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Novel Applications of Silk Nonwovens in Living Enclosures

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Abstract: *The silkworm is one of Nature's marvelous architects. It builds a safe and comfortable cocoon for itself while it transforms into pupa and then moth. The cocoon consists of silk proteins which of late have been found to have remarkable properties like UV protection, thermo tolerance, biocompatibility and biodegradability. This has inspired a large number of applied researches on silk for biomedical and other technical applications. This paper discusses novel applications of waste silk nonwovens for creating luxurious living spaces for the comfort of man.*

Keywords*:* Silk Nonwovens, UV Protection, Thermo Tolerance.

INTRODUCTION

Silk, 'the Queen of Textiles' is a fibre extruded by the mature silkworm, *Bombyx mori*. The silk thread is indeed harder than steel. The silkworm spins the cocoon around itself as a protective covering while it transforms into pupa and then moth. The cocoon is hard and strong yet elastic and soft to allow movement inside the cocoon (1). It is pervious to air but not to rain water. Being hygroscopic, it regulates the temperature inside and protects the silkworm from harmful UV rays. Because of molecular structure, silk can absorb up to 35% of its own weight of moisture without feeling wet. Thus the cocoon can absorb the excretion of the silkworm. The silk threads in the cocoon dissolve when they come in contact with an enzyme (cocoonase) ejected by the moth when it is ready to emerge. Silk is difficult to ignite, burns slowly and self-extinguishes when the source of the flame is removed. All these are ideal properties for safe and healthy growth of the silkworm. Thus, the silkworm is one of Nature's marvellous architects, and an inspiration for harnessing the advantages of silk and creating luxurious spaces for the comfort of man.

Figure 1. Silk waste

The silk intertwined in the cocoon consists of two proteins, the filamentous fibroin, bonded by gummy sericin (2). Silk thread is unwound from the cocoon by reeling process and used for making silk yarns and fabrics. The lustrous silk in textiles is usually only the fibroin protein. Sericin is removed during refinement and discharged into the drain along with the chemicals used for its extraction. However, about 25 to 35% of silk in a cocoon cannot be reeled into raw silk yarn and is segregated as silk waste. Silk waste (Fig. 1) consists of unreelable parts of a cocoon, end-missing cocoons, rejected / defective cocoons, etc. (3)

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During 2014-15, India produced 28708 MT of raw silk (4) and waste silk is estimated at over 7000 MT. Silk waste is used for making spun, noil and floss silk. With the closure of larger spun silk mills, a huge quantity is exported without further processing (5). The option of using silk waste in making useful nonwovens has not been fully explored so far.

MAKING OF SILK WASTE NONWOVENS

Broadly, nonwovens are fibrous web structures in which the fibres are bonded together by mechanical entanglement, thermal fusing or chemical bonding. We have previously used silk waste and reclaimed sericin to make bio-inspired nonwovens, just like the silk cocoon. A web of boiled off silk waste was bound with reclaimed sericin to form silk nonwovens. The process is eco-friendly and simple and requires low investment. Being a handmade process, it generates employment opportunity, especially for women (5).

Traditionally, woven silk fabrics have been used for home furnishing limited to drapery, upholstery, bed spreads, cushion covers and quilts, besides silk carpets. The waste silk nonwovens offer innumerable application possibilities which are different from the traditional usage. In this paper, the nonwovens (Fig.2) have been used to make items of furniture/fixtures for interiors and construction. Thus, the possibility of employing silk waste in making nonwovens for application in an entirely new area has been demonstrated.

Figure 2. Nonwovens made from silk waste.

NOVEL APPLICATIONS FOR SILK WASTE NONWOVENS

Veneered panels for cubicles

Silk waste nonwovens were used to make panels for offices and homes. The nonwoven was passed through a pair of hot plates in a panel making machine over a plywood board which was sprayed with an adhesive. The silky nonwoven is exposed on the exterior, giving a luxurious look and texture. The silk fibres being smooth do not provide area for accumulation of dust (which tends to slip off its smooth surface). Besides, it can be conveniently cleaned using a vacuum cleaner. The panel shown in Fig.3 is made from undyed fibres. Different colours and designs are possible by varying the layout and colours of the nonwoven.

Melamine finished panels for table tops

As shown in Fig.4, the web of silk fibres in the nonwoven lends a curious design to the panel, besides making it appear luxurious. The panel is water proof and scratch proof and when used, require no maintenance. The panels were prepared by coating the nonwoven surface with a finish under high pressure conditions. They can be made in a variety of designs and colours.

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Figure 3. Veneered Silk Panel

Figure **4** Coated Panel

Window blinds

Window blinds are used to cover windows to reduce solar heat and light and keep the room cool. In winter, they need to reduce heat loss from the rooms. Silk nonwovens are the ideal materials for performing this function. Besides being shiny (reflective), they also have natural UV protection factor. The smooth fibres do not accumulate dust and can be cleaned conveniently. The handmade nonwovens have been used to make Venetian blinds and horizontal blinds which are under evaluation.

Lamp shades

The function of a lamp shade is to control and manipulate light output for visual comfort. Silk is a colourless translucent fibre with a triangular cross section. Each fibre acts as a tiny prism and scatters light, giving silk its unique characteristic lustre. It is ideally suited for making lamp shades. Silk nonwovens are not only aesthetic but also filter light effectively. They can be designed in either natural shades or dyed (silk has extraordinary ability to absorb dyes) and textured to enhance visual interest and allow light to shine through. One of the lampshades made from silk nonwovens is shown in Fig.5.

Figure 5. Silk Lampshade

Acoustic panels

There is a growing requirement of acoustic rooms in home theatres, offices, lecture rooms, auditoria, hospitals, factory halls, transportation terminals, etc. The acoustic properties of the silk cocoon are being investigated in order to explore their use in making eco-friendly acoustic panels.

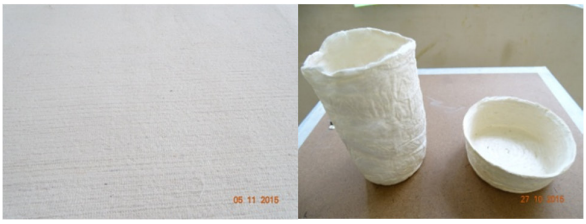

Figure 6. Needle punched non-woven Figure 7. Moulded Silk Articles

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Miscellaneous products

Silk waste has been converted into needle punched nonwoven with a cotton cloth backing for the first time, making it a completely natural and eco-friendly, as both the fibres are biodegradable (Fig.6). They have been dyed using natural dyes into beautiful shades. These mechanically bonded nonwovens are being used to develop bulletin boards, mouse pads, meditation mats, yoga mats, etc. The Fig.7 shows moulded products made from waste silk.

CONCLUSION

Silk waste in the form of nonwovens is ideally suitable to be modelled inside living enclosures and augment home textiles made of silk. The possibilities are innumerable and only a few are illustrated in this paper. Silk has most of the properties needed for this application like strength, elongation (flexibility), hygroscopicity, U.V protection, light transmission, etc. Its antimicrobial / flame retardant properties can be enhancing with suitable treatments. The idea of integrating these two disciplines, i.e. silk waste utilization and interior / construction needs to be explored further for maximum exploitation.

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