A Novel Chitosan-based Sponge Coated With Self-assembly Thrombin/Tannic Acid Multilayer Films As A Hemostatic Dressing

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Conclusion

Silver nanoparticles have attracted a great deal of attention in the last years owing to the broad-spectrum antimicrobial activity. The dramatic expansion of its applications brings to the requirement to investigate potential toxic effects of silver nanoparticles towards human body as well as the environment. Therefore, it is of great significance to develop a green method for synthesis of silver nanoparticles with low toxicity.

In addition, it has been confirmed that stabilizing agents play critical roles in biocompatibility and toxicity through influencing surface properties of silver nanoparticles. In this respect, natural polymers, especially chitosan, which show excellent biocompatibility and nice stabilizing ability, are considered as the most appropriate alternatives of stabilizing agents. Chitosan, a linear nontoxic biocompatible polymer, derived from a widely distributed natural polysaccharide chitin, has been widely used in biomedical applications. However, the addition of reducing agents were still inevitable which may be toxic.

Recently, highly soluble chitosan derivative has been synthesized by the conjugation of bio-inspired catechol to chitosan.[19] The catechol-conjugated chitosan (CSS) acts as stabilizing and reducing agent, due to the stabilizing effect of chitosan and the reductive activity of aromatic phenols in catechol. It is obvious that CSS is an ideal reducing and stabilizing agent for the green synthesis of silver nanoparticles in aqueous phase.

