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Automotive textiles – fashion, well-being and future perspectives

Abstract

The importance of well-being and its consideration in applications of modern textile designs, be they for apparel, the home environment or industrial designs such as in automotives, are of great value from the research point of view. Nowadays, car interiors have become more important for the well-being of people, as they spend more time in the car than in the past. Currently, entire car interiors are made up from various textile materials. Micro-organisms can grow onto textile substrates (Unchin 2003) and for car interiors, malodours and microbial growth are of great concern. Techniques have been developed to resolve these issues by enhancing the functional properties of textiles during finishing processes by imparting properties such as fragrance finishing (Buchbauer 1994 & Holme 2007), anti-microbial finishing (Gao & Cranston 2008) and cosmeto-textiles for skin care (Fisher 2007). There is an increasing trend toward these finishes as they provide consumers with textile products for well-being and to cater for fashion perspectives. Until now anti-microbial/anti-odour finishes have been predominantly of a chemical nature. Chitosan, a natural biopolymer, has applications in medical textiles, skin care, weight loss and numerous other products. This paper will report on studies that highlight the possibilities for the utilisation of chitosan to incorporate fragrance and anti-microbial properties into automotive textiles to enhance the wellness of vehicle users.

Introduction

New interiors in automotives are pushing fashion-forward designs. Automotive show takes place in different cities round the globe, debuting the new generations of automobiles offering innovative touches to a series of features. Car interiors have always been about smart and contemporary designs aimed at the style-conscious customer who appreciates a unique look. In particular, concept designs are currently influencing automotive users' choices of style and fashion and thus helping customers' desire for more expressive vehicles. Car manufacturing companies are employing fashion designers to design car seats and interiors because of their distinctive flair and good looks and, in addition, providing the satisfaction of self- customisation. Car interiors are designed currently in such a way that, at first glance, they give a good impression and highlight the special features of the interiors and aim at making a fashion statement each time the car is out for a drive. New trends involve designing the car interiors themselves linked to the emotion of the customers and creating that "must-have-it" appeal which fashion is all about. Automobiles have always been a product that is involved with users' fashion consciousness. Apart from the fashion, the functionality of car interior textiles plays a part in the selection or design aspect of it. Customers definitely care about choice and personalisation – from the car's sky roof, door panels or the back of the seats and that is where the new range of finishing techniques are striking a chord with different functionalities such as anti-odour, anti-microbial, fragrance finishes and many more. These finishing techniques can provide customers with an extra edge in terms of fashion and well-being.

Automotive textiles have been classified as belonging to a category called "Mobiltech" which is one of the main streams of technical textiles. Technical textiles provide significant opportunities for business to achieve sustainable growth to escape from the tough competitive environment faced by traditional textile manufacturers. Technical textile products are mainly used for their performance or functional characteristics rather than for their aesthetics. End uses served by technical textiles are numerous and diverse. They include agriculture and horticulture, architecture, building and construction, clothing technology, geotextiles, functional textiles and automotive textiles. Recently, car interior textiles, as a part of automotive textiles (mainly seat coverings), have become more significant. New seat covering products offer various functional characteristics such as water repellence, stain resistance and more. As standards of living are improving and consumers demand more comfort and quality, this has led the automotive industry to come up with new features to attract and satisfy those consumers. Recent developments in anti-odour and anti-microbial finishing, along with application of chitosan for automotive purposes, are reported in this paper.

Overview of worldwide consumption

Looking at the overview of world end-use consumption analysis by the application area in Mobiltech, the growth is significant from 1995 to the forecasted figures in 2010 (Figure 1). The growth is expected to be almost 15% from 2005 to 2010 (Jänecke 2004).

