



Study of the K/S values, wash, light & rubbing fastnesses, and antimicrobial assessment on modal, cotton and modal / cotton (50: 50) blended dyed fabrics

Jeyakodi Moses, J¹ and Radhika, R²

¹Department of Chemistry and Applied Chemistry, PSG College of Technology, Coimbatore 641 004.

²Department of Costume Design and Fashion, Bishop Appasamy College of Arts and Science, Coimbatore 641 018.

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ABSTRACT

Modal is one of the vital regenerated cellulosic fibres used in textile industries. It contains almost all the properties required for the textile applications. In this paper the physical properties, dyeing effects and antimicrobial characteristics of modal, cotton and modal / cotton (50 : 50 blend) fabrics are studied. Modal fabrics in original and in blended (50 : 50) form with cotton show good properties towards k/s value, wash, light and rubbing fastnesses and also for antimicrobial behavior.

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Introduction

Cotton fibres are generally used in the manufacturing of the varieties of garments^{1,2} of all the types. However, cotton fibre has certain limitations of uniformity in terms of length, strength, lusture and the dyeability. Rayon is a very versatile fibre has the comfort properties as natural fibres particularly cotton. It can imitate the feel and texture of silk, wool, cotton and linen. Rayon is used in the manufacturing of many apparels such as, blouses, dresses, jackets, lingerie, linings, scarves, suits, ties, hats, socks; furnishings such as, bedspreads, blankets, window treatments, upholstery, slipcovers; industrial products such as, medical surgery products³, non-woven products, tire cord, and other use materials such as, yarn, feminine hygiene products, diapers. High Wet Modulus rayon (HWM) is a modified version of viscose that has a greater strength when wet and can be mercerized like cotton. HWM rayons are also known as *polynosic* and has a trade name *modal*. Modal is a biodegradable⁴ fabric made from the spun reconstituted cellulose of Beach trees. Modal fabrics are very soft and smooth with the ability to absorb up to 50% more water than cotton. It dyes like cotton and is color fast when washed in warm water. Modal fabrics resist fading, shrinking and the buildup of hard water mineral deposits even after repeated washing.

With growth in world population and the spread of disease, the number of antibiotic resistant microorganisms is rising along with the occurrence of infections from these microorganisms. To address these growing concerns in the environment, researches are focused on the use of reusable textiles with durable finishes⁵. Hence, the need for antimicrobial textiles goes hand-in-hand with the rise in resistant strains of microorganisms^{6,7}. The present study analyses the physical properties, dyeing effect, fastness properties towards wash, light and rubbing, and antimicrobial effect of modal, cotton, and modal / cotton (50 : 50 blend) fabrics.

Materials and Methods

Materials

The details of the textile fabrics used in this study were as given in the following table (i);

Table (i). Basic textile parameters of modal, cotton and modal/cotton (blend 50 :50) woven and knitted fabrics.

S. No	Textile Material	Woven Fabric					Knitted fabric		
		End s / Inch	Pick s / Inch	GS M	Yarn Count (Ne)		Yarn count (Ne)	GS M	Loop length (mm)
					War p	Wef t			
1	Modal (100%)	84	94	146.1	27.1	26.1	27.5	136.9	2.6
2	Cotton (100%)	94	74	141.0	30.7	28.5	28.9	141.7	2.6
3	Modal / Cotton (50/50 %)	94	77	135.3	31.0	28.7	28.4	141.7	2.6

Natural dyes (kum kum, indigo, bar berry) and synthetic dyes (reactive dye (H) [reactive red HB – C.I. No. Red 24], reactive dye (M) [reactive yellow M4G – C.I. No. Yellow 22] and sulphur dye [sulphur black – C.I. No. sulphur Black 1]) used were in the commercial grade. The chemicals mentioned elsewhere for this study were in AR grade.

Methods

Pretreatment on modal, cotton and modal/cotton (blend 50 :50) woven and knitted fabric

The textile fabrics (woven and knitted) such as modal (100%), cotton (100%) and modal / cotton fabric (blend 50 : 50) were pretreated (scouring and bleaching) as per the established technique^{8,9}.

Dry crease recovery angle of modal, cotton and modal/cotton (blend 50 :50) woven and knitted fabric

Dry crease recovery angle was carried by the Shirley crease recovery tester (AATCC 2003d). A sample of the size 5cm × 2.5cm was cut from both the warp and weft directions. The sample was carefully folded into half, kept between two glass plates and a weight of 907g was placed on the top. After one minute the load was removed and the sample was placed on the fabric clamp in the tester and allowed to recover from creasing. Finally the fabric dry crease recovery angle was read and recorded¹⁰.

