Preparation and Characterisation of Temperature Regulating Silk Cocoon Extract (Sericin)/ PVA Based Smart fabric

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Keywords: Sericin, PVA, Smart fabric

Abstract: Smart fabrics help to regulate body heat and provide thermal comfort to the body. Hence from many decades research on heat transfer analysis and temperature regulating wearable clothing takes important place. Hence, here we developed green, simplistic and economical sericin/PVA film using industrial waste sericin along with PVA. For this, the fabrication of sericin/PVA was carried out by employing polymer solution casting method and slow evaporation method by varying the sericin concentration by keeping PVA constant that is in the ratio of 2:1, 1:1. Characterization techniques like X ray diffraction, and UV visible spectroscopy were carried out and fluorescence effect were studied. This research showed that higher concentration sericin/PVA film can effectively absorb phonons of UV radiation and convert into fluorescence light thereby maintaining the temperature of the film/fabric. Hence this film/fabric can be used in industries where workers are constantly exposed to harmful UV radiations.

1. Introduction

Clothing which is considered as one of the basic needs of human being, plays an important role in maintaining thermo regulation of the human body [1]. It is also considered as fabric that wraps around the skin and acts as protective shielding for humans [2]. The end result of clothing on thermal adaption relies on type of material used and properties of the clothes. Consequently, the properties of cloth, depends on skin temperature and somatic sense, whereas thermal comfort of clothes depends on heat exchange properties of textiles [1, 3]. Hence generally thermally adaptive fabrics are used to overcome the confine application of conventional fabrics and to develop a fabric with enhanced mechanical properties like in tensile, compression and toughness and thermal properties like increase thermal stability, conductivity without affecting the fundamental properties of the fabrics.
Change in life style of very individual and improved civilization has made to discover an alternate for natural fibres which fulfils the limitations of conventional textiles [4]. Sericin a type of protein and gummy substance present at outer shell of the cocoon has considered as waste in silk production industries but it got unique properties like hydrophilic, antioxidant, anticancer and especially in protecting from UV radiation [5, 6]. Therefore responsible for photo stability of the cocoons. Sericin consists of various amino acids which are crosslink. Due to this ability of the sericin, it can be blend easily with other macromolecules particularly synthetic polymers enhances the physical properties of the materials [7-9]. Hence sericin can be used in natural and artificial fibres and improves the thermal stability of the blend [10]. This ability of the sericin opens an window for use of sericin in temperature regulating fabric research. Polymers which are macromolecules, formed by the joining the building blocks called monomers are widely used in textile industries to fulfil the requirements of the consumer. Few properties of polymers like light weight, high strength, resistant to chemicals and ability to process easily has made polymers to use in textiles [11-13].

2. Experimental

2.1 Materials

Multi voltine cocoons were kindly provided by central sericultural research and training institute, sriramapura, Mysore. Poly vinyl alcohol, distilled water, whatman filter paper and gloves were purchased from padmashri scientific, Mysuru. Distilled water is used throughout experiment.

2.2 Synthesis of silk extraction (Sericin)

Multi voltine cocoons were selected for sericin extraction and then pupae were removed by cutting the cocoons. Weight of the 5 cocoons was weighed using digital weighing machine and they weighed about 4gms. These weighed cut cocoons were immersed in 50ml distilled water and boiled for approximately half an hour. Then extracted solution was filtered using whatman paper and collected in beaker. Hence by this process 8wt % of silk sericin was obtained as shown in figure.

![Figure 1: Schematic representation of extraction of silk sericin](image)

2.3 Fabrication of silk cocoon extract (sericin)/ polymer based smart fabric

4gms of PVA granules were weighed using digital weighing machine and dissolved thoroughly in 50ml of boiling water by continuous stirring using magnetic stirrer. After it was completely dissolved, 8 wt % of PVA solution was obtained. Then prepared 20ml of PVA solution is measured and mixed
thoroughly with different quantity of extraction of silk sericin at approximately 50\(^0\)C, so that homogeneously blended mixture is obtained. For this different quantity of sericin like 40ml, 20ml was mixed continuously with 20ml of PVA that is by keeping PVA constant.

![Figure 2](image)

**Figure 2**: Schematic representation of fabrication of silk cocoon extract (sericin)/ Polymer based smart fabric.

### 2.4 Material characterization

The XRD patterns of sericin/PVA film were obtained from desktop X-ray powder diffraction instrumentation, Bruker, Germany and 2\(\theta\) ranging from 14 to 70\(^0\). Absorption spectrometry and transmittance spectrometry were carried out using UV Visible spectrometer from the range 100 to 700 nm.

