Introduction

This work involves the encapsulation of magnetic nanoparticles (NPs) along with a protein model drug human serum albumin (HSA) by biocompatible and FDA approved poly(D,L-lactic-co-glycolic) acid (PLGA) which has excellent drug loading capacity. The size of PLGA NPs and the encapsulation efficiency of model drug were determined and optimized.

Materials

Poly(D,L-lactic-co-glycolic acid, PLGA), magnetic nanoparticles (Fe₃O₄ - magnetite), model drug (human serum albumin, HSA), organic solvent (dichloromethane, DCM), emulsifier (polyvinyl alcohol, PVA) and Micro BCA protein assay kit.

Nanoparticles preparation and analysis methods

- Preparation: Double emulsion solvent evaporation method.
- Size: dynamic light scattering method by Malvern Zetasizer.
- Protein encapsulation efficiency: micro BCA method.

Process variables

Five important process variables influencing the process:
- Weight ratio of iron oxide relative to the weight of PLGA in the organic phase (F1),
- Concentration of PLGA in the organic phase (F2),
- Concentration of HSA in the inner aqueous phase (F3),
- Volume ratio of the outer aqueous phase and the organic phase (F4),
- Time span of the ultrasonic treatment in the second emulsification (F5).

Experimental design

- 3⁵ type fractional factorial experimental design was carried out by STATISTICA® software.
- Results were evaluated with the same software.

Effect of process variables on the mean size

- Mean size was affected strongly by PLGA concentration (F2) and the duration of ultrasonic treatment (F5) (Figure 1).
- Regression equation was obtained by statistical analysis.

Effect of process variables on encapsulation efficiency

- If the volume ratio increases, available energy per unit volume reduces: result is larger nanoparticles (Figure 2).
- Size distribution broadens with the increase in PLGA concentration and decrease in sonication time (Figure 3).

Effect of process variables on protein model drug encapsulation efficiency

- Encapsulation efficiency was affected strongly by PLGA (F2) and HSA (F3) concentration.
- Regression equation was obtained by statistical analysis.

Effect of significant factors on the encapsulation efficiency

- Increase in PLGA concentration increases the viscosity resulting higher mass transfer resistance which will prevent protein loss by diffusion towards the external phase resulting higher encapsulation efficiency (Figure 5).
- HSA concentration high, protein loss by diffusion towards the external aqueous phase is high.

Conclusion

- Size and encapsulation efficiency of PLGA NPs were investigated and optimized.
- If higher iron oxide concentration is desired to achieve sufficient level of magnetism (e.g. 10%), NPs of less than 160 nm can be obtained with more than 80% encapsulation efficiency which is more than acceptable.