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Designing and Manufacturing of Microencapsulated Device

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ABSTRACT

Microencapsulation is a physical or mechanical process which tends to trap some materials and have pores with diameters less than millimeters and more of a nanometer. In recent years, application of Microencapsulation has been important in the food industry. Extrusion is a physical technique of Microencapsulation which can be used to encapsulate sensitive materials. In general, this method involves passing a solution containing sensitive materials through of the nozzle at a very higher pressure. In this paper we picked the encapsulation method that fit our needs best, so using extrusion method, the encapsulation was designed and manufactured in department of research and innovation at machinery industry Urmia Sahand, Urmia, Iran. All parts of the device have been designed with such features to be simply applied as well as cleansing and sterilization. The reasons for microencapsulation are countless. Here, it is mainly used to isolate vitamin C by using the combination of sodium alginate and gum Arabic and isolate probiotic by using sodium alginate 2%. The diameter of produced micro-encapsulates range 70–85 micrometer (μm).
KEYWORDS: Extrusion, Microcapsules, Partical size, Probiotic

1. INTRODUCTION

Microencapsulation is a process which is used to increase the nutritional value in the industry. In general Encapsulation involves incorporating food ingredients, enzymes, cells or other materials on a micro metric scale. The applications of micro-encapsulation are numerous. In this process materials are surrounded by a coating in order to be protected in any conditions such as heat, etc. It is mainly used to increase the stability and life of the product being encapsulated and prevent inappropriate chemical reaction of useful elements with other materials. Generally speaking, microencapsulation is capable of controlling the liberation of these elements in an adequate time[8]. This technique involves mass transferring as it passes through the path between the core (nutrients) and shell (capsule or coating). The trapped materials of interest inside are often liquid, solid and gas. This method reduces the response of the core material with the outside environment (light, oxygen and water), slow evaporation of core material to the outside environment, reducing lumping of core material, uniformity in the core material, and the conversion from liquid to solid, control the release of core material in order to obtain the appropriate time and uniformly distribution of core material where the amount of this material is not significant. Microecapsules are very small in size, diameter of 1-1000 microns [1]. The capsule wall is designed to prevent the diffusion of core material to the outside environment (until the right time) which is the nutrient. This method is protecting sensitive components like the taste of foods, vitamins, or salt water, oxygen and light. Also liquids that is difficult to work with converts to powders that easily are immersed in water and protect the certain elements of the other ingredients in the food product during storage.

Microencapsulation in material science refers to the coating of microscopic particles with another material. Generally speaking, microencapsulation is the process of putting a microscopic wall around a core substance. But there are a lot of different methods to get the job done. Physical encapsulation methods like spray drying or fluid bed coating may be appropriate for some applications. While chemical encapsulation methods such as coacervation, interfacial polymerization and in situ polymerization may be appropriate for others.

The technique of microencapsulation depends on the physical and chemical properties of the material to be encapsulated. Encapsulation methods are broadly categorized as either physical or chemical. Different methods can be used to encapsulate such asphysico-mechanical and physico-chemical methods. In physico-mechanical method (spray-drying), sensitive materials are encapsulated in the gas phase. In the chemical method (extrusion and emulsion), materials are encapsulated in the liquid. Three useful methods for encapsulation are extrusion, emulsion

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and spray-drying drying[3]. Each one will depend on the composition of the capsule made and the environment it is included in.

Generally, Micro-encapsulation consists of three steps. Step (1): inoculating sensitive compounds in a matrix that can be solid or liquid. When the core is liquid, inoculums release and dissolve in the matrix. Step (2): solid matrix is pressed while the liquid matrix is released. The third step involves a sustained chemical method (polymerization), physico-chemical (gel formation) and physical processes (evaporation, solidification and coagulation) [2].

Microcapsulation with extrusion method involves the production of small droplets encapsulating material, by passing the solution through small holes or nozzles. The smaller the internal diameter of the nozzle, the smaller capsules are. This method is relatively qualified and contains no detrimental solvents and can be applied in aerobic and anaerobic phase. In this method the core material is surrounded by a wall material. This process includes conducting released core material in the molten mass of carbohydrates into the tub filled with water absorbent liquid. When it meets the liquid, carbohydrate membrane gets hard and core materials can be trapped extruded Filaments are finding the way out of the tub filled with liquid and using anti glomeration like dried calcium tri-phosphate and getting formed in sizes[5].

Material should be qualified with rheological properties at high concentrations and easily available during the encapsulation process. These materials include carbohydrates, lipids, proteins and film material obtained from synthetic and semi-synthetic natural polymers. This article describes how to use extrusion method in order to design and manufacture the encapsulation device to give microcapsules with a diameter of less than 100 microns. The quality of produced microcapsules, appearance, uniformity and size of microcapsules will be examined.

