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Cyclodextrins for Encapsulations in the Agri-Food Industry

Recently a book with the title „Encapsulations" has been published by Academic Press (Elsevier) in the series of „Nanotechnology in the Agri-Food Industry" [1]. Three of the 20 chapters are dedicated entirely for cyclodextrin encapsulations and cyclodextrins are discussed in further 7 chapters as a novel approach for nanoencapsulation of flavors and aromas in addition to electrodynamic microencapsulation, coacervation, emulsion diffusion method, supercritical fluid technologies, liposomes, etc.

Various aspects of encapsulation by cyclodextrins are covered with some overlapping information in the various chapters written by different authors.

Chapter 2 gives an overview on the most investigated nanocapsules (polymeric nanocarriers, lipid-based nanocarriers and molecular complexes) [2].

Chapter 3 describes on the beneficial properties of cyclodextrins in a short paragraph in a subchapter dedicated to carbohydrate encapsulation materials [3]. Further polysaccharides, such as chitosan, dextran, modified starch, cashew gum and inulin are mentioned.

Chapter 4 gives a detailed evaluation of the experimental techniques used for studying the flavor/cyclodextrin complexes including static head space chromatography, UV-visible and fluorescence spectroscopy, isothermal titration calorimetry, phase solubility studies, NMR spectroscopy, thermoanalytical methods and microscopy [4]. There is a large table listing the methods of complexation and analysis for over 100 aroma compounds and essential oils with references. Effect of encapsulation, such as solubility enhancement, protection, controlled release, improved organoleptic behavior and masked off-flavors, active packaging as well as improved handling and dosage are discussed.

The authors of chapter 6 express their concern on the higher cost of CDs compared to the conventional carrier materials. The other drawback is that the most versatile BCD can be used limited (ADI 0—5 mg/day/kg body weight) and the soluble CD derivatives such as HPBCD or methylated CDs are not approved in food [5].

Chapter 8 gives several examples of molecular encapsulations in the food industry [6]. Effect on the organoleptic properties (reduction of bitterness, protection of color and clarity of juices, masking unpleasant odor), extraction of cholesterol, removal of toxins, and stabilization of antioxidants, such as vitamins, anthocyanins, flavonoids, curcumin, resveratrol are discussed. The application of CDs in sensors for detecting volatile amines and flavonoids in food is also pointed out.

Electrospinning as a novel cost-effective and versatile technique useful for the preparation of edible nanofibers as carriers of flavors and antimicrobials is shown in chapter 9 [7]. The complex is formed during the electrospinning process.

Complexation of polyphenols, such as curcumin, rutin, chlorogenic acid with the advantage of reduced bitter taste, improved storage stability and bioavailability is summarized in chapter 13 [8].

Compared to microencapsulation, nanoencapsulation not only protects the included essential oils from degradation and volatilization, but improves also the bioefficacy as discussed in chapter 15 [9]. For instance, CD-complexed cinnamon bark and clove oil, garlic oil and isothiocyanates showed enhanced antimicrobial effect.

Chapter 17 focuses on the encapsulation of antioxidants (flavonoids and phenolic acids) [10]. Several examples are shown on the application in food products, food supplements and packaging.

A general overview on the nanoencapsulation of flavors and aromas is given in the chapter of CycloLab (chapter 18) [11]. Starting with the history dating back to the sixties of the last century, the advantages are summerized, the approval status of CDs in food is evaluated, and the methods of preparation and analysis are shortly outlined. Flavor complexes in food processing to reduce the loss in color, odor and taste are revealed. Several examples are given to illustrate the advantages of nanoencapsulation of flavors in aroma preserving food packaging.

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Motility, Acrosome reaction, Endangered species

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4-Vinylpyridine, β-CD, Molecularly imprinted polymers (MIPs), Atom transfer radical polymerization

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Zirconia-supported cobalt oxide catalysts, Cobalt nitrate, Cobalt acetate, Cobalt acetylacetonate, Counteranion, Cyclodextrin

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Crown ethers, Cryptands, Cyclophanes, Cyclodextrins, Calixarenes, Cucurbiturils, Zn-porphyrin macrocycles, Cavitands

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Fuel cell technology, Nanocatalyst, Electrocatalyst

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Chemical synthesis method, Transmittance spectra

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Volatilization, HPBCD, Biodegradation of both fluorene and pyrene, Dehydrogenase activity

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Cationic and anionic branched β-cyclodextrins, Wastewater, Layer by layer assembling

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Metal biocide, Marine biofouling, Polymer β-CD

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Enzymatic methodology, Schiff bases, Oxidized β-cyclodextrin

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Microwave-assisted inverse emulsion polymerization, β-Cyclodextrin, Acrylamide, Kinetic behavior, Thermodynamics

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Pyrene as a fluorescent probe, Molecular dynamics simulation, Quantum-chemical modeling

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Adamantine-modified primary antibodies, Carboxymethyl-β-cyclodextrin, Electrochemical, Immunosensor

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Biosensor, Lecithin/β-cyclodextrin, Fluorescence detection

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Methyl-β-cyclodextrin, Capillary electrophoresis

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Sodium cholate, n-Butanol, γ-Cyclodextrin, Capillary electrophoresis, Cis-trans isomerization, Combined dosage form

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β-Cyclodextrin, Adamantine, Supramolecular "bridge", Electrochemiluminescence, Enzyme catalysis

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Maleic anhydride modified β-cyclodextrin, Chiral selector

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Coprecipitation method, Electron transfer rate, Electrochemical impedance spectroscopy, Cyclic voltammetry, Electrochemical sensor

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4-Fluoroamphetamine, 4-Fluoromethamphetamine, Sulfated β-cyclodextrin, Chiral selector, Enantioseparation, Position isomers

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Amine-modified β-cyclodextrin, Nanocomposite, Signal amplification, Mucin-1, N-(aminobutyl)-N-(ethylisoluminol), Ferrocenecarboxylic acid

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Content of PAHs, Solution of cyclodextrins, Biochar-amended soil

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γ-CD, Tryptophan enantiomers, Recognition mechanism, Enantioselective electrochemical and photoluminescence quenching, Graphene oxide, Molecular docking

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Benzene, Toluene, Hexane, Ethanol, Acetonitrile, Aromatic amino acids

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HPBCD, RP-HPTLC, PAHs, Endocrine disruptors

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