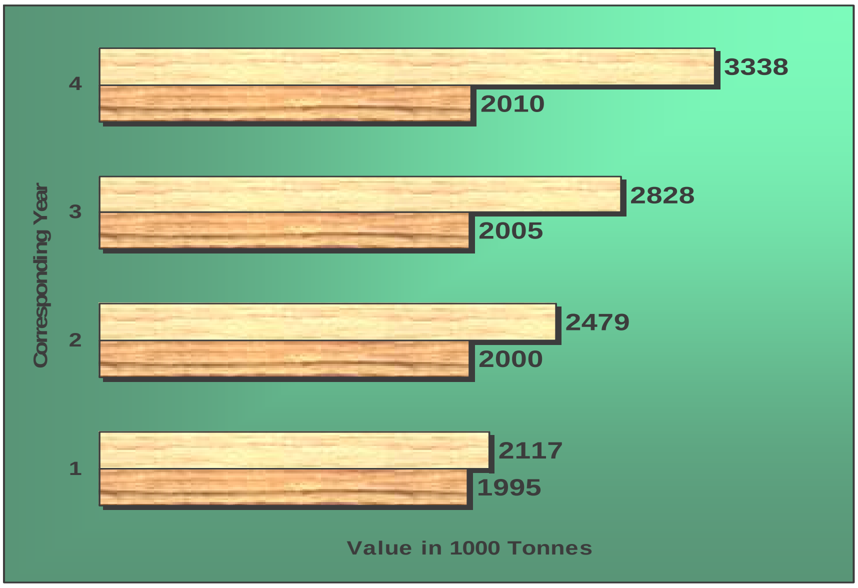


Figure 1. World end-use consumption analysis by application area in Mobiltech (Jänecke 2004)

Automotive Textiles

Automobiles consume on average 20 kg of textile material per unit (Fung & Hardcastle 2001). Besides the evident use in seat covers, other elements such as carpets, body liners, safety belts and air bags also have textile applications. In addition, textile structures in the form of flexible reinforcement for tyres, water hoses, brake pipes, bumpers and various types of belts are used (Car makers increase their use of composites 2008 and Composites on the Road 2003). Figure 2 shows textile applications in different areas of automobiles.

Figure 2. Automotive textile applications (Austin 2007)

The requirements for textiles and textile structures used in automotives are different from those used in clothing and other applications. The performance of these automotive textiles depends on the fibre properties, fabric structures and various finishes used in the manufacturing processes.

Polyester (PET) fibres have excellent resistance to chemicals. In addition, they have very good resistance to acids, but are less resistant to alkali and are not affected by any of the bleaching agents. Properties such as high tenacity, high resistance to abrasion and excellent resistance to direct exposure to sunlight make polyester a popular fibre for automotive textiles. Now almost 90% of the fibres used in car seats are polyester (Fung & Hardcastle 2001).

Anti-odour and fragrance finishing

Anti-odour and fragrance finishing is a process whereby the substrate is subjected to the inclusion of fragrance/essential oils which are reputed to give effects such as curing hypertension, losing weight, relieving pain, urging sexual passion and many more. The term “Aromachology” (Butcher 1998) was coined in 1982 to denote the field that is dedicated to the study of the interrelationship between psychology and fragrance technology to elicit a variety of specific feelings and emotions – such as relaxation, exhilaration, sensuality, happiness and well-being – through odours via the stimulation of olfactory pathways in the brain, especially the limbic system (Buchbauer 1994).

Microencapsulation

The fragrance compounds and essential oils are volatile substances. The most difficult task in preparing fragrance finished textiles is how to prolong the fragrant effect in the finished textiles. Microencapsulation is an effective and popular technique to solve this problem (Shirley Institute 1998 and Mei 1995). Microcapsules are miniature containers that are normally spherical if they enclose a liquid or gas, and roughly of the shape of the enclosed particle if they contain a solid. The material (core) enclosed in the capsule is protected from the environmental effects by the coating or covering as shown in Figure 3. The substance that is encapsulated may be called the core material, the active ingredient or agent, fill, payload, nucleus or internal phase. The material encapsulating the core is referred to as the coating, membrane, shell, wall material or covering. Microcapsules may have one or multiple shells arranged in strata of varying thicknesses around the core depending on the end use (Microtech laboratories 2007).

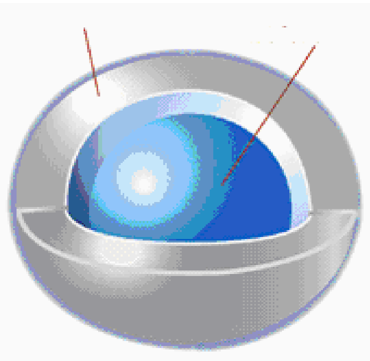


Figure 3. Microcapsule core and covering (Microtech laboratories 2007)

The covering must be able to release the encapsulated material when required either by mechanical action or external force. This property has enabled microcapsules to serve many useful functions and find applications in different fields of technology (Schaab 1985). For example, the storage life of a volatile compound can be increased markedly by microencapsulation (Aggarwal 1998). Substances may be microencapsulated such that the core compound within the capsules can last for a specific period. Core materials can be released gradually through the capsule walls which is known as controlled release or diffusion. External conditions triggering the capsule walls to rupture, melt or dissolve are the other possibilities of releasing the core material.

