Silver Nanoparticle Hydrogels: Optimizing and Stabilizing Silver Nanoparticles for Potential Industrial and Commercial Use

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This study aimed to develop a scalable, cost-effective method for producing high-quality silver nanoparticle (AgNP)-containing hydrogels. AgNPs (1–100 nm) are promising in biomedical applications due to their antimicrobial properties, but commercial formulations remain expensive with limited alternatives. We optimized AgNP synthesis, stabilization, and formulation to improve nanoparticle size uniformity, surface charge, and colloidal stability. AgNPs were synthesized using sodium borohydride ($NaBH_4$) as a reducing agent. Following our initial preparation, we evaluated capping agents to determine the most suitable one—particularly focusing on the borohydride method. We tested both polyvinylpyrrolidone (PVP, 40,000 Daltons) and citrate. Citrate produced debris and poorly stabilized AgNPs, whereas PVP enabled clean, uniform, and stable nanoparticle formation. This confirmed PVP as the optimal capping agent. UV-Vis spectroscopy showed a plasmon peak at ~400 nm, confirming the presence of small spherical AgNPs. Dynamic Light Scattering (DLS) revealed sizes of 33.62 nm (citrate) and 86.93 nm (borohydride). Zeta potential measurements indicated –42.9 mV for citrate and –6.37 mV for borohydride alone. However, the inclusion of PVP with borohydride significantly improved nanoparticle stability by preventing aggregation. The resulting AgNPs were incorporated into hydrogel matrices and evaluated for physical and chemical consistency. Inductively Coupled Plasma Mass Spectrometry (ICP-MS) confirmed silver content and composition. This study presents a streamlined synthesis route for producing stable, reproducible AgNP-hydrogel formulations, offering a cost-effective solution for biomedical and industrial applications.

Awards Won: