which can be used to prepare stable and unique nanostructures, are gaining more attention. Naturally derived materials such as biopolymers could be a good alternative to toxic reagents such as trisodium citrate and borohydrides for use in synthesis methods due to the absence of biohazards associated with their byproducts and subsequent waste management.

Alginate is a naturally occurring polysaccharide composed of linear polymer chains of α-L-guluronate (G) and β-d-mannuronate (M) units in such an arrangement that the copolymer units appear to be in the form of an irregular block pattern. The biodegradability and biocompatibility of alginate, together with its ability to form gels upon reacting with divalent cations, make it highly useful in various biological applications, such as developing 3D tissue/organs for tissue engineering, wound healing scaffolds, and drug delivery platforms.

Herein, we report a new, green and facile route for synthesizing Ag-NPs having heterostructured morphologies using alginate and glucose as the capping and reducing agents, respectively. The as-synthesized Ag-NPs showed excellent stability and sensing activity towards the presence of hydrogen peroxide even at a very low concentration of 10-7 M.

Experimental Methods

Method: For the reaction, to 100 mL of distilled water taken in a round bottom flask was added 1.0 g of sodium alginate powder, and the resulting solution was heated to 60 °C with vigorous stirring to obtain a clear solution. After 60 min, 5 mL of AgNO3 solution (1 M) was added to the alginate solution with continuous stirring to obtain Ag+/alginate solution. This step was followed by the addition of 10 mL of glucose solution (0.08 M) under continuous stirring. The reaction was maintained at 80 °C and run for 48 hours. Aliquots were taken at different time intervals (1, 5, 24 & 48 hours) to monitor the growth of the particles. To analyze the sensing properties of the Ag-NPs, different concentrations of hydrogen peroxide solutions (2000 µL) were added to the silver nanoparticle solution in a quartz cuvette at a ratio of 1:1.5. The change in the UV–vis spectrum with varying concentrations of H2O2 in the range from 10-1 to 10-7 due to the catalytic reaction between the silver nanoparticles and hydrogen peroxide was monitored.

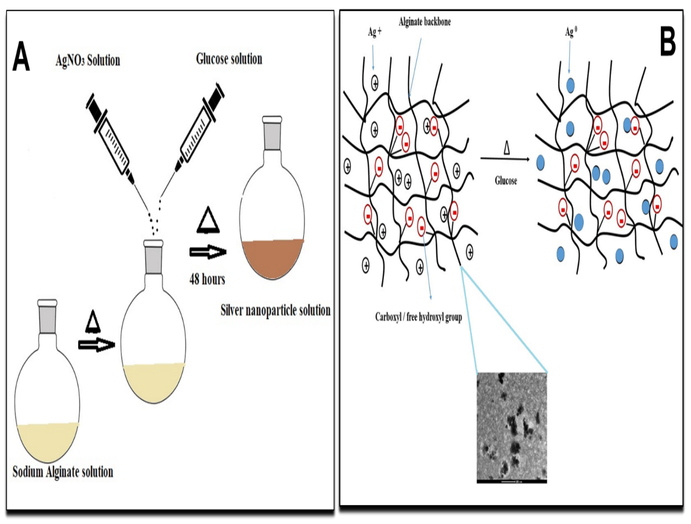

Figure 1: (A) Schematic representation of the synthesis of sodium alginate-capped Ag-NPs (B) Schematic representation of the formation of alginate-capped Ag-NPs

Results and discussion

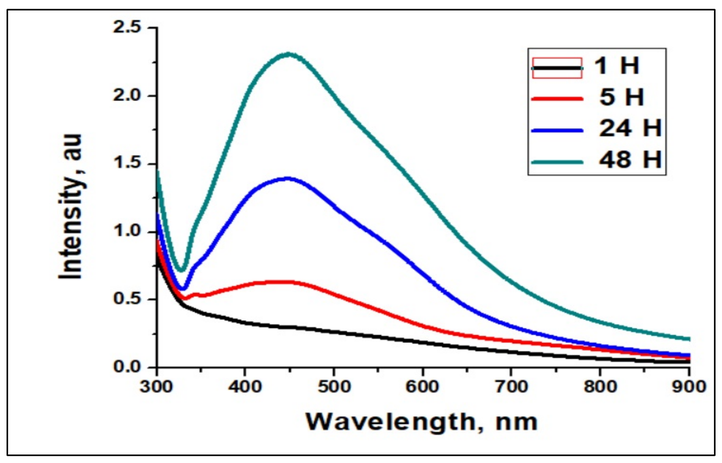

Figure 2: (A) UV absorption spectra of alginate-capped Ag-NPs at different reaction times.