Drape coefficient of modal, cotton and modal/cotton (blend 50 :50) woven and knitted fabric

The sample in circular specimen (30cm diameter) was held concentrically between two small horizontal discs and was allowed to drape into folds under its own weight. A light was shone from underneath the specimen and the shadow that the fabric casts was traced on to an annular piece of paper, the same size as the unsupported part of the fabric specimen. To measure the areas involved, the whole paper ring was weighed and then the shadow part of the ring was cut away and weighed. The paper was assumed to have uniform mass per unit area so that the measured mass was proportional to the area.

The fabric was tested in both ways up so that a total of six measurements were made on the same specimen. The drape coefficient¹¹ as percentage (DC) of the samples was calculated using the following formula as per standard BS 5058:1973

$$\text{Drape coefficient (\%)} = \frac{\text{Mass of shaded area}}{\text{Total mass of paper ring}} \times 100$$

Dyeing of modal, cotton and modal/cotton (blend 50:50) woven and knitted fabric

The dyeability of fabrics (woven and knitted) such as modal (100%), cotton (100%) and modal / cotton (50 : 50) was investigated using natural and synthetic dyes. Dyeing was carried out at boil for two hours with a material to liquor ratio of 1:20 as per the established technique of dyeing for natural and synthetic dyes^{12,13,14}. The dyed samples were washed, soaped and dried.

K/S analysis of the dyed modal, cotton and modal/cotton (blend 50 :50) woven and knitted fabric

Colorimetric data of natural and synthetic dyed textile fabrics were determined by AATCC 135-1985 (2003) technique using a Datascolor SF 600 plus spectrophotometer interfaced to a PC¹⁵. Measurements were taken regarding colour presence, brightness, dullness and colour intensity with the specular component of the light excluded and the UV component included using illuminant D65 and 10° standard observer. Each fabric was folded once so as to give two thickness and average of five readings were taken each time.

Color fastness analysis of the modal, cotton and modal/cotton (blend 50 :50) woven and knitted fabric

The natural and synthetic dyed samples were washed¹⁶ under condition IIIA of AATCC Test Method 124-2001 (2003) to determine the color change effect of dyed fabrics. Light fastness tests¹⁷ were carried out according to AATCC Test Method 16 E-1998 (2003). The samples were exposed to 5, 10 AFUs (AATCC Fading Unit) to determine the color change AATCC 16-1998 (2003). AATCC standardized crock meter was used to determine the rubbing fastness¹⁸ of natural dyed fabrics under wet and dry condition to assess the color change and staining property AATCC 61-1996 (2003).

Antimicrobial assessment of the modal, cotton and modal/cotton (blend 50 :50) woven and knitted fabric

The antibacterial activity on the natural dyed (kum kum, indigo and bar berry) and synthetic dyed (reactive dyes (H & M) and sulphur dyes) modal, cotton, modal / cotton (50 : 50 blend) woven and knitted fabrics was assessed¹⁹ qualitatively according to the AATCC test method 147-2004 by the parallel streak method.

Results and Discussion

Physical properties of modal, cotton and modal/cotton (blend 50 :50) woven and knitted fabric

The physical properties of woven fabric such as tensile strength, stiffness, crease recovery angle and drape coefficient and of knitted fabric such as bursting strength and mean drape coefficient for modal, cotton and modal/cotton (50 : 50 blend) fabrics are shown in Table 1. The modal fabric and modal/cotton blend (50:50) show higher values of tensile strength (434.5 N (warp) & 374.6 N (weft) and 409.7 N (warp) & 332.3 N (weft)), stiffness (1.64 cm (warp) & 1.53 cm (weft) and 1.73 cm (warp) & 1.59 cm (weft)), and crease recovery angle (131 (warp) & 133 (weft) and 104 (warp) & 107 (weft)) respectively both in warp and in weft directions compared to that of the cotton fabric. However, the mean drape coefficient (%) of cotton fabric (80.65) is higher than that shown by modal (66.45 %) and modal / cotton (50:50) fabrics (69.73) respectively. Whereas in the case of knitted fabric cotton shows greater values than that shown by modal and modal / cotton (50:50 blend) fabrics for bursting strength and mean drape coefficient respectively.

