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Color Character in Natural Indigo Dyeing: the Effect of Reducing Agent

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1. INTRODUCTION

Natural indigo, the oldest of the blue dyes, has been used worldwide. Because it is insoluble in water, it should be converted into a water-soluble form for dyeing. Suitable reducing agent with some alkali has been used for conversion[1]. In this study, the effect of reducing agent for natural indigo dyeing onto ramie and silk fabrics was investigated in terms of dye uptake and color character.

2. EXPERIMENTAL

Materials

The fabrics used were a scoured and bleached 100% silk and ramie. Natural indigo dye was prepared from *Polygonum tinctorium*, cultivated in Naju. All the chemicals used were of reagent grade.

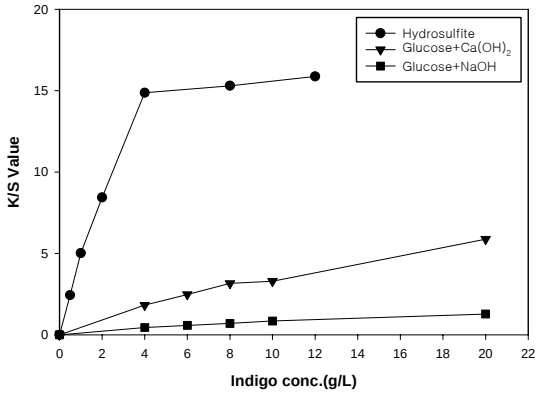
Dyeing

Reduction and dyeing was carried out in one-step process by using an automatic laboratory dyeing machine(Ahiba Nuance, Data Color International, USA). Reduction/dyeing conditions used were as follows.

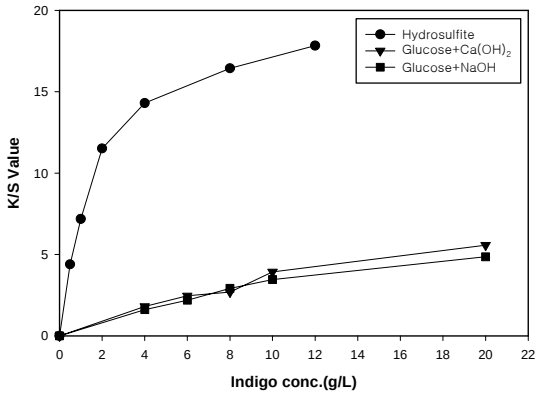
- hydrosulfite system: hydrosulfite 3g/L, 60℃, 30min
- glucose/$Ca(OH)_2$ system: glucose 10g/L, $Ca(OH)_2$ 6g/L, 60℃, 50min
- glucose/NaOH system: Glucose 10g/L, NaOH 6g/L, 60℃, 50min
- traditional fermentation system: niram/lye (1:10 ratio, pH11.0), 20℃, 30min

3. RESULTS AND DISCUSSION

Fig. 1 shows the effect of reducing agents on the dye uptake of ramie and silk fabrics. The dye uptake of ramie and silk fabrics was increased progressively with indigo concentration. Hydrosulfite was much more effective than glucose for both ramie and silk fabrics, resulting in much higher dye uptake. For silk dyeing with glucose system, $Ca(OH)_2$ provided better dye uptake than NaOH. Silk showed very low dye uptake with NaOH. On the other hand, ramie was not affected by alkali type. On the basis of results, it was found that the glucose system, although it is eco-friendly, has limitation in getting high color strength. Further research is needed for more effective process.



(a) silk



(b) ramie

Fig. 1. Effect of reducing agents on the dye uptake: (a) silk, (b) ramie.

Fig. 2 shows Hue, Value, and Chroma of the silk and ramie fabrics dyed with different reducing system. With hydrosulfite system, ramie showed 2.5PB to 5PB color irrespective of color strength while silk showed broader color in the range of 10BG(blue green) to 5PB(purple blue). In general, ramie showed 2.5PB to 7.5PB regardless of reducing system. At high color strength, traditional fermentation method gave more purplish color than hydrosulfite system. Interestingly, silk fabric with glucose system showed 7.5B to 2.5B(blue) color, shifting toward greenish blue. More greenish color was obtained with NaOH

than with $Ca(OH)_2$. Value(lightness) decreased as color strength increased, resulting in darker color with high K/S value, irrespective of reducing system and fabric type. It tended larger decrease in lower color strength and got less decrease at higher color strength.

