



EFFECT OF UV IRRADIATION ON THE DYEING OF COTTON FABRIC WITH REACTIVE BLUE 204

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Abstract: *Reactive dyes are synthetic organic compounds used on a wide scale in textile industry, for painting materials of different types and compositions (e.g. 100% cotton, wool, natural satin, viscose, synthetic fibres). Reactive dyes are solid compounds (powders) completely water soluble at normal temperature and pressure conditions. Their structures contain chromophore groups, which generate colour, and auxochrome groups, which determine the compounds water solubility and the capacity to fix to the textile fiber. Such organic compounds absorb UV-Vis radiations at specific wavelengths, corresponding to maximum absorption peaks, in both solution and dyed fiber. The human organism, through the dyed clothing, comes in direct contact with those dyes which can undergo modifications once exposed to UV radiations, having the possibility to reach the organism via cutaneous transport. As it is known, the provoked negative effects are stronger during summer when UV radiations are more intense and in order to reduce their intensity dark coloured clothing is avoided. Dyes can be transformed in compounds which are easily absorbed into the skin. Some of these metabolites can be less toxic than the original corresponding dye, whilst others, such as free radicals, are potentially cancerous. Knowledge of the biological effects of the organic dyes, reactive dyes in particular, correlated with their structural and physical characteristics, permanently consists an issue of high scientific and practical interest and its solution may contribute in the diminishing of risk factors and improving of population health. UV radiation influence on the structural and colour modifications of textile materials were studied. Colour modifications are due to structural changes in aromatic and carbonil groups. In most cases photo-oxidative processes were identified in the dye structure. Dyeing was performed using non-irradiated and irradiated cotton painted with reactive blue dye 204.*

Key words: Cotton fabric, Ultraviolet protection, Reactive Blue 204, Photodegradation, Cellulose

1. INTRODUCTION

Reactive dyes are organic synthesis compounds used on a wide scale in the textile industry, for painting materials of different types and composition (e.g. 100% cotton, wool, natural satin, viscose, synthetic fibres) [1], [2], [3], [4]. Their multiple applications are due to the covalent binding and good attachment to the fiber, features which endow the painted material with strong lasting colour and good resistance to washing and rubbing [5], [6].

The dye's complex structure and high resistance to degradation under weathering factors, make them environmentally hazardous. The high quantities of reactive dyes in residual waters are ecologically harmful, due to their colour and especially to toxicity of the decomposition products, and are cancerous for wildlife and humans.

Knowing the reactive dyes biological effects, correlated with physical and structural characteristics has become a permanent issue of high scientific and practical interest and its solution may contribute in the diminishing of risk factors and improving of population health. The need of such research has risen from the fact that textiles dyed with the Reactive Blue 204 dye undergo significant and important colour and structural modifications at the dye-substrate interface.

2. EXPERIMENTAL

2.1. Materials and methods

A fabric, manufactured mainly of alkaline cleaned and bleached cotton fibers was obtained from a commercial source (IASITEX S.A. Iasi, Romania). Fabric dyeing was achieved by fleet depletion technique in alkaline media (pH 9-10) with computerized plant Mathias Polycolor Uniprogramer 2002 type (Werner Mathias AG, Switzerland). Aqueous solutions containig 5% dye Reactive Blue 204 ($C_{42}H_{28}O_{20}N_{14}S_6Cl_2F_2Na_6$, $M_n = 1487.97$ g/mol) was used to paint the fabric [5].

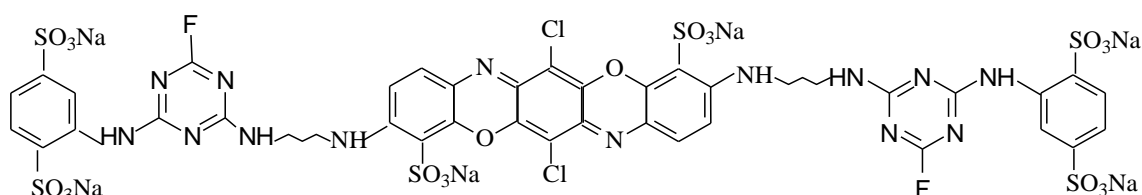


Fig. 1: Reactive Blue 204 (Cibacron Blue F-GFN) [5]

The temperature in the dyeing bath increased from 21 to 80 °C with a heating rate of 5 °C min^{-1} . Rinsing with hot water, cold water and finally with distilled water was used to remove the traces of unreacted dye. The Reactive Blue 204 has an absorbtion maximum in the visible domain at 636 nm for solutions of concentrations $c = 8 \mu g/mL = 0,008$ g‰, at neutral pH (Fig. 2).

