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CUBOSOMES-AN INTRODUCTION

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ABSTRACT

Cubosomes are microscopic particles composed of a particular kind of fat, like phytotriol or glycerol monoolein that organize themselves into a certain cube-like shape. They are receiving a lot of attention because of their ability to efficiently transport and deliver food ingredients, cosmetics, and pharmaceuticals.

KEYWORDS:Phytantriol; Hydrophobic; Biodegradability; Drug delivery; Nanotechnology.

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INTRODUCTION

Cubosomes are emerging as a very promising agent in nanotechnology, mostly for drug delivery systems [1]. They are small, less than 1 micron particles with a unique structure that enables controlled medication release and retention [2]. Cubosomes is composed of bicontinuous cubic liquid crystalline phase—two water areas divided by non-crossing lipid bilayers [3]. After that, the bilayers fold into a structure that resembles a three-dimensional honeycomb, providing a huge internal surface area [4]. Lipids such as monoolein or phytantriol at specific temperatures are typical sources; polymers, like Pluronic F127, frequently stabilize them [5].

Applications and Benefits

Because cubosomes can serve as multipurpose delivery systems for hydrophobic, hydrophilic, and amphiphilic medications, their application can be extended through a variety of administration methods, including oral, ophthalmic, and transdermal [6]. Their ability to target the tumor while reducing adverse effects makes them extremely promising in the treatment of cancer [7].For example, research indicates that they can enhance drug absorption in lung cancer and decrease the size of skin cancer tumors [8]. They are also appropriate for sustained release systems that will improve patient compliance because of their biodegradability and bioadhesive qualities [9].

Challenges and Future Outlook

Cubosomes have a lot of potential, however there are still issues with their long-term stability and clinical scalability [10]. It is true that recent studies have advanced preparation methods (such as microfluidics), but this is insufficient to encourage broader usage [11].

Features of Cubosomes Structure

Cubosomes are optically isotropic structures with a large internal surface area that have been demonstrated to enhance drug loading capacities [12]. Two non-intersecting aqueous channels and a honeycomb-like bicontinuous system are produced by the three-dimensional cubic lattice arrangement of lipid bilayers in cubosomes [13]

Three proposed cubic phases are:

- **P-surface** (Primitive), which is a very simple form of cubic lattice.
- **G-surface** (Gyroid), a complex, triply periodic minimal surface.
- **D-surface** (Diamond) another triply periodic minimal surface with a structure reminiscent of diamond [14, 15].

For appropriate nanoscale applications, all of these sizes usually fall between 100 and 500 nm. The fact that this structure is also present in biological systems like mitochondrial membranes and stressed cells provides a natural biological parallel [16].

Natural Formation and Occurrence

When amphiphilic lipids, such as phytantriol or water monoolein (GMO), come into contact with water at a specific temperature, they self-organize to form cubosomes [17]. GMOs are used preferentially because they are safe, biocompatible, and biodegradable, and they melt between 35 and 37 degrees Celsius [18]. Because phytotriol does not contain an ester group, it has much better chemical stability and is much more pure (95%) and compatible with controlled medication release [19]. In order to stabilize and avoid aggregation, stabilizers such polyvinyl alcohol (PVA), Myrj59, or Pluronic F127 (Poloxamer 407) are added at concentrations between 2.5% and 20% w/w [20]. The biological relevance of these structures is demonstrated by the fact that they are naturally present in stressed cells and mitochondrial membranes [21].

Advance and Future Directions

Recent advances have centered on the development of cubosomes for clinical use, with some key developments:

- **Cancer Treatment** and **Theranostics**: In order to improve targeting effectiveness and reduce payload toxicity, cubosomes are being researched for both therapeutic and diagnostic (theranostic) applications [22].
- **Advanced Preparation Methods**: Recently, techniques based on microfluidics have emerged as a means of producing stable cubosomes with control over their size and structure [23].
- **Topical Formulations**:Due to its bioadhesive and prolonged-release properties, cubosomes are being investigated for the treatment of skin and ocular disorders such as psoriasis, acne, fungal keratitis, glaucoma, conjunctivitis, and uveitis [24]

Limitations

Despite its potential, obstacles include maintaining stability over the long term, scaling up to industrial manufacturing, and standardizing preparation methods [25]. Current ongoing research is aimed at resolving these issues and bringing cubosomes into useful therapeutic applications, including the possibility of drug delivery systems, the future of cubosomes is bright.

CONCLUSION

A quickly evolving area of science and medicine, cubosomes and nanobiotechnology hold enormous promise for use in therapeutic systems, medication transport, and diagnostics. Cubosomes are nanostructured liquid-crystalline particles with a high degree of biocompatibility and design flexibility. Because of their shape, loading capacities, and biocompatibility, they can be used as nanomedicine carriers. They are especially beneficial for the employment of these particles in therapies since they offer hydrophilic and hydrophobic compositions optimal delivery properties.

Cubosomes are a prime illustration of how biology and engineering can be combined at the nanoscale in the larger field of nanobiotechnology. Further investigation is anticipated to reveal novel uses for cubosomes integration with biosensors, genetically modified organisms, and stimuli-responsive materials in personalized medicine.

