

## Effects of Temperature and Time on the Dyeing and Spectroscopic Properties of Direct Blue Dye

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**Summary:** Direct blue dye was prepared and applied to cellulosic fiber at different temperatures and time. It was found that there is a marked effect on the fastness properties of dye with increase in temperature and time period of dyeing. The dye show a good co-relationship between the data obtained during this investigation.

### Introduction

Direct dyes have been given the generic name "direct" because these were the first group of synthetic dyes that could dye cotton without the help of mordant. For the same reasons these are also known as substantive dyes. It has been estimated that about 75% of all the direct dyes have azo structure out of which about 50% are disazo type. The disazo dyes are brighter than the polykissazo types and represent almost all hue sectors [1, 2].

Congo red, the first direct dye was produced from benzidine and naphthionic acid. It soon lost its importance for dyeing cotton because of its extreme sensitivity to acids and was later used mainly as an acid indicator. Many direct dyes made from benzidine have been withdrawn from manufacture on account of the occurrence of carcinoma of the bladder, which is known to be caused by benzidine and certain derivative [3].

An intensive search was undertaken into alternatives produced from less hazardous intermediates [4,5]. Principally by the substitution of existing benzidine derivatives by analogous dyes, in which benzidine is replaced by a structurally similar but less hazardous diamine. These diamines may be ortho or meta tolidine or dianisidine, however these diamines are also suspected of having carcinogenic activity and are controlled substances. Secondly by the use of new diamines including 4,4'-diaminobenz-anilide, 4,4'-diaminodiphenylether, 4,4'-diamino-diphenylsulphone and 1,5-diamino-naphthalenes.

Another novel intermediate synthesized for this purpose is 7-amino-3- (4' amino phenyl quinoline) that has been used by R.Krishnam and co-

worker to prepare various disazo and trisazo derivatives. They found that the diazonium cation on the phenyl ring being the more reactive, but unfortunately the novel dyes were deficient in tinctorial power and light fastness [6]. F.Calogero and co-workers used 5, 5'-diamino-2, 2'-bipyridine and found that this novel component was much less genotoxic than benzidine itself and the derived dyes were also less genotoxic [7].

Serious and meaningful study of mechanism or theory of dyeing started only in 1930s when measurement of the adsorbed dye became possible with the electronic spectrophotometer [8]. Distribution of dye between the fiber and the dye solution and also its rate of adsorption during dyeing could then be assigned definite values. The essential basis of the dyeing theory is a consideration of the energy system. Transfer and adsorption of the dissolved dye from solution to fibers results in reaching a state of lower energy or higher stability. The dye fiber bond formation always releases energy and so a more stable structure is obtained. The bonding process, however, is reversible and by treating the dyed fabrics with boiling water, all the water soluble dyes can theoretically migrate out of the fibers. This paper presents the study of the effect of time and temperature on the dyeing and fastness properties like washing, light, perspiration and sea water of the prepared dye.

### Results and Discussion

In order to study the effect of different factors on the dyeing properties, direct blue dye having the formula as shown in scheme-1 was synthesized by

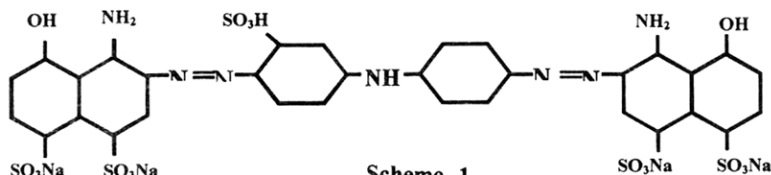
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the conventional method of diazotization, purified and its  $\lambda_{\max}$  in visible region was determined. The colour fastness to washing, light, perspiration and sea water were also determined. The data presented in table-1 shows the effect of temperature and time on the exhaustion of the dye. Increase in temperature decreases the amount of dye absorbed by the fiber at equilibrium. As the temperature reaches 85°C the rate at which equilibrium is attained increases until it reaches a maximum. Affinity however, decreases with further increase in temperature. Similarly in 40 minutes maximum exhaustion of dye is achieved. The wash fastness rating of the dye is about 3-4. This may be due to the relatively large number of auxochromes in the dye anion which contribute to the poor wash fastness of the dye. The dye has a moderate light fastness. This may be attributed to the fact that direct dye molecules are affected by the photochemical degradation due to the U.V. radiation of sunlight, as well as by atmospheric pollutants. A relatively short exposure to direct sunlight is enough to initiate degradation of the dye molecule. The resultant breakdown of the dye anion is seen as fading of the dye material.

