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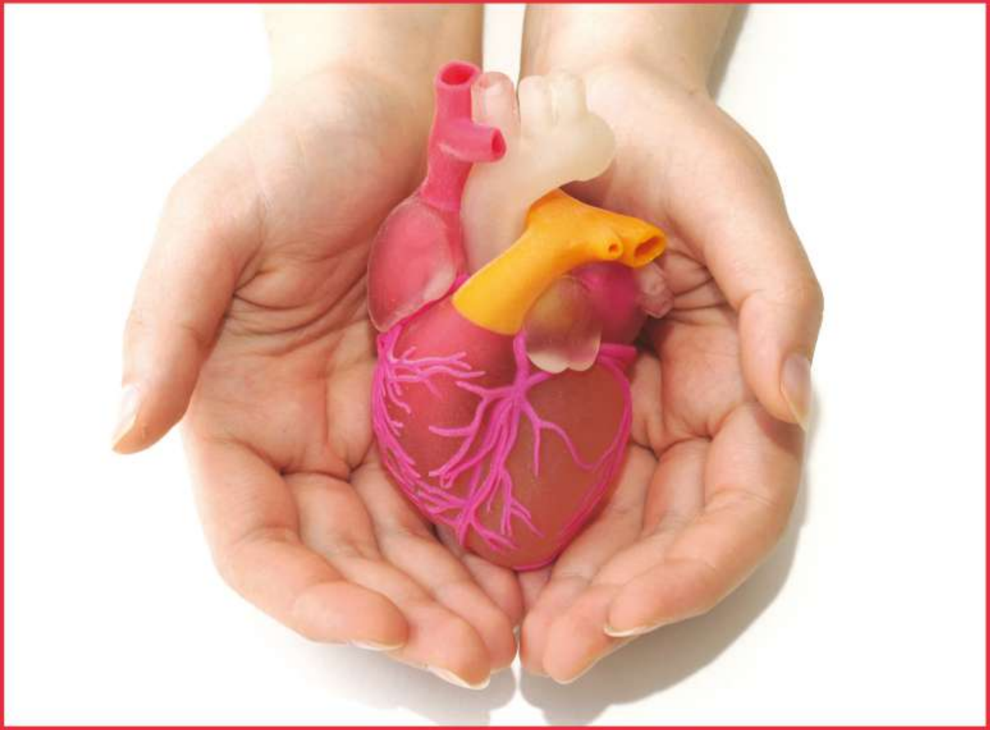

SMART POLYMER NANOCOMPOSITES

BIOMEDICAL AND ENVIRONMENTAL APPLICATIONS

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SHOWKAT AHMAD BHAWANI,
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CHAPTER ELEVEN

Smart polymer composites in bioseparation

Nayeem Ahmed
Department of Chemistry, University of Kashmir, Srinagar, India

11.1 Introduction

Polymer composites which undergo variations in reaction to external stimuli are called intelligent polymers composites, or smart polymers composites (SPCs). The recent applications of SPCs in the field of biotechnology are summarized in this chapter. A number of products have been developed due to progress in biotechnology involving DNA recombinant technology and cell culture techniques. One of the fundamental steps in the development and manufacture of the products is recovery and purification as the final product cost is mostly determined by the separation and purification cost [1]. Therefore, in addition to retaining the biological activity of the product, there is a persistent requirement to acquire swift and economic isolation and purification processes with good product yield. Bioseparation processes demand distinctive approaches from those used in conventional chemical industries [2], i.e., only a few kilograms of a protein produced per year might sell for millions of dollars in the pharmaceutical industry but, in industrial biotechnology, large amounts in tons of bio-based polymers, such as Biopol or Xanthan gum, could be made per year, also yielding millions of dollars in sales but at a considerably lower unit mass price. Entirely new processes for the separation of biological products are often needed to handle unfamiliar material properties (Fig. 11.1). The desired product might be a single component present in low concentration that requires to be separated from bulk water and other soluble components [3].

