Psyllium as an alternative natural thickener for the printing of wool

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Abstract: *An attempt has been made to study the effect of psyllium as a natural thickener for printing of wool using acid dyes. The optimization of process parameters such as concentration of psyllium and the viscosity of printing paste have been carried out. To draw the comparison, the scoured wool fabric was printed with optimized printing recipe for psyllium and also with conventional thickeners viz. sodium alginate and gaur gum. The effect of different thickeners on the fabric properties were rationalized in terms of colour strength, bending length i.e. stiffness of the fabric and fastness to rubbing, washing as well as water. The optimized psyllium concentration required for printing i.e. 3.5%, has been observed in terms of better yield, soft handle along with good fastness properties at lower cost. As per literature survey, a scanty of work has been reported for psyllium as a thickener for textile application.*

Keywords: *Psyllium, viscosity, acid dye, soft handle, color yield.*

1. Introduction

Natural thickener has been used for printing of natural textile substrates such as wool, cotton, and silk since the development of civilization [1]. With the advent of synthetic thickener in the early 20th century, the use of natural thickener declined to significant extends [2]. With increasing awareness about ill effects of synthetic dyes as well as pigments used for dyeing and printing, the demand for organic products, natural dyed and printed textile materials is increasing day by day [3, 4, 5, 6, 7]. In recent years, the use of synthetic thickeners and modified thickener is under severe criticism for their high water pollution at the manufacturing stage and washing of printed fabric. Synthetic thickener has many advantages over natural such as soft handle of printed fabric, pseudoplastic rheology, high viscosity, consistency in viscosity, high reproducibility, smoother and sharper prints and better colour yield except of few limitations such as the environmental risks due to their non-biodegradable nature, cost and sensitivity to electrolyte [1, 3, 8, 9]. Alternatively natural thickeners proved less hazardous due to their biodegradable nature. The basic requirement for selecting a thickener for print paste includes the compatibility with other print paste additives, good colour yield, ease of preparation, high viscosity at low add on, easily available at low cost, easily removal from printed fabric during washing step and also provide soft handle to fabric [10]. The printing quality primarily depends on the physicochemical properties of the printing paste as well as on the printing process conditions, the fixation process and the washing off of printing paste after fixation [1]. Hardly, any single thickener is capable to meet all requirements under all practical situations. A wide range of natural thickeners available in market such as sodium alginate, guar gum, cellulose, starch etc. is available in the market for printing of textile fabric materials. Sodium alginate and guar gum are most commonly used as thickener in the field of textile printing.

Sodium alginate (natural polysaccharide) is derived from seaweed and widely used thickener for printing with reactive dyes. The hydroxyl groups of other carbohydrate materials are generally capable to react with the dye and give low color yield or unsatisfactory fabric handle, due to insolubilization of the thickener. Sodium alginate contains hydroxyl groups, but the reaction between alginate and dye is limited by mutual anion repulsion of the carboxyl groups of alginate and sulphonic acid groups of dye. The repulsion additionally promotes migration of dye molecules from the thickener into the fabric during steaming [11, 12, 13]. On the other side, when the wool fabric is impregnated with sodium alginate paste and later on printed with acid dyes using ink jet printer, gives good results at a concentration of 6%. It was also studied that concentration of sodium alginate as a thickener has a little effect on color yield [14]. Guar gum (natural polysaccharide) a class of locust bean gum, is an another popular thickener, composed of sugar galactose and mannose. It is also known for its excellent property to produce the print with sharp rich sharpness. Unmodified guar gum has a large number of hydroxyl groups and forms a very complex cross-linking with the reactive dye, which further leads to poor colour yield on the fabric [13, 15, 16].

Psyllium, the seed of Plantago, is widely available throughout the temperate region of the world and has high economic value. The Psyllium seed yields colloidal mucilage consisting mainly of xylose, arabinose, galacturonic, 4-O-methylglucuronic acid, tannins, fatty oils [17]. Psyllium has been extensively recognized for its safe and cholesterol-lowering effects, effective laxative activity, and insulin sensitivity improvement capacity [18, 19] . Hence, it has no negative impact on the environment. Recently, its use as a flocculant for treating textile effluent has been reported [20, 21]. The rheology study of the psyllium at different concentrations, temperature and pH has been studied indicating its elastic properties and being an anionic polysaccharide, bears a negative charge due to ionized carboxyl groups [22]. The psyllium crop may be good alternative of commercial crop in winter season if commercially exploited as thickener for printing in Indian subcontinent.

