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A comparative study on morphology and dyeing behavior of ahimsa silk and mulberry silk

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Abstract
Silk is widely used because of its beauty and acclaimed as the queen of textiles. Traditionally silkworms or silk-producing moths are killed during the collection of their silk cocoons. To eliminate the traditional process, there are few researchers who have developed a new technique for producing silk. The silk spun from Mulberry pierced cocoon without killing pupae for silk extraction considered as "Ahimsa silk" or is also called as "Peace silk". Ahimsa silk is widely accepted by Hindus, Jain community, yogis and environmentalists who strongly believed in non-violence. The present study was formulated to identify the morphological and dyeing behavior of Ahimsa silk and Mulberry silk. No such significant difference was found in FTIR in both the silk fabric but difference was seen in microscopic view and as well as in dyeing behavior. Ahimsa Silk showed better result in all the dyeing parameters.

Keywords: Ahisma silk, mulberry silk, FTIR, k/s value, microscopic view

1. Introduction
One of the world's greatest culprits in environmental pollution is something we use every day and probably give the least consideration to its environmental impact is our clothes [Lee, 2014] [1]. Finding ways to curb the environmental pollution caused by textile production starts with finding new ways to produce fabrics that don't require toxins and large amounts of water, and which minimize harm to local the ecology [Vadhani, 2015] [2].
Sustainable textiles are textiles (or fabrics) that are grown and created in an environmentally friendly way, using minimal chemicals and less harm to other living bodies. For a textile to be sustainable, it has to be made from a renewable resource, it has to have a good ecological footprint (how much land it takes to bring it to full growth and support it), it should not use any (or use little) chemicals in the growing and processing of it and must be non-violent. Textile fashion companies are focusing more on sustainable products these days, so that they can meet the environmental and social aspects. Sustainable fibres provide solution for the companies facing issues regarding environmental problems; these fibres are also favourable to meet the market demands of quality products these days [Kumari *et.al*. 2013] [3].
One such fabric that supports sustainable environment is Ahimsa silk. Very few are aware about what happens to the small worms that produces one of the most stunning fabrics, silk.
Silk is widely used because of its beauty and acclaimed as the queen of textiles. Traditionally silkworms or silk-producing moths are killed during the collection of their silk cocoons. To eliminate the traditional process, there are few researchers who have developed a new technique for producing silk. The silk spun from Mulberry pierced cocoon without killing pupae for silk extraction considered as "Ahimsa silk" or is also called as "Peace silk". Ahimsa silk is widely accepted by Hindus, Jain community, yogis and environmentalists who strongly believed in non-violence.
People have assumptions that one has to completely change everything to adapt to eco-friendly living. However, this can be achieved by making small changes at various levels and taking small steps towards making our earth green and a beautiful place to live [IIT Delhi, 2009]. The present study was formulated to identify the differences in the properties of Ahimsa silk and Mulberry silk which were best understood by examining the morphological, geometrical, mechanical and aesthetic properties of the silk fabric Also the dyeing behavior of both the fibers were evaluated.

2. Methodology

2.1 Materials

2.1.1 Fabric: Pure Ahimsa Silk and Pure Mulburry Silk

2.1.4 Dyes: Acid Dye (red and blue)

2.2 Methods

2.2.1 Morphological Study

2.2.1.1 Fourier Transform Infrared Spectroscopy (FTIR)

In Infrared spectroscopy, IR radiation is passed through a sample. Some of the infrared radiation is absorbed by the sample and some of it is passed through (transmitted). This test was performed to identify and compare the groups present in Ahimsa silk and Mulberry silk.

2.2.1.2 Microscopic view

The cross-section can be made as follows: A bundle of straight and parallel fibres is embedded in a cork with the help of a needle in which the yarn or filaments are threaded.

2.2.2 Kinetic Study of the Dyeing Parameters of Ahimsa Silk and Mulberry Silk

2.2.2.1 Dyeing with Acid Dye

Both Ahimsa Silk and Mulberry silk was dyed with acid dyes in two colors red and blue with the variables of time (30min, 60min & 90min), temperature (60°C, 80°C & 100°C) and pH (3,5 & 7) and keeping the MLR 1:40 in ratio.

