ELSEVIER

Dyes and Pigments 47 (2000) 269–275

DYES and PIGMENTS

www.elsevier.com/locate/dyepig

Printing properties of a high substituted guar gum and its mixture with alginate

Sonja Šostar Turk [a,*], Reinhold Schneider [b]

[a] *University of Maribor, Faculty of Mechanical Engineering, Institute for Textile Chemistry, Ecology and Colour Science, Smetanova ul. 17, PO Box 224, SL-2000 Maribor, Slovenia*

[b] *Institute of Textile Chemistry of the German Institutes for Textile and Fibre Research Stuttgart, Korschalstr. 26, 73770 Denkendorf, Germany*

Received 7 June 2000; received in revised form 27 June 2000; accepted 19 July 2000

Abstract

Highly substituted guar gum can be used in the printing of cotton with bifunctional reactive dyes as an alternative to alginate. In this work, a bifunctional reactive dye and blends of substituted guar gum and alginate were used. The rheological, technological and colorimetric parameters of the mixed printing pastes were studied and compared with those of alginate printing pastes. © 2000 Elsevier Science Ltd. All rights reserved.

Keywords: Textile printing; Guar gum; Alginate; Rheology; Colorimetry; Fabric stiffness

1. Introduction

In the textile industry more than 70% of all printed substrates are cellulosic fabrics. The most important printing method after pigment printing is that with reactive dyes. The consumption of reactive dyes continues to increase, since these dyes produce brilliant shades of very good fastness and levelling properties on cellulosic fibres.

At present, sodium alginates are the most widely used thickeners in reactive dye printing. Alginates are chain-forming heteropolysaccarides made up of blocks of mannuronic acid and guluronic acid; their use in printing with reactive dyes represents the largest application for these polymers. Alginates offer the printer several advantages: they wash out easily and cause no fabric stiffness. However, the fluctuation in the price and quality of the products are a major deficiency of these polymers which affects the development and use of alternative thickeners such as guar gums [1]. The world market for guar gum is estimated to be around 150 000 ton/year and around 70% of guar gum is produced in India and Pakistan. In recent years, seed production in these countries has become extensive and an excess of the product has driven prices down [2].

The gum obtained from the guar plant is a natural high molecular weight hydrocolloidal

* Corresponding author. Tel.: +386-2220-7894; fax: +386-2220-7990.

E-mail address: sonja.sostar@uni-mb.si (S. Šostar Turk).

PII: S0143-7208(00)00055-3

polysaccharide composed of galactan and mannan units combined throughout glycoside linkages, and which may be described chemically as a galactomannan [2]. It is the most commonly used natural gum because of its cost effective, thickening effect. Unmodified guar gum has a large number of hydroxyl groups and can undergo crosslinking with bifunctional reactive dyes. It is well known that the combination of low substituted guar gums with bifunctional reactive dyes causes fabric stiffness [3,4], whereas printing with most monofunctional vinylsulphone reactive dyes in conjunction with guar gums results in excellent printing quality and good fabric handle [3–5]. Moreover, the modification of natural polysaccharides results in new paste properties for broader applications [1]. For this reason, it was decided to assess blends of highly substituted (carboxymethylised with DS = 1.4) guar gum and alginates in the printing of cellulosic fibres with bifunctional vinylsulphone dyes. The rheological, technological and colorimetric parameters of the guar gum thickeners have been studied and compared with those of alginate thickeners.

