

Xanthan Gum by *Xanthomonas Campestris* as Printing Thickener on Cotton Fabrics with Reactive Dyes

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Abstract. Xanthan gum is one of the natural extracellular polysaccharide, which is produced by the bacterium *Xanthomonas campestris* and by other species of *Xanthomonas*, with good rheological characteristics, is used as thickener for textile printing process. In this study, xanthan gum (produce by *X. campestris* using tofu dregs as its carbon source) was used as a printing thickener on cotton fabrics and its performance comparison with commercial xanthan gum and sodium alginate was presented. Printing characteristics were evaluated by measuring K/S value, the stiffness of fabrics and color fastness properties to rubbing, washing, sweat, and sunlight according to SNI ISO 105-C06-2010. The results showed that xanthan gum produced from tofu dregs bio-conversion has a good performance to overall color fastness properties when used as a thickener on cotton fabrics with reactive dyes. Color fastness to dry give a value of 4-5 and wet rubbing of 3-4, higher than commercial xanthan gum and alginate that give value of 3 and 3-4. Color fastness to washing (value of color stains) gives a value of 4-5, higher than the commercial xanthan gum that give a value of 4 and similar with sodium alginate. A similar result was found that xanthan gum from tofu dregs has a higher performance of K/S with a value of 11.949 compared to its commercial counterpart that gives a value of 4.476. The stiffness of cotton fabrics using xanthan gum produced from tofu dregs was higher than commercial xanthan gum in the textile printing process with reactive dyes. Xanthan gum from tofu dregs has good performance for application in the textile printing process with reactive dyes.

Keywords: Color Fastness, Stiffness, K/S, Cotton, Printing, Reactive Dyes.

1 Introduction

Textile fabric printing is the process of applying colors to a textile fabric in the intended design and pattern. A thick paste of dye is used in printing to prevent the color from spreading to undesired area by capillary effect; therefore the role of a thickener is important to this process. Textile printing pastes are usually used to transfer dyes or pigments onto a textile material in a controlled way [1]. Printing pastes are usually prepared by solubilizing thickening agents in water with good screen-ability and a uniform penetrability into the fabrics [2]. Thickening agents are very important in the formulation of printing pastes, and must be compatible with other additives[3].

In the textile industries, the majority of printed materials is cotton fabrics and is generally colored with reactive dyes. A successful print depend on the type of thickener used, ensured through the modulation sharpness of mark, good hand, clean drawing pattern, rheological

properties, preventing dye migration, also a homogenous distribution of the printing paste on the screen and its uniform flow through the screen openings [3][4]. Sodium alginate and guar gum are commonly used as thickener for cotton printing [4][5]. Polysaccharides and its derivatives with high molecular weight are widely used in textile applications for sizing, textile coating and finishing agents, also in textile printing as a thickener. Selection of thickener determined by the type of fabric to be printed, the printing conditions, the type of dye used. Depending on the chemical structure, dyes may interact with thickening agents. Alginates and xanthan gum are excellent thickeners for printing application, because they are non-reactive with hydrodynamic thickener and can impart high viscosities at low concentration. Xanthan gum is one of the natural extracellular polysaccharide, which is produced by the bacterium *Xanthomonas campestris* and by other species of *Xanthomonas*, with good rheological characteristics such as a high degree of pseudoplasticity, a high viscosity even at low concentration, stability and compatibility with most metallic salts, excellent solubility and stability in acidic and alkaline solutions, can be substituting sodium alginate [6]. Color fastness to wash, color fastness to rubbing, color fastness to sweat, color fastness to sunlight, sharpness, handling, are importance properties for printing.

The important materials for the formulation of printing paste are the colorant and the thickener system. Different fibers have an affinity to different dyes e.g. reactive dyes are usually used for printing on cellulosic fabrics, while disperse dyes are commonly used to color synthetic fibers such as polyester. In the printing textile process, natural thickeners such as sodium alginate (SA) are commonly used and excellent for printing application. SA has good properties, high viscosities at low concentrations and good rheology.

The purpose of this work was to study the use of xanthan gum produced by *Xanthomonas campestris* using tofu dregs as its carbon source and used as a printing thickener on cotton fabrics.

2 Experimental

2.1 Chemicals

Chemicals used in this work are both AR (analytical reagent) and LR (laboratory reagent) grade purchased from Merck, Sigma-Aldrich, and Brataco Chemica. *Xanthomonas campestris* was obtained from environmental laboratory culture collection of biotechnology and bioscience research center, Institut Teknologi Bandung.

2.2 Preparation of the printing paste and printing process

Thickening agent preparation: Thickening agent was prepared by using xanthan gum tofu dregs, xanthan gum commercial and sodium alginate 5% w/v respectively. The dispersion mixture was stirred following by adding the water until a thick emulsion was formed.

Printing paste preparation: The printing paste for reactive dyes printing on cotton fabrics was prepared using the following composition (**Table 1**). All ingredients are thoroughly mixed

using an electric stirrer until they become a paste. Add enough deionized water to form a paste weighing 1 kg.

Printing procedure: Cotton was printed using the flat hand screen technique. The print paste was spread across the screen and squeezed by a squeegee for passing the paste through the screen. Printed samples were dried at 100 °C for 2 min and fixed by superheated steam at 180 °C for 1 min. Printing samples were rinsed with cold water for 15 min and then hot water for 15 min at 80 °C, followed by soaping agent 2 ml/l, then rinsed well and air dried at room temperature [7].

