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Sustainable fragrance cum antimicrobial finishing on cotton: Indigenous essential oil

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ABSTRACT

Fragrance finishing of textile has been enormously increased and used in domestic and industrial application. Fragrance can be synthesis chemically but available in natural and inorganic. The investigation of this research is to study the combined effect of fragrance and antimicrobial finishing on cotton fabric by lavender essential oil with the use of β-Cyclodextrin, Chitosan citrate and β-Cyclodextrin/Grafted Chitosan through pad-dry method. Fourier Transform Infrared spectroscopy (FTIR) was used to study the formation of ester bonds between β-cyclodextrin/grafted chitosan and cotton celluloses. For all the finished fabric samples fragrance release rate performance and antimicrobial properties were measure by standard test methods. The results revealed that β-CD was highly soluble in 0.6 gpl NaOH solution and 80 gpl β-CD and 6% essential lavender oil solutions were found to be a most suitable combination for fragrance and antimicrobial finishing. FTIR studies reveal about the formation of a carboxylic ester between cotton and β-Cyclodextrin/Grafted Chitosan at 1730 cm^{-1} ester peak.

1. Introduction

The fragrance is the word, which represents indulgence, pleasure, and luxury (Toda and Morimoto, 2008). Fragrances have been used widely in different engineering fields includes textile, medicine, food, tobacco, leather, papermaking, cosmetics etc. due to their antibacterial effect, sedative effect and tranquillization (Kyle, 2006; Nelson, 2001). Nowadays, finishing a textile with fragrance is an important commercial target and an engineering challenge. Pure fragrance compounds and essential oils have been used traditionally in folk medicine for a long time (Chandrasekaran et al., 2015). The term aromatherapy was a coin in the late 1920s by the French cosmetic chemist R.M. Gattefosse, who noticed the excellent antiseptic properties and skin permeability of essential oils (Butcher, 1998). A fragrance is a mixture of individual chemicals and has its own unique properties. Each fragrance component is interacted differently, according to chemical and structural nature (Herman, 2009).

In aromatherapy textiles, herbs essential oil is use for antimicrobial, fragrance and medical properties (Ghayempour and Montazer, 2016). Over the last 50 years, plants utilized as a potential source of natural aromas in the form of essential oils (Cheng et al., 2008). In literature, it has been reported that the essential oils with high aromatic index are used as insect repellency and antimicrobial growth agent (Matsushi-Shikiso Chemical Co Ltd., 1994). Lavenders are one of the aromatic plants, which has been used medical application and fragrance industry, including soaps, colognes, perfumes, skin lotions and other cosmetics purpose (Hamada et al., 2001). It belongs to the mint family and found in the Mediterranean region of Africa and some part of Asia (Piccaglia et al., 1993). Lavender fragrance oil is believed to be of benefit for numbers of ailments, including stress, anxiety, exhaustion, irritability, headaches, migraines, depression, colds, digestion (Cheng et al., 2008). Presently, sustainability and making eco-friendly product are the focus of the textile and apparel industry. Microencapsulation can be an important tool to protect unstable or non-substantive biodegradable fragrance (Samanta et al., 2014).

During the preparation of aromatherapy textile, the most difficult task is to prolong the lifetime of fragrance. Micro-encapsulation technique found to be an effective solution of this difficulty (Samanta et al., 2016; Yip and Luk, 2016). Although there are many effective approaches of micro-encapsulation for decreasing fragrance-release, cyclodextrins are the best among them (Buschmann et al., 1991). β-CD can be incorporated onto textile by means of spraying, printing, padding, grafting, surface coating, impregnation, ink jet printing and via sol-gel (Agrawal and Warmoeskerken, 2008; Martel, 2002a,

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2002b). In the textile area, cyclodextrin has been used for imparting properties i.e., UV protection, slow release of fragrances, insecticide delivery, and antibacterial activity (Andreaus et al., 2010). The most notable feature of CDs is their ability to form solid inclusion complexes (host–guest complexes) with a very wide range of solid, liquid and gaseous compounds by molecular complexation (Meo et al., 2003). They have a high level of biocompatibility and are approved by FDA (Food and Drug Administration), thus CDs are friendly to humans. Furthermore, CDs are now readily available, and their price and production costs have declined in recent years (Jug et al., 2008).

The Chitosan is N-deacetylated form of chitin that is obtained by alkaline treatment of chitin (50% of aqueous NaOH) at high temperature (Kurita, 1998). Chitosan and its derivatives have become useful polysaccharides in the biomedical area because of its biocompatible, biodegradable, and non-toxic properties (Lee et al., 1997). It is utilized in the textile industry as an antimicrobial agent due to its ability to provide protection against allergies and infection diseases, coupled with moisture retention and wound healing capabilities (Dutta et al., 2004).

Although, the chemicals and processes used in this research are environment friendly and highly compatible. β-CD, Chitosan and lavender oil are drives form natural resources and readily available including least prices. This work has been done by focusing the triple bottom line of suitability i.e. economic, society and environment.

The aim of this research was to explore the lavender oil as an excellent value addition to home furnishings. The characterization of lavender essential oil with β-Cyclodextrin, chitosan citrate and β-Cyclodextrin/Grafted Chitosan were studied by FTIR spectra of cotton. On finished textile, the effects of fragrance, antimicrobial finishing of treated fabrics were done through pad-dry method.

