



## Spectrophotometric Analysis of Some Reactive AZO Dyes Used in Textile Industries

### KEYWORDS

Reactive dyes, azo dyes, beta sulphatoethyl sulphone, absorption maxima and absorption spectrum

**Poonam Gupta**

Department of Biotechnology,  
School of Life Sciences, Khandari  
Campus, Dr. B. R. Ambedkar  
University, Agra-282004, Uttar  
Pradesh, India.

**\* Siddhartha Barun**

Gujarat State Biotechnology  
Mission, Gandhinagar- 382017,  
Gujarat, India. \* Corresponding  
author

**Shikha Roy**

Biotechnology Laboratory,  
Department of Botany, University  
of Rajasthan, Jaipur – 302 004,  
Rajasthan, India.

### ABSTRACT

In the present study absorption maxima ( $\lambda_{max}$ ) and absorption spectrum of six textile reactive azo dyes were studied. The absorption maxima (visible range) for the various dyes obtained were: - Red-5B (512 nm), Orange-3R (492 nm), Yellow-GR (415 nm), Black-B (597 nm), Turquoise Blue-G (661 nm) and Blue-3R (666nm). During the absorption spectrum study multiple peaks were obtained, in UV as well as Visible range. All the dyes were showing multiple peaks in UV range and single peak in the visible range except Turquoise Blue-G and Blue-3R. This study provides some information regarding structure of the relatively less studied dyes and could be utilized to follow the course of dye degradation by the microbial cultures.

### INTRODUCTION

Synthetic dyes are extensively used in the textile and printing industries (Moreira et al., 2000; Soares et al., 2002 and Park et al., 2006). Azo dyes account for the majority of all textile dye stuffs produced and have been the most commonly used synthetic dyes in the textile, food, paper making, color paper printing, leather and cosmetic industries (Powell et al., 1979, Carliell et al., 1995a and Chang et al., 2001). They are the largest class of dyes (Stolz, 2001) and have one or more azo groups ( $R_1-N=N-R_2$ ) having aromatic rings mostly substituted by sulfonate groups. These complex aromatic substituted structures make conjugated system and are responsible for intense color, high water solubility and resistance to degradation of azo dyes under natural conditions (O'Neill et al., 2000; and Rajaguru et al., 2000).

Reactive dye is a class of highly colored organic substances, primarily utilized for tinting textiles (cotton, wool and nylon) that attach themselves to their substrates by a chemical reaction that forms a covalent bond between the molecule of dye and that of the fibre. The dyestuff thus becomes a part of the fibre and is much less likely to be removed by washing than are dyestuffs that adhere by adsorption. The vinyl sulphone (VS) based reactive dyes are widely used for dyeing and printing of cellulosic fibers for its very good fastness properties. These dyes have very good features like, good solubility even in presence of alkali and very good fastness properties.

The spectrophotometric analysis, which includes study of absorption maxima ( $\lambda_{max}$ ) and absorption spectrum, gives a rough outline of the chemical structure of the commercial dyes. Also it can help to follow the course of dye degradation by the microbial cultures, in comparison to the respective controls.

### MATERIALS AND METHODS

Dyes selected for this study belonged to Beta Sulphatoethyl sulphone class also designated as Vinyl sulfone based reactive azo dyes which included- Red-5B/Red-35 (azo dye); Orange-3R/Orange-16 and Yellow-GR/Yellow-15 (monoazo dyes); Black-B/Black-5 (diazo dye); Blue-3R/Blue-28 (reactive anthraquinone dye); and Turquoise Blue-G/ Blue-28 (copper phthalocyanin dye). Three different concentrations (0.1%; 0.01% and 0.001%) for each of the six dyes were utilized to determine their respective absorption maximum ( $\lambda_{max}$ ) in

the visible range (700 -400 nm). Using UV-1700 Pharmaspec Shimadzu (UV- Visible) spectrophotometer spectrum of each of the six dyes at two (0.01% and 0.001%) concentrations were obtained in the range of 190-700 nm. Literature survey was also conducted to obtain information about the chemical structure, formula, absorption maxima etc. and to compare them with the results obtained experimentally.

### RESULTS AND DISCUSSION

#### (a) Dyes:

The information gathered (on the basis of literature survey) about the chemical structure and chemical name of the dyes is given in the Table 1.