Anti-microbial Finishing

Another possible source of malodour is from microbial growth on the textile substrate. A variety of species of micro-organisms such as bacteria, fungi and mildew can grow on the textile substrate, provided that the substrate contains required nutrients for the microorganisms. These organisms not only cause undesired odour but also cause degradation of the textile by staining and deteriorating the fabric surface (Unchin 2003). The need to restrain the growth of microbes on the textile substrate has led to the discovery of anti-microbial finishes. Table 1 shows some common micro-organisms which are harmful to humans as well as textiles (Ramachandran 2004).

Table 1. Some harmful microorganisms (Ramachandran 2004)

Bacteria	**Fungi**
Gram positive bacteria	Cloth damaging fungi
Staphylococcus aureus or pyogens	Aspergillus niger
Staphylococcus epidermidis	Aspergillus fumigatus
Corynebacterium diphtheroids	Trichoderma viride
Gram negative bacteria	Curvularia lunota
Escherichia coli	Penicillum species
Klebsiealla pneumoniae	Crop damaging fungi
Proteus vulgaris	Fusarium species
Pseudomonas pyocynans	Rhizoctonia solani
Salmonella typhi	Sclerotium rolfsii
Vibrio colerae	

Evaluation of anti-microbial activity

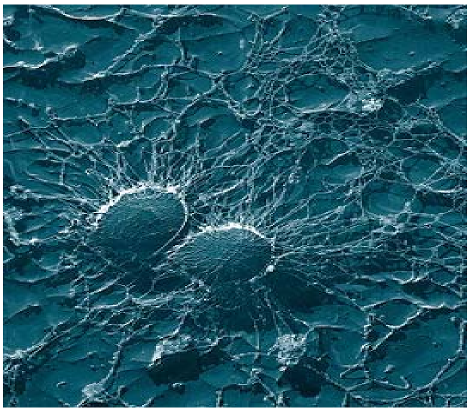
There are several methods available for assessment of the anti-microbial activity of the treated textile substrates. These methods are mainly divided into two groups. The bulk samples are usually tested and evaluated with qualitative procedures to observe the anti-microbial activity, whereas the confirmatory or quantitative tests define the anti-microbial activity with percentage reduction giving the efficacy of the anti-microbial agent assessed. The quantitative tests are more time consuming and give a detailed assessment of the efficiency of the anti-microbial agent and are thus appropriate for a small number of samples. The available standard methods used to evaluate the anti-microbial activity are given in Table 2.

Table 2: Different standard test methods for testing anti-microbial activity

Agar diffusion tests	Suspension tests
AATCC TM 147	AATCC TM 100
JIS L 1902-2002	JIS L 1902-2002
SN 195920-1992	SN 195924-1992

Two bacterial species *Staphylococcus aureus* (Gram positive) and *Klebsiella pneumoniae* (Gram negative) are recommended in most of the test methods. Strains of these two bacteria as shown in Figure 5 are used to evaluate qualitative and quantitative test methods.

a. *Klebsiella pneumoniae (*http://en.wikipedia.org/wiki/Klebsiella_pneumoniae*)*



b. *Staphylococcus aureus* (http://en.wikipedia.org/wiki/Staphylococcus_aureus)

Figure 5. Strains of a. *Klebsiella pneumoniae* and b. *Staphylococcus aureus*

Both of these bacteria are pathogens and precarious for health, thus requiring safe handling. Previous studies undertaken for evaluating anti-microbial properties used either the standard procedures or modification of the standard procedures. The modification involves using different bacterial strains and exposure time and different media to grow the bacterial strains.

The present study investigates the development of 100% polyester automotive fabrics with anti-odour and anti-microbial properties. To achieve this, chitosan, a naturally available polymer, was utilised as a binder and also as an anti-microbial agent. This study also evaluates the slow or delayed fragrance release properties of chitosan-finished fabrics and their application to automotive textiles.

Materials and methods

Two 100% polyester finished automotive seat fabrics (woven and knit) were used for the experimentation. Strawberry microcapsules were used in combination with chitosan and applied to the selected fabric with a pad-dry-cure process. Finished fabric samples were then tested for fragrance retention and anti-microbial activity. Anti-microbial tests were done with a modification of AATCC TM 100 method. Anti-microbial efficacy was determined based on duplicated and averaged test results. Percentage bacterial reduction was calculated according to the following equation:

$$R = (B - A) / B \times 100\% \qquad (1.1)$$

Where, R is the percentage bacterial reduction, B and A are the number of live bacterial colonies in the flask before and after shaking for one hour.

Results

Scanning electron microscope images of untreated and chitosan-treated polyester samples are given in Figures 6 and 7.

