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A Critical Assessment on Functional Materials in Food Nanotechnology

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ABSTRACT

Keeping leadership in food and food processing industry, We have to work with nanotechnology and nano-bio-info in the future. The markets are changing already. Tomorrow we will design food by shaping molecules and atoms. The nanofood market is expected to surge from 2.6 bn. US dollars today to 7.0 bn. US dollars in 2006 and to 20.4 bn. US dollars in 2010. More than 200 Companies around the world are today active in research and development. USA is the leader followed by Japan and China. By 2015 Asian with more than 50 percent of the worldpopulation will be the biggest market for Nanofood with the leading of China. Nanotechnology can be applied to packaging (nanocomposites), controlled delivery systems (nanoencapsulation), and to develop nanodevices (nanosensors) for detection at molecular level. The demand for eco friendly nanocomposite films is in worldwide, since it can provide enhanced gas and moisture barrier properties, increased stiffness with lighter weight, strength and thermal stability. In mechanical terms, nanocomposites differ from conventional composite materialsdue to the exceptionally high surface to volume ratio of the reinforcing phase and its exceptionally high aspect ratio. Nano packaging can also be designed to release antimicrobials, antioxidants, enzymes, flavours and neutraceuticals to extend the shelf life of food products. On the other side, with technology of manipulating the molecules and the atoms of food, the future food industry has a powerful method to design food with much more capability and precision, lower costs and sustainability. Thus nanotechnology has a high potential to modernize the food industry.

Keywords: Nanotechnology, Nanosensors, Nanocomposites, Nanoencapsulation

1. INTRODUCTION

Nanotechnology, a short form of nanoscale science, focuses on the characterisation, fabrication and manipulation of biological and non biological structures smaller than 100nm. It should be understood that the entire field of nanoscience is essentially an electric derivative of established disciplines such as chemistry, interface science, microfabrication technology and so on. Development of nanotechnology in industries are driven by fundamental and applied research in physics, chemistry, biology, engineering and materials science. In contrast, application of nanotechnology in food industries are rather limited. However, achievements and discoveries in nanotechnology are beginning to impact the food industry and associated industries; this affect important aspects from food safety to the molecular synthesis of new food products and ingredient (Chen and others 2006). Since food are complex biological systems that are governed by many of the same basic mechanisms and principles that biologist and biochemists study. However, foods undergo a variety of postharvest and processing-induced modification that affect the biological and biochemical functionality of system. Nanotechnology allows scientists to measure, control, and manipulate matter at the nanoscale level to change those properties and functions in a beneficial way. Functional ingredients (for example drugs, vitamins, antimicrobials, antioxidants, flavourings, colorants and preservatives) are essential components of a wide range of industrial products, including agrochemicals and foods. These Functional ingredients come in a variety of different molecular and physical forms such as polarities (polar, nonpolar, amphiphilic), molecular weight (low to high) and physical state (solid, liquid and gas). Functional ingredients are rarely utilized directly in their pure form. Instead, they are often incorporated into some form of delivery system. The characteristics of the delivery system are one of the most important factors influencing the efficacy of functional ingredients in many industrial products.

A wide variety of delivery system has been developed to encapsulate functional ingredients, including simple solution, association collides, Each type of delivery system has its own specific advantage and disadvantage for encapsulation, protection, and delivery of functional ingredients as well as cost, regulatory status, ease of use, biodegradability, and biocompatibility. A number of potential delivery systems based on nanotechnology follow.

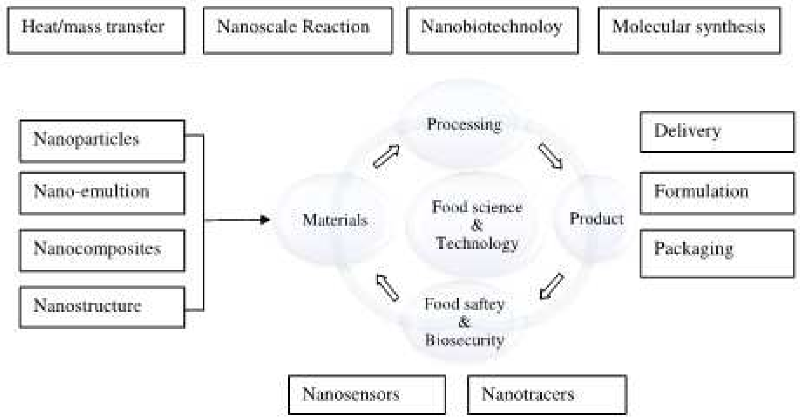

Figure1: Application matrix of nanotechnology in food science and technology

Nanoparticles

Particles in the nanometer-siezed range can often be produced using food grade biopolymers such as proteins or polysaccharides (Chang and Chen 2005; Gupta and Gupta 2005). These particles may be formed by promoting self- association or aggregation of single biopolymers or by inducing phase separation in mixed biopolymer systems, for example using aggregative (net attraction) or segregative (net repulsion) interactions. Functional ingredients can be encapsulated in nanoparticles formed and released in response to specific environmental triggers by altering the solution condition to induce complete particles dissolution or changes in particle porosity.