### 2.5 Fluorescence effect

UV radiation absorption and fluorescence effect were determined using high resolution laser beam in dark chamber.

### 3 Results and Discussion

#### 3.1 Ultraviolet- Visible Spectroscopy

In fig 3a, the PVA alone will not show any considerable absorption in any UV region. Absorption of higher concentration film (2:1 sericin/PVA film) has higher absorption rate. The maximum absorption starts from wavelength 200nm to 230nm, in UVC region. By the obtained plot it is clear that as the concentration of the silk extraction increases, the absorption rate also increases in UVC region.

Transmission of light/ radiation is more in case of PVA that indicates it alone is incapable of absorbing UV radiations especially in the range between 230 to 300nm. In the same region, if we observe higher concentration film (2:1 sericin/PVA film) transmission rate is considerably less that is almost zero at 230 nm. Hence higher concentration film has got an ability to absorb almost all incident radiations and hence places a very important role in absorbing UV radiation.
Figure 3a & b: UV-visible absorption and Transmission spectra of sericin/PVA film

3.2 X-ray Powder Diffraction

Figure 4: XRD of sericin/PVA films

Figure 4 shows different concentration of sericin in PVA. By monitoring the shape, position and intensity of the reflection or absorption type of crystallographic structure can be determined. Hence the below plotted graph obtained in the figure 4 indicates that crystallographic structure of various concentration of the sericin/PVA film. As shown in graph A, Pure PVA film has sharp peaks at 17 to 18.5° that indicate crystalline property. Further diffraction angle has no spark peaks indicating amorphous property. Hence PVA film is a semi crystalline material. As shown in graph B 1:1 sericin/PVA film has a broad valley without sharp edges, indicating amorphous property. Hence sericin/PVA is an amorphous material. Even graph C shows broad valley indicating amorphous
property of the film. Therefore by observing the graph, it clearly indicates that as the concentration of the sericin in the developed film increases, amorphicity of the material also increases.

3.3 Fluorescence effect

![Fluorescence effect images](image)

**Figure 5:** Fluorescence effect of UV light on (a) plain paper, (b) 1:1 sericin/PVA film and (c) 2:1 sericin/PVA film

UV light/radiation was made to fall on plain paper as shown in fig 5 a, it transmitted UV light (purple colour light) without absorbing. Then the same source of UV light was made to fall on PVA host film, again it transmitted hazardous UV light as shown in fig b. Later same source was made to incident on various concentration of sericin/PVA film, that absorbed phonons of UV light and transmitted non hazardous fluorescence light (green colour light) of various intensity as shown on fig c & d. Therefore by comparing various images of figure 5, higher concentration sericin/PVA film can effectively absorbed phonons of UV radiation and emit low intensity fluorescence light.

According to the principle of fluorescence, sericin/PVA film absorbs phonons (heat) of the UV source. This absorbed radiation excites the system and makes the electrons in the ground state to jump to higher energy level. After a lag time, approximately few nano seconds (life time of fluorescence), the excited electrons returns back to the ground state. While returning back the electron releases the stored energy in the form of photons (light). Hence according to Newton’s law of conservation of energy “phonons of the UV radiation are converted into photons”. Therefore we can say that sericin/PVA laminated fabric absorbs UV radiation and releases a distinct green fluorescent colour as shown in figure

4. Conclusion

In this present research, sericin/PVA film has been developed a green, simplistic and economical film. For this, the fabrication of sericin/PVA was carried out by employing polymer solution casting method and slow evaporation method by varying the sericin concentration by keeping PVA constant that is in the ratio of 2:1, 1:1. The obtained results showed that increase in the concentration of the sericin in PVA increases the absorption capacity from 0.69 to 10 (Au) at 230nm wavelength. Transmission spectra of UV spectroscopy showed decrease in transmission from 19 to 0% at 230nm wavelength. The images of fluorescence effect of the developed film/fabric showed that presence of sericin in PVA has intensively reduced the adverse impact of UV phonons by converting phonons into fluorescence light, their by maintains the temperature of the developed film/fabric which is due to the strong conduction of phonons in the developed film. Therefore this developed amorphous sericin/PVA film is mechanically elastic and flexible, visibly transparent. Ability of developed film to absorb phonons of UV radiation and to convert harmful UV phonons into non hazardous fluorescence light and transmitting the heat. Hence, this film is the right choice to be used in gloves/fabrics especially in industries where workers are constantly exposed to harmful UV radiation and military persons who are directly exposed to sunlight so has to maintain comfortable temperature for the wearer.
Acknowledgments

This work was supported by NIE- Centre for research and development and provided financial assistant. The authors also thank sericultural research and training institute and faculty of The NIE, Mysuru.

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