Polymer microsphere formulation techniques for drug delivery applications

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Introduction

Polymer microspheres enable prolonged and controlled release of drugs. Microspheres made from poly(lactide-co-glycolic acid) polymers are biodegradable, biocompatible, and easily customizable, making them suitable for drug delivery. However, there is currently insufficient research data on the formulation techniques and process parameters affecting them. Therefore, this work studies two microsphere formulation techniques: batch process (Fig. 1) and microfluidic process (Fig. 2).

Materials and methods

Microspheres were fabricated from Poly(lactide-co-glycolic acid) polymer. Encapsulation was studied by encapsulating two model compounds: FITC dextran and Coumarin 6. In both formulation processes, the polymer was dissolved in the oil phase, and the model compound was dissolved either in the oil phase (single emulsion) or in the water 1 phase (double emulsion). The release of FITC dextran was studied by incubating microspheres at 37°C for over 100 days.

Batch process

In the batch process microspheres are formed with a homogenizer.

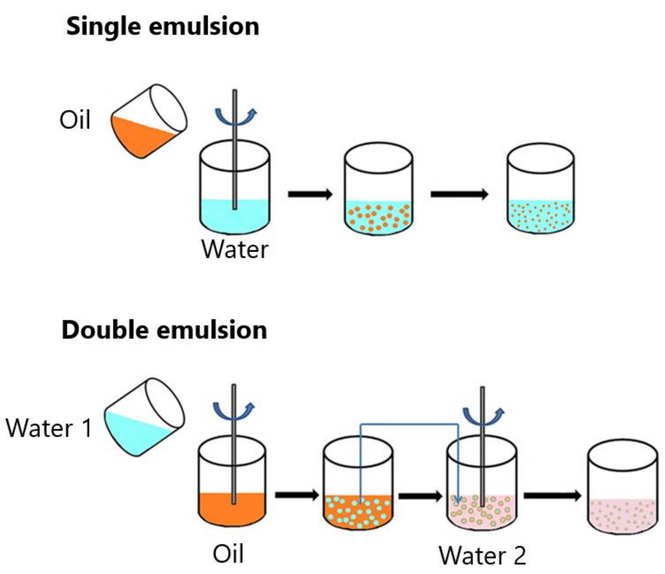

Fig.1. Single and double emulsion methods for the batch process. Adapted from (Ruan et al., 2022)

Microfluidic process

In the microfluidic process, microspheres are formed when two immiscible phases meet in a microchip.

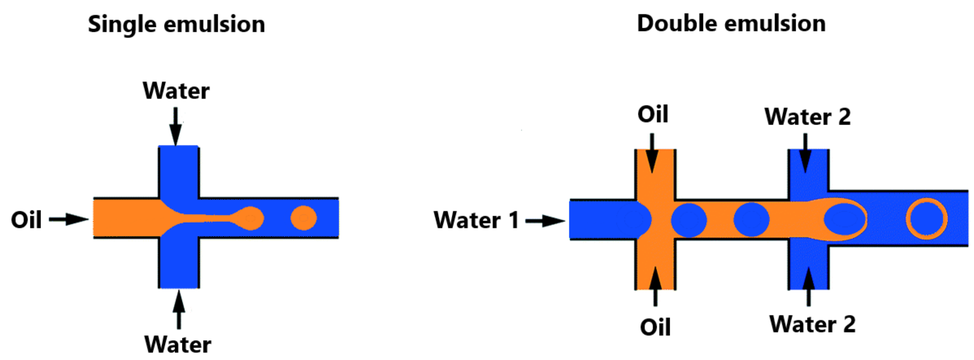

Fig.2. Single and double emulsion methods for the microfluidic process.

Results

Encapsulation efficiency

The encapsulation efficiency was over 90% at best for both FITC dextran and Coumarin 6 -loaded microspheres formulated with the batch process. The encapsulation of FITC dextran inside microfluidic-formulated microspheres was unsuccessful. Coumarin 6 was encapsulated using microfluidics with encapsulation efficiency of 53% .

