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MICROENCAPSULATION IN TEXTILE – AN OVERVIEW

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ABSTRACT

The radical changes in technology have made it possible to blend it seamlessly with any surface. With the size of technology getting smaller and smaller, fabric seems to be the most appropriate carrier for its application. Microencapsulation, the technology of enclosing active substances and their controlled release to impart specific benefits is gaining importance in biomedical fields. Relatively small size on capsules, the ease of application and low economic input are some of the factors encouraging scientists to exploit this technology for varied applications. In this review paper an attempt has been made to present complete insights to the micro-encapsulation process and materials involved in it, methods of application and their release mechanisms along with benefits and challenges faced during their application.

KEYWORDS: Microcapsule, Cosmetotextiles, Coacervation, Polymer.

INTRODUCTION

Microencapsulation, a controlled drug delivery system has got a wide range of applications in all the major scientific areas like pharmaceutical, food industry, agriculture, cosmetotextiles, sound absorbing etc. Among the various scientific fields, application of microencapsule in medical and cosmetotextiles are more recent. The historical background, diverse range of ingredients, their application, market status and durability concerns related to the commercial viability of microencapsulated cosmetic and medical textiles have thoroughly been studies.[1,2,3,4,5] Active ingredients like essential oils, fragrances, vitamins and even drugs can be encapsulated and applied onto textiles either via spinning or by finishing. Microencapsulation is gaining increased importance due to its cost effectiveness, ease of application and ability to facilitate incorporation of different ingredients to impart special functionality to textiles with controlled release mechanism.

Encapsulation may be defined as 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 100µ in size. All three states of matter (solids, liquids, gases) may be microencapsulated. This allows liquid and gas phase materials to be handled more easily as solids, and can afford some measure of protection to those handling hazardous materials.

Microcapsule contains a core and shell layers in which core contains hydrogel from natural or semi synthetic or synthetic sources, have active ingredient in the form of liquid or solid or its mixture and it is covered with polymer which too can be from natural or synthetic sources, called as shell or wall or sheath or outer layer or matrix or membrane. The formation of microcapsule is shown in Fig.1. The main purpose of this shell is to protect the core material from external environment. Examples of sheath polymer are namely PVA, Polyethylene, paraffin, gelatin, ethyl cellulose, carboxymethyl cellulose etc. Coating material should be pliable, film forming, tasteless and stable. It should not react with acid or base in the core material. It should be non-hygroscopic and must exhibit controlled release of the core. It can be flexible, hard, brittle depending on the application.

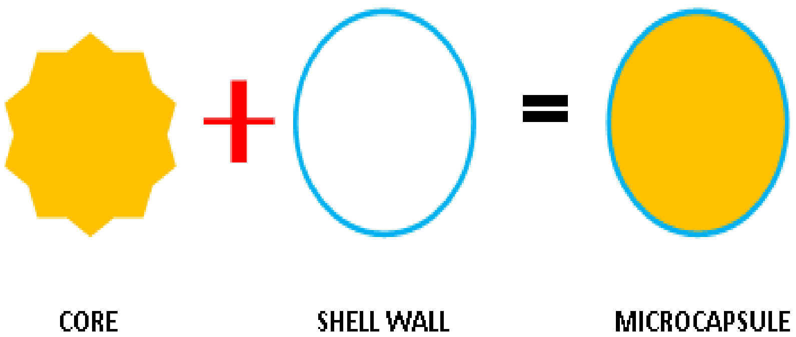

Fig.1: Formation of microcapsule.

MECHANISM OF RELEASE OF CORE MATERIAL

The core in the form of liquid or solid or mixture of both will be released in various ways due to change in temperature, frictional contact, applied pressure, biodegradation and breakage of capsule, which leads to diffusion through the shell wall.

Different methods of application of microencapsulation

1) Complex coacervation: The coating material is dissolved in a solvent. The active core material is dispersed in this solution of coating material. This forms the three phases of the solution and then solvent evaporates and left behind is the sheath over core material.

2) Coating by air: The solid form of active core is dispersed by moving air steam in upward movement and these particles get coated with the help of the solvent polymer solution sprayed to the moving core particle, there by coating takes place.

3) Coating by Pan: The core particle is poured in the pan and polymer is slowly added inside the pan which rotating at slower speed to ensure proper coating on the surface of the core material.

4) Centrifugal extrusion: In this system concentric feed system is used and contains the head of nozzle for both core and shell part. The active core in liquid form is placed in the center part of the nozzle and the polymer in melt or solution form is placed in the shell part of the nozzle and when it emerges at exit, vibration take place, followed by curing action there by formation of microcapsule.

5) Solvent evaporation method: The polymer material is dissolved in the volatile solution and the active core material is slowly dissolved in this dissolved polymer volatile solution. The solution is heated to evaporate the solvent leaving the microcapsule.