In the present study, it has been studied that the psyllium can be used as a natural thickener for the printing of wool with acid dyes. The optimization of psyllium concentration for printing paste was carried out and printing properties in terms of viscosity, color yield, fastness properties were compared with conventional thickeners i.e. sodium alginate and gaur gum.

2. Material and Method

2.1 Material

Scoured wool twill fabric, having 66/54 EPI/PPI and 22/42 Nm warp and weft count was locally purchased. The chemicals used were citric acid, urea, sodium chlorate (provided by Merck Specialties Pvt. Ltd.) and Sera Sperse CSN (as a soaping agent) as commercial grade auxiliary is supplied by Dystar India. Supralan Red CG (acid milling), Telon Blue GGL (acid levelling) and Isolan Red 2S-BR (1:2 metal complex) as acid dyes used for printing of wool were also supplied by Dystar India. The powder form of sodium alginate and guar gum were of laboratory grade whereas psyllium husk powder of commercial food grade was supplied by Sidhpur (isabgol processing company), India.

2.2 Methods

2.2.1 Preparation of printing paste

The print paste was prepared by dissolving thickener powder in hot water with continuous stirring using mechanical agitator. The prepared paste was stored for overnight. Another paste was prepared by mixing urea in warm water and cooled to room temperature. To this, required amount of dye and other auxiliaries were added and stirred until a smooth paste was not obtained. Calculated amount, as shown in table 1, of prepared thickener stock paste was added to this dye paste.

Table 1: Printing paste composition for Acid dyes

S. No.	Constituent	Concentration (%)
1	Psyllium/ sodium alginate / Guar Gum	$X^{\#}$/ 5*/ 5*
2	Dye	2
3	Urea	5
4	Citric Acid	3
5	Sodium Chlorate	1.5
6	Water	To make the paste volume 100 gm

 # optimized concentration
**minimum concentration used in conventional process*

2.2.2 Printing of fabric

Print paste was applied to the wool fabric sample using flat screen printing technique. Printed wool fabric sample was dried at 90°C for 5 minutes and then steamed at 102°C for 15 minutes to fix the dye. After that the printed fabric was washed with 2 g/L Sera Sperse CSN at 60°C for 15 minutes to remove unfixed dye and print paste. After soaping and washing, the printed samples were rinsed in warm and then cold water. Finally the fabric was dried at 90°C for 5 minutes.

2.2.3 Viscosity of the print paste

The viscosity of the print paste was measured at shear rate of 12 $(s)^{-1}$ and 25°C using a Brookfield Viscometer, Model RVF. The apparent viscosity (η) was calculated using the following formula as

$$\eta = \frac{\tau}{D} \quad (1)$$

where D and τ are the rate of shear $(s)^{-1}$ and shear stress (dyne/cm^2), respectively [23].

2.2.4 Color Strength Measurement

Datacolor SF 600 reflectance spectrophotometer integrated with computer was used for measurement of colour characteristics in terms of relative colour strengths (K/S values). The colour strength in the visible regionof the spectrum was determined on the basis of Kubelka-Munk equation [7].

$$\frac{K}{S} = \frac{(1-R)^2}{2R} \quad (2)$$

Where K is the absorption coefficient, R is the reflectance of the dyed sample and S is the scattering coefficient.

2.2.5 Fastness Testing

The printed and washed wool fabric were subjected to following fastness tests, fastness to rubbing; AATCC 116 [24]. Colour fastness to washing; AATCC 61 [25]. Colour fastness to water; AATCC 107 [26].

2.2.6 Fabric handle

The fabric handle can be determined by measuring bending length of printed wool fabric using fabric stiffness tester; ASTM (E290-09) [27].

3. Results and Discussion

In this study, an attempt has been carried out to evaluate psyllium as an alternative thickener to sodium alginate and gaur gum in textile printing.

3.1 Viscosity of the print paste

Figure 1 shows the effect of varying concentration of psyllium (0.5 to 5%) on the print paste viscosity. The viscosity of print paste is increased at very slow rate upto 1.5% concentration of psyllium beyond that it is increased at faster rate up to 4 % and finally started levelling off. It was also observed that viscosity at concentration below 2% was very low and might not provide the appropriate viscosity to the printing paste for sharp prints.

