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Encapsulation in Liposomes and the Critical Role of the Encapsulated Substance

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Key words: drug delivery, liposomes, preparation techniques, encapsulation efficiency

Liposomes are widely used as versatile drug delivery systems, but their preparation methods significantly influence their encapsulation efficiency and physicochemical properties. This study presents a systematic comparison of five conventional liposome preparation techniques: the heating method, the film method with extrusion, the film method with sonication, the freezing-thawing method, and a combination of film method with extrusion and freezing-thawing cycles. Two model substances, 5(6)-carboxyfluorescein (CF) and D-(+)-glucose (GLU), were chosen to examine how different physicochemical properties affect encapsulation efficiency across these methods.

The results demonstrate that the method's effectiveness strongly depends on the physicochemical properties of the encapsulated substance. The film method with extrusion achieved the highest encapsulation for CF, while sonication-based techniques performed better for the more hydrophilic and less permeable GLU. The heating method resulted in highly heterogeneous liposomes with inefficient cholesterol incorporation and the freezing-thawing method showed the lowest encapsulation efficiency in this study.

Furthermore, we observed that encapsulation efficiency in sonication-based methods depends on the concentration of the loading solution, suggesting interactions between the assembling bilayer and the molecules of solute. These findings emphasize that the choice of liposome preparation method should be tailored to the specific physicochemical properties of the encapsulated substance rather than relying on a one-size-fits-all approach.