Development of Luminescent CBD-Loaded Liposomes for Enhanced Bioavailability and Real-Time Nanoparticle Tracking

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ABSTRACT

Cannabidiol (CBD), a natural compound in Cannabis sativa, is known for its potential to alleviate anxiety, relieve pain, and manage epilepsy-related seizures. Enhancing CBD's solubility and bioavailability through nanoencapsulation in liposomes has emerged as a promising strategy to improve therapeutic efficacy. Liposomes, prepared here using a modified Bangham method, are lipid vesicles capable of encapsulating both hydrophilic and lipophilic substances, making them effective carriers for drugs and bioactive molecules. This project aimed to develop luminescent liposomes containing CBD and TiO_2Eu nanocrystals, allowing both enhanced bioavailability and tracking of the nanoparticles within the carrier system. The use of TiO_2Eu nanocrystals, known for their luminescent properties, introduces a valuable tool for tracking the distribution and stability of liposomes in biological systems, enabling in-depth analysis of biodistribution, cellular uptake, and localization at a molecular level. Liposome synthesis involved dissolving lecithin-derived lipids in a chloroform and methanol solution, incorporating CBD and TiO_2Eu nanoparticles, followed by solvent evaporation to create a dry lipid film. This film was hydrated with saline solution and stirred to form liposomes. Characterization utilized thermogravimetric analysis (TGA) and Fourier-transform infrared (FTIR) spectroscopy, along with luminescence analysis of the nanocrystals. FTIR results revealed distinct compound-specific bonds—C=C for CBD, P-O for liposomes, and Ti-O for TiO_2—confirming successful encapsulation. TGA studies highlighted mass loss due to solvent evaporation, with Liposome + TiO_2Eu and Liposome + CBD + TiO_2Eu showing greater losses between 100–200°C, possibly due to TiO_2Eu interactions. Major decomposition occurred between 200–400°C, with pure liposomes decomposing gradually while Liposome + CBD demonstrated lower thermal stability. TiO_2Eu contributed stabilizing effects, slowing down decomposition, and provided a balanced effect when combined with CBD. Above 400°C, TiO_2Eu-containing samples retained higher residual mass, indicating greater thermal resistance. Overall, the development of CBD and TiO_2Eu-laden liposomes significantly enhanced CBD solubility and bioavailability while enabling luminescent tracking. This feature allows for real-time tracking of the nanoparticles, aiding in studying their biodistribution and improving understanding of pharmacokinetics. Physicochemical analyses confirmed essential chemical interactions and provided insights into thermal stability. TiO_2Eu increased thermal resistance, while CBD reduced it at higher temperatures yet improved solubility. This modified liposomal encapsulation approach effectively protected bioactive compounds, suggesting expanded therapeutic potential for future applications in pharmaceutical and biotechnological formulations.

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