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International Journal for Modern Trends in Science and Technology, 7(03): 80-83, 2021

ISSN: 2455-3778 online
DOI: https://doi.org/10.46501/IJMTST0703014
Available online at: http://www.ijmtst.com/vol7issue03.html

Ultraviolet Protection Activity of Selected Herbal and Biopolymer for Textile Application

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To Cite this Article
Dr. Banupriya J and Dr. V Maheshwari, “Ultraviolet Protection Activity of Selected Herbal and Biopolymer for Textile Application”, *International Journal for Modern Trends in Science and Technology*, Vol. 07, Issue 03, March 2021, pp.: 80-83.

Article Info
Received on 06-February-2021, Revised on 28-February-2021, Accepted on 03-March-2021, Published on 11-March-2021.

ABSTRACT

The textile protection of human skin against ultraviolet radiation is very important problem and over recent years researches have shown increasing interests in this area. This research work deals with the causing harm effects of ultraviolet rays and protection against them through the woven materials by using Opuntia littoralis herbal extract and Chitosan biopolymer extract with nano encapsulation method. Finishing of fabric with an eco friendly manner is getting very advanced nowadays. So, this research work is fully based on ecofriendly and skin friendly. The samples were imparted with herb and biopolymer nanocapsules which showed best results for ultraviolet protection even after 30 washes.The finished sample was analyzed for its morphology using FESEM and FT-IR.

***KEYWORDS**: Ultraviolet, Textile materials, Herbs, Biopolymer and Nanoencapsulation.*

INTRODUCTION

Ultraviolet (UV) radiations can act in different ways on the functionalization of textiles, through pre- or posttreatments, in order to change their performance in dyeing and finishing processes. The growing consumer awareness of the dangers of the sun has influenced textile industry. The consumers want products that enable them to stay in the sun for a longer period of time. Most products are targeted at a specific market and nearly every manufacturer has a complete range of products. The most recent introductions have focused on products for children, athletes, or for those who want UVA protection. Apart from drastically reducing exposure to the sun, the most frequently recommended form of UV protection is the use of sunscreen, hats and proper selection of clothing[(2)].

Nowadays it is necessary to build up a ultraviolet protective textile once, as in these days UV radiation is found to be attainment in the earth surface. The ultraviolet radiation (UVR) ranges from 40 nm to 400nm with further classified into UV-A (320 to 400 nm), UV-B (290 to 320 nm), and UV-C (200 to 290 nm). UV-C is totally absorbed by the upper atmospheric ozone layer and does not reach the earth[(1)]. UV-A weaken the immunological response of skin cells and UV-B creates dangerous skin cancer. Plants are a sustainable source of medicinal products especially in traditional medical practices.

Plants contain active substances such as alkaloids, tannins etc., produced during their secondary metabolism which serve as a potential reservoir of medicinal products[(3)]. Biopolymers which are polymers that are generated from renewable natural sources are often biodegradable and non toxic to produce. The natural polymers, mainly polysaccharides, are obtained from various sources including plants, microbes, algae and fungae. Some are neutral and others, such as the carboxylate or sulfate groups, possess a negative charge. Chitosan is the cationic polysaccharide currently known[4]

Recent studies have enabled the use of nano particles in medicine to unlock new frontiers in diagnosing, treating, and preventing disease; relieving pain; and preserving and improving human health. Along with the herbs and biopoymer filled nanoparticles exhibit unique properties due to their size, distribution, and morphology. So, the research is focused on nano encapsulation method.

MATERIALS AND METHODS

2.1 Collection and preparation of herb extraction

The herbal extract selected for the present study was Phyllode of *Opuntia littoralis* which was collected in and around Coimbatore. Phyllode of *Opuntia littoralis* was washed with sterilized distilled water and dried for nearly 18 days under shadow dry. The substrate was passed through sieve to separate the unwanted residue to obtain fine powder.

2.2 Collection and preparation of biopolymer extraction

The Chitosan biopolymer which was extracted from crab shell was collected from fish market, Coimbatore. The crabs' exoskeletons were placed in 250 ml beakers and treated in boiling sodium hydroxide (2% and 4% weight/volume) for one hour in order to dissolve the proteins and sugars which isolated the crude chitin. After the samples were boiled in sodium hydroxide, the beakers containing the crab shell samples were removed from the hot plate and then allowed to cool for 30 minutes at room temperature. The exoskeletons were then further crushed to pieces of 0.5 -5.0 millimeter using a mortar and pestle.

