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Editorial

Nanotechnology for Food Engineering: Biomembrane and Nanocarriers

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Nanotechnology has been hired in various areas of food engineering and technology. Recent research has begun to address the potential applications of nanotechnology for functional foods and nutraceuticals by applying the new concepts and engineering approaches involved in nanomaterials to target delivery of bioactive compounds and nutrients. “Nano” must exist naturally in food because even in natural foods, structural components are built from molecules and, during digestion, break down into molecules. There is strong interest in significantly improving the quality of foods, especially nanocarriers, in order to improve the encapsulation efficiency of the carrier and to control the release rate under various stimulus conditions for target delivery by using biocompatibility materials and optimizing their size.

In this point of view, the designs of suitable nanocarriers grew in importance because nanomaterials could be highly toxic, have very low bioavailability, and require protection from rapid degradation and excretion. Such carriers generally need to be stable, biocompatible, and biodegradable, and have the ability to target specific digestion process.

The miniaturization of electronic devices coupled with advances in microscale manufacturing technology has prompted studies on increased thermal management and cooling performance in microchannels. S. A. Memon and colleagues analyzed these thermal performances of the water-based salt hydrate S44 nanoparticle (as the phase change material) slurry flow through a microchannel heat sink. In this study, they suggested that the salt hydrate S44 would provide better thermal performance than lauric acid and provided a design guideline for manufacturing phase change material particles and microchannel heat sinks.

On the other hand, in the study by S. H. Lee et al., mushroom-shaped microstructure-based dry adhesives are expected to be applied in various fields, thanks to their unique properties, such as strong adhesive force, repeatability, durability, reversibility, and self-cleaning. However, in order for dry adhesives to be widely used, the efficiency of the production process needs to be increased. Until now, dry adhesives have been made by fabricating a silicon master using a complex surface micromachining process and then replicating thermosetting or UV-curable resins. S. H. Lee et al. introduced a method to continuously fabricate a mushroom-like microstructure by continuously fabricating a simple microstructure using a simple molding process and resin inking. The fabricated microstructures showed similar properties to general dry adhesives and showed adhesion of about 13 N/cm^2 to the smooth surface.

Besides, its nutraceuticals are a natural way to achieve a therapeutic outcome with minimal or no side effects. However, they are subject to degradation resulting from exposure to environmental factors such as humidity, oxygen, heat, light, and extreme pH. The biomembrane is one of the important molecular assemblies that contribute in an essential way to the functioning of organelles and of biological cells at large. A systematic study of the "Membranome," in addition to the genome and proteome, is expected to be achieved in the 21st century with considerable potential for biomedicine, bioengineering, biomaterials, and functional food engineering development. In addition, enzymes are produced by all living organisms, from microorganisms to plants and animals; enzymes are necessary for nearly all of life's chemical breakdown of complex molecules into simpler ones which often results in a release of energy and the biochemical synthesis of complex substances with the energy storage.

In this context, biomembrane technology such as liposome presents exciting opportunities for food technologists in areas such as encapsulation and controlled release of food materials, as well as the enhanced bioavailability, stability, and shelf-life of sensitive ingredients.

Watanabe and colleagues explored the functional hydration behavior such as interrelation between hydration and molecular properties at lipid membrane interfaces. Common aspects of interfacial water can be obtained by overviewing fundamental functions and properties at different temporal and spatial scales. It is important to understand the hydrogen bonding and structural properties of water and to evaluate the individual molecular species having different hydration properties. Water molecules form hydrogen bonds with biomolecules and contribute to the adjustment of their properties, such as surface charge, hydrophilicity, and structural flexibility. In this review, the fundamental properties of water molecules and the methods used for the analyses of water dynamics are summarized. In particular, the interrelation between the hydration properties, determined by molecules, and the properties of molecules, determined by their hydration properties, are discussed using the lipid membrane as an example.