K/S values of Dyed Modal, Cotton and Modal / Cotton (50 : 50) woven and knitted fabric

The K/S values of the dyes such as kum kum, indigo, bar berry, reactive dyes (H and M) and sulphur dyes applied on modal, cotton, modal / cotton (50 : 50 blend) fabrics are given in Table 2. From this table it is seen that cotton fabric (both woven and knitted) shows maximum k/s value for the dyes such as kum kum, indigo, bar berry, reactive dyes (H & M) and sulphur dye followed by modal / cotton (50 : 50 blend) and modal fabrics respectively. In all these cases the differences in the k/s values are marginal only. The k/s values shown by all the dyed fabrics (modal, cotton, modal / cotton (50 : 50 blend)) are above 12 and hence it is considered as a good dye value suitable for textiles and garments.

Washing fastness of the Dyed Modal, Cotton and Modal / Cotton (50: 50) woven and knitted fabric

The washing fastness of the natural dyed (kum kum, indigo and bar berry) and synthetic dyed (reactive dyes (H & M) and sulphur dyes) modal, cotton, modal / cotton (50: 50 blend) woven and knitted fabrics are given in Table 3. It is evident from this table that modal fabric in its original form and in 50 : 50 blend form with cotton dyed with kum kum, indigo, barberry, reactive dyes (H & M) and sulphur dyes shows maximum wash fastness properties in both woven and knitted categories followed by the cotton fabrics (woven and knitted). However the difference is not significant. The high wash fastness of modal fabric dyed with different dyes is due to the strong reaction between the reactive groups present in both the fibre polymers and the dye structure.

Light fastness of the Dyed Modal, Cotton and Modal / Cotton (50 : 50) woven and knitted fabric

The light fastness of the natural dyed (kum kum, indigo and bar berry) and synthetic dyed (reactive dyes (H & M) and

sulphur dyes) modal, cotton, modal / cotton (50 : 50 blend) woven and knitted fabrics are given in Table 4. From this table, it is seen that the light fastness of synthetic dyes is maximum compared to those of natural dyes applied on both woven and knitted modal, cotton and modal / cotton (50 : 50 blend) fabrics. Similarly, natural dyes also give good light fastness with a maximum for Indigo dyes followed by kum kum and bar berry. In general, the light fastness of all these dyes (kum kum, indigo, bar berry, reactive dyes (H & M) and sulphur dyes) dyed on woven and knitted modal, cotton and modal / cotton (50 : 50 blend) fabrics ranges from moderate (rating 4) to very good (rating 6). The modal fabrics dyed with these dyes show certain increase in the light fastness than that of cotton fabrics. The increase in light fastness for dyed modal fabrics is due to the strong reaction of these dyes with the fibre polymer.

Rubbing fastness of the Dyed Modal, Cotton and Modal / Cotton (50 : 50) woven and knitted fabric

The rubbing fastness both in wet and dry state of the natural dyed (kum kum, indigo and bar berry) and synthetic dyed (reactive dyes (H & M) and sulphur dyes) modal, cotton, modal / cotton (50 : 50 blend) woven and knitted fabrics are given in Table 5. Table 5 shows that the rubbing fastness in dry state is extremely good than that of wet state. Indigo, sulphur dye and reactive dyes show more rubbing fastness than other dyes (kum kum and bar berry) applied on modal, cotton and modal / cotton (50 : 50 blend) woven and knitted fabrics in the dry state whereas in the corresponding wet state, as expected the rubbing fastness is in the poor form. Modal fabrics show an edge over cotton fabrics dyed with natural (kum kum, indigo and bar berry) and synthetic (reactive (H & M) and sulphur) dyes.

Antibacterial assessment of the natural and synthetic dyed Modal, Cotton and Modal / Cotton (50 : 50) woven and knitted fabric

The antimicrobial assessment of the natural dyed (kum kum, indigo and bar berry) and synthetic dyed (reactive dyes (H & M) and sulphur dyes) modal, cotton, modal / cotton (50 : 50 blend) woven and knitted fabrics are given in Table 6. The antimicrobial activity of these samples was assessed by qualitative test method. All these dyed samples showed a higher zone of inhibition against *Staphylococcus aureus* when compared to *Escherichia coli*. In general, the modal fabric shows a higher zone of inhibition (both by *Staphylococcus aureus* and *Escherichia coli*) followed by cotton / modal (50 : 50) fabric and cotton fabric (woven and knitted). The reactive (H) dye shows maximum inhibition followed by reactive (M) dye and sulphur dye in synthetic dye category whereas indigo gives maximum inhibition followed by bar berry and kum dum in the natural dye category on modal, cotton, and modal / cotton (50 : 50) fabrics (woven and knitted) exhibited by *staphylococcus aureus* and *escherichia coli*.