The bioseparation process involves three steps:

- Separating of the target constituent and impurities
- Separation of the phases
- Recovery of the target component

The use of SPCs in affinity precipitation, where the SPC leads to the establishment of a new phase, is due to their ability to undergo phase separation.

Smart Polymer Nanocomposites
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EXTRACTION OF NATURAL PRODUCTS FROM AGRO-INDUSTRIAL WASTES

A GREEN AND SUSTAINABLE APPROACH

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SHOWKAT AHMAD BHAWANI
ANISH KHAN
FASIHUDDIN BADRUDDIN AHMAD

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8

Extraction of bioactive compounds from agro-industrial waste

Nayeem Ahmed

DEPARTMENT OF CHEMISTRY, UNIVERSITY OF KASHMIR, SRINAGAR, INDIA

8.1 Introduction

Per year, approximately, 1.3 billion tons of food is wasted globally because of the primary and secondary processes involved in the supply chain mechanism. The wastage involves losses caused during the production and post harvesting processes of the food products. In developing world these processes represent about 75% of food losses and in developed world the wastage at the consumption stage is the primary culprit [1,2]. Specifically, the agri-food industry is accountable for the creation of large volumes of organic waste [biomasses] ending up around 140 billion tons per year [2–4]. Safe disposal and processing of this waste leads to the addition toward the overall cost of the food and also negatively impacts the environment. But if we look at it the other way, then these waste products present us an opportunity to obtain low cost source for energy, biofuel and other value-added chemicals (Figs. 8.1 and 8.2). Therefore, recovery and further processing of these waste materials represents a valuable opportunity [5].

Agricultural wastes comprise of a large variety of residues which include molasses, bagasse, oilseed cakes/ straw, stem, stalk, leaves, husk, shell, peel, lint, seeds, pulp, whole pomace, stubble, which originate from cereals, pulses, legumes, fruits, vegetables, oil seeds, coffee, tea, etc. (Table 8.1). Natural products, because of their wide biological profiles, are considered an attractive value-added motif and specially among them, phenolic compounds are recognized for their benefits to humans in the prevention of cancer and cardiovascular diseases [6–8]. These benefits have been extensively studied and partially attributed to their capability of acting as potent antioxidants and scavengers of reactive oxygen species which are generated under oxidative stress conditions and are therefore responsible for the leading toward several inflammatory and degenerative diseases [9–11]. Therefore, because of these properties, the natural phenolic compounds (Fig. 8.3) have been used as ingredients in food supplements [7,12–15] and additives for functionalization of materials in biomedicine [16–18], cosmetic [19–22], or food industry [23–27].

In this context, it is very important to comply with the principles of the green economy, and achieve the extraction products using environmentally friendly, sustainable and economic

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VALUE-ADDED INGREDIENTS AND ENRICHMENTS OF BEVERAGES

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15

SELF-ASSEMBLED SYSTEMS BASED ON SURFACTANTS AND POLYMERS AS STABILIZERS FOR CITRAL IN BEVERAGES

Oyais Ahmad Chat[*,†], Parvaiz Ahmad Bhat[*,†], Nighat Nazir[‡], Aijaz Ahmad Dar[*]

[*]Physical Chemistry Division, Department of Chemistry, University of Kashmir, Srinagar, Jammu and Kashmir, India, [†]Department of Chemistry, Government Degree College, Pulwama, Jammu and Kashmir, India, [‡]Department of Chemistry, Islamia College of Science and Commerce, Srinagar, Jammu and Kashmir, India

