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Application of micro-encapsulation technology in functional textile

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Abstract

In this review paper **Microencapsulation Technology** had introduced as the wide range of applications in textile, food and other business sectors. Textile manufacturers are demonstrating increasing interest in the application of durable fragrances to textile as well as skin softeners. Other potential applications include, insect repellents, dyes, vitamins, antimicrobials, medicated bandage, phase change materials and in specific medical applications, antibiotics, hormones and other drugs, examples of each technology are described. A short summary of a new microencapsulation technology with roots in the textile industry, yeast based microencapsulation, is also described. This article is a review of microencapsulation and materials involved in it, morphology of microcapsules, microencapsulation technologies, purposes of microencapsulation, and benefits of microencapsulation, release mechanisms, and application fields, with special emphasis on microencapsulated additives in functional textile and procedure of encapsulating on the textile substrate.

***Keywords*: Microencapsulation; Textiles; Fragrance; Phase-change materials.**

Introduction

Microencapsulation is the process of surrounding or enveloping one substance within another substance on a very small scale, yielding capsules ranging from less than one micron to several hundred microns in size. The encapsulation efficiency of the microparticles or microsphere or microcapsule depends upon different factors like concentration of the polymer, solubility of polymer in solvent, rate of solvent removal, solubility of organic solvent in water etc. Microencapsulation may be achieved by a myriad of techniques. Substances may be microencapsulated with the intention that the core Material be confined within capsule walls for a specific period of time. Alternatively, core materials may be encapsulated so that the core material will be released either gradually through the capsule walls, known as controlled release or diffusion, or when external conditions trigger the capsule walls to rupture, melt, or dissolve. [1,2,4]

What is Microencapsulation?

Microencapsulation is the cost effective and long lasting method in storing volatile substances over a long period of time .
Microcapsules are available with a wide range of products. These products have different properties related to the nature of the encapsulated substances. Microcapsules are small particles a size of between one and several hundred micrometers composed of liquid, solid or gas core and a coat, which protects the core material from external conditions. The intention of microencapsulation besides the protection of core substances is also separation of the reactants, controlled release, reduction of toxicity, reduction of volatility, etc. The polymer used for the coat may be natural or synthetic and it depends of the coat if Microcapsule is permeable or not. Regarding to the purpose of use the suitable microcapsules are chosen.[3]

Materials involved in microencapsulation

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Materials involved in microencapsulation

Microencapsulation is the process by which individual particles or droplets of solid or liquid material **(the core)** are surrounded or coated with a continuous film of polymeric material **(the shell)** to produce capsules in the micrometer to millimeter range, known as microcapsules. [3,4]

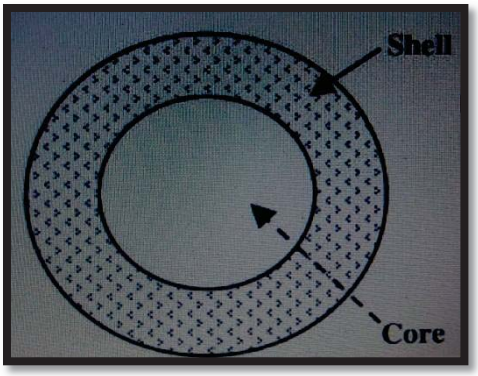


Figure : Microcapsule with core and shell

Core Material:

The material to be coated

- It may be liquid or solid
- Liquid core may be dissolved or dispersed material
- Composition of coating material:
- Drug or active constituent
- Additive like diluents
- Stabilizers
- Release rate enhancers

Coating Material:

Inert substance which coats on core with desired thickness

- Compatible with the core material
- Stabilization of core material.
- Inert toward active ingredients.
- Controlled release under specific conditions.
- The coating can be flexible, brittle, hard, thin etc.
- Abundantly and cheaply available
- Composition of coating
- Inert polymer
- Plasticizer
- Colouring agent
- **Gums:** Gum arabic, sodium alginate, carragenan
- **Carbohydrates:** Starch, dextran, sucrose
- **Celluloses:**Carboxymethylcellulose,methyc ellulose.
- **Lipids:** Bees wax, stearic acid, phospholipids.
- **Proteins:** Gelatin, albumin.[4]

