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Abstract

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Effects of β-Cyclodextrin as a capping agent on the antibacterial properties of Ag NPs

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Introduction

The persistence of antibiotic resistant bacteria has renewed interest in the use of silver and silver based compounds, including silver nanoparticles (AgNPs), as alternative antibacterial agents. The high thermal stability, low toxicity to human cells and effective broadspectrum antibacterial activity of AgNPs have been exploited in a range of commercial products. AgNPs can be synthesised in a number of ways, with borohydride reduction of silver salts being the most common. Stabilisation is achieved using capping agents that bind to the nanoparticle surface and improve stability and water solubility, which are essential to prevent aggregation.

Experimental

In the present study, silver nanoparticles (AgNPs) were synthesised by reducing silver salts using $NaBH_4$ followed by capping with varying concentrations of β cyclodextrin (β-CD). Synthesized β-CD capped Ag NPs characterized by UV-Vis, FTIR, DLS, and TEM. Antibacterial activity against *Escherichia coli*, *Pseudomonas aeruginosa* and *Staphylococcus aureus* was determined by the microtitre well method. Cytotoxicity of β-CD capped and uncapped Ag NPs were analysed by Alamar blue test.

Results and discussion

The Ag NPs were spherical under transmission electron microscopy, whilst dynamic light scattering showed average diameters of capped particles to be smaller (4–7 nm) than their uncapped equivalents (17 nm). FTIR confirmed β-CD binding to the Ag NP surface. This suggests that there are chemisorptions between the CD molecules and Ag NPs via the rim hydroxyl groups. Capped particles demonstrated superior photostability when exposed to intense ultraviolet radiation for 4 h. We have observed interesting effects of β-CD as a capping agent, such as the lowering of the nanoparticles MIC against both Gram-negative (*Escherichia coli* and *Pseudomonas aeruginosa*) and Gram-positive (*Staphylococcus aureus*) bacteria. The antibacterial activity of all test samples were concentration dependent as moderate inhibition was observed when exposed to lower concentration but increased significantly as the concentration increased. The bacterial growth kinetics was monitored in the presence of different test samples. It was found that the biocidal action of β-CD capped Ag NPs was more efficient at low dose for longer period of time, whereas uncapped Ag NPs were found to diminish killing activities with increased aging time. The results demonstrated that the β-CD capped Ag NPs showed significantly higher (up to 3.5 fold) antibacterial activity ($p < 0.05$) against all the tested organisms versus uncapped equivalent silver concentrations.

Conclusion

Therefore it can be concluded that:

- Antibacterial activity of Ag NPs is affected by the level of CD used as a capping agent
- Increased levels of CD lead to higher antibacterial efficacy at lower silver ion concentrations.

The influence of β-CD concentration was seen to delay bacterial growth, indicating that a Trojan horse mechanism may be occurring owing to bacterial carbohydrate affinity, thereby enhancing silver ion absorption.