2.3 Synthesis of Nanoparticles from Herbal and biopolymer Extraction

The Nanoparticles were synthesized by using each 100 ml of Herbal extracts solvents of the Phyllode of *Opuntia littoralis* and Chitosan biopolymer. Initially 250 ml of sodium alginate (base solution) (3.35mg/ml) was prepared, followed by 150 ml of calcium chloride (3 mg / ml) preparation. Drop by drop calcium chloride ($CaCl_2$) solution was added into sodium alginate solution at room temperature for 30 minutes with constant stirring. Then the Herbal extract was added with continous stirring for 45-60 minutes into the above mixture and kept aside for 24 hours undisturbed. After incubation, pellets were removed for charaterization and upper layer thrown away.

2.4 Preparation of Herbal Biopolymer Nanocomposite

In order to synthesize the composite, vortex method was used for the synthesis of Herbal Biopolymer nanocomposites. Herbal biopolymer nanocomposites was prepared by mechanical mixing which a homogenous solution both herbal and biopolymer nanocomposites solution was equally taken in 1000ml beaker and was stirred for one hour at 60°C.The speed of the stirrer can be varied as the setup has a speed controller attached to it. To this solution, one milliliter of two percent glutaraldehyde solution in water is added under stirring at room temperature (25°C). The nanocomposite prepared was subjected to nanoencapsulation.

2.5 Nanocomposite finishing using exhaust method

To finish the fabric, a sample of about one liter solution containing 600 grams of nanocapsules was used. Using oven maintained at 50°C, the fabric was dipped in the herbal biopolymer nanoencapsulation solution with binder for 30 minutes, removed and air dried in the shade.

2.6 Assessment of Ultraviolet Protection Factor by AATCC 183–1999 test method

The protection for the fabric from UV rays is by UV protection factor (UPF). The reduction in the amount of ultraviolet radiation affecting the skin passage through the fabric is assessed by UPF. For example, when wet processed treated Nanocomposite finished fabric samples have a UPF of 20, the only $1/20^{th}$ of Ultraviolet radiation reaches the skin. Ultraviolet transmittance through the fabric samples was determined within a wave length range from 280 to 400 nm using a Shimadzu UV/V Spectrophotometer[5].

2.7 Evaluation of Wash Durability of Finished Fabric samples by AATCC 124 1996 method

This method had a material to liquor ratio of 1:30 with 0.2% detergent using AATCC 124 1996 standard reference detergent. The washing machine conditions of water level were 18 ± 1 gallon, agitator speed: 179 ± 2 Strokes Per Minute, wash time: 12 minutes, spin speed: 645 ± 15 revolutions per minute, final spin cycle: five to six minutes. One laundering cycle included subsequent steps of five minutes of laundering and two minutes of rinsing, followed by another two minutes of rinsing and tumble drying.

2.8 Field Emission Scanning Electron Microscope (FESEM)

The surface morphology of controlled and finished fabric samples was analyzed using field emission scanning electron microscope[6]. The scanning electron microscope radiates high energy electrons in a focused beam to generate a variety of signals on the surface of the fabric samples. The signals derived from the samples reveal information regarding texture, chemical composition, crystalline structure and orientation of materials[7].

2.9Fourier-Transform Infrared Spectroscopy (FT-IR)

Fourier transform infrared spectroscopy (FT-IR) was an analytical tool to identify the nature of chemicals that are coated on the fabric specimen. The Fourier Transform Infrared spectrometer is most useful for identifying active chemical components whether organic or inorganic. It also helps to know to what extent the molecules of the finishing chemicals are attached to fiber molecules of the specimen. The samples were analyzed for their variations in chemical groups using FT-IR spectroscopy.

RESULTS AND DISCUSSION

3.1 Qualitative assessment of the Ultraviolet Protection efficacy of the Nanoencapsulate finished and washed fabric samples by AATCC 183-1999 method

Qualitative Ultraviolet Protection of the Herbal Chitosan nanoencapsulate finished and washed samples are depicted in the following Table-1.

Table-1: Ultraviolet Protection efficacy of Controlled, Nanoencapsulate finished and washed samples

S. NO	Fabric sample	UPF Range	% UV Radiation Blocked	Protection Category
1	Controlled sample (Untreated)	0	0	0
2	Treated sample	50++	99.24	Excellent
3	After 10 washes	50+	98.08	Very good
4	After 20 washes	50+	95.57	Good
5	After 30 washes	50+	94.16	Good

From the above Table-1, it was clearly seen that the sample Controlled sample did not block Ultraviolet radiation. Whereas, the treated sample showed excellent Ultraviolet Protection. After repeated washings, the washed samples 10, 20 & 30 washes showed gradual reduction in the Ultraviolet Protection by 98.08%, 95.57% and 94.16% respectively.

3.2 Analysis of the Nanoencapsulate fabric sample by Fourier Transmission Scanning Electron Microscope (FESEM)

The surface topography of the herbal and biopolymer nano encapsulate fabric sample was observed using Fourier transmission scanning electron microscope (FESEM). The characteristic of the nanoencapsulate fabric sample was analyzed.