15.1 Introduction

Citral is widely used as an additionally added active flavoring ingredient for enrichment of foods (Choi et al., 2009b) and beverages (Piorkowski and Mcclements, 2014), well known for its pleasant, strong, lemon-like aroma (Berk, 2016). The *European Commission (2002/113/EC, 2002; 2004/1935/EC, 2004; 89/107/EEC, 1989)* has accepted the use of citral, linalool, limonene, etc. as flavorings in beverages/food products, and have also been generally recognized as safe (GRAS) by the US Food and Drug Administration (FDA). Chemically citral is an acyclic monoterpene aldehyde (3,7-dimethyl-2,6-octadienal), comprising of two geometrical isomers, the more stable citral-a (α-citral, geranial, *E*-isomer, (E)-3,7-dimethyl-2,6-octadienal) and citral-b (β-citral, neral, *Z*-isomer, (Z)-3,7-dimethyl-2,6-octadienal) are in the proportion of 75% and 25%, respectively (Schieberle and Grosch, 1988). The name citral has been derived from *Backhousia citriodora* F. Muell, being its original source (Southwell et al., 2000). Citral is mainly obtained from *Litsea cubeba* oil and lemon grass oil (*Cymbopogon)* (Berger, 2007; Pihlasalo et al., 2007; Maswal and Dar, 2014; Skaria et al., 2012). Citral is also obtained from isoprenol (obtained by addition of formaldehyde to isobutylene), isoprene (from petrochemicals), pyrolysis of limonene (from sulfate turpentine), and from pinenes (from turpentine) (Berger, 2007). Citral has a wide range of medicinal and therapeutic uses; as

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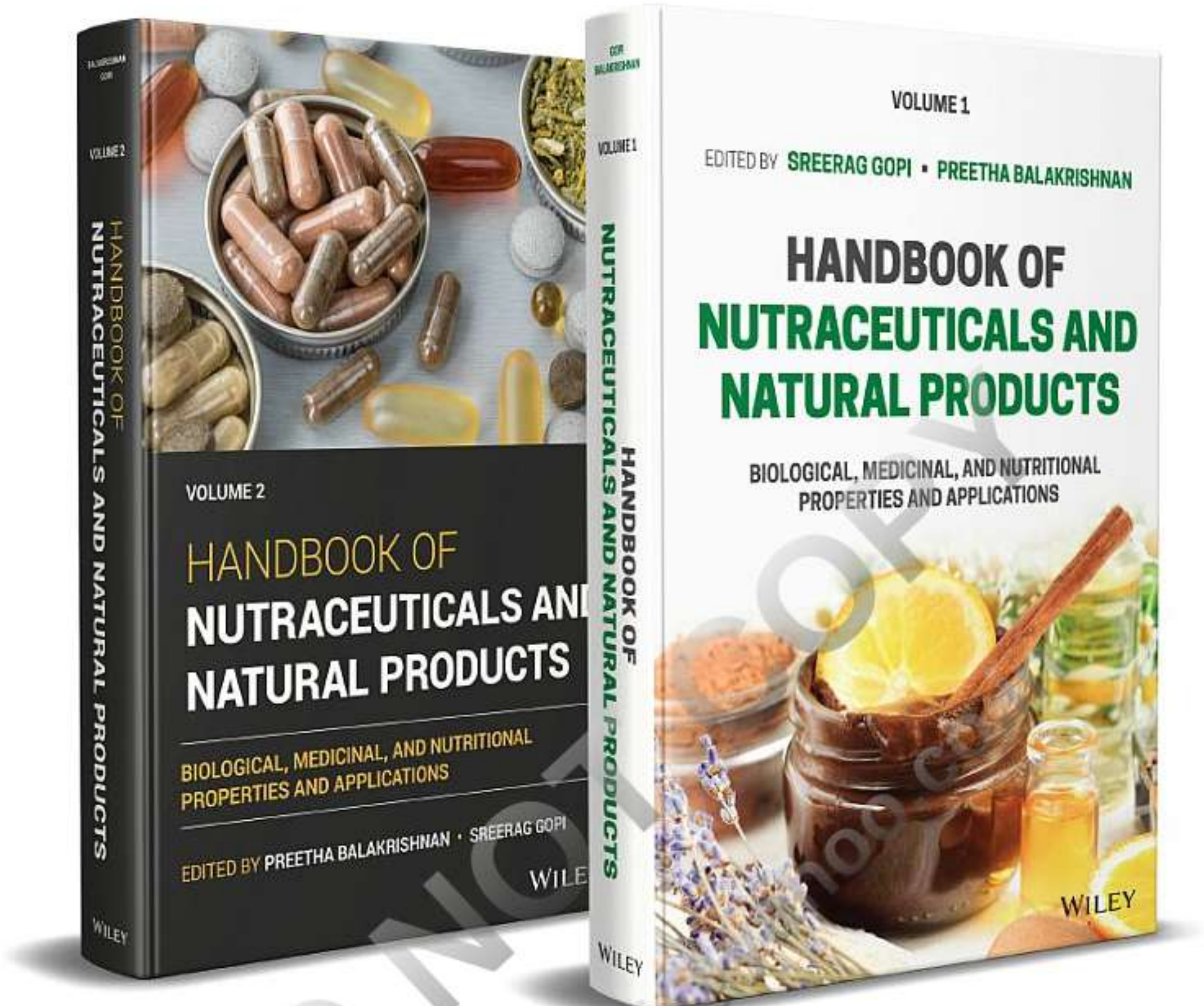
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16
Surfactant and Polymer-Based Self-Assemblies for Encapsulation, Protection, and Release of Nutraceuticals