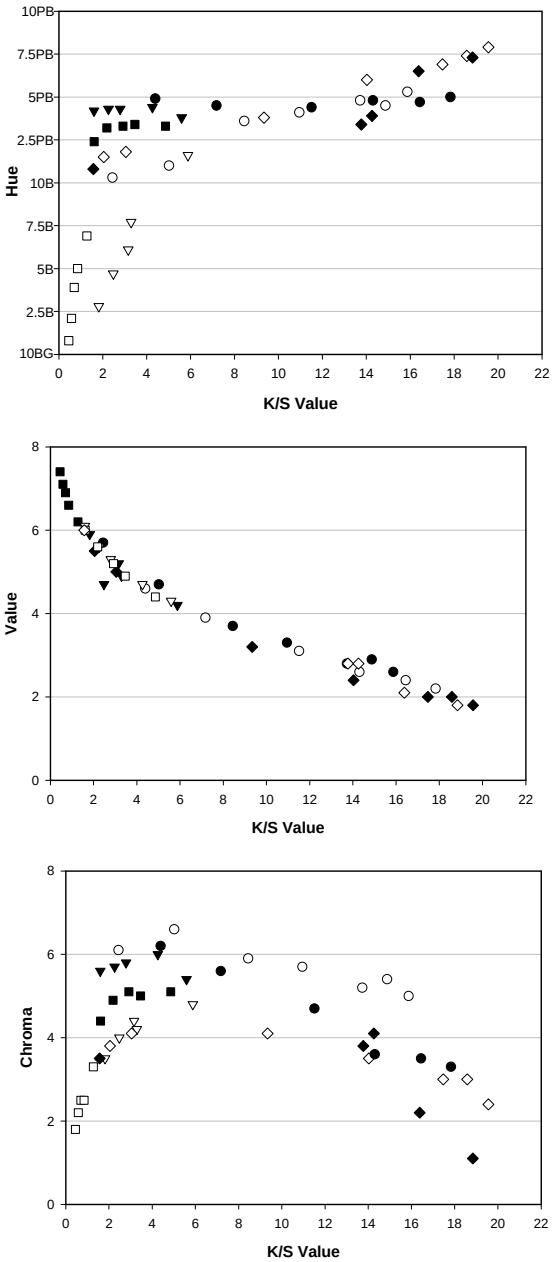


Fig. 2. Color characters of the dyed silk(open symbol) and ramie(filled symbol) depending on color strength:
○, ●; hydrosulfite, ▽, ▼; glucose/$Ca(OH)_2$,
□, ■; glucose/ NaOH, ◇, ◆; traditional fermentation.

Chroma(saturation) was varied widely depending on reducing system and fabric type. The most vivid color was obtained with hydrosulfite system for both silk and ramie. Especially, silk fabric showed more vivid color and the vividness of color was not changed much with the increase of color strength than ramie. The traditional fermentation method produced much duller color than hydrosulfite system for both of silk and ramie. Glucose system gave the least vivid color. Compared with ramie, silk fabrics showed much duller color and the chroma value of silk fabric was increased sharply as K/S value increased.

Table 1 shows CIELab color coordinates of the ramie and silk fabrics with different reducing system. Glucose system, especially with $Ca(OH)_2$, produced more bluish color on ramie, indicated by smaller b* value and more greenish color on silk fabric, indicated by smaller a* value, compared with hydrosulfite system.

Table 1. CIELab coordinates of the dyed fabrics with different type of reducing agent

			Indigo conc. (g/L)	L^*	a^*	b^*
Ramie	Hydrosulfite		4	27.02	-1.06	-15.87
			8	24.99	-1.12	-14.94
	Glucose	$Ca(OH)_2$	4	63.52	-3.96	-20.12
			8	55.57	-3.59	-21.37
		NaOH	4	62.55	-5.29	-15.11
			8	54.48	-4.59	-18.72
Silk	Hydrosulfite		4	30.29	-2.27	-22.77
			8	30.16	-1.63	-22.06
	Glucose	$Ca(OH)_2$	4	60.87	-14.95	-7.67
			8	54.08	-14.53	-12.87
		NaOH	4	75.42	-8.54	-2.68
			8	71.00	-10.01	-5.66

4. CONCLUSION

• Hydrosulfite system was much more effective than glucose system, obtaining much higher dye uptake.
• Hydrosulfite and glucose system produced 2.5PB to 5PB color on ramie. Whereas on silk 10BG(blue green) to 5PB(purple blue) was obtained by hydrosulfite and 7.5B to 10BG by glucose system on silk.
• The most vivid color was obtained with hydrosulfite system for both silk and ramie, than with glucose and traditional fermentation system.

5. REFERENCES

[1] F. Govaerta, E. Temmerman, P. Kiekens; *Analytica Chimica Acta*, 385, 307-314(1999).
[2] Y. Shin, K. Son. D. I. Yoo; *Journal of the Korean Society of Clothing and Textiles,* 32(12), 1963-1970(2008).