Experimental Section

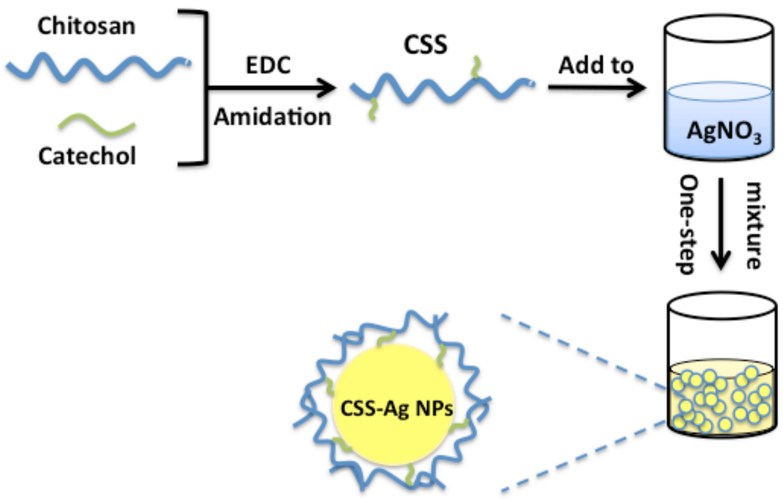

Fig.1 The Experimental process flow chart

Results and Discussions

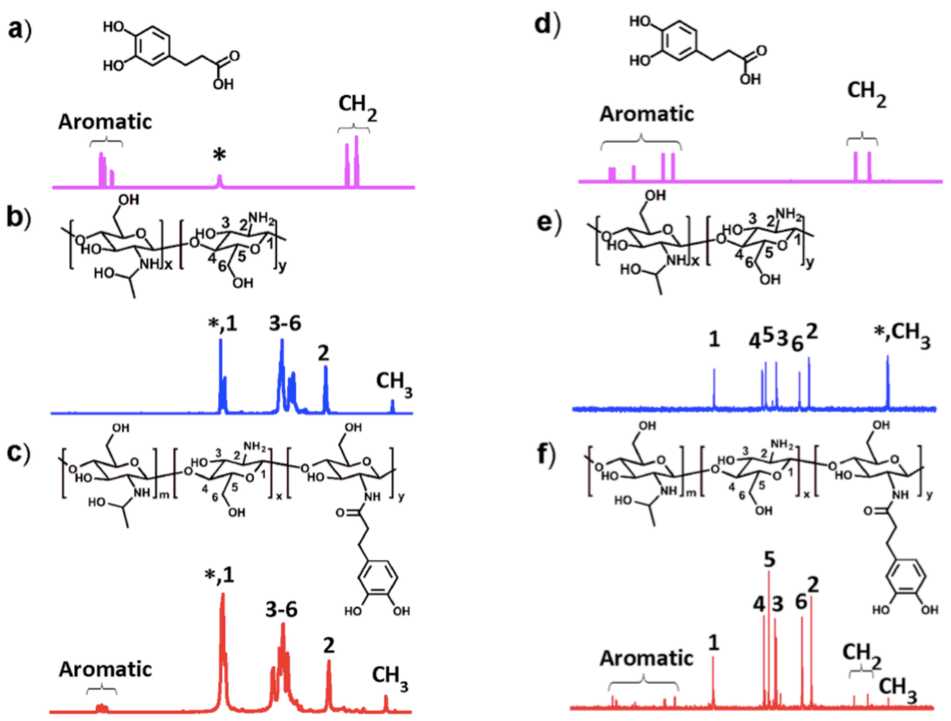

Fig. 2 ^{1}H NMR spectra of HCA (a), chitosan (b), CSS (c); ^{13}C NMR spectra of HCA (d), chitosan (e), CSS (f).

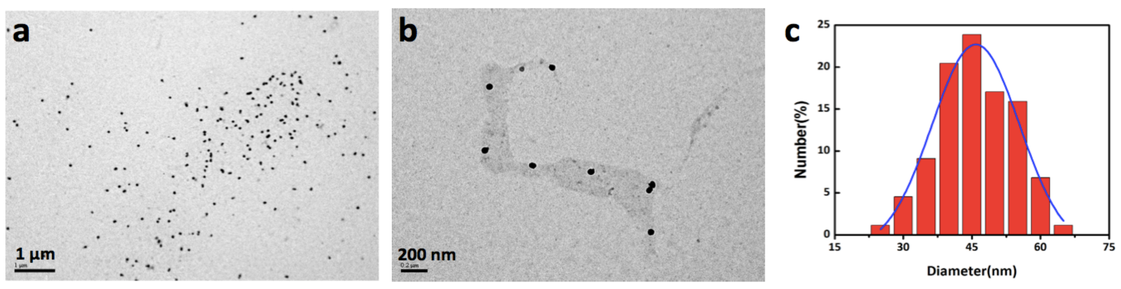

Fig. 3 (a-b) TEM images of CSS-Ag NPs, and (c) size distribution of CSS-Ag NPs based on TEM images .

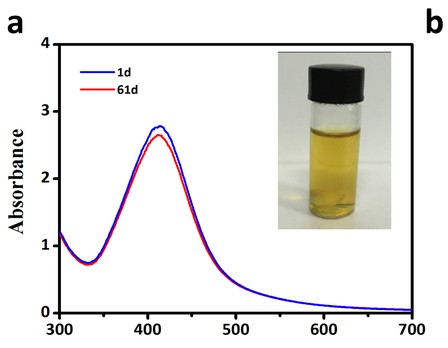

Fig. 4 a) UV-vis spectra of CSS-Ag NPs stored for 1 day and 61 days. The inset shows the optical photo of CSS-Ag NPs solution. b) Inhibition zones produced by CSS-Ag NPs at different concentration (5, 10 and 20 μg/mL) and CSS solution as control for S. aureus and E. coli.