#### (b) Absorption maximum of the dyes:

The observations undertaken to obtain the  $\lambda_{max}$  for the selected six dyes are tabulated in the Table 2. The results indicate that same wavelength for maximum absorption ( $\lambda_{max}$ ) was obtained at all the three concentrations for each of the six dyes. The absorption maxima for the various dyes obtained through this experiment in the visible range are - Red-5B (512 nm), Orange-3R (492 nm), Yellow-GR (415 nm), Black-B (597 nm), Turquoise Blue-G (661 nm) and Blue-3R (666 nm). These values are very close to the  $\lambda_{max}$  figures obtained from other literature sources as shown in Table 1, except in the case of Red-5B and Blue-3R, for which the data is not available (Table 1).

#### (c) Spectrum analysis of the dyes:

The spectrum covering the UV-Visible range (190-700 nm), showed multiple peaks (absorption maxima) for all the dyes at both the concentrations (Table 3). In all the cases peaks were obtained in both UV (200-400 nm) and the Visible (400-700 nm) range. There was very slight variation of just 1 or 2 nm in the peaks of a particular dye at the two concentrations (0.01% and 0.001%) In case of Red-5B four peaks were obtained (512, 379, 308, and 232 nm), out of which only one peak was in the visible range (512nm), while the remaining three are in the UV range (379, 308, and 232 nm). Orange-3R dye has also given four peaks (492, 388, 295 and 254 nm), one in the visible region (492 nm) and three in the UV range (388, 295 and 254 nm). Only two peaks (415 and 257 nm) were obtained for Yellow-GR, one in the visible range (415nm) and the other in the UV range (257 nm). In case of dye Black-B three peaks were obtained (597, 391 and 311

nm), one in the visible range (597 nm) and the other two in UV range (391 and 311 nm). The observations were quite different in case of Turquoise Blue-G (661, 620 and 334 nm) and Blue-3R (666, 616, 557 and 334 nm), where multiple peaks were obtained in the visible region but single peak in the UV range. The single peak in the UV range was obtained at the same wavelength for both the dyes (Turquoise Blue-G and Blue-3R) i. e. 334 nm, indicating quite similar aromatic structure of the two dyes. The two peak wavelengths of the visible region are quite similar for both dyes, but the third and the unique peak (557 nm) was observed only in case of Blue-3R and this might be responsible for difference in the shades of the two due to minor modification in the molecular structure. On the basis of the spectrum studies it can be concluded that all the 6 selected textile dyes (Red-5B; Orange-3R; Yellow-GR; Black-B; Turquoise Blue-G and Blue-3R) were showing absorption peaks in both visible and the UV range and this can be ascribed to the presence of chromophoric azo bonds, which imparts color to the dye (responsible for visible re-

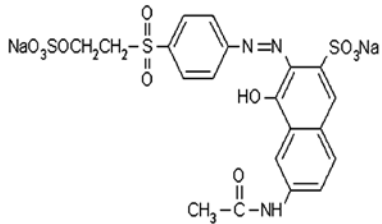
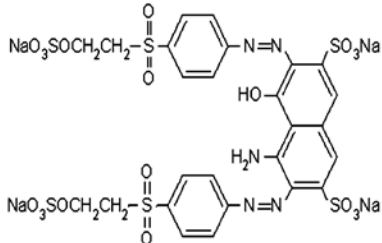
gion's peaks) and both aryl and naphthalene- like moieties (responsible for UV region's peaks) (Silverstein et al., 1991).

The absorption maximum (visible range –  $\lambda_{max}$ ) obtained for each of the dye is exactly same in both the experiments and also quite similar to the information obtained about some of the dyes through literature survey. In case of the absorption peaks in UV range similar peaks are reported in the literature also for dyes Orange-3R and Black-5. This study provides important information regarding the absorption properties of the selected dyes that could be utilized to study their course of biodegradation.

#### ACKNOWLEDGEMENT

Authors are thankful to Head, Department of Botany, University of Rajasthan, Jaipur for providing facilities. Authors would also like to extend their thanks to CSIR for granting the fellowships.