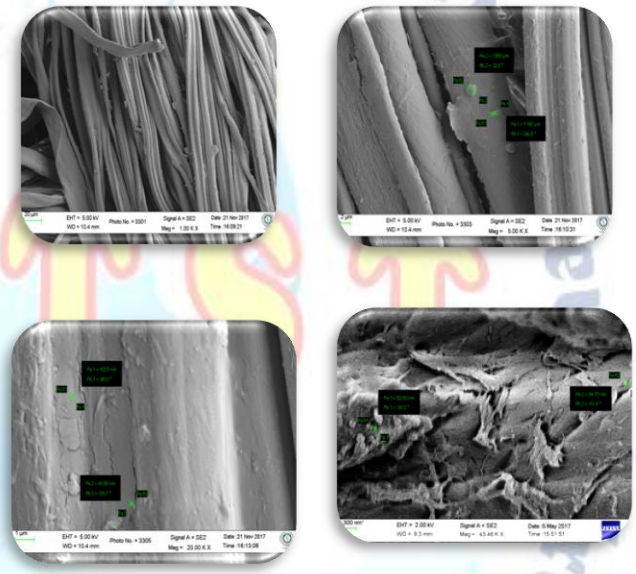


Plate-1: FESEM imaging of the nano encapsulate fabric sample

The above Plate-1 shows the Fourier transmission scanning electron microscopic images of the bamboo/cotton woven nano encapsulate fabric sample. The imaging was done with different magnifications like 1.00KX, 5.00KX, 20.00KX and 43.46KX. The images of the FESEM showed the extracts were fixed to the fabric yarns as nanocapsules.

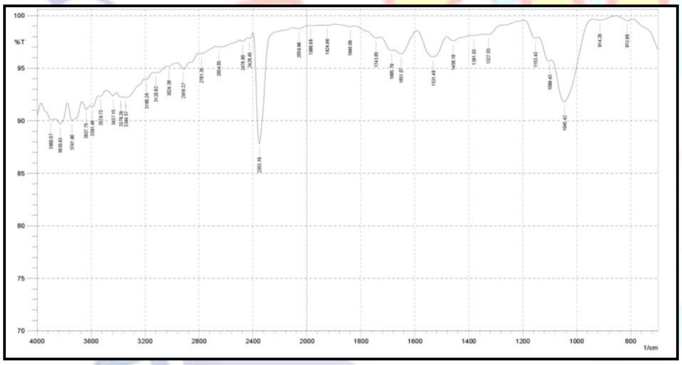
3.3 Analysis of Fourier-Transform Infrared Spectroscopy (FT-IR) with Nanoencapsulate finished fabric sample

The functional group of the Nanoencapsulate finished fabric sample was identified by using Fourier-transform infrared spectroscopy (FT-IR).

Table-2: FT-IR absorption frequencies for Nanoencapsulate finished fabric sample

Frequency (cm^{-1})	Bond	Functional groups
813	C–H bend	Alkenes
914	O–H bend	carboxylic acids
1045	C–O stretch	alcohols, carboxylic acids, esters, ethers
1099,1153	C-N stretch	Aliphatic amines
1327	C-N stretch	Aromatic amines
1458	C-H bend	Alkanes
1531	N–O asymmetric stretch	nitro compounds
1651	-C=C stretch	Alkenes
1685	C=O stretch	α-β-unsaturated aldehydes, ketones
2353	C≡ N stretch	Nitriles
2781	C-H stretch	Aldehydes
2916	C-H stretch	Alkanes
3344, 3379	N-H stretch	1°, 2° amines, amides
3637	O-H stretch	Alcohols, phenols.
1369	C–H rock	Alkanes
1442	C–C stretch (in–ring)	Aromatics

Figure- 1: FT-IR absorption frequencies for Nanoencapsulate finished fabric sample



The FT-IR was adopted to characterize the potential interactions. In the spectra, the FT-IR spectrum was used to discover the functional group of the different components based on the peak value in the area of infrared radiation. The functional group identification is based on the FT-IR peaks attributed to the stretching and bending vibrations. The result of FT-IR analysis revealed the presence of alkenes, esters, aliphatic amines, aromatic amines, alkanes, α,β-unsaturated aldehydes, ketones, aldehydes, nitriles, alkanes, 1°, 2° amines, amides, phenols and nitro compounds which were represented in Table 2 and Figure 1.

CONCLUSION

Thus, from the findings, it can be concluded that application of UV protective finish with herbal biopolymer nanoencapsulation on bamboo/cotton fabrics by using *Opuntia littoralis* herbal extract and Chitosan biopolymer improved UV protective properties to a greater extent, leading to excellent protection. This UV protective property can be used for development of medical textiles as well as for apparels for daily use. The new source for natural plant material and biopolymer which can be combined with new technologies such nanotechnology to develop effective and durable textile materials. This nanoencapusalation method showed good washing properties even after 30 washes.

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