

Influence of pH and Gelatin Concentration on the Size and Zeta Potential of Gelatin Colloidal Dispersions



Lothar Mallia, Emmanuel Sinagra and Claude Farrugia

Department of Chemistry, University of Malta, Msida MSD2080, Malta

Introduction

Gelatin is a heterogeneous mixture of water-soluble proteins. Its broad molecular weight profile may be responsible for the variation in the experimental conditions required for nanoparticle formation.¹ Since this may hinder the application of gelatin nanoparticles, it is important to determine the effect of several factors on the properties and stability of primary dispersions. The phase behaviour of gelatin in ethanol-water binary solvent systems has already been studied using transmittance values.² The objective of this project was to use dynamic light scattering and laser Doppler electrophoresis to increase the understanding of the effects of pH and various dilute gelatin concentrations on the size, polydispersity and zeta potential of dispersions of B225 bovine skin gelatin in hydroalcoholic solutions.

Methodology

Gelatin stock solutions were prepared by heating B225 bovine skin gelatin to 45-50 °C with medium stirring for 25-30 minutes. The pH was adjusted using dilute HCl or NaOH. Gelatin stock solutions were prepared with concentrations in the range of 0.05-1.25% w/w gelatin, and adjusted to pHs, from pH 6 to pH 9. Hydroalcoholic solutions were added to the gelatin stock solutions such that the resulting three-component mixtures contained 0-80% w/w ethanol in 10% increments and six different gelatin concentrations ranging from 0.01-0.25% w/w gelatin. The z-average size (d.nm), polydispersity index, mean count rate (kcps), zeta potential (mV) and zeta deviation (mV) of the dispersions was recorded using a Malvern Zetasizer NanoZS. General Linear Model (GLM) multivariate analysis was performed on the results generated. The effect of the fixed factors on the dependent variables was determined using Tukey Post-Hoc analysis.

Results

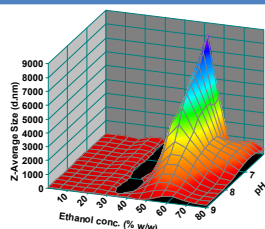


Figure 1: 3D Surface Plot of Z-Average Size (d.nm) against Ethanol concentration (% w/w) for 0.25% w/w Gelatin across all the pH range.

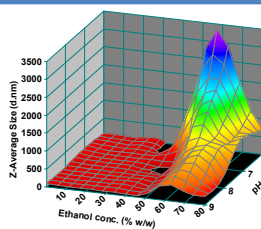


Figure 4: 3D Surface Plot of Z-Average Size (d.nm) against Ethanol concentration (% w/w) for 0.10% w/w Gelatin across all the pH range.

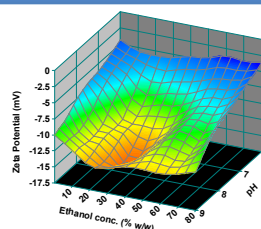


Figure 7: 3D Surface Plot of Zeta Potential (mV) against Ethanol concentration (% w/w) for 0.25% w/w Gelatin across all the pH range.

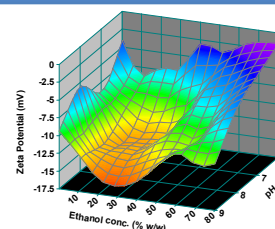


Figure 10: 3D Surface Plot of Zeta Potential (mV) against Ethanol concentration (% w/w) for 0.10% w/w Gelatin across all the pH range.

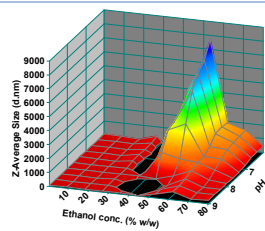


Figure 2: 3D Surface Plot of Z-Average Size (d.nm) against Ethanol concentration (% w/w) for 0.20% w/w Gelatin across all the pH range.

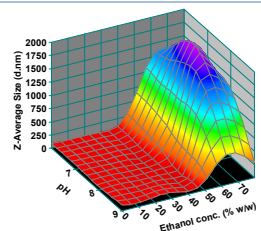


Figure 5: 3D Surface Plot of Z-Average Size (d.nm) against pH for 0.05% w/w Gelatin across all the Ethanol concentration range (% w/w).