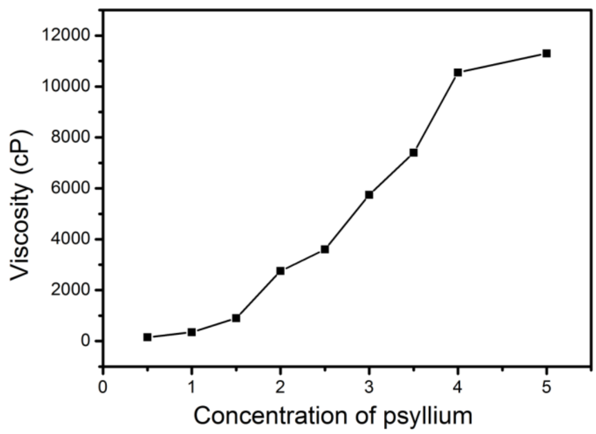

Figure 1: Viscosity of print paste at different concentrations of psyllium (%)

3.2Effect of psyllium concentration on color yield

For the optimization of the psyllium's concentration for print paste, the effect of variation of psyllium concentration on color yield was studied using Supralan Red CG. Figure 2 shows an effect of the colour yield in the terms of K/S at λ_{680} for samples printed with varying concentration of psyllium from 2% to 5%.

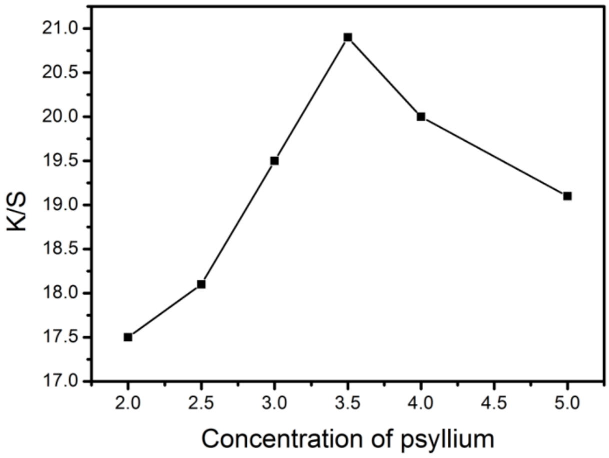

Figure 2: K/S values of printed samples at different concentration of psyllium (%)

The result indicates that with the increase in the psyllium concentration, K/S values increased up to the concentration of 3.5% beyond that K/S values decreased with further increase in concentration of thickener i.e. (K/S values of 17.51 at 2%, 18.14 at 2.5%, 19.52 at 3%, 20.96 at 3.5%, 20.12 at 4% and 19.15 at 5%.). This may be attributed to the higher paste viscosity leads to poor transfer of the colour yield on the fabric. The K/S values of samples printed with sodium alginate were found lower than the K/S values of samples printed with psyllium at all concentrations. The sample printed with guar gum, shows comparative similar colour yield to samples printed with psyllium at different concentrations but psyllium's concentration but the less concentration of psyllium has been used when it was compared with the concentration used for guar gum. The optimum psyllium concentration for printing is 3.5%.

3.3 Bending Length

Figure 3 shows the results for bending length of the samples printed with varying concentration of psyllium from 2% to 5%.

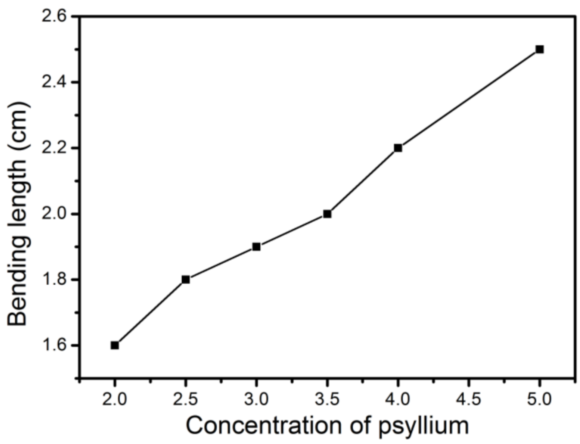

Figure 3: Bending length at different concentration of psyllium (%)