## Experimental

### Synthesis of dye

Direct blue dye was obtained by coupling 4, 4'-diamino diphenylamine-2-sulphonic acid with 1-amino-8-naphthol-3, 6-disulphonic acid in a weakly basic medium [9]. The dye obtained was separated from the reaction mixture by filtration and purified by using a mixture of chloroform and methanol. The structural formula is shown in scheme-1.



### Equipment

The dyeing was performed in closed pot dyeing bath. The visible spectra were recorded on Nova spectrophotometer. The instrument was set on 100% transmittance.

### Dyeing and fastness properties

The dye was applied to cellulosic fiber from aqueous liquor to which an electrolyte is added at

different temperatures and time using a dyeing machine by the following procedure. Dyeing of 1% depth of the dye was carried out on 5 gm fabric by keeping the dyeing machine at different temperatures ranging from 45°C to 100°C, and the liquor to goods ratio of 1:20. After that the specimens were removed from the dyeing bath, rinsed and dried. The absorbance of the remaining liquor at different temperatures was determined spectrophotometrically at a wavelength of 462 nm. Same procedure was applied by varying the time of dyeing ranging from 5 to 55 minutes. After the required time intervals specimens were removed from the liquor, aliquots of dye solution were taken out and analyzed for amount of dye uptake at these time intervals. Absorbances of the diluted liquor after every 5 minute intervals were determined at 462 nm. These effects are more clearly demonstrated in Fig-1 and 2.

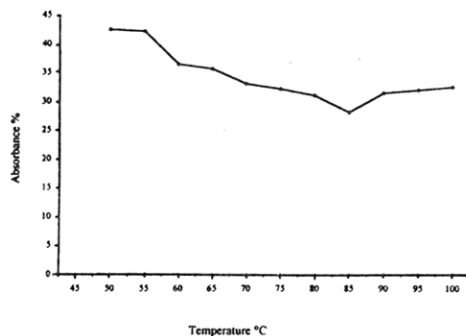


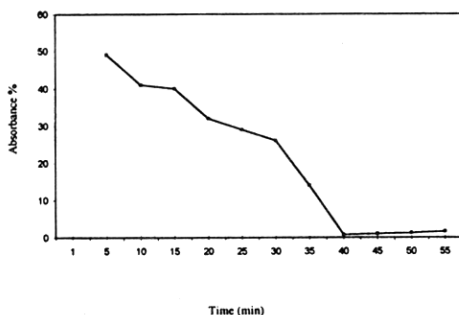
Fig.1: Relation between absorbance and Temperature at  $\lambda_{\max}$  462 nm.

### Colour fastness to washing

The washing fastness test was carried out according to ISO CO1 procedure [10]. In this test a specimen measuring 40 mm x 100 mm was cut and placed between the two single fiber adjacent fabrics also measuring 40mm x 100 mm by sewing along one of the shorter sides. The composite specimen was then placed in the container containing necessary amount of soap solution (5 g of soap per liter of water) previously heated to 40°C to give a liquor

Table-1: Effect of light, washing, perspiration and sea water on Direct Blue Dye at different temperatures and time