6) Spray Drying: The core material is dissolved in the polymer in the form of solution or in melt form and it is sprayed and dried, there by shell material solidifies and thus the formation of microcapsule.[6]

Recent Studies

Investigation of the mosquito repellent finish using citronella oil on cotton fabric against aedesaegypti mosquitos was conducted. A 100% cotton fabric with plain weave was bleached and padded with microencapsulated citronella oil. A solution of ethanol and citronella oil were sprayed on the bleached cotton fabric to make it wet. Result showed that the cotton fabric microencapsulated with citronella oil exhibited better repellency against mosquitos than citronella oil and ethanol sprayed fabric.[7]

Nonwoven adhesive tape made from 100% bamboo fibers by spun lace technology were microencapsulated using green tea and coffee powder as core and assessed for their antimicrobial activity. The assessment of the antimicrobial activity and abrasion resistance of nonwoven tape encapsulated with coffee showed better results compared with that of green tea.[8]

A research on microencapsulation of extract from Amman pacharisi, Amanakku, Avaram was done to investigate their effect on insect repellency and the wash durability was also assessed. The finishes were applied on to denim fabric made with 100% cotton and blended materials of different composition including cotton-polyester, poly-lycra, core-spun lycra. It was found that wash durability and mosquito repellency of 100% cotton fabric were better as compared to rest of the samples.[9]

A 100% modal and bamboo fabric was used to find the mosquito repellency with different concentration of herbs and sheath material to optimize the process. It was reported that the optimized concentration of extract from neem showed better repellency.[10]

Lemongrass oil and gum acacia were used in core and sheath to produce microcapsule and applied on 100% cotton knitted bleached fabric. The mosquito repellency of the finished fabric was examined and found to be good.[11]

Acalypha indica extracted by hydro distillation process, used as core along with gum acacia as sheath and applied on knitted cotton fabric to study the mosquito repellency by excito chamber method. It was concluded that good resistance was found against mosquitos.[12]

Two experimental studies on cotton fabric were conducted using lemongrass oil as core along with crosslinking agent. Microcapsules were developed by exhaust as well as complex coacervation methods. The finishes were applied on the fabric by pad – dry – cure method. The fragrance retention property of microcapsule lemongrass oil by complex coacervation technique showed better results compared with exhaust method. Also the fabric can withstand its aroma property upto 30 washes.[13]

The lemon grass oil and citronella applied on lyocel fabric with the help of gums through conservation technique and studied for their aroma therapeutic effect. It was reported that lemon grass oil fragranced fabric has significant effect in reducing the psychological factors such as anxiety, mood swings and stress levels etc.[14]

Microencapsulated aroma oil was applied on ramie and cotton blended fabric and its bending rigidity in both warp and weft way was examined. It was found that there was an increase in bending rigidity in both directions.[15]

Microencapsule produced from polyurethane and urea combination using limonene oil in the core. The durability and effectiveness was assessed using scanning electron microscope.[16]

Microcapsules for three different applications namely antimicrobial essential oil for nonwovens, animal repellency for agriculture textile and thermal control shoe insoles from phase change material (PCM) were developed. Situ polymerization was used to produce the sheath material. The author suggested to modify the process parameter in order to achieve different release mechanism. It was also reported that in order to achieve a prolonged release of oil in case of animal repellency for agriculture textiles, the microcapsule should be permeable. There should be a target release of essential oil in the case of shoe insole. Wall should be impermeable in the case of PCM, since there should not be any contact between the core and sheath material.[17]

A two factor three level full factorial design was used to study the effect of amount of thyme oil and concentration of wall material on microencapsulation yield, particle size distribution and capsule loading. Nonwoven fabric was used. Thyme oil used in core and gelatin and gum arabic were used in sheath and microencapsulated by coacervation method. In was concluded that 10 ml of thyme oil and 2% sheath concentration resulted in good microcapsule size. At these conditions, the yield of encapsulation was 74.72%, mean size of microcapsules was 25.37 micron and oil loading was 36.38%. Antimicrobial activity tests revealed that thyme oil showed antibacterial activity against S. aureus ve C. albicans and E. coli.[18]

The effect of resin quantity on the washing resistance of microcapsule was examined and the results showed that higher the resin quantity higher the durability of microcapsules.[19]

A study on sound absorption property of microencapsulated fabric was conducted. Optically bleached fabrics of two different gsm were taken. Lavender oil was used as a core to form the microencapsules. It was reported that the sound absorption property of higher gsm showed better result.[20]

Polyetheyle glycol (PEG) was used to produce microcapsules by in-situ polymerization technique using urea- formaldehyde to study the thermal regulating of fabric and it was reported that FTIR analysis confirmed the presence of PEG within the microcapsules, Differential Scanning Calorimeter confirms that the energy storage capacity of the produced micro- capsules was 12.78 J/g.[21]

The degummed silk fabrics treated with microencapsulated oils namely lemon and Eucalyptus used in core and melamine-formaldehyde used in shell by pad-dry-cure process and studied the effect of UV light and heat on aroma of silk fabric. It was reported that there is a reduction in the durability of 40 % finish in both the oils after 48 hour irradiation. This indicated that there was a strong effect of UV on durability of finish.[22]

CONCLUSION

Microencapsulation has proven as one of the most effective ways of incorporating desirable qualities to textile materials. It is fascinating that our clothing is now able to actively moisturize, heal and even can release fragrances to reduce anxiety. The growing health awareness among consumers is further propelling researchers to try and test all possible ingredients to deliver expected performance. New materials are being explored and a major shift is towards the use of organic compounds both in sheath and core. There is no doubt that this technology has a promising future, however, one aspect that seems critical is the intended delivery of the encapsulated core on particular external stimulus. There is a need to optimize the methods of producing microcapsules and extend the shelf life of treated materials to achieve large scale industrial production for each specific application.

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