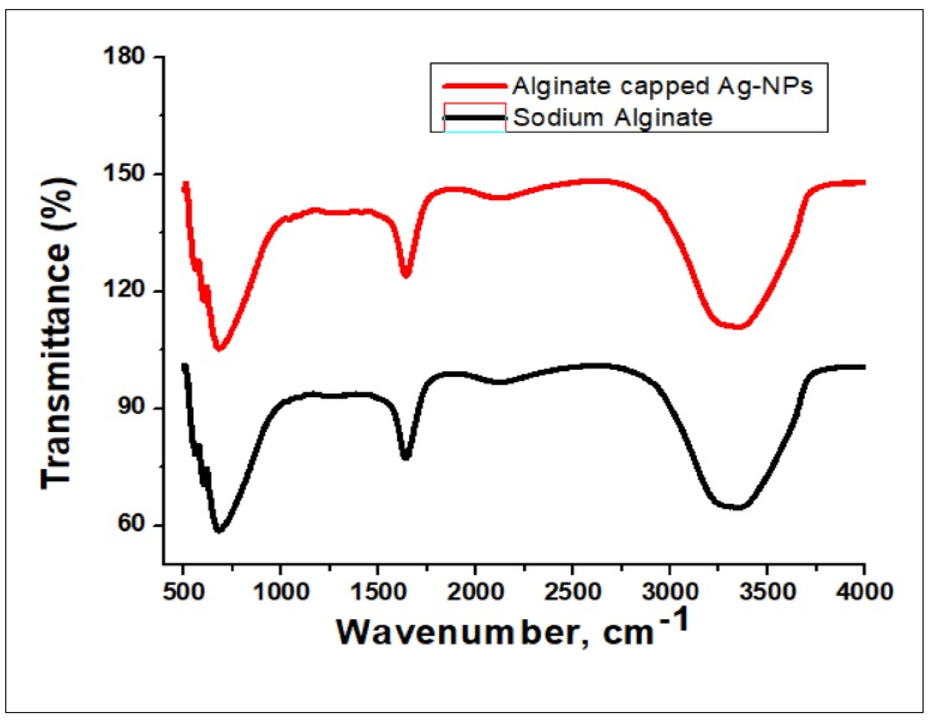

Figure 3: FTIR spectra of the Ag-NPs.

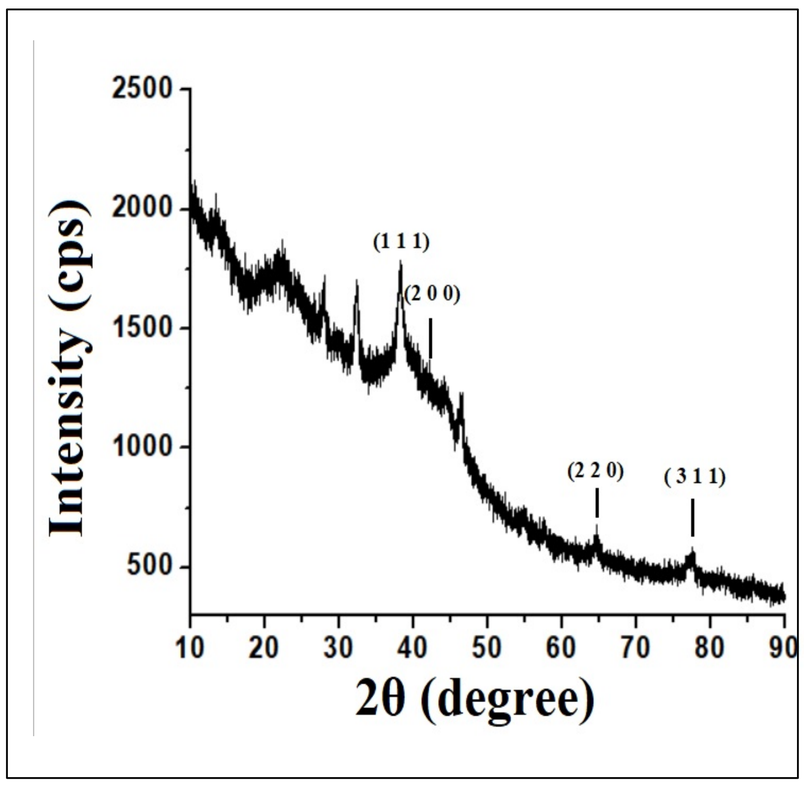

Figure 4. XRD pattern of the Ag-NPs .