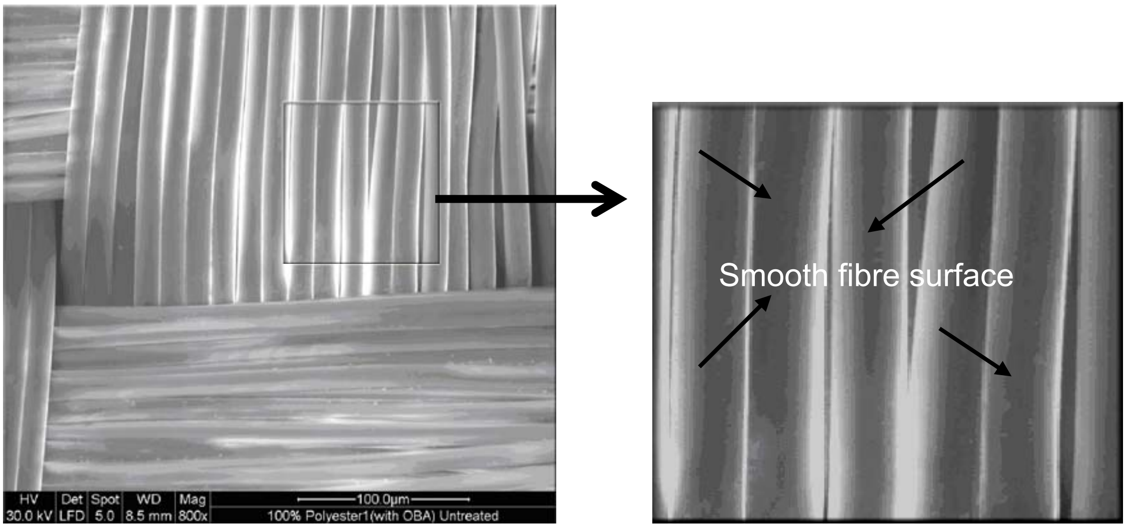


Figure 6. Polyester (woven, untreated) at 800 × magnification showing plain fibre surface

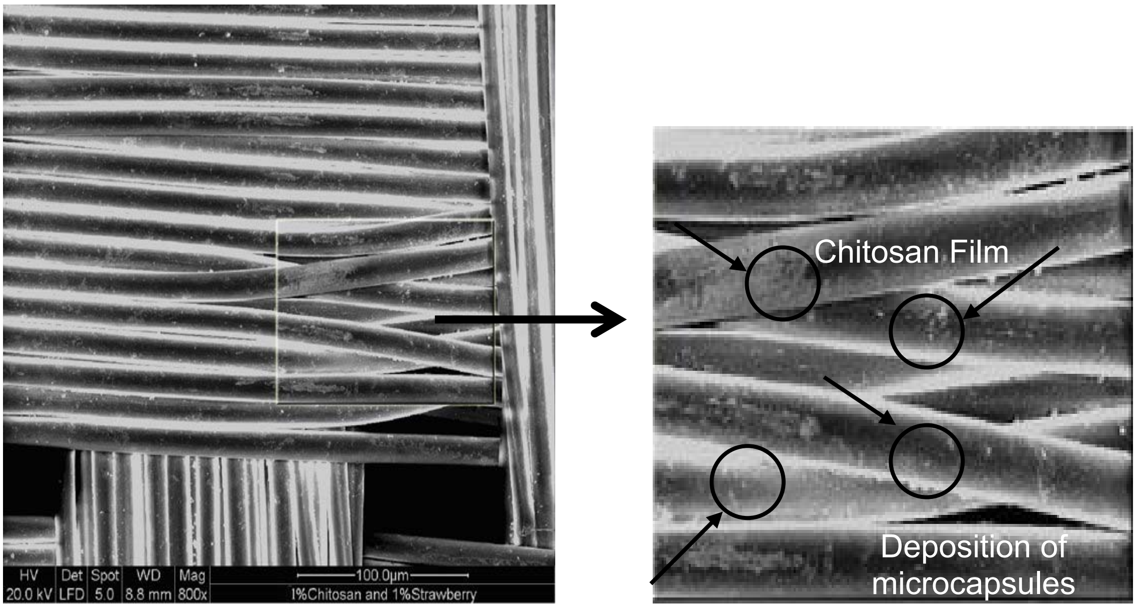


Figure 7. Polyester (woven, treated) at 800 × magnification showing the chitosan film entrapping the microcapsules

The untreated sample shows the smooth outer surface of the fibres (Figure 6) and the chitosan treated sample shows a rougher surface due to the film formation of chitosan and the presence of microcapsules (Figure 7).

