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, Carlell et al., 1995a and Chang et al., 2001). They are the largest class of dyes (Stolz, 2001) and have one or more azo groups (R₁–N=N–R₂) 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 dying and printing of cellulosic fibres 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 (λ 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 dye class also designated as Vinyl sulphone based reactive azo sulfones which included- Red-5B/Red-35 (azo dye); Orange-3R/Orange-16 and Yellow-GR/Yellow-15 (monoazo dyes); Black-B/Black-5 (diaoz dye); Blue-3R/Blue-28 (reactive anthraquione dye); and Turquoise Blue-G/Blue-28 (copper phthalocyanine dye). Three different concentrations (0.1% R; 0.01% and 0.001%) for each of the six dyes were utilized to determine their respective absorption maximum (λ 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 λ max for the selected six dyes are tabulated in the Table 2. The results indicate that same wavelength for maximum absorption (λ 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 λ 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

ABSTRACT

In the present study absorption maxima (λ 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 (666 nm). 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.
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 region’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 | 2-Naphtalenesulfonic acid, 6-(acetylamino)-4-hydroxy-3-((4-((2-(sulfooxy)ethyl) sulfonyl)phenyl)azo)-, disodium salt | 494/493<sup>a,b</sup>, 388 |
| Orange-3R| Not available | Reactive Orange-16 | [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> |
| Yellow-GR| Not available | Reactive Yellow -15 | [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> |
| Black B  | Not available | Reactive Black- 5 | [copper, (29H,31H phthalocyaninato(2-)-N29,N30,N31,N32)-, sulfo(4-((2 sulfooxy)ethyl)sulfonyl)phenyl)lamino) sulfonyl derivs] | 664<sup>a,b</sup> |
| Turquoise Blue-G | Not available | Reactive Blue- 21 | | |
| Blue-3R  | Not available | Reactive Blue-28 | Not available | Not Available |

Here:
- <sup>a</sup> = Devi and Kaushik 2005
- <sup>b</sup> = Raju et al. 2007
- <sup>c</sup> = 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 |
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                    |             |
|           | 0.01%         | 230.0 0.278                    |             |
|           |               | 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                    |             |
|           | 0.01%         | 391.0 1.900                    |             |
|           |               | 311.0 1.397                    |             |
| Turquoise Blue-G | 0.001%  | 662.0 0.269                    |             |
|           |               | 621.0 0.235                    |             |
|           |               | 336.0 0.251                    |             |
|           | 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                    |             |
|           | 0.01%         | 558.0 0.131                    |             |
|           |               | 334.0 0.191                    |             |
|           |               | 666.0 0.983                    |             |
|           |               | 616.0 0.982                    |             |
|           |               | 557.0 0.885                    |             |
|           |               | 334.0 1.375                    |             |