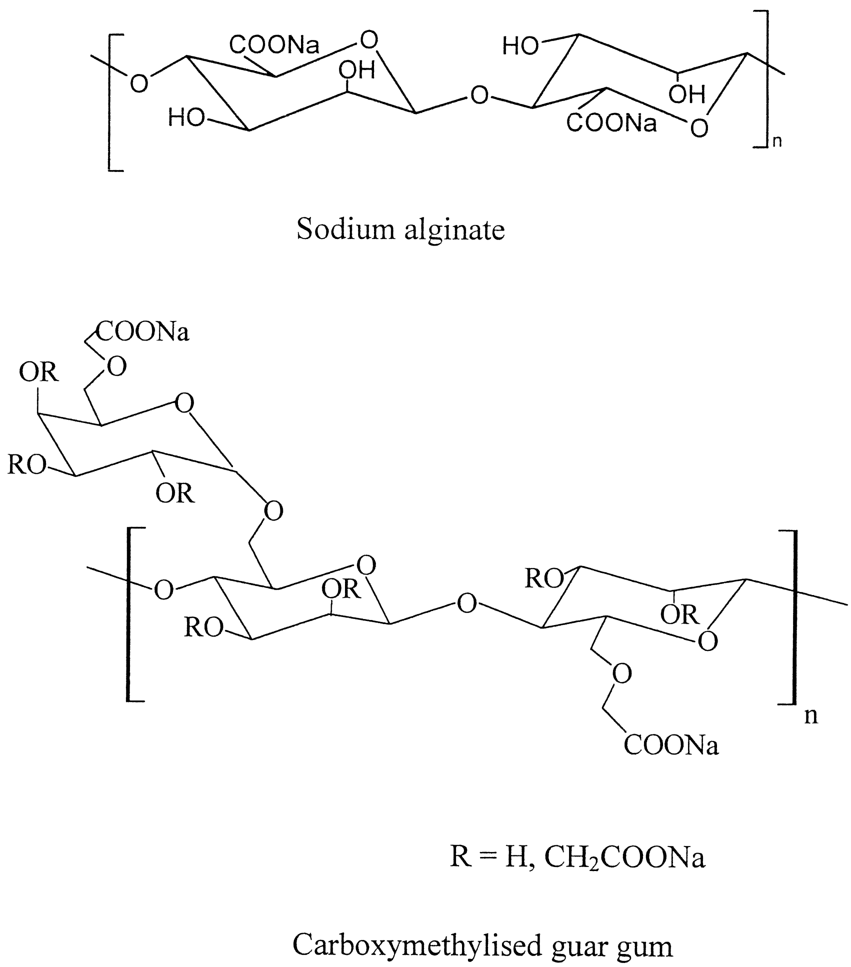


Fig. 1. The structure of thickeners.

2. Experimental

2.1. Materials

The thickeners used were sodium alginate and carboxymethyl guar gum (Fig. 1) [1,3,4]. The sodium alginate used in this study was obtained from CHT R. Beitlich, and the substituted guar gum with DS = 1.4 was produced by Meyhall AG. The substitution levels and the amounts of used thickeners are given in Table 1. The dye used was the bifunctional vinylsulphone dye C.I. Reactive Black 5 (Fig. 2).

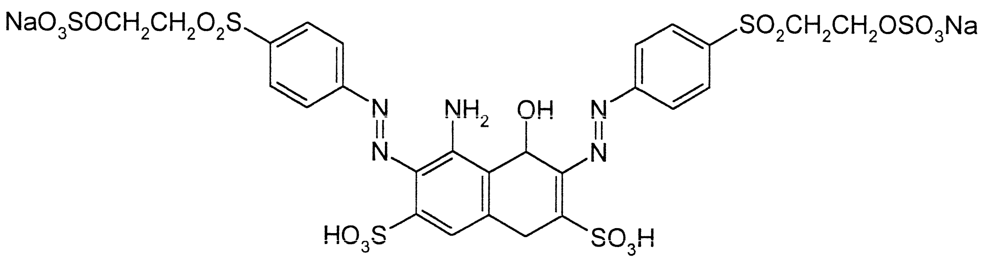
All experiments were performed on woven viscose fabric (warp: 59% viscose filament 133 dtexf30 with 46 threats/cm, weft: 41% viscoseyarn 20 tex with 21 threats/cm, fabric mass 111.5 g m^{-2}).

2.2. Preparation of the printing paste and the printing process

The thickener and demineralised water were well stirred in a mixer and left in a refrigerator overnight to attain full swelling. The blends were prepared by mixing the stock pastes according to Table 1. To prepare the printing paste, 50 g kg^{-1} dye and 25 g kg^{-1} of $NaCHO_3$ were added to each thickener mixture and the resulting mixture stirred for another 15 min. At a shear rate of $\dot{\gamma} = 8.2\ l\ s^{-1}$ all printing pastes were adjusted to a viscosity in the range of 5–10 Pa s. A flat screen printing technique on a Zimmer laboratory printing machine (Type MDF-R-273) was used to apply the paste to the viscose fabric. A squeegee diameter of 15 mm and a printing speed of 5 m min^{-1} at a pressure of grade 6 were used.

Table 1
The thickeners and the mixture of thickeners used

Thickener	Substitution level	Ratio	Abbreviation	Amount of thickener (g/kg printing paste)
Sodium alginate	0	–	ALMV	38.4
Substituted guar gum	1.4	–	CMG	91.0
Substituted guar gum:sodium alginate	–	90:10	CMAL9	91.1
Substituted guar gum:sodium alginate	-	80:20	CMAL8	85.7
Substituted guar gum:sodium alginate	–	70:30	CMAL7	79.3
Substituted guar gum:sodium alginate	–	60:40	CMAL6	73.0
Substituted guar gum:sodium alginate	–	50:50	CMAL5	67.1



C.I. Reactive Black 5

Fig. 2. The structure of dye.