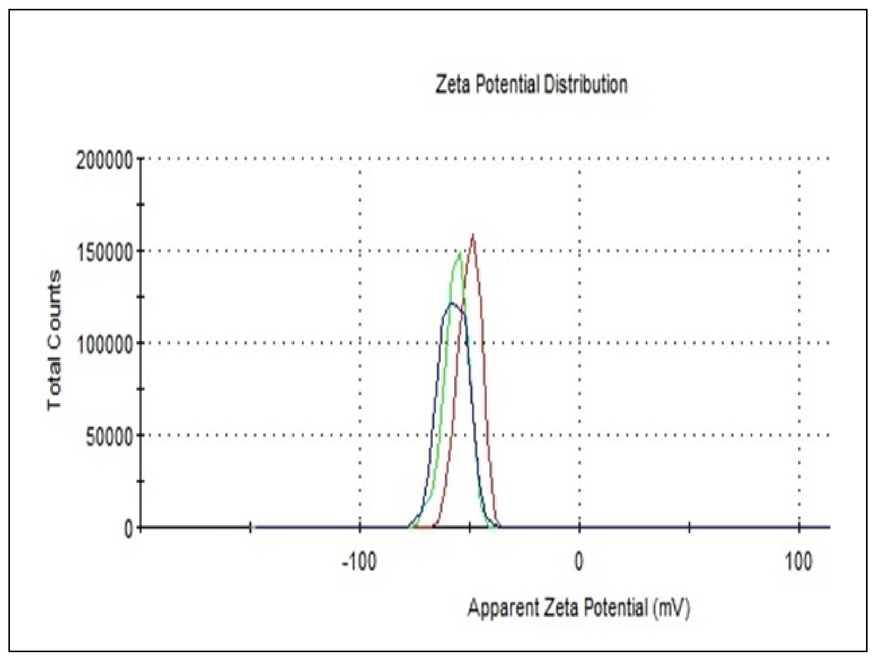

Figure 6: Zeta potential distribution of Ag-NPs at 48 h reaction time.

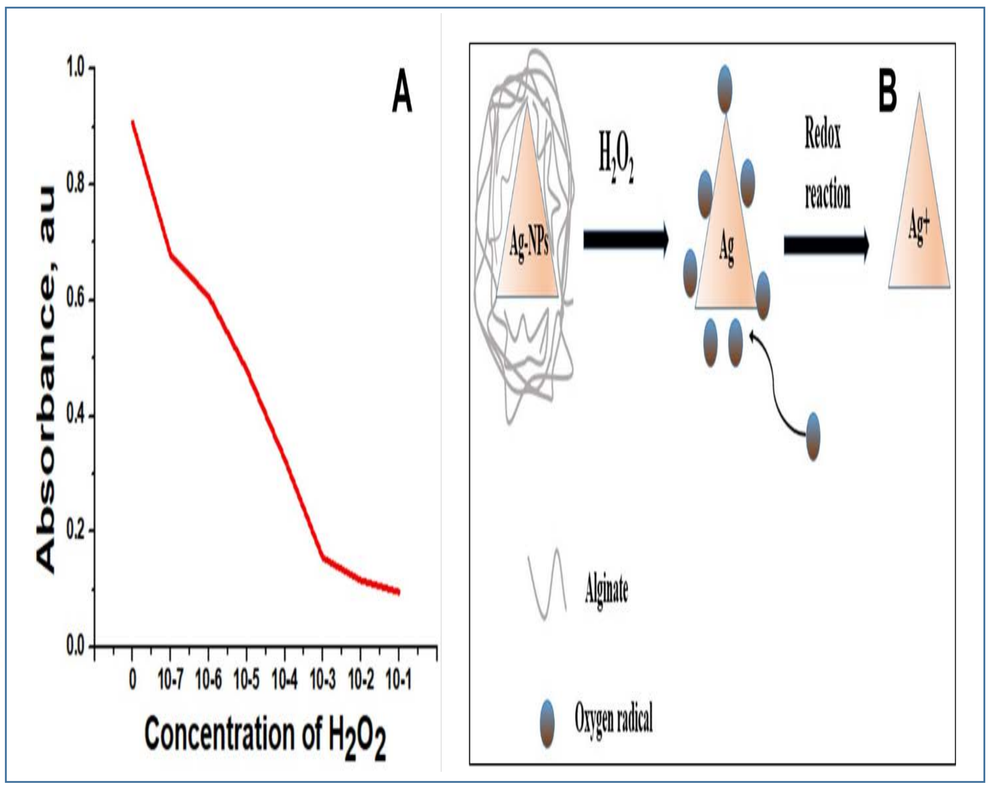

Figure 7: (A) Change in absorbance versus H2O2 concentration. (B) Possible mechanism of the reaction between the Ag-NPs and H2O2

