Examination of the embedding properties of β-cyclodextrin and four essential oils

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Abstract. The purpose of this study is to examine the efficacy and efficiency of encapsulating four plant essential oils with distinct functional groups—camellia, lemon, and bay oils—by creating inclusion complexes with β-cyclodextrin. Fourier transform infrared spectroscopy (FT-IR) was used to characterise the essential oil/ β-cyclodextrin microcapsules that were made using the co-precipitation procedure. The creation of inclusion complexes was validated by Fourier transform infrared spectroscopy analysis. In conclusion, essential oils with various functional groups can be encapsulated using β-cyclodextrin as a wall material. The study's findings offer a theoretical foundation for the use of essential oil microcapsules in related industries such feed additives and the preservation of fruits and vegetables.

Keywords: β-CD；essential oil；inclusion complexes.

Abbreviations: β-CD , β-Cyclodextrins ;LCEO, litsea cubeba essential oil; CAEO, Camellia sinensis essential oil; LEEO , Lemon essential oil; LAEO, Laurel essential oil; FTIR, Fourier transform infrared spectroscopy.

1. Introduction

The primary source of plant essential oils is the volatile substances found in a plant's flowers, leaves, stems, seeds, fruits, roots, or skins. Plant essential oils are a safe, non-toxic, and pure natural substance with antibacterial, anti-tumor, anti-inflammatory, antioxidant, and insect-repelling properties [1]. Their companies additionally have promising application prospects in the field of food freshness preservation. However, the development and application of plant essential oils have been limited by their volatile nature, weak solubility in water, and pungent odor [2]. The expression "microcapsule technology" describes the process of using synthetic or natural polymer materials for the wall and various core elements embedded in them to create a sealed or semi-sealed material [3]. It could improve the stability of essential oils' active constituents, lessen the influence of the outside world on them, and produce long-lasting antimicrobial effects and sustained release [4]. β-Cyclodextrin (CD) generates inclusion complexes with tiny essential oil molecules, enhancing their water solubility and offering protection and prolonged release due to its distinct, unique outer hydrophilic and inner hydrophobic cavity chemical structures [5]. Because the embedded components solidify into powders or particles, they make transportation easier, and because of their superior dispersibility , they can be combined with other materials or ingredients to maximize usage efficiency. Essential oils' economic worth is significantly increased by the creation of essential oil microcapsules that merely retain the aromatic components of the oils in addition to successfully regulating their delayed release of active compounds [6].

In this work, β-CD was utilized as the wall material, and the essential oils of Laurel, Lemon, Litsea cubeba, and Camellia sinensis were used as the core materials. The co-precipitation approach was employed for preparing the essential oils/ β-CD microcapsules for use as feed additives, fruit and vegetable preservation, and other applications. FT-IR was used to describe the microcapsules. This involved theoretical information about the application of essential oils in feed, food, and other industries.

2. Experiment

2.1 Materials

Shanghai Yuanye Biotechnology Co., Ltd. provides the essential oils of Atractylodes macrocephala and Camellia sinensis, while China National Pharmaceutical Group Chemical Reagent Co., Ltd. is the source of β - CD. Shanghai McLean Biochemical Technology Co., Ltd. is the supplier of essential oils for lemon and laurel.

2.2 Preparation of inclusion complexes

The inclusion complexes were prepared according to a previous report [7]with some modifications. At 55 ° C, add 3 g of β -CD and 200 mL of distilled water to a conical flask and stir for 30 minutes. Add a specific amount of four essential oils to the solution after it has cooled to room temperature in order to create essential oil complexes with various mole fractions. Then, oscillate the mixture in a vortex for 3 minutes, and stir it in the dark at 30 ° C for 4 hours. Subsequently, maintain overnight at 4 ° C to achieve an equilibrium reaction. To obtain embedding products, essential oils are recycled using β -CD inclusion complexes and freeze-drying.

2.3 Efficiency of Packaging (EE)

Weigh the physical combination, inclusion complex, and essential oil (200 uL) to 100 mg. After that, add anhydrous sodium sulphate and use 10 millilitres of anhydrous ethanol to dilute the mixture. To give the active ingredients time to dissolve in the solution, leave the mixture for 24h. Utilising UV spectrophotometry, determine the absorbance and total essential oil content. To find the EE parameters, use the formula below:

The following is the formula used to calculate EE parameters:

$$EE= \frac{\text{Retentive amount of essential oil}}{\text{initial amount of essential oil}} \times 100$$

2.4 FT-IR spectroscopy

Use FT-IR spectroscopy (Thermo Fisher Scientific NI10, American) to identify the material. Mix the sample with desiccated KBr to produce tablets with a 4000-400 cm-1 distribution.

2.5 Statistical analyses

Using the Duncan's multiple range test and SPSS statistical software version 21.0 (Chicago, Illinois, USA, SPSS Inc.), the significant differences between the means (P<0.05) were investigated.

3. Results and discussion

3.1 Encapsulation efficiency (EE)

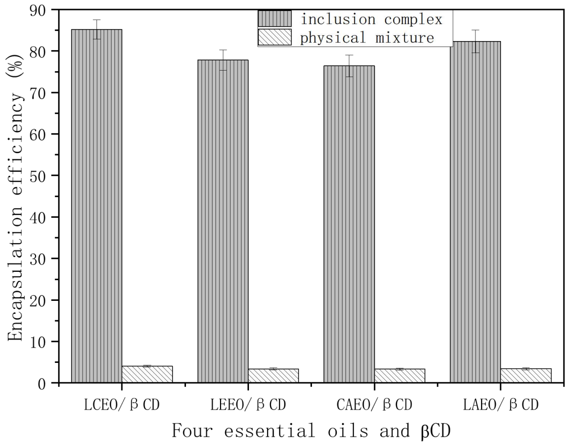

Fig. 1. Encapsulation rates of four essential oils and β-CD

Figure 1 illustrates the efficacy of using cyclodextrin to encapsulate four essential oils. When wall and core materials have a mass ratio of 1:4, the composite's EE value falls between 76.4% and 85.2%. The physicochemical properties and chemical structure of created molecules, as well as the interaction between essential oils and βCD, could be the reason for this disparity in EE. The equilibrium points in solution of different chemicals that form inclusion complexes also differ.