2.3. Methods

A Rheolab MC 100 rheometer (Physica) equipped with a MK 25 cone and plate measuring system was used to undertake the rheological measurements. Dynamic viscosity was determined by rotary measurements and viscoelasticity of the pastes was measured using the oscillatory shear test in the linear viscoelastic range. The extent of dye penetration and the colour strength (K/S) of the printed fabric were determined from reflectance measurements using a Spectraflash SF 600+ (Datacolor) spectrophotometer. The stiffness of the washed and conditioned printed samples was measured using a Frank bending rigidity apparatus according to DIN 53212. The colour fastness of the prints to washing was determined according to DIN 54002 and the dry and wet rubbing fastness of the prints was determined according to DIN 54021.

3. Results and discussion

3.1. Rheological properties of thickeners

The print properties of printing pastes mostly depend on the rheological and physical–chemical properties of the printing pastes. These properties (viscosity and viscoelasticity) are closely related to the chemical structure of the thickener, its concentration and interaction with other components [1,4]. Fig. 3 clearly shows that a strong decrease in viscosity occurred with increasing shear rate for the substituted guar gum. While such pseudoplastic or shear thinning behaviour is typical for all printing pastes, it is marked for guar gum pastes. Alginates are less shear thinning [1,4] and are more Newtonian than guar gum. The shear sensitivity of printing pastes prepared from guar gum and alginate varies depending on the ratio of the two components; higher amounts of alginate in the mixture reduce the pseudoplastic behaviour of the printing pastes.

The amount of alginate has also a strong influence on the viscoelastic properties of the printing paste (Fig. 4). The viscoelastic character of the various pastes is expressed as the loss factor tan δ which represents the ratio of the loss modulus to the storage modulus. The elasticity of guar pastes, which possess a low loss factor, influences printing quality significantly [6–12]. In the case of pure alginate thickener, the shape of the curve in Fig. 4 is the same as that for the alginate mixtures and for guar gum, but the curve is displaced to higher tan δ values above. This means that the viscous modulus is greater than the elastic modulus and, therefore, that the viscous component prevails in the case of alginate. In the case of pure guar gum, it is evident from Fig. 4 that the elastic component

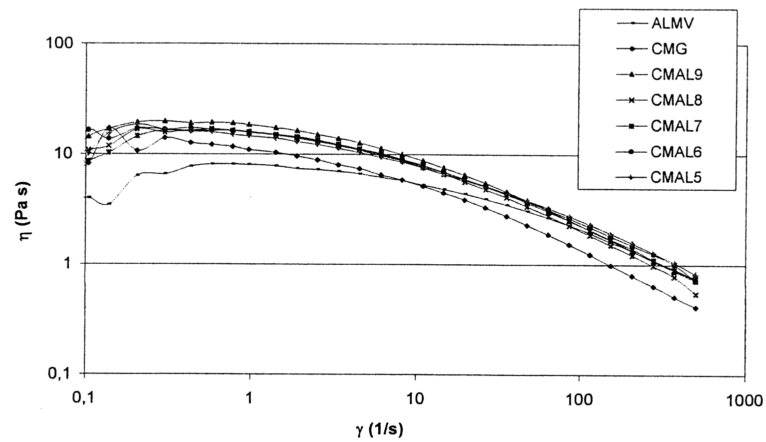


Fig. 3. The influence of the thickeners on the viscosity curve of printing paste with the reactive dye C.I. Reactive Black 5.

dominates. Blends of guar gum and alginate show intermediate behaviour for which an increase in alginate component reduces the elastic properties of the pastes.

3.2. The extent of penetration and colour strength

Viscoelasticity and shear sensitivity influence paste add-on, penetration and colour strength. As shown in Fig. 5, both paste add-on and the extent of penetration strongly depend on the amount of alginate in the printing paste. Paste add-on as well as penetration of the guar paste was very low compared to pure alginate, which can be attributed to the elastic behaviour of the printing paste (low loss factor). Paste add-on, extent of penetration as well as colour strength each increase with increasing amount of alginate in the paste, since the system becomes more Newtonian with increased viscous modulus. Print, pastes with a high loss factor and Newtonian-like characteristics result in favourable printing qualities [1,4,6,7,13].