**Table 1: Structure, chemical name and  $\lambda_{max}$  of the dyes (courtesy Remazol Reactive Brand and Sigma-Aldrich)**

Dye Name	Structure	C. I Name	Chemical Name	$\lambda_{max}$ (nm)
Red-5B	Not available	Reactive Red-35	Not available	Not Available
Orange-3R		Reactive Orange-16	2-Naphthalenesulfonic acid, 6-(acetylamino)- 4-hydroxy- 3-((4-((2-(sulfooxy)ethyl) sulfonyl)phenyl) azo)-, disodium salt	494/493 <sup>a,b</sup> , 388
Yellow-GR	Not available	Reactive Yellow -15	[benzenesulfonic acid, 4-(4,5-dihydro-4-((2- methoxy-5-methyl-4-((2-(sulfooxy)ethyl) sulfonyl)phenyl) azo)-3-methyl-5- oxo-1H-pyrazol-1-yl)-]	413 <sup>a,b</sup>
Black B		Reactive Black- 5	[2,7-naphthalenedisulfonic acid, 4-amino-5- hydroxy-3,6-bis((4-((2 (sulfooxy) ethyl)sulfonyl)phenyl)azo)-tetrasodium salt]	597/595 <sup>c</sup> , 310 <sup>c</sup>
Turquoise Blue-G	Not available	Reactive Blue- 21	[copper, (29H,31H phthalocyaninato(2-)-N29,N30,N31,N32)-, sulfo((4-((2- sulfooxy)ethyl)sulfonyl)phenyl)amino) sulfonyl derivs]	664 <sup>a,b</sup>
Blue-3R	Not available	Reactive Blue-28	Not available	Not available

#### Here:

a = Devi and Kaushik 2005

b = Raju et al. 2007

c = Lucas et al. 2005

**Table -2: Determination of the  $\lambda_{max}$  of the dyes**

Dye	Dye Conc. (%)	Absorbance at Wavelength $\lambda$ (nm)									
		507	508	509	510	511	512	513	514	515	516
Red-5B	0.10%	20.01	20.15	20.7	23.45	25.9	31.61	26.82	24.24	22.48	20.12
	0.01%	2.24	2.37	2.54	2.58	3.34	4.16	3.56	3.42	2.11	1.9
	0.001%	0.3	0.31	0.32	0.33	0.34	0.42	0.35	0.33	0.31	0.29

Orange-3R		488	489	490	491	492	493	494	495	496	497
	0.10%	27.6	29.81	30.54	31.4	34.56	33.8	32.8	28.34	28	27.4
	0.01%	3.6	4.27	4.69	5.2	6.8	5.9	5.43	4.26	3.7	3.12
	0.001%	0.41	0.45	0.48	0.48	0.96	0.87	0.81	0.47	0.47	0.32
Yellow-GR		411	412	413	414	415	416	417	418	419	420
	0.10%	31.24	32.56	35.7	40.02	42.12	39.64	37.11	34.8	32.83	30.65
	0.01%	6.5	6.92	7.54	8.86	9.76	7.98	7.54	7.28	6.76	6.04
	0.001%	0.67	0.69	0.73	1.09	1.23	1.03	0.93	0.87	0.67	0.66
Black-B		591	592	593	594	595	596	597	598	599	600
	0.10%	22.31	22.32	22.33	22.34	22.37	23.12	24.78	23.58	23.54	22.45
	0.01%	2.38	2.39	2.39	2.4	2.52	2.71	3.84	2.97	2.63	2.34
	0.001%	0.29	0.29	0.29	0.3	0.31	0.35	0.46	0.36	0.31	0.3
Turquoise Blue-G		659	660	661	662	663	664	665	666	667	668
	0.10%	20.15	20.34	22.45	20.89	20.74	20.46	20.4	20.38	20.3	19.8
	0.01%	2.72	2.77	3.54	3.12	3.09	2.95	2.88	2.84	2.8	2.64
	0.001%	0.38	0.39	0.49	0.47	0.46	0.44	0.44	0.43	0.42	0.37
Blue-3R		662	663	664	665	666	667	668	669	670	671
	0.10%	29.16	29.3	29.44	29.5	31.54	30.78	29.65	29.63	29.57	29.54
	0.01%	3.65	3.69	3.72	3.77	4.83	4.02	3.95	3.8	3.76	3.75
	0.001%	0.47	0.49	0.51	0.59	0.71	0.64	0.58	0.55	0.53	0.51

Table -3: Absorption Peaks and the respective absorbance values for dyes spectrum (UV-Visible)