Conclusions

From this research work the following conclusions are arrived;

i) Modal and Modal / Cotton (50 : 50 blend) woven fabrics are good in tensile strength, stiffness and crease recovery angle; whereas cotton woven fabric is good for mean drape coefficient. However among the knitted fabric cotton is good in bursting strength and mean drape coefficient.

ii) The K/S values obtained for the dyes kum kum, indigo, bar berry, reactive dyes (H and M) and sulphur dyes applied on Modal, and Modal / Cotton (50 : 50 blend) woven and knitted

fabric are similar to those obtained on the corresponding cotton fabric.

iii) The wash fastness of dyed modal and modal / cotton (50 : 50 blend) fabrics is good similar to those obtained on cotton fabric.

iv) Similar to wash fastness the light fastness and rub fastness in dry state are good for modal, and modal / cotton (50 : 50 blend) fabric dyed with kum kum, indigo, bar berry, reactive dyes (H and M) and sulphur dyes compared with those obtained on cotton fabric.

v) The antimicrobial character of modal fabric in its original form and its blend with cotton dyed with both natural dye (kum kum, bar berry, and indigo) and synthetic dye (reactive (H & M) and sulphur) is good when compared with the corresponding cotton fabric.

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Table 1. Physical properties of modal, cotton and modal/cotton (blend 50 :50) woven and knitted fabric

S. No.	Textile Material	Woven Fabric						Knitted Fabric				
		Tensile Strength (N)		Stiffness [Bending length cm]		Crease Recovery angle (°)		Mean Drape Coefficient (%)	Bursting strength			Mean drape coefficient (%)
		Wp	Wt	Wp	Wt	Wp	Wt		Test area (cm ²)	(kPa)	Mean height at burst (mm)	
1	Modal (100%)	434.5	374.6	1.64	1.53	131	133	66.45	7.3	499.5	10.3	48.50
2	Cotton (100%)	362	316.5	1.83	1.68	99	100	80.65	7.3	629.1	12.1	63.96
3	Modal / Cotton (50/50%)	409.7	332.3	1.73	1.59	104	107	69.73	7.3	577.7	11.3	56.51

Wp → Warp

Wt → Weft

Table 2. K/S values of Dyed Modal, Cotton and Modal / Cotton (50 : 50) woven and knitted fabric

S.No.	Dyes	Colours obtained	K/S values of the Dyed Fabric					
			Woven			Knitted		
			Modal	Cotton	Modal / Cotton (50 : 50)	Modal	Cotton	Modal / Cotton (50 : 50)
1	Kum kum	Red	12.51	14.50	13.15	12.25	13.70	12.98
2	Indigo	Blue	13.24	14.60	14.30	12.98	14.01	13.45
3	Bar berry	Yellow	12.75	14.54	13.41	12.65	13.95	13.32
4	Reactive Dye (H)	Red	13.95	14.87	14.95	13.62	14.42	14.25
5	Reactive dye (M)	Yellow	13.84	14.84	14.41	13.54	14.30	13.98
6	Sulphur Dye	Black	13.60	14.65	14.32	13.32	14.21	13.65

Table 3. Washing fastness of the Dyed Modal, Cotton and Modal / Cotton (50 : 50) woven and knitted fabric

S.No.	Dyes	Washing fastness of the Dyed Fabric					
		Woven			Knitted		
		Modal	Cotton	Modal / Cotton (50 : 50)	Modal	Cotton	Modal / Cotton (50 : 50)
1	Kum kum	3-4	3-4	3-4	3-4	3-4	3-4
2	Indigo	4	4	4	4	3-4	4
3	Bar berry	3-4	3-4	3-4	3-4	3-4	3-4
4	Reactive Dye (H)	4-5	4	4-5	4-5	4	4-5
5	Reactive dye (M)	4-5	4	4-5	4-5	3-4	4-5
6	Sulphur Dye	4-5	4	4-5	4-5	4	4-5

Table 4. Light fastness of the Dyed Modal, Cotton and Modal / Cotton (50 : 50) woven and knitted fabric

S.No.	Dyes	Light fastness of the Dyed Fabric					
		Woven			Knitted		
		Modal	Cotton	Modal / Cotton (50 : 50)	Modal	Cotton	Modal / Cotton (50 : 50)
1	Kum kum	5	5	5	4-5	4-5	4-5
2	Indigo	5-6	5-6	5-6	5-6	5	5-6
3	Bar berry	4-5	4	4-5	4-5	4	4-5
4	Reactive Dye (H)	6	5-6	6	5-6	5-6	5-6
5	Reactive dye (M)	5-6	5	5-6	5-6	5	5-6
6	Sulphur Dye	6	5-6	5-6	5-6	5-6	5-6