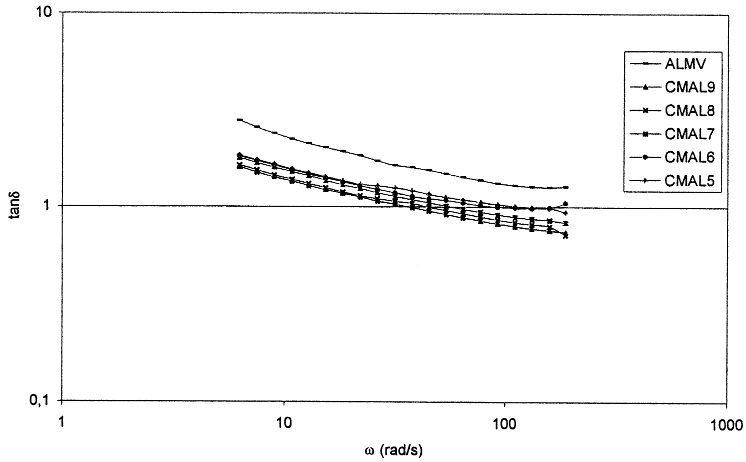


Fig. 4. The influence of the thickeners on the loss factor tan δ depending on the angular frequency of the used printing paste with the reactive dye C.I. Reactive Black 5.

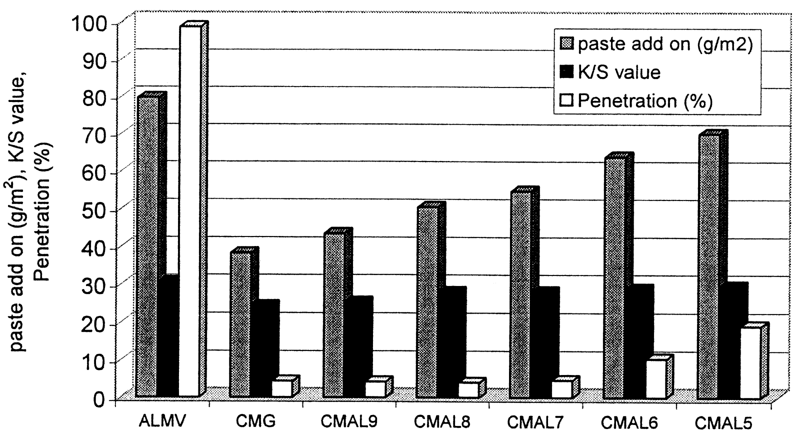


Fig. 5. The relations between paste add on, K/S value and penetration.

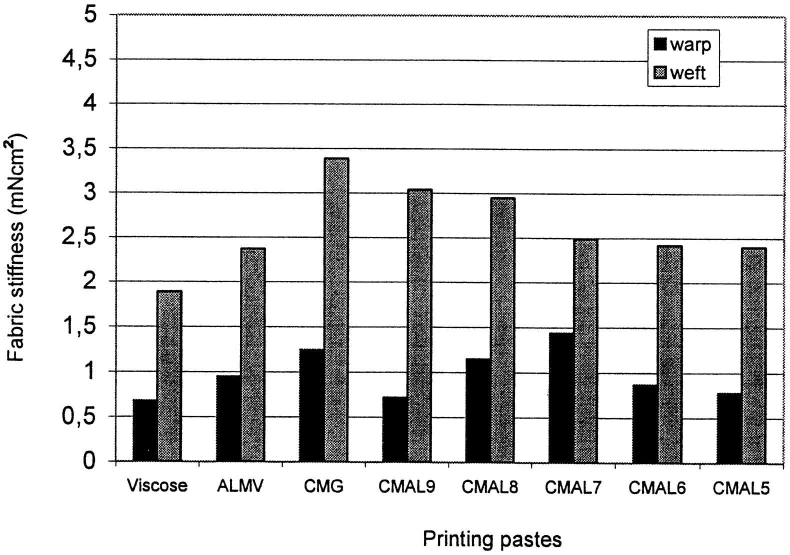


Fig. 6. The influence of the thickener on fabric stiffness of viscose.