Table 1. Composition of the printing paste in 1 kg

Material	Unit	Value
Thickening agent	g	700
Urea	g	20
Resist salt	g	1
Reactive dyes	g	30
Sodium carbonate	g	2
Deionized water	g	247

Color value: The printed samples were assessed for the depth of color strength and Fastness properties. The color strength (K/S) value was evaluated using a spectrophotometer. The K/S is a function of color depth and calculated by the Kubelka-Munk equation [8][9]:

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

Where R is the reflectance at complete opacity, K is the absorption coefficient, and S is the scattering coefficient.

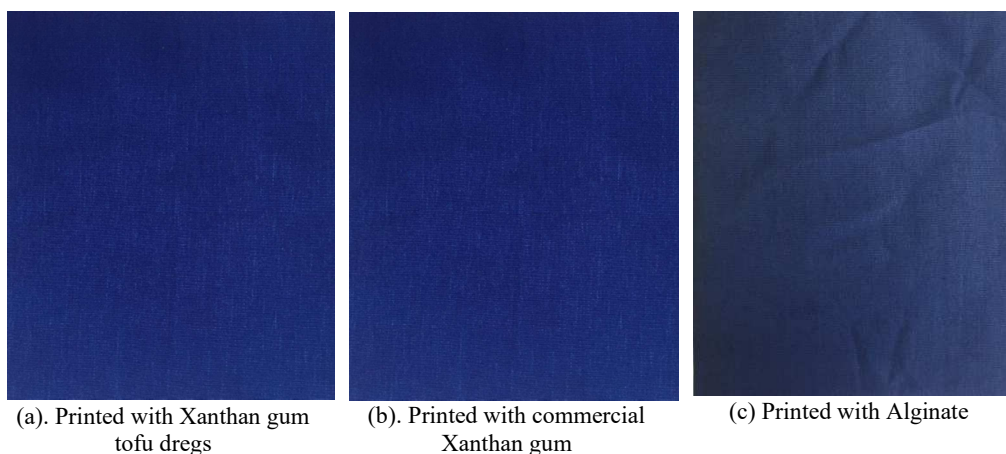
Fastness testing: Color fastness properties for rubbing fastness, washing fastness, sweat fastness, and sunlight fastness of the dyed samples were evaluated according to SNI ISO 105-X12:2012, SNI ISO 105-C06:2010, SNI ISO 105-E04:2010, SNI ISO 105-B01:2010, respectively [[10],[11],[12],[13]].

3 Result and discussion

Color Value: A study on reactive printing with three different of thickening agent (xanthan gum tofu dregs, commercial xanthan gum, sodium alginate) was carried out. The effect of different thickeners on color value has been shown in **Table 2**. K/S value of samples printed with xanthan gum (tofu dregs), commercial xanthan gum and sodium alginate are 11.946; 3.894; and 5.844, respectively. Xanthan gum (tofu dregs) was the best printed result, and the next good results were observed for sodium alginate and commercial xanthan gum, respectively. The higher the K/S value are the better, that mean the depth of color of the printed sample (**Fig. 1**).

Table 2. Color value of printed cotton fabric using different of thickening agent

Thickening Agent	Area	K/S	L*	a*	b*	ΔE	Handling	Sharpness level
Xanthan gum (tofu dregs)	Up	11.946	37.73	6.47	-40.39		Very Good	Very Good
Commercial xanthan gum	Up	3.894	47.42	6.15	-35.85	6.36 (high)	Good	Good
Sodium alginate	Up	5.844	36.60	6.59	-23.83	7.72 (high)	Good	Good

**Fig.1.** Cotton fabrics printed by thickeners**Table 3.** Color fastness of printed cotton fabric using different of thickening agent

Color Fastness	Thickening Agent				
	Xanthan gum (tofu dregs)	Commercial xanthan gum	Sodium alginate		
Rubbing (SNI ISO 105-X12: 2012)	Wet	3-4	3	3-4	
	Dry	4-5	4-5	4-5	
Washing (SNI ISO 105-C06: 2010)	Change of color	4-5	4	4-5	
	Stain of color	4-5	3	4-5	
	Change of color	Acid	4-5	4	4-5
Sweat (SNI ISO 105-E04 : 2010)	Base	4-5	4	4-5	
	Stain of color	Acid	3-4	4-5	4-5
	Base	4	4-5	4-5	
Sunlight (SNI ISO 105-B01: 2010)		4-5	3-4	4	

Where, 1= very poor; 2 = poor; 3 = Good; 4 = very good; and 5 = excellent

Printed results using xanthan gum (tofu dregs) also shows a good handling properties and sharpness level, as shown in **Table 2** and **Figure 1**. The study results, showed that the depth of the color (K/S value), xanthan gum tofu dregs was the 11.946; 5.844; and 3.894, respectively. The handling properties and sharpness level of xanthan gum (tofu dregs) give the best printed result compared with sodium alginate and its commercial counterpart. Fastness properties analysis of washing, rubbing, sweat and sunlight fastness of printed cotton fabrics using

thickeners from xanthan gum (tofu dregs), sodium alginate and xanthan gum commercial as thickening agents are presented in **Table 3**. The washing fastness rating of printed cotton fabrics with xanthan gum (tofu dregs) is very good, similar result to sodium alginate thickener (4-5).

The shift to an era of more environmentally friendly products has encouraged the industry to create eco-green products with low environmental impact. The use of natural and/or bio-based material such as fibres (coffee ground, banana, hemp, lotus, pineapple, etc); bio-surfactant; bio-detergent; oleochemicals; natural dyes; and other bio-based materials draws much attention worldwide to date [[14],[15],[16]].

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