Dye	Concentration	Peak Detection	
		Wavelength (nm)	Absorbance
Red-5B	0.001%	512.0	0.175
		379.0	0.08
		308.0	0.128
		230.0	0.278
	0.01%	512.0	1.357
		379.0	0.363
		308.0	0.764
		232.0	1.589
Orange-3R	0.001%	492.0	0.256
		387.0	0.173
		295.0	0.265
		252.0	0.300
	0.01%	492.0	2.150
		388.0	1.320
		295.0	2.124
		254.0	2.334
Yellow-GR	0.001%	415.0	0.274
		256.0	0.288
	0.01%	415.0	2.161
		257.0	1.974

Black-B	0.001%	597.0	0.235
		391.0	0.110
		309.0	0.194
Black-B	0.01%	597.0	1.900
		391.0	0.662
		311.0	1.397
Turquoise Blue-G	0.001%	662.0	0.269
		621.0	0.235
		336.0	0.251
Turquoise Blue-G	0.01%	661.0	1.880
		620.0	1.827
		334.0	1.878
Blue-3R	0.001%	667.0	0.167
		617.0	0.162
		558.0	0.131
	0.01%	334.0	0.191
		666.0	0.983
		616.0	0.982
Blue-3R	0.01%	557.0	0.885
		334.0	1.375

REFERENCE

Carliell C.M., Barclay S.J., Naidoo N., Buckley C.A., Mulholland D.A. and Senior E. (1995a). Microbial decolorization of a reactive azo dye under anaerobic conditions. *Water S. A.*, 21: 61-69. | Chang J., Chou C., Lin Y., Lin P., Ho J. and Hu T.L. (2001). Kinetic characteristics of bacterial azo dye decolorization by *Pseudomonas luteola*. *Water Res.*, 35: 2841-2850. | Devi M. and Kaushik, B. D. (2005). Decolorization of textile dyes and dye effluent by *Aspergillus* sp. *Indian J. Microbiol.* 45: 41-44. | Lucas M.S., Amaral C., Sampaio A., Peres J.A. and Dias A.A. (2006). Biodegradation of the diazo dye Reactive Black 5 by a wild isolate of *Candida oleophila*. *Enzyme and Microbial Technology*, 39(1): 51-55. | Moreira M.T., Mielgo I., Feijoo G. and Lema J.M. (2000). Evaluation of different fungal strains in the decolorisation of synthetic dyes. *Biotechnology Letters*, 22: 1499-1503. | O'Neill C., Lopez A., Esteves S., Hawkes F.R., Hawkes D.L. and Wilcox S. (2000). Azo-dye degradation in an anaerobic-aerobic treatment system operating on simulated textile effluent. *Applied Microbiology and Biotechnology*, 53 (2): 249-254. | Park C., Lee M., Lee B., Kim S.W., Chase H.A., Lee J. and Kim S. (2007). Biodegradation and biosorption for decolorization of synthetic dyes by *Funalia trogii*. *Biochemical Engineering Journal*, 36(1): 59-65. | Powell R., Murray M., Chen C. and Lee A. (1979). Survey of the manufacture, import and uses for benzidine, related substances and related dyes and pigments. EPA report 560/13-79-005. Environmental Protection Agency, Washington, DC, USA. | Rajaguru P., Kalaiselvi K., Palanivel M. and Subburam V. (2000). Biodegradation of azo dyes in a sequential anaerobic-aerobic system *Applied Microbiology and Biotechnology*, 54 (2): 268-273. | Raju N. S., Venkataramana G. V., Girish S. T., Raghavendra V. B. and Shivashankar P. (2007). Isolation and evaluation of indigenous soil fungi for decolorization of textile dyes. *Journal of Applied Sciences*, 7 (2): 298-301. | Silverstein R.M.C., Bassler G.C. and Morrill T.C. (1991). *Spectrophotometric identification of organic compounds*, New York: John Wiley and Sons. | Soares G.M., Amorim M.T., Hrdina R. and Ferreire M.C. (2002). Studies on the biotransformation of novel diazo dyes by laccase. *Process Biochemistry*, 37: 581-587. | Stolz, A. (2001). Basic and applied aspects in the microbial degradation of azo dyes. *Applied Microbiol Biotechnol.*, 56: 69-80. |