Table 2
Colour fastness to washing at 60°C

Sample	Change in colour of sample	Change in colour of adjacent material	
		Viscose	Wool
ALMV	4–5	5	4
CMG	5	5	4
CMAL9	4–5	5	4
CMAL8	5	5	4
CMAL7	4–5	5	4
CMAL6	4–5	5	4
CMAL5	4–5	5	4

3.3. Determination of fabric stiffness

The structure and reactivity of the dye has a major impact on fabric stiffness [5]. While no crosslinking can take place with monofunctional VS reactive dyes, which have only one reactive centre, reactive dyes with two centres may increase fabric stiffness in reactive printing [3,4], since they can act as a bridge between fabrics and thickening agents. As shown in Fig. 6, printing with the bifunctional reactive dye caused a small increase in fabric stiffness, even when alginate was used as the thickening agent. Guar pastes yielded higher stiffness values than pure alginate pastes whilst mixtures showed intermediate behaviour. The increase of fabric stiffness is a consequence of the remaining thickener, which is due to the higher reactivity of substituted guar gums compared to alginates. It can be concluded from Fig. 6 that highly substituted guar gum, as well as its mixture with alginate, can be used for reactive printing since fabric stiffness values are comparable to that of prints with alginate.

3.4. Colour fastness

One of the most interesting properties for quality printing in terms of serviceability is colour fastness, which is also a measure of the stability of the dye–fibre system. The results of relevant tests are presented in Tables 2 and 3, from which it is evident that the fastness of prints obtained using guar gum was comparable to that activated for prints using alginate.

Table 3
Colour fastness to wet and dry rubbing

Sample	Dry rubbing				Wet rubbing			
	Warp		Weft		Warp		Weft	
	Sample	Cotton	Sample	Cotton	Sample	Cotton	Sample	Cotton
ALMV	5	5	5	5	4	3	4–5	3
CMG	5	5	5	5	4–5	3	4–5	3
CMAL9	5	5	5	5	4–5	3	4–5	3
CMAL8	5	5	5	5	4–5	3	4–5	3
CMAL7	5	5	5	5	4–5	3	4–5	3
CMAL6	5	5	5	4	4–5	3	4–5	3
CMAL5	5	5	5	4	5	2	4–5	3

4. Conclusion

Substituted guar gum represents a very attractive thickener for printing with bifunctional reactive dyes. Printing pastes made of highly substituted guar gums possess pseudoplastic rheological behaviour and display lower paste add-on and penetration than alginate pastes. The addition of alginate to guar gum paste reduces the pseudoplasticity and elasticity of the paste, which results in improved paste add-on and penetration. Mixtures of highly substituted guar gum and alginate can be used in reactive printing and afford prints of high colour strength and good fastness.

References

[1] Šostar Turk S, Schneider R. Guar gum as an environment-friendly alternative thickener in printing with reactive dyes. Dyes and Pigments 1998;39:211–21.

[2] Whistler RL, BeMiller JN. Industrial gums, polysaccharides and their derivates. Academic Press, INC1993.

[3] Šostar Turk S, Schneider R. A study of fabric stiffness with guar gum in reactive printing. Dyes and Pigments 1999;41:167–75.

[4] Šostar Turk S. Guar substitute as an alternative environment-friendly thickener for viscose printing using reactive dyes. PhD thesis, University of Maribor, 1995.

[5] Kokol V. The consequences of interactions between the guar thickener and different types of reactive dyes. Master's work, University of Maribor, 1998.

[6] Herlinger H, Schulz G, Erzinger U. Rheologische Charakterisierung und Qualitätsbeurteilung von Druckpasten und Verdickungen. Textil Praxis International 1987;10:1231.

[7] Erzinger U. Rheologie und Konturenschärfe im Textildruck mit Polymerisatverdickungsmitteln, Stuttgart Universität, Dissertation, 1987.

[8] Lederer K, Schurz J, Königchofer F. Die Auswertung von Anlaufmessungen bei Newtonschen und elastoviskosen Flüssigkeiten. Rheologica Acta 1969;8(4):234–43.

[9] Elbert H, Fuss F, Heald T, Kropf R, Schultheiss I, Varvig Jetal. Measurement of the viscosity of liquid textile dyes. JSDC 1989;2(105):84–90.

[10] Heinz W. Zur Messung visko-elastischer Stoffeigenschaften mit einem Rotations-viskosimeter. Materialprüf 1960;2(9):345–51.

[11] Schurz J. Physikalische Chemie der Hochpolymere. Heidelberg: Springer Verlag, 1974.

[12] Wielinga WC. Guarprodukte als Verdickungsmittel für den Textildruck II. Methanol Textlberichte 1986;1:111–125

[13] Schneider R, Belz C, Šostar Turk S, Oppermann W. Die drucktechnischen Eigenschaften syntetischer und modifizierter natürlicher Verdickungsmittel beim Reaktivdruck. Textilveredlung 1995;30(3/4):60–4.