Morphology of microcapsules

The morphology of microcapsules depends mainly on the core material and the deposition process of the shell.
1- Mononuclear (core-shell) microcapsules contain the shell around the core.
2- Polynuclear capsules have many cores enclosed within the shell.
3- Matrix encapsulation in which the core material is distributed homogeneously into the shell material.
In addition to these three basic morphologies,microcapsules can also be mononuclear withmultiple shells, or they may form clusters of microcapsules. **[5,6,7]**

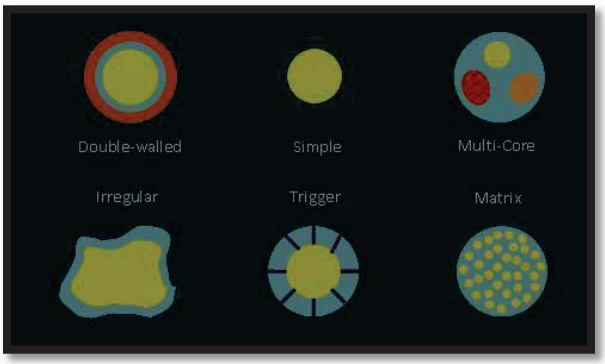


Figure : Morphology of microcapsule

Reasons for encapsulation

The reasons for microencapsulation are countless. In some cases, the core must be isolated from its surroundings, as in isolating vitamins from the deteriorating effects of oxygen, retarding evaporation of a volatile core, improving the handling properties of a sticky material, or isolating a reactive core from chemical attack. In other cases, the objective is not to isolate the core completely but to control the rate at which it leaves the microcapsule, as in the controlled release of drugs or pesticides.
Microencapsulation of materials is resorted to ensure that the encapsulated material reaches the area of action without getting adversely affected by the environment through which it passes.

The principal reasons for encapsulation are as follows.
1. Separation of incompatible components
2. Conversion of liquids to free flowing solids
3. Increased stability (protection of the encapsulated materials against oxidation or deactivation due to reaction in the environment)
4. Masking of odour, taste and activity of encapsulated materials
5. Protection of the immediate environment

6. Controlled release of active compounds (sustained or delayed release)
7. Targeted release of encapsulated materials .[8,9,10]

Techniques for manufacturing of microcapsules

Many different manufacturing approaches have been adopted for microencapsulation. The most commonly used techniques are as follows-

Physical methods

- Spray-Drying
- . Air-suspension coating
- Pan coating
- Centrifugal Extrusion

Chemical process

- Solvent Evaporation
- Coacervation-Phase separation

The impermeable coats can be ruined by:
- outer force
- high temperature,
- light
- solvent or water

In other words they can break, melt or burn down, decompose, dry up or dissolve. In medicine the impermeable capsules containing medicament are used. They dissolve at the appropriate pH value and the active substance is released .
The permeable coats of microcapsules continually release the core substances. The release can be slow or sustained .

Microcapsules can be applied to textiles by padding, coating, spraying or immersion. For all these methods a binder is required. It may be acrylic, polyurethane, silicone, starch, etc. Its role is to fix the capsules onto the fabric and to hold them in place during washing and wear. Microcapsules can be applied to silk, cotton, synthetic fibre, etc. and may contain perfumes, dyes, antimicrobials, phase change materials, vitamins and other substances .[13-16]

The use of microcapsules in textiles

Micro Encapsulation Finishes
Definition of Microcapsule; in simple terms, Quest defines a capsule as "a miniature container that protects its contents from evaporation, oxidation and contamination until its release is triggered by gentle rubbing or shaking." During encapsulation, tiny droplets of benefit-laden products such as moisturizers, fragrances, deodorizers, vitamins, or repellents are wrapped with a protective coating to form a capsule.[7,11,30]