REFERENCES

1. Garg, G., Saraf, S., & Saraf, S. (2007). Cubosomes: an overview. Biological and Pharmaceutical Bulletin, 30(2), 350-353.
2. Karami, Z., & Hamidi, M. (2016). Cubosomes: remarkable drug delivery potential. Drug discovery today, 21(5), 789-801.
3. Barriga, H. M., Holme, M. N., & Stevens, M. M. (2019). Cubosomes: the next generation of smart lipid nanoparticles?. Angewandte Chemie International Edition, 58(10), 2958-2978.
4. Gaballa, S. A., El Garhy, O. H., & Abdelkader, H. (2020). Cubosomes: composition, preparation, and drug delivery applications. Journal of advanced biomedical and pharmaceutical sciences, 3(1), 1-9.

5. Abourehab, M. A., Ansari, M. J., Singh, A., Hassan, A., Abdelgawad, M. A., Shrivastav, P., ... & Pramanik, S. (2022). Cubosomes as an emerging platform for drug delivery: a review of the state of the art. Journal of Materials Chemistry B, 10(15), 2781-2819.
6. Pan, X., Han, K., Peng, X., Yang, Z., Qin, L., Zhu, C., ... & Wu, C. (2013). Nanostructed cubosomes as advanced drug delivery system. Current pharmaceutical design, 19(35), 6290-6297.
7. Azmi, I. D., Moghimi, S. M., & Yaghmur, A. (2015). Cubosomes and hexosomes as versatile platforms for drug delivery. Therapeutic delivery, 6(12), 1347-1364.
8. Spicer, P. T. (2005). Progress in liquid crystalline dispersions: cubosomes. Current Opinion in Colloid & Interface Science, 10(5-6), 274-279.
9. Bhosale, R. R., Osmani, R. A., Harkare, B. R., & Ghodake, P. P. (2013). Cubosomes: the inimitable nanoparticulate drug carriers. Sch. Acad. J. Pharm, 2(6), 481-486.
10. Varghese, R., Salvi, S., Sood, P., Kulkarni, B., & Kumar, D. (2022). Cubosomes in cancer drug delivery: A review. Colloid and Interface Science Communications, 46, 100561.
11. Oliveira, C., Ferreira, C. J., Sousa, M., Paris, J. L., Gaspar, R., Silva, B. F., ... & Botelho, C. M. (2022). A versatile nanocarrier—cubosomes, characterization, and applications. Nanomaterials, 12(13), 2224.
12. Sivadasan, D., Sultan, M. H., Alqahtani, S. S., & Javed, S. (2023). Cubosomes in drug delivery—a comprehensive review on its structural components, preparation techniques and therapeutic applications. Biomedicines, 11(4), 1114.
13. Boyd, B. J. (2003). Characterisation of drug release from cubosomes using the pressure ultrafiltration method. International journal of pharmaceutics, 260(2), 239-247.
14. Grandes Reyes, C. F., Ha, S., & Kim, K. T. (2023). Synthesis and applications of polymer cubosomes and hexosomes. Journal of Polymer Science, 61(12), 1196-1213.
15. Tilekar, K., Khade, P., Kakade, S., Kotwal, S., & Patil, R. (2014). Cubosomes-a drug delivery system. International Journal of Pharmaceutical, Chemical & Biological Sciences, 4(4).
16. Spicer, P. T., Hayden, K. L., Lynch, M. L., Ofori-Boateng, A., & Burns, J. L. (2001). Novel process for producing cubic liquid crystalline nanoparticles (cubosomes). Langmuir, 17(19), 5748-5756.
17. Li, C., Pan, Y., Xiao, T., Xiang, L., Li, Q., Tian, F., ... & Mai, Y. (2023). Metal organic framework cubosomes. Angewandte Chemie, 135(11), e202215985.
18. Umar, H., Wahab, H. A., Gazzali, A. M., Tahir, H., & Ahmad, W. (2022). Cubosomes: design, development, and tumor-targeted drug delivery applications. Polymers, 14(15), 3118.
19. Yaghmur, A., & Mu, H. (2021). Recent advances in drug delivery applications of cubosomes, hexosomes, and solid lipid nanoparticles. Acta Pharmaceutica Sinica B, 11(4), 871-885.
20. Abourehab, M. A., Ansari, M. J., Singh, A., Hassan, A., Abdelgawad, M. A., Shrivastav, P., ... & Pramanik, S. (2022). Cubosomes as an emerging platform for drug delivery: a review of the state of the art. Journal of Materials Chemistry B, 10(15), 2781-2819.
21. Bhosale, R. R., Osmani, R. A., Harkare, B. R., & Ghodake, P. P. (2013). Cubosomes: the inimitable nanoparticulate drug carriers. Sch. Acad. J. Pharm, 2(6), 481-486.
22. Attri, N., Das, S., Banerjee, J., Shamsuddin, S. H., Dash, S. K., & Pramanik, A. (2024). Liposomes to cubosomes: The evolution of lipidic nanocarriers and their cutting-edge biomedical applications. ACS Applied Bio Materials, 7(5), 2677-2694.
23. Almoshari, Y. (2022). Development, therapeutic evaluation and theranostic applications of cubosomes on cancers: An updated review. Pharmaceutics, 14(3), 600.

24. Palma, A. S., Casadei, B. R., Lotierzo, M. C., de Castro, R. D., & Barbosa, L. R. S. (2023). A short review on the applicability and use of cubosomes as nanocarriers. Biophysical reviews, 15(4), 553-567.

25. Hartnett, T. E., O'Connor, A. J., & Ladewig, K. (2015). Cubosomes and other potential ocular drug delivery vehicles for macromolecular therapeutics. Expert Opinion on Drug Delivery, 12(9), 1513-1526.

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