Chitosan-capped gold nanoparticles: Application as temperature history indicator during frozen storage

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Temperature is the most crucial factor affecting the quality by influencing kinetics of physical, chemical and microbial spoilage in perishable food commodities. The storage temperature of the temperature-sensitive products like chilled, refrigerated and frozen products are monitored strictly to overcome these spoilage-associated changes. At present, the temperature history of frozen products in the food processing establishments is monitored using temperature recorders. There is no mechanism to track the temperature abuse of foods during transportation and distribution and in retail stores. A visible temperature abuse indicator will be useful for maintaining the proper storage conditions at all stages. This can be achieved through nanotechnological interventions by using nanotechnology-based biosensors like time-temperature indicator (TTI) for frozen storage applications. TTI - belonging to the smart packaging technology - are becoming popular as they provide very helpful information on whether a threshold temperature has been exceeded over time or not, visually. Among the metal nanoparticles, gold nanoparticles (AuNPs) have attracted considerable attention across the globe due to its unique therapeutic activity, optical behaviour and inert and non-toxic nature. Although many researchers have demonstrated the synthesis of AuNPs using chitosan (Wang *et al.*, 2006; Huang and Yang, 2004) there is very limited reports on the use of chitosan-capped gold NPs for biosensor applications.

At ICAR-CIFT, Cochin a study was undertaken to optimize the conditions for synthesising the chitosan-capped gold NPs and to assess its application as temperature abuse indicator for frozen stored foods. Low molecular weight chitosan with degree of deacetylation of 81.34% was used to optimize chitosan concentration, heating temperature and time for the synthesis of AuNPs. Chitosan concentration of 0.25% (w/v) at heating temperature of 90 ºC for 15 min. was found to be optimum for the synthesis of AuNPs. In UV-Vis spectra, the AuNPs exhibits a Surface Plasmon Resonance (SPR) band at around 526 nm due to collective oscillations of the electron at the surface of the nanoparticles that is correlated with the electromagnetic field of the incoming light. In the present study, λ_{max} was observed at 530 and 540 nm for 0.125 and 0.25% chitosan, respectively, indicating a shifting peak to the right (red-shift) mainly due to the formation of AuNPs of various shapes, size or concentration dependencies (Fig. 1). The size of the chitosan-capped gold NPs was 30.6 nm for 0.25% chitosan compared to 59.8 and 175.6 nm for 0.125 and 0.0625% chitosan, respectively. The zeta potential was least for 0.25% chitosan-capped gold NPs and increased with the decrease in the chitosan concentration. FTIR spectra of chitosan-capped gold nanoparticles exhibited almost similar peaks as that of pure chitosan indicating uniform deposition of chitosan over gold nanoparticles (Fig. 2). To assess the effectiveness of chitosan-capped gold NP as temperature abuse indicators, the frozen AuNPs prepared from different

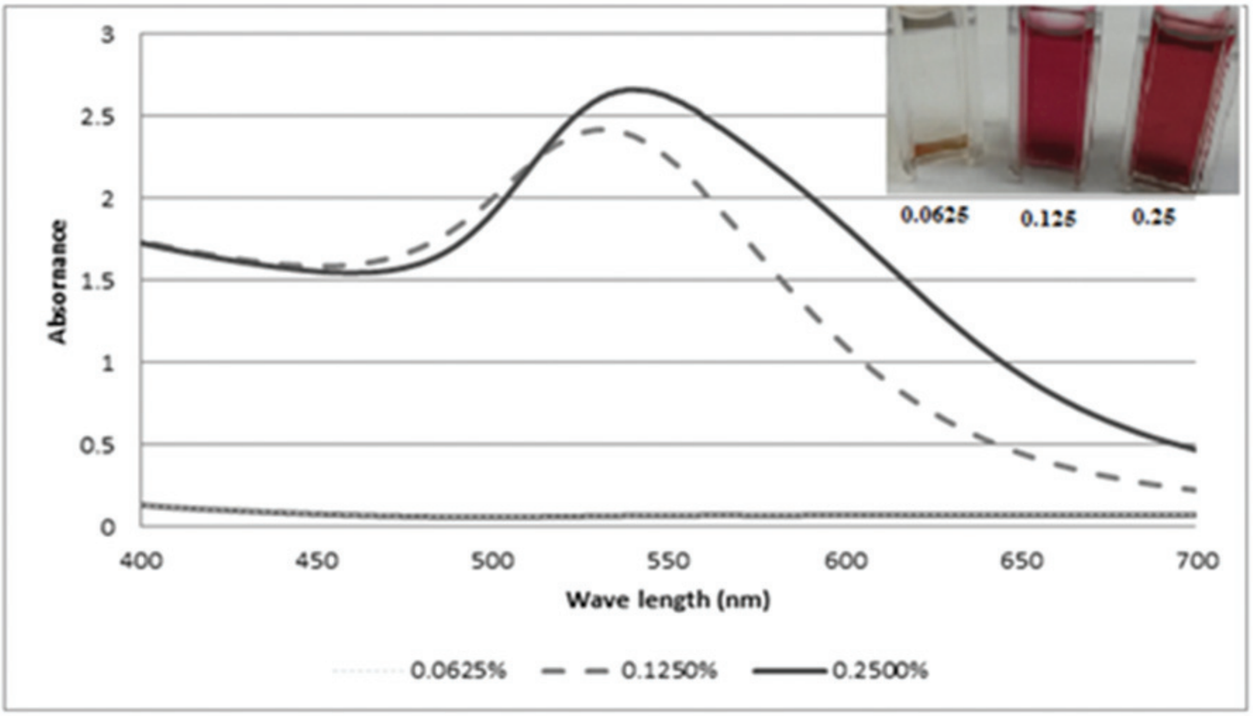

Fig. 1. Effect of chitosan concentration (0.0625, 0.125 and 0.25%) on the UV-Visible spectra and visible colour (inset) of chitosan-capped gold nanoparticles