Saima Afzal[1], Mohd Sajid Lone[1], Pawandeep Kaur[1], Firdous Ahmad Ahanger[1], Nighat Nazir[2], and Aijaz Ahmad Dar[1]

[1] Soft Matter Research Group, Department of Chemistry, University of Kashmir, Srinagar, Jammu and Kashmir, India

[2] Department of Chemistry, Islamia College of Science and Commerce, Hawal, Jammu and Kashmir, India

16.1 Introduction

Customer satisfaction regarding the effect of the general well-being of food products on human health has been gaining increasing importance due to the advent of more food processing techniques. In contemporary times, it is possible to fabricate palatable foods by employing different bioengineering methods through various encapsulation methods and carriers, which has opened up a huge food service industry across the globe. Owing to the rapid advancements in the nanoscopic imaging and other related physicochemical characterization techniques, the revelations about the very captivating microstructure of the food has been on the rise (Livney 2015). This has greatly enhanced our abilities to understand and manipulate the food microstructure for obtaining better food properties and functionalities. The elaborate relation between food and health has been the driving force behind the rapid and inclusive increase in scientific literature to alleviate the occurrence of diseases like obesity, cancer, and diabetes. The term "nutraceutical" is a link between food and medicine derived from the combination of terms "nutrition" and "pharmaceutics." The famous quote by Hippocrates (400 BC), "Let food be thy medicine and medicine be thy food" sums up the entire significance of nutraceuticals and underscores their importance and familiarity among the masses since time immemorial (Helal et al. 2019). Pertinently, in the recent past the nutraceutical industry has picked up pace so fast that its estimated market is expected to reach about 49 billion USD in 2023 (Chen and Hu 2020). Nutraceuticals are not essential for life, but they have a significant effect on the human health depending on their amount and type present within a living body. A significant body of literature points toward the fact that nutraceuticals enhance the human resistance to the diseases and hence promote good health (Asghar et al. 2018). Owing to their beneficial effects, they have been used as treatments against different health ailments, like cancer, inflammation, atherosclerosis, obesity, and diabetes in addition to having antiaging and antioxidant properties (Table 16.1). (Bourbon et al. 2018; Zhang et al. 2019)

The nutraceuticals are quite often the bioactive molecules or molecules derived from plant sources. Such molecules suffer from lots of challenges that have been on the forefront confronting scientists for harvesting their health benefits like the low aqueous solubility, chemical instabilities (due to the changes in pH, ionic strength, etc. along the gut), and their targeted delivery (Chen and Hu 2020). The developments in the food nanotechnology hold a promising future in order to provide with the new and effective strategies in combating such challenges related to the bioavailability and stability of the nutraceuticals.