To quantify the inhibition of bacterial growth against Gram-negative *Klebsiella pneumoniae* for woven and knitted fabric samples antibacterial test was carried out. The reduction percentage of bacteria was calculated using Equation 1.1 and tabulated in Table 3 and 4 respectively.

Table 3: Antibacterial test results for woven polyester against *Klebsiella pneumoniae*

Sample	Experiment number	Bacteria count before shaking	Bacteria count after shaking	Percentage reduction
Fabric (Woven)	1	244	0	100%
	2	298	0	100%
	3	253	1	99.6%

Table 4: Confirmatory test results for knit polyester against *Klebsiella pneumoniae*

Sample	Experiment number	Bacteria count before shaking	Bacteria count after shaking	Percentage reduction
Fabric (Knit)	1	244	1	99.6%
	2	298	0	100%
	3	253	0	100%

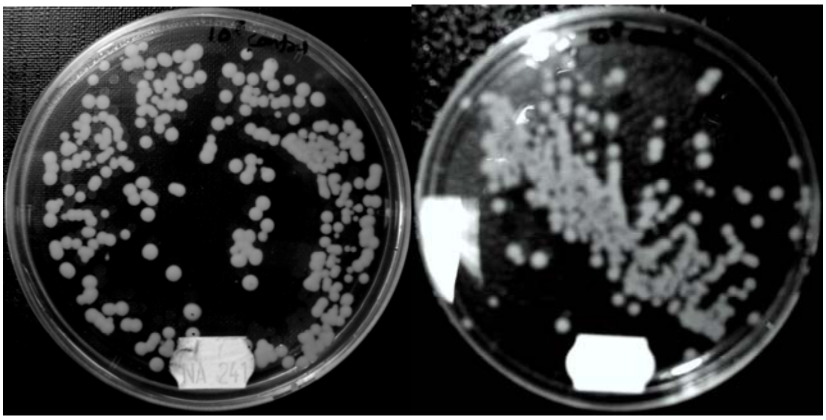


Figure 8. Control (untreated) for woven and knitted samples showing bacterial growth on agar plate

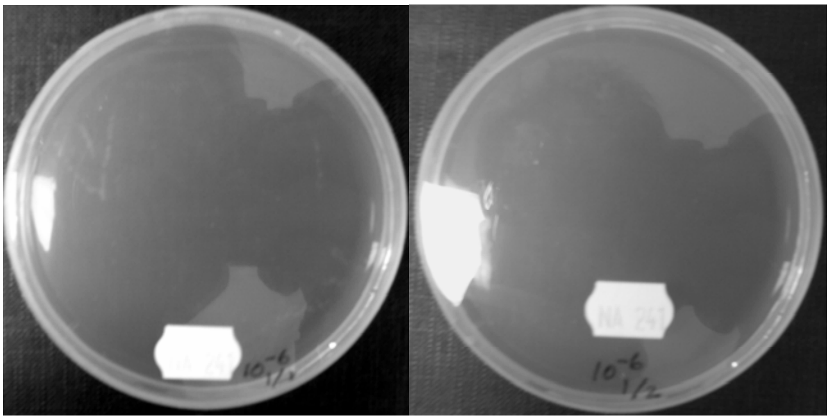


Figure 9. Chitosan (treated) woven and knit samples respectively showing no bacterial growth on agar plate

The above results show that appropriate concentrations of chitosan and strawberry microcapsule-treated samples were very effective in killing the Gram-negative bacteria *K. pneumoniae* (Figures 8 and 9) thus attributing to the antimicrobial property of the treated automotive fabrics.

Conclusion

The above experiments illustrate the use of anti-microbial properties of the natural biopolymer chitosan. In addition, it also shows chitosan can hold the fragrance carrier microcapsules on treated polyester automotive fabrics. This process successfully imparted both fragrance retention and anti-microbial attributes to automotive fabrics for the well-being of automobile users.

In the past, fashion trends have been to showcase the style, shape and fit, which are exhibited at fashion shows and highlighted by the use of models. The comfort, durability and washability, dry-cleaning and cost took a back seat. Now, with the advent of new chemicals and innovative processes, comfort, aesthetic values and durability etc. can be enhanced. To improve the mood and well-being of users, certain fragrances and anti-bacterial/anti-microbial treatments can be introduced with ease into the fabrics and garments. In addition, the technology is available currently for application of any fragrances that can be incorporated into the automotive seat fabrics as per the individual selection of the automotive user. Furthermore, this process can be easily adapted to enhance the well-being of fashion conscious customers into their favourite fashionable clothing with an extra edge.

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