2. MATERIALS AND METHODS

2.1 Materials

All materials used in manufacturing that direct contact with foods were made stainless steel 304 and 316 and Electric gearbox made in Japan.

2.2 Manufacture of microcapsulated device

Design of microencapsulated device was done in department of research and innovation of machinery industry Urmia Sahand. All parts of the device have been designed with such features to be simply applied as well as easy cleansing and sterilization. Then basic raw materials for manufacturing were prepared. According to *turnery center plan* and turning attachment prepared materials were manufactured. Then sealing of joints were done by O-rings. Reticular plate with holes or nozzles of 100 mm was installed on the system.. To create pressing and extruding in chamber, the some piston was used and a manual gearbox moves this piston up and down. Utilized nitrogen gas capsule in system was from Urmia oxygen plant. The capsule has a manometer for controlling the pressure and gauge pressureincapsule internal load and output load. The capsule using a hose with high level of pressure to *withstand 20* was attached to the device. Stainless steel-304 was used to make output chamber in order to stabilize the manufactured microcapsules. To prevent sticking Microcapsules together, a mixture was placed in the container.to isolating stabilized microcapsules a stainless *steel-316 strainer* was used having hole diameter of 30 microns, which was mounted on the stainless steel-304 chassis was used. According to move isolated micro-capsules easily, Chassis needs to be mobile plant. The energy for electric gearbox was provided with electric power 220V. After plugging device and pressing start button, the device was turned on.

The pressure of nitrogen gas capsule was set using a manometer 10.Encapsulation compounds enter into the production chamber via inlet funnel. By rotating the manual gearbox, piston is moving downward and creates extrusion pressure. The mixture in chamber is clearly established (turns on). Finally the microcapsules inside the colander (filter) are isolated from stabilized soluble liquid.

2.3 Measuring the diameter of capsules

Optical microscopy was used to determine particle size. The diameter of encapsulated random samples was measured by using a software and image analysis[4].

All measurements were taken at room temperature within 2 hours after making capsule with 2 replications. Capsules were observed by optical microscope with a magnification of x40.

3. RESULTS AND DISCUSSION

Figure 1 shows an overview of the microencapsulated device. The device was evaluated at Department of food Engineering, Agriculture and Natural Resources Research Center of West Azarbayjan, Urmia, Iran as follows: Microencapsulates were separated by filtration of calcium chloride solution (Figure 2).
- For microencapsulation of vitamin C using a mixture of sodium alginate and gum Arabic.

Encapsulated vitamin C was utilized to enrichment of apple juice. The results showed that encapsulation preserves this vitamin in comparison with the sample which contains released vitamin C in apple juice. Micro-encapsulation of the ascorbic acid prevent the changing color of this juice and increases the stability as well[7].
Microencapsulation of the probiotic *Bifidbacterium bifidium* using sodium alginate 2%.

Figure 1. An overview of the microencapsulated device

Figure 2.Isolating Microencapsules by filter

Encapsulated probiotic were used in the production of probiotic orange juice. The results showed that number of probiotic in samples containing encapsulated probiotic are less than about 2 cycles logarithmic in comparison with juice containing released probiotic during storage. Sheikh Qassimi and Zomorodi [6] also suggested that the number of encapsulated *Lactobacillus acidophilus* in apple juice was about 2 cycles logarithmic more than the other sample which corresponded with the obtained results.

The size and shape of microcapsules

Based on the size of the particles, Encapsulation is categorized in three groups: Nanoencapsulation (particle size less than 1 mμ), Microencapsulation (particle size between 1 and 1000 mμ) and Macroencapsulation (particle size more than 1000 mμ).Among this three groups, microencapsulation is more applicable. Given the results produced capsules placed in microencapsulation group.

The results obtained from optical microscopy revealed that the capsules are mostly spherical and uniform. Capsules were having a smooth and uniform surface (Figure 3).The mean of diameter of capsules of sodium alginate 2% was 82 ±5 mμ and for sodium alginate and Arabic gum was 70 ±5 mμ.

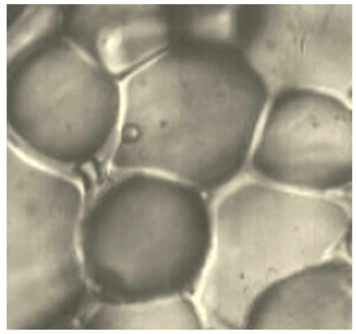

Figure 3. Microcapsules of sodium alginate, using optical microscopy.

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