2. Material and methods

2.1. Material

A 100% cotton fabric procured from 'Vardhman Fabrics', Ludhiana was used for experiment work. The specifications and properties of cotton mentioned in Tables 1 and 2 respectively. All analytical grades chemicals purchased from SDFCL Fine-Chem Limited Mumbai.

2.2. Experimental procedure

The analysis of solubility of β-CD in different mediums such as water, ethanol, and NaOH was determined by dissolving different concentrations of β-CD (10–100 gpl) in water, 50% ethanol and 6gpl NaOH for 30 min (Joshi et al., 2009). Calibration of lavender oil for fragrance analysis was done by measuring the absorbance of different concentrations of lavender as (1–10%) in 100% ethanol through UV/ Visible spectrophotometer at λmax (344 nm). A calibration curve thus obtained to detection of the unknown concentration of fragrance in the solution. Optimization of β-CD concentration for finishing was analyzed by weight gain and phenolphthalein titration. For phenolphthalein titration a 1% phenolphthalein solution was prepared in 80% ethanol and pH of the solution was adjusted to 10.5 by using electronic pH meter and 0.5 M sodium hydroxide solution followed by wavelength of phenolphthalein solution was obtained as λ_{max} 558 nm through UV/ Visible spectrophotometer, β-cyclodextrin treated fabric samples with different concentration were cut to a dimension of 1×1 cm and immersed independently in 30 ml phenolphthalein solution as prepared above and shaken at 35 °C for 1 h in orbital shaker at 100 rpm, then fabric was removed from the solution and absorbance of phenolphthalein solution was measured with a dilution factor of 4 at λ_{max} 558 nm. After calibration of lavender oil, different concentrations of lavender oil (1–10%) with 100% ethanol were prepared and immersed 0.1g fabric samples in each concentration followed by measurement of absorbance of remaining solution. Inclusion complex formation between β-CD and lavender was analyzed by using their optimized concentrations. Four sets of fragrance finished samples were prepared namely Lavender alone (L), β-CD and lavender (β-CD-L), Chitosan citrate and lavender (CC-L) and β-CD/ grafted chitosan and lavender (β-CD-CS-L). Characterization of β-CD-C and β-CD-CS was done in the experimental process to synthesized β-CD-CS, which were a two-step process: esterification of β-CD with citric acid and then it's grafting with chitosan. In general, the incorporation of a guest molecule involves the wider (secondary hydroxyl groups) towards rim side of β-CD. Therefore, the primary hydroxyl group side of β-CD has been suitable for conjugating with citric acid. In addition, FTIR comparative spectra of cotton, cotton with β-CD, cotton with β-CD-C and cotton with β-CD-CS were obtained to examine the esterification of β-CD with citric acid and chitosan.

Table 1
Fabric structural details.

S.No	Features	Details
1	G.S.M	236
2	Weave	2/1 Twill weave
3	Warp Count	2/40 s
4	Weft Count	2/20 s
5	E.P.I	64
6	P.P.I	78

2.3. Analytical methods

The fragrance release rates (qualitatively and quantitatively), laundering durability (ISO 105-C01:1989 and physical properties i.e. Tensile Strength (IS 1969-1968), Bending Length (IS: 6490-1971). Crease recovery (IS: 4681-1968), Drape (BS 5058:1973), Air permeability (IS: 11056-1984), Tear strength (ASTM D1424-09) and antimicrobial properties (AATCC Test Method 147–2004) of finished fabric samples were evaluated and investigated through international testing standard methods. Different apparatus and equipment like water bath (Laboratory glassware co. Ambala), Electronic pH meter (PH-009(I)), Electronic weighing balance (CAS Model MW-11 series), UV/Visible spectrophotometer (Lab India analytical UV 3000$^+$), Orbital shaker (Bio-Technology Lab, M.D.U Rohtak). Padding mangles (Electronic & Engg. Company), Drying oven (Kaypee Udyog, Ambala), Laundrometer (RBE, Mumbai), Tensile tester (Globe-Tex Industries), Shirley Stiffness tester, Tearing strength tester (Elmatear), Drape tester (Curisk), Crease recovery tester (Shirley), Air permeability tester (Prolific) and FTIR (Perkin Elimer) were used for experimental and analysis.

3. Results and discussion

3.1. Characterization and optimization

3.1.1. Solubility analysis of β-CD

The β-CD solubility percentage in different mediums i.e. water, NaOH, ethanol is shown in Fig. 1. It was found that the β-CD highly soluble in 0.6gpl NaOH solution almost 100 percentages as compared with 50% ethanol and water. This may be due to the reduction of hydrophobic nature of β-CD, resulting in the breakdown of intermolecular hydrogen bond of β-CD when reacting with NaOH solution (Faruk et al., 2012).

3.1.2. Calibration of lavender

The absorbance of lavender oil with different concentrations (1–10%) were measured against blank sample at λ_{max} (344 nm) by using UV/Visible spectrophotometer. Fig. 2 shows the concentrations versus absorbance curve. The slope of the linear line was calculated from the equation to evaluate the unknown concentration of lavender oil in the cotton samples.