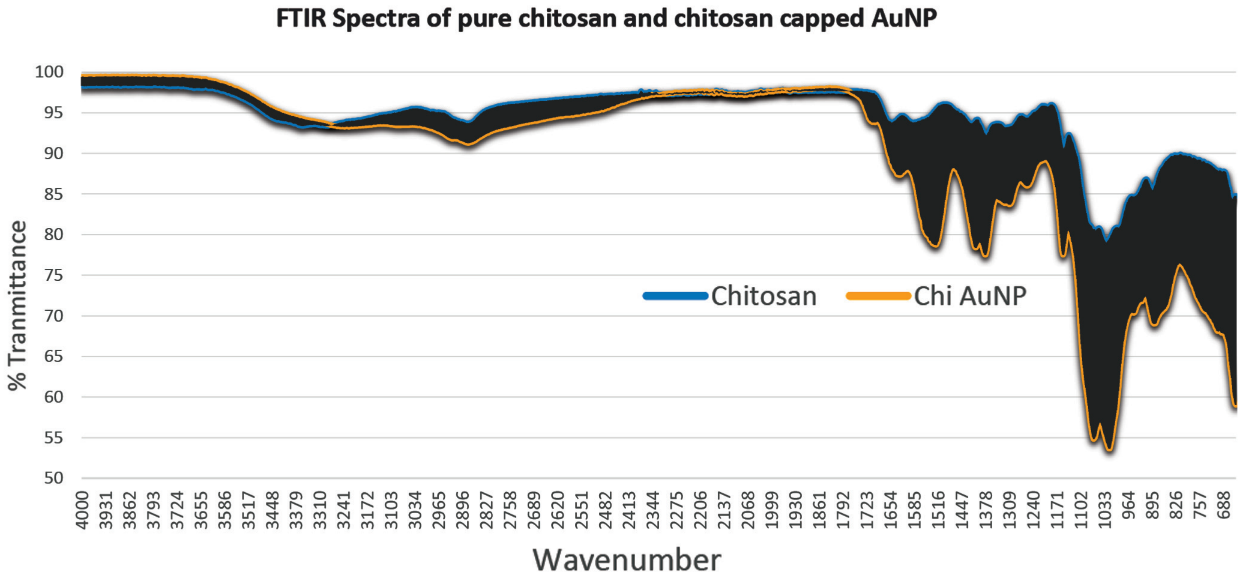

Fig. 2. FTIR spectra of pure chitosan and chitosan-capped AuNP

concentration of chitosan were exposed to temperature abuse condition (37 °C) and variations in the chitosan-capped AuNPs were characterized. Upon exposure to temperature abuse conditions, the peak intensity increased with increase in the period, particularly in 0.25% chitosan-capped AuNP and λ_{max} observed a shift towards left at 520-524 nm (Fig 3). Exposure to abused temperature for over 4 h showed a clear difference in the peak intensity as well as visible colour changes. The study revealed that chitosan-capped gold nanoparticles can be used as temperature history indicator for food products as well as for pharma products.

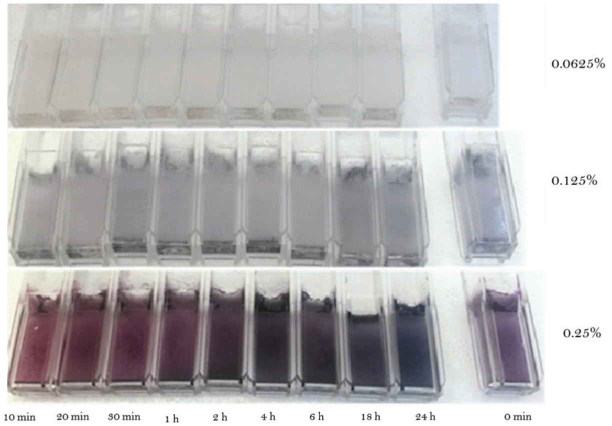

Fig. 3. Effect of temperature abuse on the visible colour change of chitosan AuNP at different concentrations (0.0625, 0.125 and 0.25%) exposed to different time intervals (0 min. to 24 h)

References

Huang, H. and Yang, X. (2004) - Synthesis of chitosan-stabilized gold nano particles in the absence/presence of tripolyphosphate. *Biomacro mol.*, **5(6):** 2430-2346.

Wang, B., Chen, K., Jiang, S., Reincke, F., Tong, W., Wang, D. and Gao, C. (2006) - Chitosan-mediated synthesis of gold nanoparticles on patterned poly(dimethylsiloxane) surfaces. *Biomacromol.*, **7(4):** 1203-1209.