2.2.2.2 Color Strength Measurement

Strength of any colorant (dyestuff / pigment) is related to absorption property. It measure reflectance and not absorbance. It is known to us that when reflectance is more, absorbance is less and when reflectance is less, absorbance is more. Kubelka – Munk theory gives the following relation between reflectance and absorbance:

$K/S = [\{(1-R)\ 2 / 2R\}]$

Where R is the reflectance, K is absorbance and S is the scattering. K/S Vs Wavelength curve is always characteristics of every colorant. Instrument used to measure the K/S value was MACBETH COLOR- EYE 3100

3. Results and discussions

3.1 Morphological Study

3.1.1 Fourier Transform Infrared Spectroscopy (FTIR)

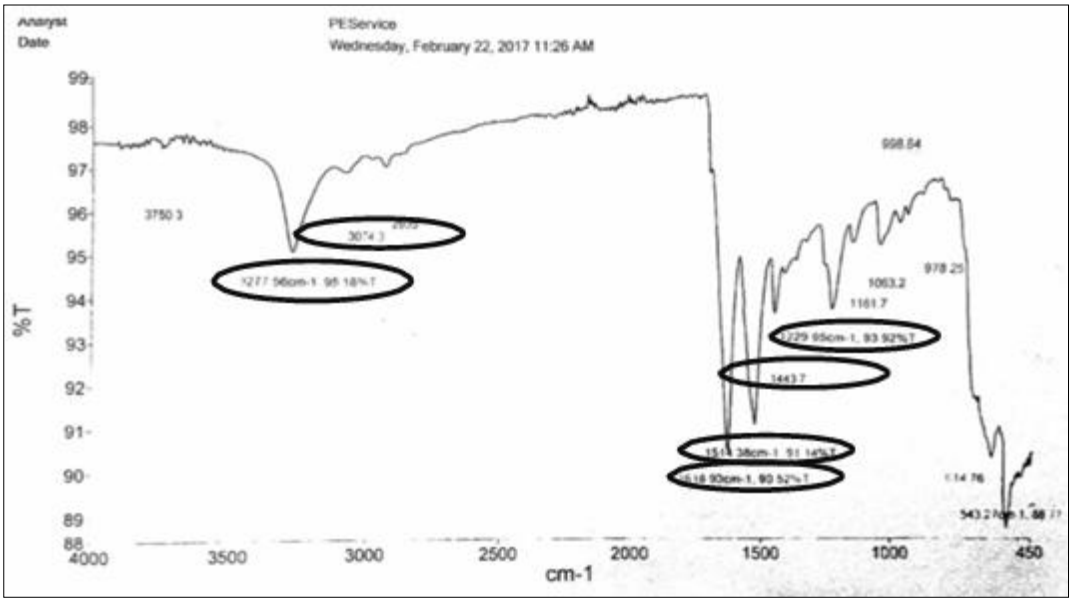

Fig 3.1: FTIR of Mulberry Silk

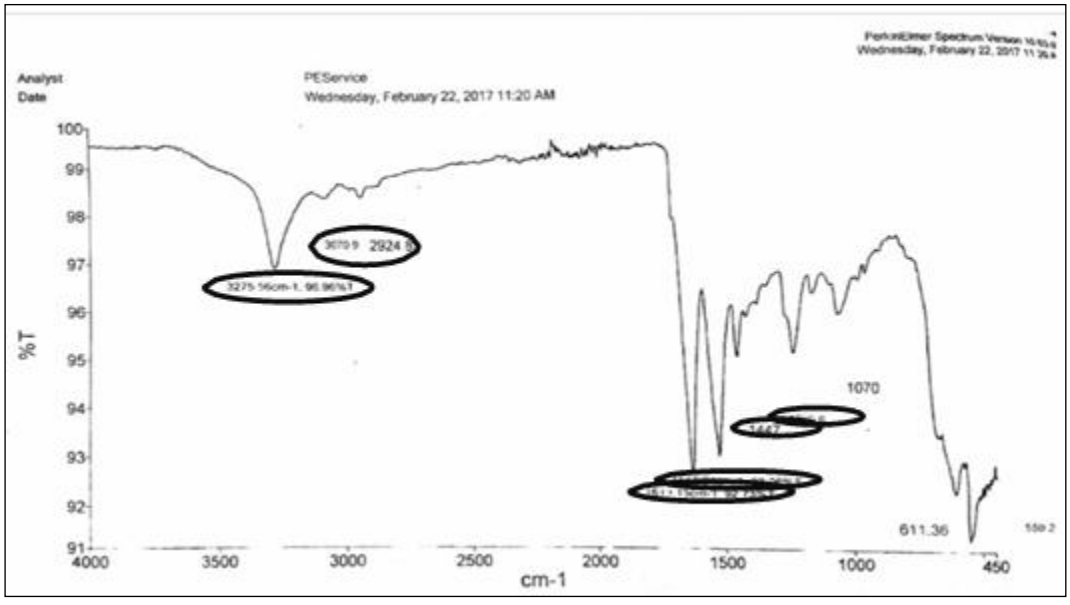

Fig 3.2: FTIR of Ahimsa Silk

Table 3.1: FTIR of Mulberry and Ahimsa Silk

1 peak Name	Mulberry Silk		Ahimsa Silk	
	List of Peaks Area/ Height		List of Peaks Area/ Height	
	X (cm-1)	Y (%T)	X (cm-1)	Y (%T)
1	1229.95	93.92	1229.60	95.20
2	1443.70	91.10	1447	95.10
3	1514.38	91.14	1513.94	93.06
4	1618.93	90.52	1619.15	92.73
5	2935	97.10	2924.80	98.75
6	3277.56	95.18	3275.56	96.96

From the above Table and Figure, almost similar peaks are observed. Peaks are as follows:

