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Microencapsulation for Textile Finishing

[1]KhushbooShrimali, [2]Dr.ElaManojDedhia,
[1]Ph.D. Scholar, SNDT Women's University, Mumbai
[2]*Associate Professor & Head of Department Textile & Fashion Technology,*
NirmalaNiketan College of Home Science, Mumbai (Affiliated to University of Mumbai)

I. Introduction

A rise in environment concerns and demands for environment friendly processing of textiles has led to the development of many new cleaner and greener technologies (Melih Gunay 2013). Science has come up with many technologies for the eco processing of textiles, which includes, Enzymatic Finishing of textiles, Plasma Technology, Finishing by Natural products and Microencapsulation.

Micro-encapsulation is a process in which small capsules of many useful properties are made by using tiny particles or droplets surrounded by a coating. The material inside the microcapsule is called as the core material whereas the wall is called a shell, coating, or membrane. Usually, microcapsules have diameters between a few micrometres and a few millimetres. This technique is now widely used in Textile finishing also.

Many special and functional properties can be imparted to the fabrics by microencapsulating the core material. This core material can be any substance having a special function to perform for the fabric. In this article, we will be discussing about imparting speciality finishes to the fabrics by the method of microencapsulation. Encapsulation has allowed moisturisers, therapeutic oils, and insecticides to be incorporated into fabrics.

Microencapsulation of anti-microbial agents is also gaining popularity in sportswear and medical textiles. This technique has a vast application in various fields like Textile Finishes, Industrial chemicals, Agro chemicals, Food additives, Flavours and Essences, Pesticides and Herbicides, Sealants, Cosmetics, Nutraceuticals, Pharmaceuticals and Adhesives (Umer H. 2011).

II. Reasons For Encapsulation

Microencapsulation of materials is done to facilitate the area of action of the encapsulated material without getting adversely affected by the environment through which it passes. The principal reasons for encapsulation are as follows:

- Separation of incompatible components
- Conversion of liquids to free flowing solids
- Increased stability (protection of the encapsulated materials against oxidation or deactivation due toreaction in the environment)
- Masking of odor, taste and activity of encapsulated materials
- Protection of the immediate environment
- Controlled release of active compounds (sustained or delayed release)
- Targeted release of encapsulated materials (Dubey et al. 2009).

The microcapsules can introduce important new qualities to garments and fabrics, such as enhanced stability and the controlled release of active compounds. Microencapsulation is a unique technique which facilitates a controlled release of these properties as and when required and also enhances its durability (Chinta S.K. 2013).

In herbal finishing of textiles, herbal extracts are used as the "core material" along with the wall material to give a micro-encapsulated finish which is more durable as compared to the other process of finishing. This wall material can be a chemical compound like Sodium alginate or certain substances that has its origin from plants such as, Gum acacia. The microencapsulated herbal extracts become more effective when tested for anti-microbial activity and wash durability upto 20 washes (Barari M. 2009).

Microencapsulation also has a very popular application in the use of fragrance encapsulated capsules onto fabrics. The capsules applied on the fabrics are resistant to breakage under normal conditions. The application of pressure on the fabric results in the release of fragrance from the capsules which acts as healing element in aromatherapy (Sudha et.al. 2005).

Microencapsulated herbal extracts such as Aloe barbadensis Mill, Bitter Gourd, Ginger and Cuminum cyminum Linn. has successful application in which the herbal extracts are used as core material and gum acacia as wall material. They show potential for anti-microbial activity against Staphylococcus aureus and Escherichia coli (Ganesan P. 2012).

According to a study, microencapsulated extracts of Andrographis paniculata, when applied on the fabric to impart mosquito repellency finish, gave good mosquito repellent activity up to 30 washes (Ramya K. 2014).

III. Microencapsulation In Cosmetic Textiles

The major use of this technique in cosmetic textiles is in the application of vitamins, essential oils, skin moisturizing agents, skin cooling and anti-aging agents etc.(Cheng S.Y et al. 2008). The techniques of imparting these finishes through microencapsulation have been studied in past also, some of which are discussed below:

Yamato et.al. studied microcapsules having active substances that can improve the physiological conditions of human skin. The microcapsule was gradually released when the textile structure was subjected to light pressure created due to the movement of human body (U.S Patent 1993).

According to a study conducted by Nelson et al, after the core material was encapsulated, waste yeast cells were attached to cotton and wool fibers by using cross linking agents and binders. This resulted in any advantageous properties like high loading, thermoplastic, protection from light, oxygen and harmful environment and cost effectiveness (Bishop et al. 1998).

A cooling effect for fabrics was also produced by microencapsulation of Questice, which is a mild slow release coolant having little odour. Questice is hydrolysed by the skin's natural enzymes to produce menthol, giving a cooling sensation. This effect is body responsive and provides cooling when needed (Kumar 2004; In-cosmetics, 2007).

IV. Use Of Microencapsules In Textiles

Phase-change materials

Phase-change materials perform the function of changing the aggregation from solid to liquid within certain range of temperature. Microcapsules of phase-change materials reduce the effect of extreme variations in temperatures. This facilitates thethermoregulation of clothing and the constant temperature is provided. These kinds of microcapsules are applied to different materials, vests, parkas, snowsuits, blankets, mattresses, duvets etc. (Nelson, 2002).

Fragrance finishes

Fragrance finishes have been directly applied on to fibers and fabrics numerous times, but the aroma does not last for more than two wash cycles. Microencapsulation of fragrances is a technique which when used on the fabric gives a longer effect. This technique is commonly used in aromatherapy in which microcapsules may contain essential oil flavours like lavender, rosemary, pine etc. This is basically done to treat insomnia, headache, and to prevent bad odour.