In the study by M. Hirose et al., the authors investigate the L-proline-catalyzed Michael addition reaction of *N*-[*p*(2-benzimidazolyl)phenyl]maleimide (BIPM) and acetone was employed because BIPM is reported to be a good substrate to monitor L-proline-catalyzed reactions through the fluorescence of the product. The effect of liposome membranes on this reaction was kinetically analyzed using fluorescence spectroscopy. The kinetics of the reaction were different from those of the constituent lipids of the liposomes. Zwitterionic 1,2-dipalmitoyl-*sn*-glycero-3-phosphocholine liposome, which is in the solid-ordered phase, had a better value of reaction rate, suggesting that the reaction rate constants of this reaction in liposome membrane systems could be regulated by the characteristics of the liposome membrane (i.e., the phase state and surface charge). Based on the results obtained, a plausible model of the L-proline-catalyzed Michael addition reaction was discussed. The obtained results provide us with an easily detectable method to assess the reactivity of L-proline in biological systems.

It is necessary to describe the current circumstances of nanotechnology utilized in the food sector in order to develop the novel functional foods and to present a comprehensive perspective to food scientists embarking on research about nanotechnology.

The free enzyme is easily denatured under the conditions of strong acid or alkali in the process of degumming. Therefore, many scholars have been working on the nanocarrier material since the rise of immobilizing technology. A magnetic immobilized enzyme can be oriented to replace the traditional mechanical stirring under the external magnetic field, avoiding the loss of enzyme on the magnetic carrier caused by mechanical stirring to improve the catalytic efficiency of the immobilized enzyme. At the same time, it can be quickly separated from the reaction system and easy to operate. J. Yang et al. developed the nanomagnetic carrier (Fe_3O_4-SiO_2-p(glycidyl methacrylate, GMA)) prepared by atom transfer radical polymerization and immobilized the free phospholipase C (PLC) to the nanomagnetic carrier. Phospholipids were successfully converted to 1,2-diacylglycerol in degumming process. The enzymatic properties of PLC-Fe_3O_4-SiO_2-p(GMA) showed that the tolerance pH range was widened and the tolerance temperature increased by 10°C.

In nanoemulsion-based oral delivery systems for functional lipophilic compounds, it is important to know how the interfacial membrane affects the stability of compounds incorporated into the emulsion for the prevention of lipid oxidation. J. Kim et al. investigated the influence of oxidants on the stability of α-tocopherol in model nanoemulsions and the role of interfacial membrane organized by nonionic emulsifiers (P10L, P10S, P20S, P23L, and P100S) because the structural and physicochemical properties of emulsifiers play important roles in the nanoemulsion stability and in the storage stability of functional compounds incorporated into the oil droplets. Although their data are still insufficient to generalize the influence of droplet interface characteristics on the oxidative stability of emulsified oils, it was an excellent example out of relevant studies.

In addition, H. Yu et al. described the current applications of nanotechnology in food science including flavor control, enhancement of bioavailability of bioactive compounds, and detection of deleterious substances in foods. Furthermore, they provided a well-organized overview of classification, preparative methods, and safety issues of nanomaterials for food science. Nanotechnology in foods has progressed year upon year as they described; however, further research is necessary to maximize the number of uses within the food industry. In particular, the safety concerns regarding the consumption of nanomaterials in foods must be addressed before the products are released to the market. Therefore, it is necessary to standardize test procedures to determine the impact of nanomaterials.

Whilst it is clear from the studies included in this special issue that many advances have been made in food engineering, there is a crucial key issue still to be overcome. That is, nanotechnology in foods has progressed year upon year; however, further research is necessary to maximize the number of uses within the food industry. In particular, the safety concerns regarding the consumption of nanomaterials in foods must be addressed before the products are released to the market. Therefore, it is necessary to standardize test procedures to determine the impact of nanomaterials. Finally, regulations should be introduced and constructed that can ease consumer worry and enhance consumer acceptability.

Conflicts of Interest

The Editors declare that they have no conflicts of interest regarding the publication of this special issue.

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