The bending length of the samples is increased with the increase in the concentration of thickener having a least value of 1.6 cm at 2% and highest value of 2.5 cm at 5%. It may be attribute due to increase in the concentration of the Psyllium husk on printed fabric leads to decrease in the softness of the fabric. Bending length of the samples printed with conventional thickener like sodium alginate and guar gum was found to be 2.6 cm and 2.4 cm respectively and found comparatively higher than the sample printed with psyllium which concludes that new thickener provides softer hand feel to printed fabric than conventional thickeners. This may be attributed to the low concentration usage of psylliumfor wool fabric printing.

3.4 Fastness Properties

The rubbing, washing and water fastness of the samples printed with psyllium concentration at 3.5% and others with conventional thickeners were shown in Table 2.The fastness properties in terms of rubbing, washing and water were found to be comparable for the samples printed with all thickeners.

Table 2: Fastness properties of the printed samples

S. No.	Thickener used	Concentration (%)	Rubbing Fastness		Washing Fastness		Water Fastness	
			Dry	Wet	C/C	C/S	C/C	C/S
1	Psyllium	3.5	4	2/3	2/3	4	3	4
2	Sodium Alginate	5	4	2/3	3	4	3	4
3	Guar Gum	5	4	2/3	3	4	3	4

3.5 Printing with Telon Blue GGL and Isolan Red 2S-BR

For the confirmation of the above results and effect on the acid dye class, samples were printed with 2 other commercial classes of acid dyes i.e. Telon Blue GGL (acid levelling) and Isolan Red 2S-BR (1:2 metal complex). Table 3 shows the results of K/S values, bending length, rubbing, washing and water fastness of the samples printed with acid dyes at the optimized concentration i.e. 3.5% of psyllium and conventional concentration of sodium alginate and guar gum.

Table 3: Effect of other classes ofacid dyes on the K/S, bending length and fastness properties

			Bending length	Rubbing fastness		Washing fastness		Water Fastness	
Dyes	Thickener	K/S	(cm)	Dry	Wet	C/C	C/S	C/C	C/S
Telon Blue GGL	Psyllium	18.54	1.9	4	2/3	2/3	4	3	4
	Sodium Alginate	9.35	2.6	4	2/3	3	4	3	4
	Guar Gum	18.23	2.3	4	2/3	3	4	3	4
Isolan Red 2S-BR	Psyllium	20.23	1.9	4	2/3	2	3/4	3	4
	Sodium Alginate	11.37	2.7	3/4	2/3	2/3	3/4	3	4
	Guar Gum	20.51	2.4	4	2/3	2	3/4	3	4

It was observed that the colour yield and bending length of the sample printed with psyllium were found comparable to sample printed with guar gum but they are showing higher K/S and softer hand-feel for those samples which were printed with sodium alginate. The fastness properties in terms of rubbing, washing and water fastness were found as good as for all 3 thickeners with respect to both dyes lead to conclude that psyllium as a thickener can be used with all acid dye classes without any problem.

3.6 Cost comparison

Table 4 shows the comparison of cost of the print paste prepared with Psyllium and commercial grade thickeners.

Table 4: Cost comparison of thickeners for per kg print paste

S. No.	Thickeners used	Cost of thickeners per Kg (₹)	Optimum amount of thickeners used (%)	Cost of thickeners for per kg paste (₹)
1	Psyllium	350	3.5	12.25
2	Sodium Alginate	290	5	14.50
3	Gaur Gum	100	5	5.00

Pysllium as a thickener was cheaper than sodium alginate with better thickener properties. Although, the use of synthetic thickeners provides good quality prints at low cost in comparison to natural Psyllium thickener, but Psyllium also performed well with acceptable properties of color yield and fastness for the printing of wool with acid dyes

4. Conclusion

The optimum concentration used for psyllium as a thickener for the flat bed screen printing is 3.5% which provides good results in terms of colour strength, soft handle as compared to sample printed with 5% of either sodium alginate or guar gum. Fastness properties in terms of rubbing, washing and water were found comparable for the sample printed with all the three thickeners. Psyllium as a thickener can be used for the all sub classes of acid dyes as it does not show any interaction and can provide substitute for the guar gum.

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