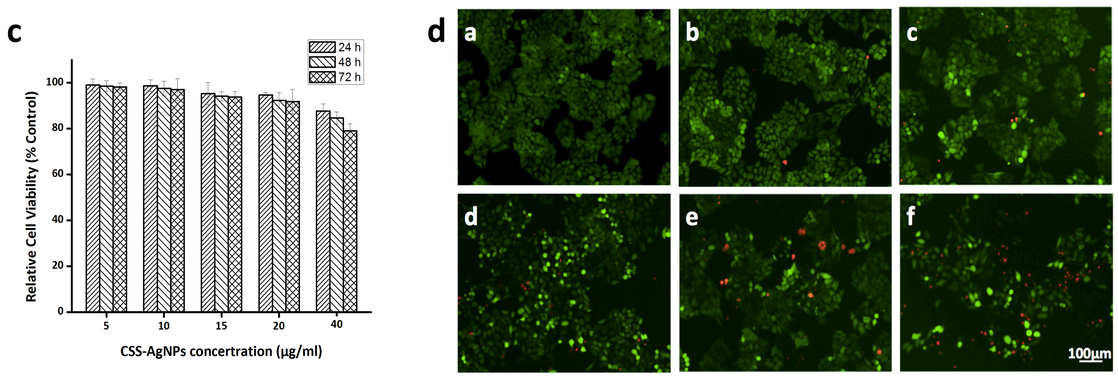

Fig. 4 a) relative cell viabilities of HepG2 cells after incubation for different time (24, 48 and 72 h) with different concentrations of CSS-Ag NPs (5, 10, 15, 20 and 40 μg/mL), measured by a MTT assay. b) FDA/PI staining assay of HepG2 cells after treatment with CSS-Ag NPs at different concentrations of 5 (b), 10 (c), 15 (d), 20 (e) and 40 (f) μg/mL for 24 h, respectively. (a) The untreated HepG2 cells served as a control group. The scale bars are 100 μm.

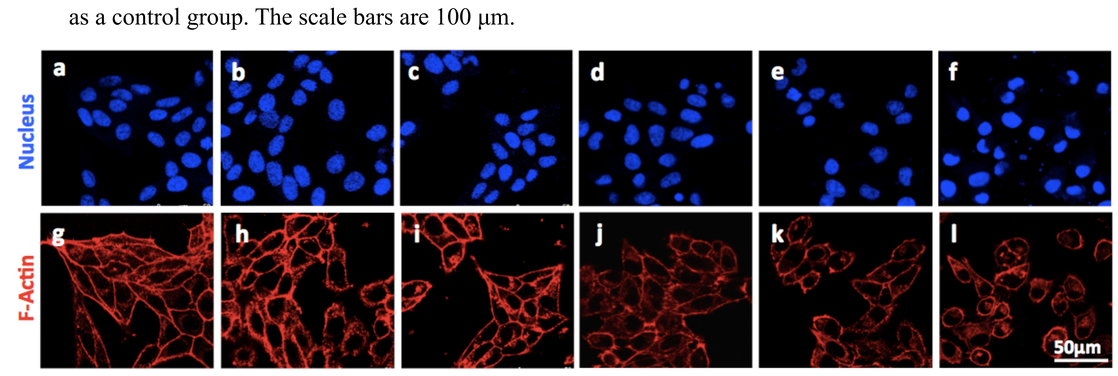

Fig. 7 Immunofluorescence images of the nuclei (a-f) and F-actin cytoskeleton (g-l) in HepG2 cells after treatments with CSS-Ag NPs at different concentrations of 5 (b, h), 10 (c, i), 15 (d, j), 20 (e, k) and 40 (f, l) μg/mL, respectively. The untreated HepG2 cells served as a control group (a, g). The scale bars are 50 μm.

Conclusion

In this study, catechol-conjugated chitosan was synthesized to prepare CSS-Ag NPs with narrow size distribution and high stability, which acted as both reducing and stabilizing agent during the preparation process. The entire preparation process complied with the principles of green chemistry. The resulting CSS-Ag NPs combined the unique properties of chitosan and silver nanoparticles, showing significant potential in biological and antibacterial fields. On one hand, CSS-Ag NPs effectively inhibited the growth of E. coli and S. aureus due to the excellent dispersibility of silver nanoparticles. On the other hand, the cytotoxic effect of CSS-Ag NPs on HepG2 cells were improved by the stabilization effect of chitosan. The effective toxic concentration of CSS-Ag NPs towards E. coli and S. aureus, is significantly lower than that towards HepG2 cells. The results demonstrated that CSS-Ag NPs could be a potential candidate using in biological and pharmaceutical fields to prevent infections caused by microorganisms.

Acknowledgements

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