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Historical perspective

Formulation and stabilization of nano-/microdispersion systems using naturally occurring edible polyelectrolytes by electrostatic deposition and complexation

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ABSTRACT

This review paper presents an overview of the formulation and functionalization of nano-/microdispersion systems composed of edible materials. We first summarized general aspects on the stability of colloidal systems and the roles of natural polyelectrolytes such as proteins and ionic polysaccharides for the formation and stabilization of colloidal systems. Then we introduced our research topics on (1) stabilization of emulsions by the electrostatic deposition using natural polyelectrolytes and (2) formulation of stable nanodispersion systems by complexation of natural polyelectrolytes. In both cases, the preparation procedures were relatively simple, without high energy input or harmful chemical addition. The properties of the nano-/microdispersion systems, such as particle size, surface charge and dispersion stability were significantly affected by the concerned materials and preparation conditions, including the type and concentration of used natural polyelectrolytes. These dispersion systems would be useful for developing novel foods having high functionality and good stability.

Contents

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1. Introduction

A colloidal dispersion (i.e. colloids) refers to a heterogeneous system which consists of a dispersed phase of very fine particles and a continuous phase called dispersion medium. Colloidal dispersions have found applications in a broad range of products used on a daily basis including foods, drugs, cosmetics, toiletries, chemicals and so forth. In fact, many natural and processed foods are colloids (colloidal dispersion) or have been in the colloidal state at some time during their formation. One way of classifying the colloidal dispersion is to group them according to the physical state of the dispersed substance (solid, liquid, gas) and of the continuous phase (solid, liquid, gas). The following Table 1 shows the classification in a colloidal dispersion system and some examples contain in each type.

Colloidal systems usually contain structural sizes with at least one linear dimension in the range of 1–1000 nm. These dimension limits are however not rigid, for in some cases (e.g. emulsions), particles of much larger size are present. Nowadays, the terms of micro/nanodispersions are often used to describe micro- or nanosized liquid-in-liquid or solid-in-liquid colloidal dispersed systems.

Fig. 1 shows a simplified diagram on the mechanism of colloidal formation. There are generally two routes in the fabrication of colloidal dispersions:

i. top-down approach involves the degradation of bulk matter into smaller particles by using energy intensive mechanical techniques. The three types of forces used in this approach are compression, impact and shear with the latter two being more important in food applications [1]. In food colloids, for example, emulsions can be produced using various homogenization devices such as high speed mixer, high pressure homogenizer, ultrasonic devices and microfluidization with the addition of emulsifiers to aid in the formation of emulsions. A fairly comprehensive coverage of these emulsification methods is presented in the work by McClements [2], therefore attempts will not be made to elaborate them here.
ii. bottom-up approach, currently developing at an unprecedented rate and is widely used for the fabrication of colloidal particles. This approach involves the condensation of molecules, monomers or ions into a liquid or solid phase, through chemical and physical processes [3]. In food colloids, the physical process of precipitation appears to be more common. It relies upon the cooperative interaction of individual (macro)molecules which spontaneously assemble in a predefined manner under thermodynamic control to build supramolecular structures, microstructures and structures of higher hierarchy [4], as in the case of casein micelle, coacervates [5], α-lactalbumin nanotubes [6] and liposomes. This can be achieved mostly by balancing the attraction and repulsion forces between a pair of (macro) molecules as building blocks to produce materials with novel functionalities [1]. Their structures are often varied, depending on chemical, physical and processing factors governing their intramolecular and intermolecular forces within and between the components in the system. Table 2 shows the comparison between top-down approach and bottom-up approach.

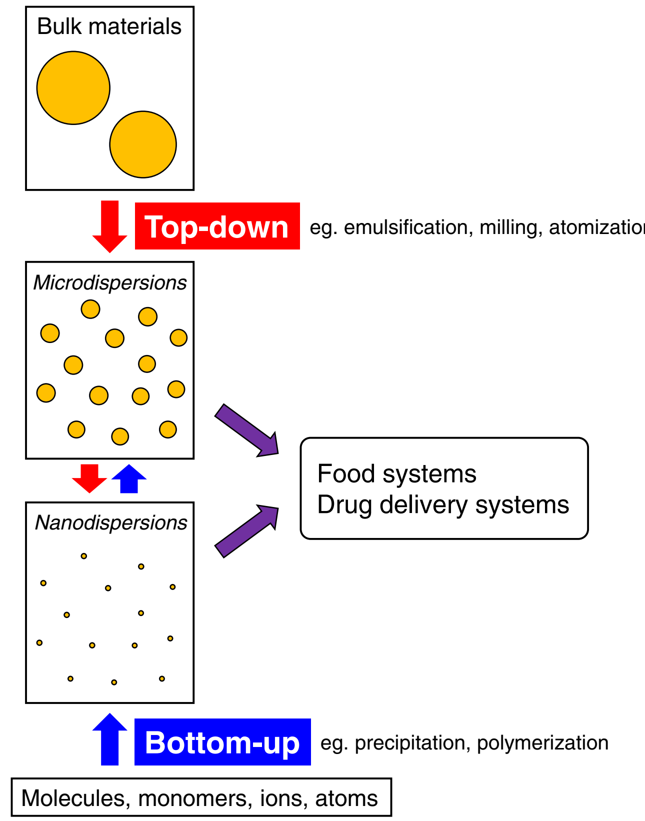

Fig. 1. Schematic illustration of top-down and bottom-up approaches in the fabrication of colloidal formation.

The scope of discussion in this review paper will largely focus on these two systems in particular to emulsions and colloidal particles (suspensions) since they are the most prevalent types of dispersions found in food. Micro/nanodispersions have many attractive

Table 1
Classification of colloidal dispersion system[a].

		Dispersed phase		
		Gas	Liquid	Solid
Continuous phase	Gas		Liquid aerosol Examples: fog, mist, aerosol spray	Solid aerosol Examples: dust, smoke
	Liquid	Foam Examples: *whipped cream*, *beer foam*, *beaten egg white*	Emulsion Examples: *milk*, *mayonnaise*, *butter*, *cheese*	Sol Examples: *fresh juice*, *soups*, paint, ink
	Solid	Solid foam Examples: *bread*, *marshmallow*, *sponge cake*, styrofoam	Gel Examples: *jellies*, *pudding*	Solid sol Examples: *ham*, *sausage*, alloy

[a] Words in italic denote examples of colloidal system in food.