# Fixation of Reactive Dyes on Ink-jet Dyeing

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## Abstract

The fixation of reactive dyes onto cotton fabrics by means of dry heat treatment was examined in terms of water regain in fabrics. Dye liquors were applied to fabrics by ink-jet printer. The fixation strongly depended on water regain. At certain level of water regain the fixation showed step-wise increase. After this point the fixation reached to saturated value. The observed results were interpreted by the aggregation behavior of dyes and reactivity of hydroxyl group of cellulose depending on the amount of the surrounding water molecules. Urea molecules played a role of water at low water regain to increase the fixation.

## Introduction

The quick response to customer's demands on the color and design of clothes has been required to dye houses because of the trend to regard individual taste for goods as a more important factor in marketing. The large item small scale production combined with quick delivery system becomes significant policy in the textile industry.
The digital printing system is a potentially prosperous solution to satisfy above requirements. In fact some dyeing factories have introduced this sort of quick response system. A small textile shop or a fashion designer can feel more advantages when they have this kind of system in their work places because their business can be maid mainly by face-to-face customer contact. The digital printing system can easily develop designer's and/or customer's ideas on textiles immediately after they appear or alter. There is a possibility to improve the productivity of textile design and to set out new textile business.
However a large investment is necessary to install ink-jet dyeing system although the cost of an ink-jet printer itself is not so expensive. The machine for steaming process accounts for the major cost of the investment. The replacement of steaming process with other cheaper dye fixation method is desirable in order to spread the use of ink-jet textile printing system. One possible candidate may be dry heat treatment which leads to a simpler continuous dyeing system using suitable heating devices.
Dye fixation on fibers achieves during steaming process where high temperature and water molecules play an important role for dye fixation. The dry heat treatment to fix dye molecules onto fibers may also require a certain degree of water regain in fibers. This study has been carried out in order to clarify the relationship between water regain and dye fixation when the dry heat treatment is applied. At low water regain, the dye fixation could be low. On the other hand the bleeding of color seems to occur at higher water regain. The appropriate water regain should be examined.

## Experimental

Cotton fabric was dyed with two reactive dyes using ink-jet printer. Before printing, cotton fabric was pretreated to add proper properties onto the fabrics. As the pretreatment, the padding of aqueous solution of 0.5% sodium alginate (300pcs), 3% sodium hydrogen carbonate and 10% (or 5%) urea was carried out onto cotton fabrics. The pickups were about 94%. Two reactive dyes, Remazol Turquoise Blue (abbr. BlueG) and Remazol Brilliant Orange 3R (abbr. Orange3R) were supplied from Dyster Japan Ltd. The molecular structures are shown in Fig.1. Printing was done on pretreated clothes of 4cm x 4cm using ink-jet printer (JF-0604, Mimaki Co. Ltd.). The water regain in cotton fabrics was controlled by storing for 24 hours at 25°C in the desiccators having saturated salt aqueous solutions. The water regains which were measured by Halogen moisture analyzer HG53 (METTLER TOLEDO) were varied from the absolute dry state to 40wt%. The dry heat treatment was done for 20 seconds at 130°C. The dye fixation was determined by spectroscopic measurements of the amount of unfixed dye that was removed by washing.

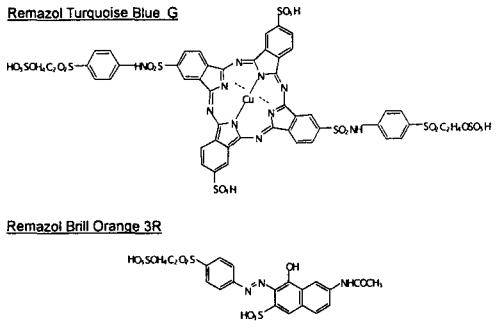


Fig.1 Molecular structure of reactive dyes used

## Results and Discussions

The relationships between dye fixation and water regain of cotton fabric for two reactive dyes are shown in Fig.2-a (BlueG), 2-b (Orange3R). Since the pretreatment agents include urea and hydrophilic polymer of alginate acid, much more water was contained in the pretreated fabrics than normal cotton. The excess water in the fabric with the highest water regain causes the bleeding of color, which derogates the commercial value. Both dyes roughly show the similar dependence of fixation on water regain. Low water regain does not make enough amount of dye to coloring to fix onto fabrics. Only naked eyes can notice slight coloring on cotton. In the case of BlueG most of dye does not fix below 6wt% of water regain. The step-wise increase of dye fixation occurs above 6wt%. After this point the fixation reaches to the saturated value. This distinctive feature suggests the existence of the threshold on the amount of water required for dye fixation. The threshold may be related with the following two kind of water.

(1) Water to accelerate a chemical bonding between –OH group of cellulose and reactive group of dye.
(2) Water to accelerate dye diffusion into polymer

Dye diffusion in cotton seems to be described by the pore diffusion mechanism [1]. According to the pore diffusion mechanism dye molecules diffuse in pore which is filled with water and then reach an adsorption site. The experimental results shows that the dye molecule can diffuse in cotton having more than 6% water regain. The corresponding amount of water may fill up the pore of cellulose to make diffusion of dye molecules active. The threshold of Orange3R for the cotton pretreated with 5wt% urea is around 10%. The thresholds depend on the molecular characteristics of dyes. It should be necessary to compare pore size and size of dye molecule or its aggregate in future. More Orange3R molecules fix on the cotton having more urea at water regain less than 10%. The effect of urea varies according to molecular structures of the dyes. The existence of the aggregates in both of dye liquors was confirmed by Small angle X-ray scattering experiments. Urea works as disaggregation agent in general. The aggregate of Orange3R may be more easily destroyed by urea than BlueG's. Smaller dye aggregate can more easily diffuse even in the state of less water.

The equivalent dye fixation was obtained by the dry heat treatment with addition appropriate amount of water to cotton instead of steaming.

## References

1. T.Hori and H.Zollinger, Text.Chem.Col., **18**, 19 (1986).

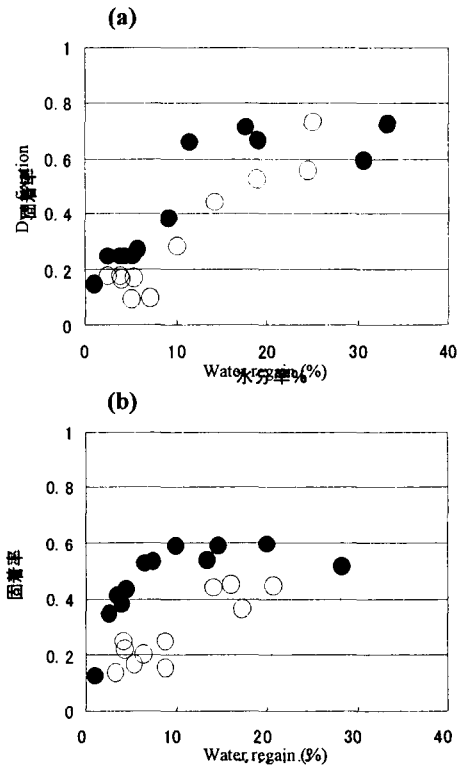


Fig.2 Dependence of dye fixation on water regain. (a): BlueG, (b) Orange3R. Open circles means 5 wt% of urea in padding liquor and closed one 10 wt%