Fire retardants

Microcapsules with fire retardant core were developed to overcome the problem of reduced softness which is caused by the direct application of fire retardant materials. They are applied to fabrics used in military applications like tentage (Nelson, 2002).

Polychromic and thermo-chromic microcapsules (colour-changing technology)

The colour changing systems changes colour in response to temperature, which is termed as thermo-chromatic and the other changes colour in response to UV light, this is known as photo-chromatic. In textiles, polychromic and thermo-chromic microcapsules can be found in product labelling, medical and security applications. There are microencapsulated thermo-chromatic dyes that change colour at specific temperature - in response of human contact (Nelson, 2002).

Antimicrobials

Bacteria often cause microbiological decay of fabrics which in turn causes loss of various useful properties of fabrics. This problem can be prevented by the use of anti-microbial finishes that can be applied with the help of microencapsulation. This finish is especially for textiles for medical and technical use. (http://www.flok.ru/news/FLOCK%20News_7.2006_e.pdf, 2006).

Counterfeiting

Imitation of high added value textiles, branded and designer goods can be dealt with by the use of microencapsulation. 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 (Nelson, 2002).

V. Techniques Of Microencapsulation

Discussed below are few of several techniques that are commonly used for Microencapsulation(Chinta S.K. 2013):

Spray-Drying

A low-cost commercial process in which microencapsulation is done by spray-drying is mostly used for the encapsulation of fragrances, oils and flavors. In this procedure, core particles are dispersed in a polymer solution and sprayed into a hot chamber. The shell material solidifies onto the core particles as the solvent evaporates such that the microcapsules obtained are of poly-nuclear or matrix type. Very often the encapsulated particles are aggregated and the use of large amounts of core material can lead to uncoated particles. However, higher loadings of core particles of up to 50–60% have been reported. Water-soluble polymers are mainly used as shell materials because a solvent-borne system produces unpleasant odors and environmental problems (Ghosh et al. 2011).

Air-suspension coating

This procedure gives a better control and flexibility. The particles are coated while suspended in an upward-moving air stream. They are supported by a perforated plate having different patterns of holes inside and outside a cylindrical insert. Just sufficient air is permitted to rise through the outer annular space to fluidize the settling particles. Most of the rising air (usually heated) flows inside the cylinder, causing the particles to rise rapidly. At the top, as the air stream diverges and slows, they settle back onto the outer bed and move downward to repeat the cycle. The particles pass through the inner cylinder many times in a few minutes methods. The air suspension process offers a wide variety of coating materials candidates for microencapsulation. The process has the capability of applying coatings in the form of solvent solutions, aqueous solution, emulsions, dispersions or hot melt in equipment ranging in capacities from one pound to 990 pounds. Core materials comprised of micron or submicron particles can be effectively encapsulated by air suspension techniques, but agglomeration of the particles to some larger size is normally achieved (Bansode et al. 2010).

Solvent Evaporation

In this technique, the processes are carried out in a liquid manufacturing vehicle. The microcapsule coating is dissolved in a volatile solvent, which is immiscible with the liquid manufacturing vehicle phase. A core material to be microencapsulated is dissolved or dispersed in the coating polymer solution. With agitation, the core coating material mixture is dispersed in the liquid manufacturing vehicle phase to obtain the appropriate size microcapsule. The mixture is then heated (if necessary) to evaporate the solvent for the polymer. In the case in which the core material is dissolved in the coating polymer solution, a matrix-type microcapsule is formed. Once all the solvent for the polymer is evaporated, the liquid vehicle temperature is reduced to ambient temperature with continued agitation. At this stage the microcapsules can be used in suspension form, coated on to substrates or isolated as powders (Dubey et al. 2009).

In-situ polymerization

In a few microencapsulation processes, the direct polymerization of a single monomer is carried out on the particle surface. In one process, e.g. Cellulose fibers are encapsulated in polyethylene while immersed in dry toluene. Usual deposition rates are about 0.5μm/min. Coating thickness ranges 0.2–75 μm (0.0079–2.95 mils). The coating is uniform, even over sharp projections (Bansode et al. 2010).

VI. Release Mechanism Of Microcapsules

The release mechanisms of encapsulated materials depend on the purpose of microencapsulation. Commonly used is the mechanism of external pressure which breaks the microcapsule wall and releases the liquid from the core. Abrasion releases the core material of the microcapsule wall, e.g. in antistatic and fragrances for textiles (abrasion in washing machines and dryers), or for grinding and cutting additives. Heat is also a factor that releases core materials in many applications. Fire retardants that are microencapsulated are released by burning of capsule walls and have application in wall papers, carpets, curtains and fire protected clothes.

In order to remain functional for numerous phase transition cycles, the microencapsulated phase change materials have to remain encapsulated within the impermeable and mechanically resistant microcapsule wall.

Due to their major function of active accumulation and release of heat, these phase change materials have application in textiles, shoes and building insulation materials.(Jothi Sri S. et al. 2012)

VII. Conclusion

In today's world of developing technologies, the technique of microencapsulation is applied in almost all the fields. It has become a prominently effective technique which enhances the property imparted to the fabric and assures its durability. The examples of application of this technique discussed in this paper are just a few of very interesting ones. A vast use of this technique can be witnessed in functional finish fabrics, medical and healthcare textiles, aromatherapy, cosmetic textiles and many more.

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