- Mulberry 1229.95 Cm-¹ and Ahimsa 1229.60 cm-¹, both forms the medium peak which indicated the presence of amine group.
- Mulberry 1443.70 cm-¹ and Ahimsa 1447 cm-¹, both forms the medium peak which indicated the presence C-H alkane group.
- Mulberry 1514.38 cm-¹ and Ahimsa 1513.94 cm-¹both forms a strong peak which indicates the presence of N-O (nitro group)
- Mulberry 1618.93 cm-¹ and Ahimsa 1619.15 cm-¹, both forming a strong peak of C=C stretching which indicates the presence of α, β-Unsaturated Ketone compound.
- Mulberry 2935 cm-¹ and Ahimsa 2924.80 cm-¹, they are forming a weak band of O-H indicating the presence of intramolecular bonds.
- Mulberry 3277.56 cm-¹ and Ahimsa 3275.56 cm-¹, these are forming the medium peak indicating the presence of N-H an aliphatic primary amine [The Libre Texts libraries, 2014].

Silk is a protein fiber and consist of amino acids. It is a natural fibre (protein), carboxylic acid group (-COOH) and amino group (-NH2) present as peptide group in silk. Also carbonyl group and imino group are presents in silk.

Functional group:

- Carboxylic acid group (-COOH) and amino group (-NH2) presents as peptide group (-CONH-)
- Carbonyl group (=CO)
- Imino group (-NH-) [Alam, 2015]

From the above results, it can be stated that no significant difference was found in functional groups of both Mulberry and Ahimsa silk.