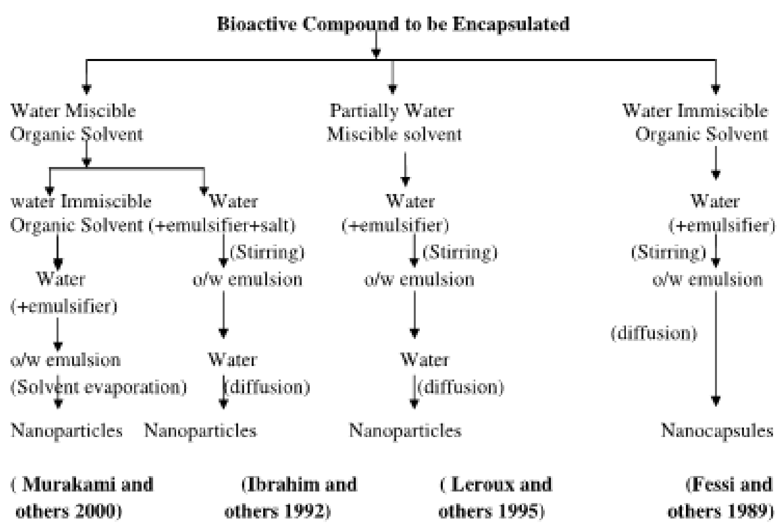

Figure 2: Overview of nanoparticle manufacturing methods

Nano-emulsion

The use of high-pressure valve homogenizers or microfluidizers often causes emulsions with droplet diameters of less than 100 to 500nm. In modern literature such emulsion are often referred to as "nano-emulsions". Functional food components can be incorporated within the droplets, the interfacial region, or the continuous phase. Encapsulating functional components within the droplets often enables a slowdown of chemical degradation processes by engineering the properties of the interfacial layer surrounding them (Mc Clements and Decker 2000). While it is difficult to engineer the interfaces to be completely impermeable to compounds in the bulk phase that may interact with the encapsulated compounds in the bulk phase that may interact with the encapsulated compounds.

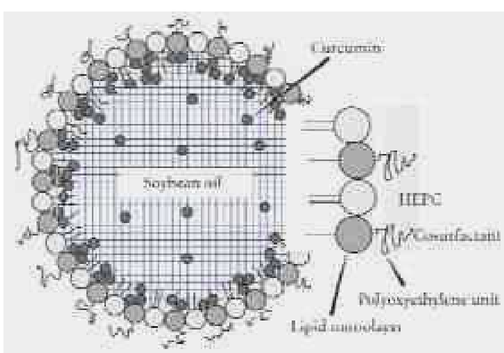

Figure3: Nano-emulsion of soyabean and curcumin

Nanocomposites

According to McGlashan and Halley, 2003 adding 5% by weight nano-sized clays increase the mechanical and thermal properties of nylon. Nano-composites are hybrid materials composed of organic polymer matrices and organophilic clay fillers. Recently, the preparation of nano-clay containing carbohydrate film has been reported (http://www.pre.wur.nl/UK/Research). In this carbohydrate are pumped together with clay layers through a high shear cell to produce a film that then contains the exfoliated clay layer. Since these layer are impermeable to water, water can only migrate through the polysaccharide matrix following a torturous path. As a consequen-ces, the nano composite carbohydrate film has substantially reduced water-vapour permeability, solving one of the long-standing problems in the production of biopolymer films.

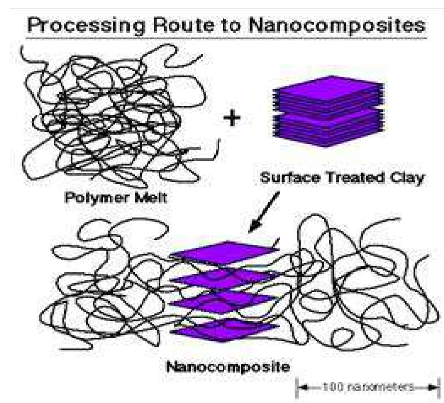

Figure 4: Formation of clay monolayer containing nanocomposite with enhanced mechanical and barrier properties

Nanostructure

It includes nanofibers and nanotubes. Nanofibers can be used as building of food packaging material and food matrix for imitation/artificial food. Nanotubes have been widely used as a nanofood application of nanotechnology. These structures have been used as low resistance conductor. According to Graveland and others it has been found that certain globular proteins from milk (hydrolyzed lactalbumin) can be made to self assemble into similarity structured nanotubes und appropriate environment condition.

An important area where food nanotechnology is increasingly used in the design of functional food ingredients such as food flavour and antioxidant. Ultimately the goal is to improve the functionality of these ingredients in foods systems, which may minimize the concentration needed. Food ingredients such as nanoparticulate lycopene and carotenoides are becoming commercially available.

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