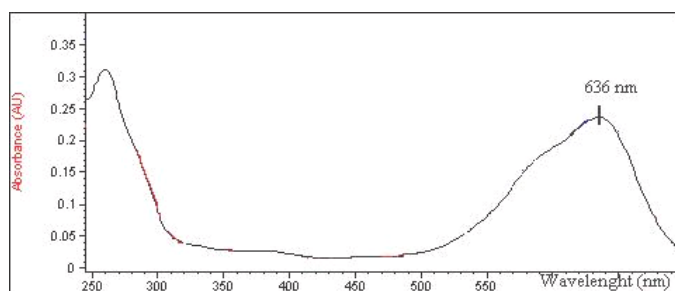


Fig. 2: UV-Vis absorbtion spectrum of Reactive Blue 204 dye

One may observe a decrease in colour intensity with irradiation time, due to dye decomposition, hence the increase in discoloration degree. The sample died with 3 % solution of Reactive Blue 204 and irradiated 25 hours was the least affected by irradiation (discoloration degree of 12.736 %).



Table 1. Colour intensity, discoloration degree and dye quantity of samples dyed with 1, 3 and 5 % solution of Reactive Blue 204 dye and UV irradiated

Reactive Blue 204 dye	Irradiation time (hours)	Discoloration degree (%)	µg dye after irradiation
(1%)	0	0	5140
	25	23.661	3924
	50	29.464	3626
	75	41.518	3006
(3%)	0	0	24489
	25	12.736	21370
	50	19.575	19695
	75	31.840	16692
(5%)	0	0	39892
	25	16.008	33506
	50	17.326	32980
	75	28.060	28698

2.2. Equipment

The 1, 3 and 5 % dyed samples were irradiated in air at periods of 25, 50, 75 and 100 hours in a rotating device of accelerated aging, equipped with a UVA lamp which has a polychrome emission spectrum, with a maximum wavelength $\lambda = 365$ nm. The aging studies were conducted by exposing the leather surface samples (70x40x0.5 mm) to UV radiation up to 100 hours in air. The samples were irradiated with UV filtered light emitted by the medium intensity mercury vapor lamp (model B-100AP, manufactured by Analytik Jena Company, with emission maximum located at 365 nm. A PMA 2100 radiometer manufactured by Solar Light Company equipped with PMA 2110 detector with response in the spectral region 320-400 nm was used to measure the irradiance and the irradiation dose during photochemical aging. The irradiance values were 23.3 Wm^{-2} . This value was measured in irradiation chamber at the level of sample holder.

Colour modifications during irradiation on the sample surfaces were followed with a Lovibond LC 100, RM 200 model apparatus manufactured by Tintometer Ltd., UK, using a white pellet from BaSO_4 as standard. The standard DIN 6174 (Farbmetrische 15 Bestimmung von Farbständen bei Körperfarben nach der CIELAB-Formel, 1979) has been used for colour evaluation using D65 illuminant and the results have been expressed in CIELAB ($L^*a^*b^*$) system. In CIELAB ($L^*a^*b^*$) the colours are described by parameters L^* which is lightness, a^* which denotes the red/green value and b^* for yellow/blue value. The colour differences between the irradiated and non-irradiated samples were calculated with Eq. 1, where with ΔL^* , Δa^* and Δb^* are the differences between each parameter after and before irradiation.

$$\Delta E = (\Delta L^{*2} + \Delta a^{*2} + \Delta b^{*2})^{1/2} \quad (1)$$

3. RESULTS AND DISCUSSIONS

Colour modification studies during UV irradiation of Reactive Blue 204 dyed cotton samples (1, 3 and 5 %)

After 25 hours irradiation time L^* values increase for samples painted with 1 % and 3 % dye, while decreasing for the one painted with 5 % dye. L^* values witness a slow ascending tendency for all three dyed samples in the irradiation time range 25–50 hours, followed by a pronounced



decrease for samples painted with 1 % and 3 % dye and a slow decrease for the one painted with 5 % dye in the range 50–75 hours (Table 2).

Table 2: Variation of chromatic parameters with UV irradiation time

Irradiation (h)	L*			a*			b*		
	1%	3%	5%	1%	3%	5%	1%	3%	5%
0	34.46	23.29	19.65	14.44	17.62	16.60	-33.22	-34.15	-32.87
25	37.04	26.81	18.37	12.72	14.33	14.06	-30.81	-31.19	-28.72
50	37.27	27.02	18.97	11.06	13.93	10.84	-27.47	-29.93	-29.75
75	35.05	24.58	17.90	8.27	13.00	8.88	-24.37	-28.67	-27.83
100	35.86	23.66	16.76	7.61	13.72	8.35	-21.00	-25.35	-27.06

L* values decrease for all dyed samples in the irradiation time range 50–100 hours. A pronounced decrease for samples painted with 1 % and 3 % dye and a slow decrease for the one painted with 5 % dye occurs in the range 50–75 hours. Samples dyed with 1 and 3 % dye discoloured in the ranges 0–25 hours and 25–50 hours, while the sample painted with 1 % dye also discoloured within the range 75–100 hours, being the most affected by UV irradiation. The sample dyed with 5 % darkens during UV irradiation. The variation of a* and b* chromatic coefficients indicates accumulation of green and yellow chromophores due to photo-oxidation processes.

4. CONCLUSIONS

Sample painted with 1 % was the most affected by UV irradiation. The sample dyed with 5 % darkens during UV irradiation. Samples behaved as if they accumulated green and yellow chromophores due to photo-oxidation processes.

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