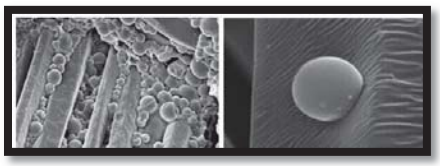
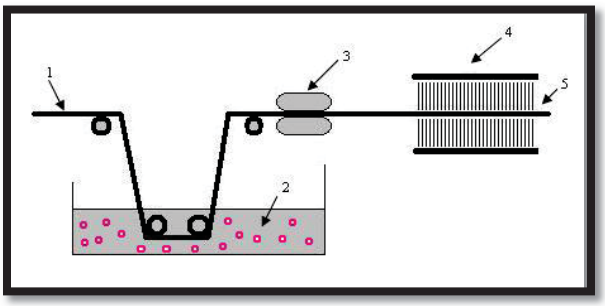


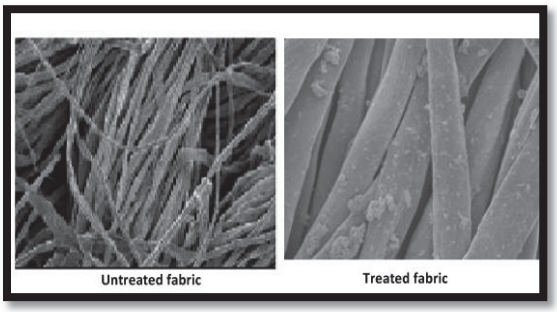
Figure Micro Encapsulation Finishes[11]

Applying method

Using padding mangle



Schematic representation of the microcapsules application in fabrics using a Foulard. 1. Untreated fabric; 2. Microcapsules bath; 3.Squeezing; 4.Drying and curing; 5. Fabric treated containing microcapsules.[30]



Release mechanism microencapsulated textile

Schematic representation of the release of the active agent on the skin.

1. Textile fibre; 2.Release of the active agent on the skin; 3.Binder. [28]

Application

Phase-change materials

The intention of microencapsulation of phase-change materials is to reduce the influence of extreme variations in temperatures. Phase-change materials are materials that change the aggregation from solid to liquid within certain range of temperature. In this way the thermoregulation of clothing is achieved and the constant temperature is provided. PCM capsules were first applied by the NASA in the early 1980s for use in space suits. Today these kinds of microcapsules are applied to different materials, vests, parkas, snowsuits, blankets, mattresses, duvets etc .[7,11]

Fragrance finishes

Numerous trials have been made at adding fragrances directly to fibre and fabrics, but the aroma vanished after one or two wash cycles. By the use of microencapsulation fragrances are able to remain on fabric for a longer period of time. Microcapsules may contain essential oil flavours like lavender, rosemary, pine and other for the effect of aromatherapy. This is used mainly to help with insomnia, headache, and to prevent bad odour. The Slovenian producer Aero Celje has developed microcapsules with essential oil that were applied to shoe sock . Vitamins and moisturisers are also applied to all types of textile substrates, including hosiery and underwear.[11]

Fire retardants

Fire retardants applied to textile products often cause the reduction of softness. To conquer these problems microcapsules with fire retardant core were developed. They are applied to fabrics used in military applications like tentage .[7,11]

Polychromic and thermochromic microcapsules (colour-changing technology)

The application of polychromic and thermochromic microcapsules can be found in textiles like product labelling and medical and security applications. One of the colour changing systems changes colour in response to temperature, this is thermochromatic and the other changes colour in response to UV light, the photochromatic. Today even microencapsulated thermochromathic dyes are produced that change colour at specific temperature - in response of human contact. [17-25]

Antimicrobials

Bacteria are often related to the notion of bad smell or disease and in textile industry the loss of useful properties of fabric often refers to microbiological decay of fibres. To prevent this problem the importance and demands of antimicrobial finishes continue to grow, especially for textiles for medical and technical use. To realize these functionalities, nanotechnology offers a lot of new possibilities Antimicrobial finishes can be applied to textiles also by microencapsulation. The release of active substances of microcapsules with antimicrobial agent is slow or sustained. Textiles with antimicrobial finishes are known in the market by different names, like Bacterbril, Biofresh, Terital, Trevia Bioactive, Amicor etc .[17-25]