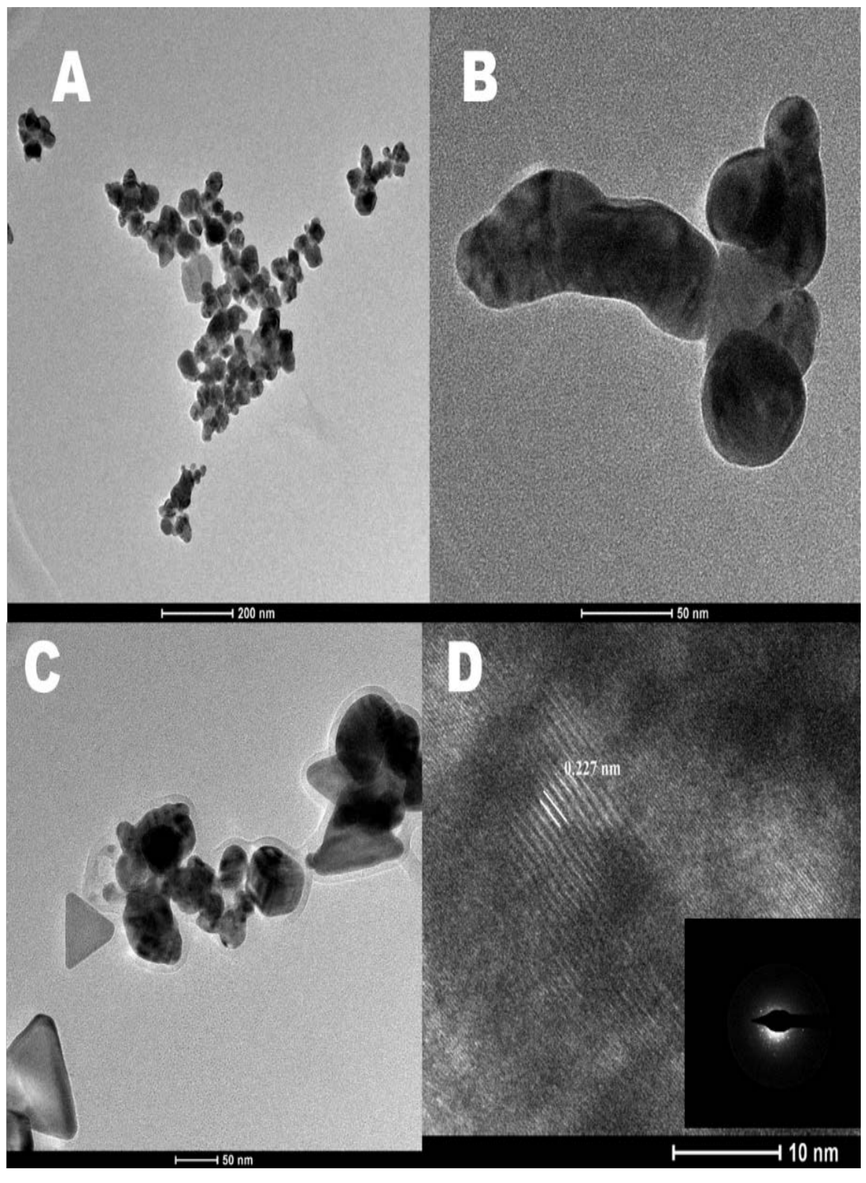

Figure 5: TEM images of alginate-capped silver nanoparticles at (A) 1 hr, (B) 24 hr and (C) 48 hr. (D) HRTEM image along with the corresponding SAED pattern (inset).

Conclusions

An innovative, simple, and green method for the synthesis of stable heterostructured sodium alginate-capped silver nanoparticles is reported. Sodium alginate was used as the capping agent, while glucose acted as the reducing agent. The as-synthesized Ag-NPs were small (30-45 nm) and spherical during the initial hours (1-10) hours of the reaction and evolved to become heterostructured after 48 hours. The as-synthesized Ag-NPs showed excellent sensing activity towards the addition of hydrogen peroxide even at a very low concentration of 10-7 M H2O2.

Acknowledgements

This project is supported by Qatar University Collaborative Grant QUCG-CAM-19/20-2. The findings achieved herein are solely the responsibility of the authors.

References

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