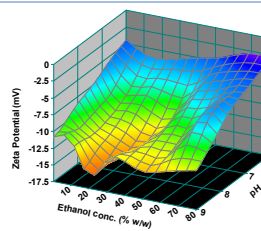


Figure 8: 3D Surface Plot of Zeta Potential (mV) against Ethanol concentration (% w/w) for 0.20% w/w Gelatin across all the pH range.

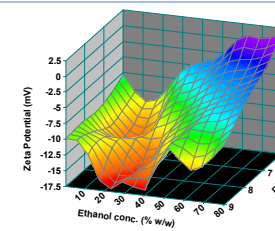


Figure 11: 3D Surface Plot of Zeta Potential (mV) against Ethanol concentration (% w/w) for 0.05% w/w Gelatin across all the pH range.

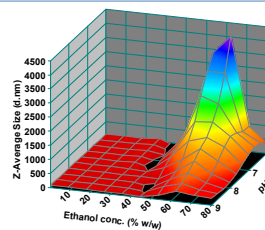


Figure 3: 3D Surface Plot of Z-Average Size (d.nm) against Ethanol concentration (% w/w) for 0.15% w/w Gelatin across all the pH range.

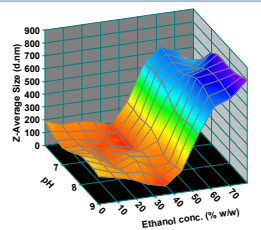


Figure 6: 3D Surface Plot of Z-Average Size (d.nm) against pH for 0.01% w/w Gelatin across all the Ethanol concentration range (% w/w).

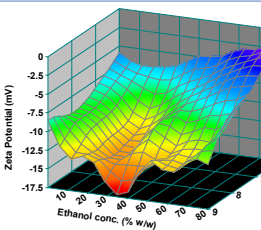


Figure 9: 3D Surface Plot of Zeta Potential (mV) against Ethanol concentration (% w/w) for 0.15% w/w Gelatin across all the pH range.

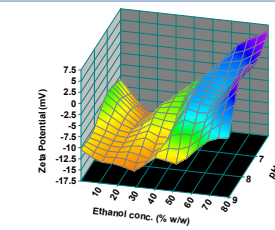


Figure 12: 3D Surface Plot of Zeta Potential (mV) against Ethanol concentration (% w/w) for 0.01% w/w Gelatin across all the pH range.

Conclusions

- The results support previous evidence that, near the isoelectric point, gelatin has a greater tendency to aggregate when subjected to the non-solvent ethanol due to the higher attractive forces resulting from the reduced net charge, whereas as one moves further away from the isoelectric point, a lower tendency to aggregate is observed, due to the higher repulsive forces resulting from the increased net negative charge.
- The increased polydispersity index and zeta deviation observed prior to phase separation are indicative of the disruption of secondary structure caused by the desolvating agent, and are consistent with the observations of Farrugia and Groves (1999)¹ on the multiparticulate nature of aggregates produced using the method of Marty *et al.* (1978)³.
- The difference in behaviour at various gelatin concentrations, particularly below 0.2% w/w, appears to indicate that truly dilute behaviour of gelatin systems exist at lower concentrations than was earlier thought (Herning *et al.*, 1991)⁴.

References

- [1] Farrugia, C. A. & Groves, M. J. (1999). Gelatin Behaviour in Dilute Aqueous Solution: Designing a Nanoparticle Formulation. *Journal of Pharmacy and Pharmacology*, 51(6), 643-649. doi:10.1211/0022357991772925
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- [3] Marty, J., Oppenheim, R., and Speiser, P. Nanoparticles – a new colloidal drug delivery system. *Pharm. Acta Helv.*, 53, 17-23 (1978).
- [4] Herning, T., Djabourou, M., Leblond, J., and Takerkart, G.: Conformation of gelatin chains in aqueous solutions: 2. A quasi-elastic light scattering study. *Polymer*, 32: 3211-3217 (1991).