Counterfeiting

Microencapsulation can be used to deal with the problem of illegal copying in high added value textiles and in branded and designer goods with providing a hidden yet clear marking system. Microcapsules applied to label contain a colour former or an activator. By the use of UV light or a solvent, microcapsules break open, the content is released, colour is developed and in this way detection is achieved. [31]

Microencapsulation: the future

The „holy grail" for most textile applications using microcapsules would be a system that is easy to apply, does not effect the existing textile properties and has a shelf-life on a garment that allows normal fabric-care processes to take place.
Currently, although capsules can survive 25–30 wash cycles, conventional ironing and other heatinput processes such as tumble-drying can cause a dramatic reduction in the desired effect.

The microencapsulation industry must take more notice of the possibilities within the textile industry

Function	Active agent	Application	Reference
Anti-bacterial	Triclosan	Under wear,Bed sheets	[17-18]
UV Protection	Ceramic Fibers Pigments	sport clothing Children's garment	[19]
Body temperature regulation	PCM (phase change materials)	Jacket (Damart)	[20]
Decontamination	Hypochlorie Amine	Decontamination of clothing	[21]
Repellence	Fluorinated Resins	T-shirts Children's garment	[22-23]
Perfume Release	Perfumes	Lingerie (Neyret)	[24-25]

and specifically design microcapsules that overcome these problems. For the future, the consumer‟s desire for novel and unique effects will always be present. But more importantly, in an ever-increasing desire for convenience, the consumer will require that fabric properties are inherent in the garment, e.g. fresh odour and softness. Consumers will expect these properties to last the lifetime of the garment, and not involve routine intervention in the form of the never-ending addition of washing aids and fabric conditioners. Microencapsulation may deliver these long-term goals.[18-21]

The desire for a healthier and more productive lifestyle will continue to generate a market for textiles that promote „well-being“. Textiles that „interact“ with the consumer, reducing stress, promoting comfort and relaxation, are possible through active delivery from microcapsules. In the last decade the textile industries of Western Europe, Japan and the US have concentrated on developing performance fabrics with added value for sports and outdoor application, as well as novel medical textiles. Microencapsulation can play a part in this continued development, for example by allowing sensing chemicals to be attached to sports clothing and medical products; these will be able to warn of damage or hazard to the wearer. Systems can also be developed that deliver measured dosages of chemicals to combat muscle pain or other more serious injuries. The potential applications of microencapsulation in textiles are as wide as the imagination of textile designers and manufacturers. Early success for some companies in producing microencapsulated finishes for textiles have come about from collaboration and adaptation of technology from other industrial sectors. The textile industry must continue to be outward looking and develop the textiles that consumer‟s desire.[18-21]

Commercially Available microencapsulated Textile Products

1) **Cognis – Skintex®**

Cognis, a textile chemical company with headquarters in Germany, has developed a microencapsulation based cosmetic treatment for textiles, known as Skintex®, [26]

2) **Speciality Textile Product – BioCap**

Another chemical company based in the United Kingdom by the name of Speciality Textile Product also makes use of the microencapsulation technology to develop their biocapsule products called BioCap. The active ingredients are those that are widely used in the cosmetics industry, including Vitamin A, D, E and aloe vera, which provide various skin care benefits and promote a sense of well-being.[27]

3) **Woolmark DevelopmentInternational Ltd (WDI) - Sensory Perception Technology**

Another new leading edge microencapsulation treatment for textiles is the so called Sensory Perception Technology (SPT), which is distributed by Woolmark Development International Ltd (WDI). Sensory Perception Technology [29]

Conclusion

The possibilities of application of microcapsules to textiles described in this paper are just some of the most interesting. Today there is almost no field where microcapsules would not be presented. Encapsulation became a very powerful tool, because it is invisible and comes to life at the slightest Touch.

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