In vitro release study

The burst was higher in the single emulsion microspheres (Fig. 3a) compared to the double emulsion microspheres (Fig. 3b), meaning a relatively large amount was released during the first day.

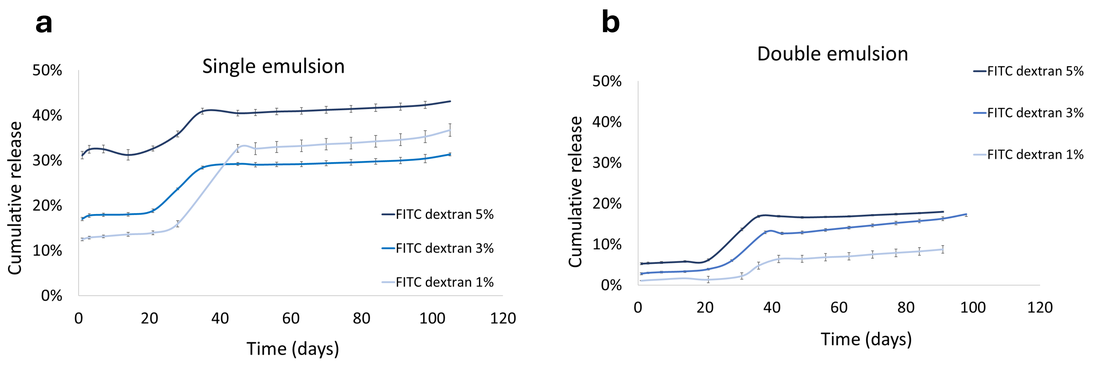

Fig 3. The cumulative release of FITC dextran from (a) single emulsion (b) double emulsion microspheres.

Polydispersity

Microspheres formulated by microfluidics (Fig. 4a) were highly uniform compared to those produced by the batch process (Fig. 4b).

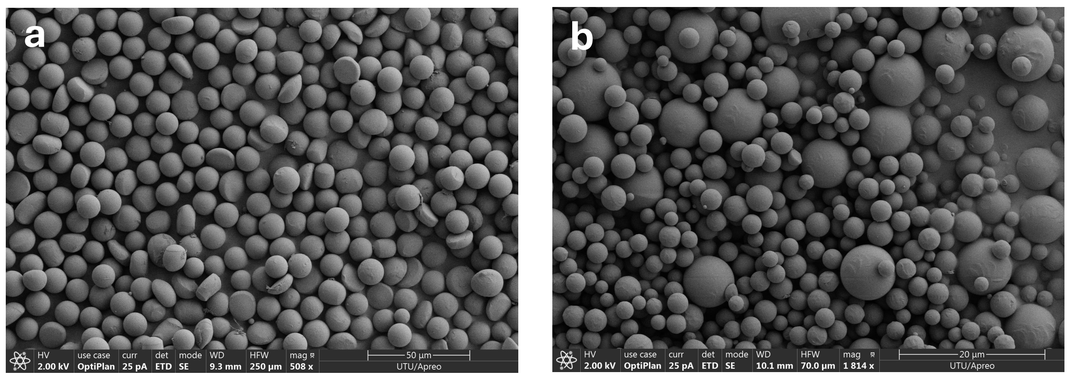

Fig.4. SEM images of microspheres formulated by (a) microfluidics (b) batch process

Conclusions

Both model compounds were successfully encapsulated with high encapsulation efficiencies. Double emulsion microspheres formulated by the batch process showed significantly lower burst compared to single emulsion microspheres, making them better candidates for drug delivery systems. Although microfluidics allows for the formation of highly uniform particles, the process requires further development to improve encapsulation.

References

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Ruan, L., Su, M., Qin, X., Ruan, Q., Lang, W., Wu, M., Chen, Y., & Lv, Q. (2022). Progress in the application of sustained-release drug microspheres in tissue engineering. *Materials Today Bio*, *16*, 100394.