3.1.2 Microscopic Study

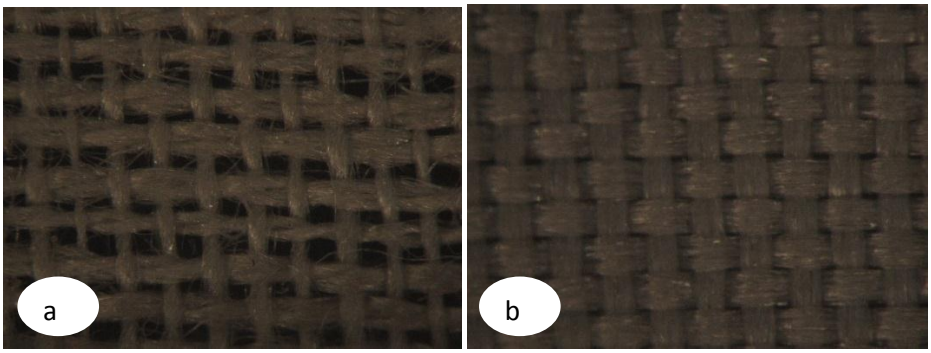

Fig 3.2: Microscopic Structure (a) Ahimsa Silk (b) Mulberry Silk.

Through microscopic view it is clear that Ahimsa silk is loosely constructed whereas Mulberry is closely constructed.

3.2 Comparing the Dyeing Behavior in Terms of K/S Values to the Dyeing Parameters

Ahimsa silk and Mulberry silk fabrics were dyed with acid dye in two colours red and blue with the variables of time (30min, 60min & 90min), temperature (60°C, 80°C & 100°C) and pH (3,5 & 7).

Table 3.2: k/s values at different time

Samples	Red color			Blue color		
	Time (minutes)			Time (minutes)		
	30	60	90	30	60	90
Ahimsa silk	21.43	22.05	20.42	21.93	22.23	21.84
Mulberry silk	20.11	20.02	16.94	20.95	20.56	20.56

Table 3.3: k/s values at different temperature

Samples	Red colour			Blue colour		
	Temperature(°C)			Temperature(°C)		
	60	80	100	60	80	100
Ahimsa silk	22.38	19.42	20.94	21.04	19.09	18.17
Mulberry silk	19.93	19.17	19.42	18.47	18.80	18.24

Table 3.4: k/s values at different pH

Samples	Red colour			Blue colour		
	pH			pH		
	3	5	7	3	5	7
Ahimsa silk	19.85	16.20	10.39	22.82	14.12	11.53
Mulberry silk	18.78	13.51	9.71	20.02	14.69	13.14

It is clear from table 3.2, 3.3 and 3.4 that in all parameters of dyeing i.e., Time, Temperature and pH where Ahimsa silk fabric showed better k/s result than Mulberry silk fabric, it is clearly seen from the microscopic structure (Figure 3.2) that the Ahimsa silk has loosely woven structure and Mulberry silk has compactly woven structure which has increased the dye absorption in Ahimsa silk fabric as compared to Mulberry silk fabric. Because a more densely woven fabric absorbs color less intensely than a more openly weaved fabric.

Initially the surface of the fibre is dyed when dyes contact with the fibre, then the dyes are entered in the core of fibre. Proper temperature and time is maintained for diffusion and penetration of dyes molecule in the fibres core. During the process, kinetic and thermodynamic reactions interact [Islam, 2012].

4. Summary and conclusion

Traditionally silkworms or silk-producing moths are killed during the collection of their silk cocoons. To eliminate the traditional process, there are few researchers who have developed a new technique for producing silk. It is a method of producing silk that do not result in the death of the insect. One such fabric that supports sustainable environment is Ahimsa silk. Ahimsa Silk is processed from cocoons without killing the pupae inside (Kudligi and Naik, 2015) [4]. Though the different type of Ahimsa Silk is being manufactured with different weaves a comparative study on the morphological and dyeing properties have not been dealt with so far. Therefore, the purpose of this study is to explore the core properties of Ahimsa silk and comparison with their kinds. In morphological study, no significant difference was found between there functional groups but the difference in their microscopic view were seen clearly as ahimsa silk was more loosely woven that compactly woven mulberry silk. Where as in terms of dyeing behavior, ahimsa silk behaved better in all the parameters i.e. time, temperature and pH which in turn increased its k/s value due to is loosely woven structure.

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