3.2 FT-IR analysis

The FTIR spectra of essential oils, inclusion complexes, and β-CD are shown in Figure 2. The β-CD infrared spectrum exhibits a symmetric stretching vibration characteristic peak of O-H at 3383 cm-1, and a characteristic peak associated with the stretching vibration of C-H at 2924 cm-1. The symmetric and asymmetric stretching vibrations of C-O-C are the characteristic peaks at 1157 and 1029 cm-1, respectively. The characteristic peak of the CD infrared spectra is comparable to what has been seen in previous studies[8].

LEEO has a high concentration of alcohols and olefins in its spectrum of guest molecules. Unsaturated C-H (C-H on olefin double bonds) stretching vibration is responsible for the absorption peak at 3072 cm-1, while saturated C-H stretching vibration is responsible for the absorption peak at 2920 cm−1. The absorption peak of 1664cm-1 is caused by C=C stretching vibration. The methyl and methylene C-H inplane asymmetric deformation vibrations are accountable for the characteristic absorption peaks at 1456 cm-1 and 1377 cm-1, respectively. The methyl C-H in-plane symmetric deformation vibration is responsible for the latter peak. The absorption peak at 887cm-1 is attributed to the C-H bending vibration on the substituted end of ene. The stretching vibration of CO is shown by the high-intensity peak at 1728 cm-1 in the infrared spectrum of CAEO. The spectral features of the inclusion compound's infrared spectrum show that the symmetric stretching vibration peak from C-O-C shifts to 1731 cm-1 and loses intensity, while the asymmetric stretching vibration peak from C-O-C increases in intensity at 1157 and 1029 cm-1[9].

In the infrared spectra of LAEO and LCEO, the characteristic peaks of CH2 vibration are at 2925 and 2916 cm-1, respectively [3].It is associated with the stretching vibration of the C=O group in the citral compound that the strong absorption band at 1674 cm-1 typically resides in. This noticeable rise highlights the presence of LCEO within the CD's hollow, and these results indicate that the guest substance is effectively encapsulated in the cavity of the CD and forms an inclusion complex.Previous results indicate that the mobility and signal intensity of encapsulated molecules are reduced by the embedding of guest molecules[10].The limitation of the guest molecules' stretching vibration in the CD cavity is responsible for the changes in the guest molecules' characteristic bands, which include the decrease, disappearance, and broadening of peak intensity. These changes also suggest the formation of inclusion complexes between the guest molecules and the wall material [11].

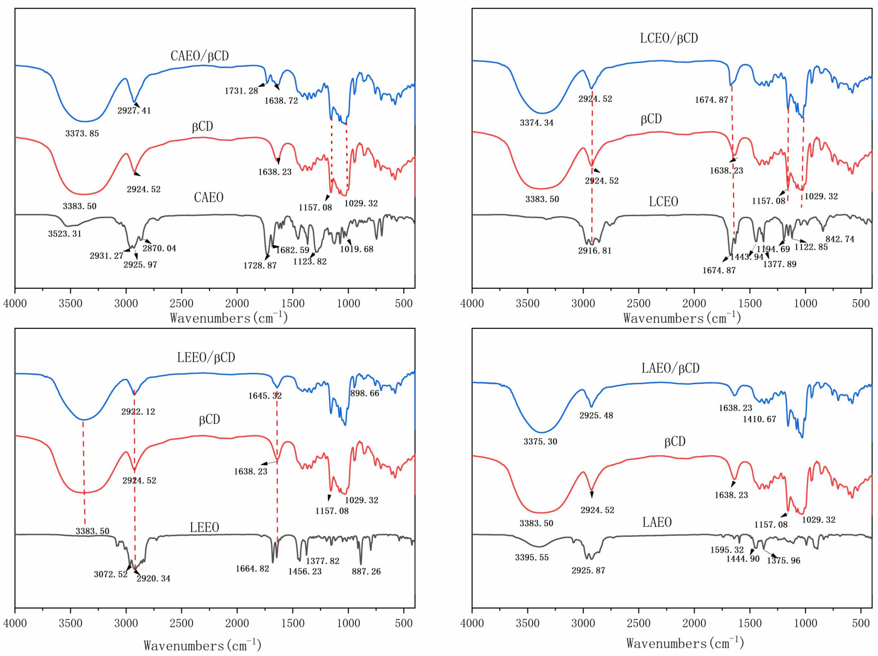

Fig .2. FTIR spectra of β-CD, essential oils, and inclusion complexes.

4. Summary

In order to create microcapsules, β-cyclodextrin (β-CD) was combined with four essential oils using the co-precipitation method. FT-IR technology, or Fourier transform infrared spectroscopy, was used to do a detailed examination of the compound. Results from measurements using Fourier transform infrared spectroscopy reveal that the complex's distinctive β-cyclodextrin and essential oil peaks have moved. In light of the aforementioned findings, it can be said that using β-cyclodextrin enhances the essential oil's controlled release, thermal stability, and antibacterial qualities while also effectively creating microcapsules.

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