Obs No	Temp °C	Time Min	Fastness to Light	Fastness to washing			Fastness to Perspiration			Fastness to Sea Water		
				Change in Colour	Staining Cotton	Staining Single Fiber	Change in Colour	Staining Cotton	Staining Single Fiber	Change in Colour	Staining Cotton	Staining Single Fiber
1.	50°	5	1-2	1-2	1-2	1-2	1-2	1	1	1-2	1-2	1-2
2.	55°	10	1-2	1-2	2	2	2	2	2	2	2-3	2
3.	60°	15	2	2	2	1-2	2	2-3	2-3	2-3	2-3	2-3
4.	65°	20	2-3	2-3	3	2-3	3	2-3	2-3	2-3	3	2-3
5.	70°	25	3	3	2-3	3	3	3	2	3-4	3	3
6.	75°	30	3-4	3	3	3-4	3	2-3	2	3	3	3
7.	80°	35	3-4	3-4	3-4	3-4	3-4	3	2-3	3	3	3
8.	85°	40	4	4	3-4	3-4	3-4	3	2-3	3	3	3
9.	90°	45	3	3-4	3	3	3-4	3	2-3	3	3	3
10.	95°	50	2-3	3-4	2-3	3	3	2-3	2-3	2-3	3	3
11.	100°	55	2-3	3	2-3	3	3	3	2-3	2-3	3	3

Fig. 2: Relation between absorbance and time at  $\lambda_{\max}$  462 nm.

ratio of 50:1 for 30 minutes. The composite specimen was removed, rinsed with cold water, then with tap water for 10 minutes. The fabric was opened out and dried. The change in colour of the specimen and the staining of the adjacent fabric was assessed with the grey scale. The results are summarized in Table-1

#### Colour fastness to artificial light (Xenon Arc Fading Lamp Test):

The colour fastness to artificial light of the dyed sample was carried out by ISO-BO2 standard procedure [10]. The test specimen of the dyed fabric was exposed to artificial light (Xenon Arc Fading Lamp) under standard conditions, using sample of Blue Wool as a reference. The colour fastness was then assessed by comparing the change in colour with that of the reference blue wool sample. The results obtained are tabulated in Table-1.

#### Colour fastness to perspiration:

This test was carried out according to ISO EO4 standard procedure [10]. In this test a specimen

measuring 40mmx100mm was cut and placed between the two single fiber adjacent fabrics also measuring 40mm x 100 by sewing along one of the shorter sides. The composite specimen was placed smoothly in a dish containing freshly prepared acidic solution of L-histidine monohydrochloride monohydrate. The specimen was thoroughly wetted out in the acidic solution at a liquor ratio of 50:1 and was allowed it to remain in the solution at room temperature for 30 minutes. The solution was poured off and the excess liquor was wiped off the specimen. The composite was then placed between two acrylic resin plates, under a pressure of 12.5 k Pa. The test device containing the composite specimen was placed in an oven for 4 hours at 37°C. The fabric was opened out, dried and the change in colour was assessed with the grey scale. Same procedure was repeated with another piece of fabric using freshly prepared alkaline solution of L-histidine monohydrochloride monohydrate. The change in colour of each specimen and the staining of the adjacent fabric was assessed with grey scale. The results are summarized in Table-1.

#### Colour fastness to sea water

This test was carried out according to ISO EO2 standard procedure [10]. In this test a specimen measuring 40 mm x 100 mm was cut and placed between two single fiber adjacent fabrics of same dimensions and then stitched together. The specimen was thoroughly wetted out in a container by immersing in sodium chloride solution (prepared by dissolving 30 g/l) at room temperature. The specimen was placed smoothly between the two glasses or acrylic resin plates under a pressure of 12.5 k Pa. The test device containing the specimen was placed in an oven for 4 hours at 37°C. The fabric was opened out

and dried. The change in colour of the specimen and the staining of the adjacent fabric was assessed with the grey scale. The results are summarized in Table-1.

### Conclusions

Direct blue dye was prepared and data obtained on the effect of temperature and time on dye exhaustion as well as on fastness properties. As far as the temperature is concerned the solublizing group present in the molecule influences the diffusion of the dye at a temperature of 85°C and maximum dye exhaustion is achieved after 40 minutes. The dye anion are attached to the cellulose polymers by hydrogen bonds and Van der Waals' forces, both of which are weak under aqueous conditions. These weak bonds may be hydrolyzed by water molecules resulting in the removal of these dyes from the polymer system. The loss of dye is seen as fading of the cellulosic material. It has further been inferred that the colour absorption of a particular dye depends on time and temperature of dyeing

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