Chemistry

New class of azo reactive disperse dyes based on quinazolinone moiety: synthesis, characterization, and dyeing performance on blend fabrics with ultraviolet protection

Ahmed A. Noser*, Saham A. Ibrahim, Adel I. Selim, Asmaa M. Sakr

Organic Chemistry, Chemistry Department, Faculty of Science, Tanta University, Tanta 31527, Egypt

*Corresponding author: Dr. Ahmed A. Noser
e-mail: ahmed.nosir@science.tanta.edu.eg

Received: 26/11/2023
Accepted: 6/12/2023

KEY WORDS
Quinazolinone, disperse, fabric, exhaustion, fastness

ABSTRACT

This study describes an efficient and simple technique for the synthesis of four new quinazolinone reactive disperse dyes, which include 1,3,5-trichlorotriazine (cyanuric chloride) group from quinazolinone and various substituted primary aromatic amines. The structures of the dyes were confirmed and elucidated by mass spectroscopy, UV-visible, FT-IR, 1H-NMR, 13C NMR, and CHN analysis. Theoretical values of all produced colors and observed data were in good agreement with the proposed chemical structure. The fabric's dyeing properties, color representation, dye exhaustion and fixation, and fastness properties are determined. These dyes have proven to be successful in dyeing blend fabrics, which are composed of 70% polyester and 30% cotton. Colorimetric data, exhaustion, and fixation investigations have produced outstanding results. These dyes have the benefit of being relatively easy to synthesize, and scaling them up is possible, favoring industrial dyeing applications. Additionally, the UV protection factor of the dyed fabrics was examined, and the results demonstrated that these dyes provided outstanding UV protection.
Introduction

When compared to azo dyes derived from simple aniline, dyes based on heterocyclic moiety were shown to have a higher degree of brightness and tinctorial strength (Yen et al., 2004; Manuela et al., 2005). These dyes are also employed to stain and paralyze microorganisms as chemotherapeutic and antibacterial agents (Algohary et al., 2021). Due to its ease of synthesis (Ming et al., 2023), wide range of pharmacological activity anticancer (Gatadi et al., 2020), anti-inflammatory (Abd El-Dayem et al., 2020), antimicrobial (Nasab et al., 2017), anti-ToCV activity (Yen et al., 2020), antiviral activity (Saul et al., 2020), and anti-influenza inhibition (Wang et al., 2020), and quinazolinone nucleus, which is present in several alkaloids, has drawn attention. Apart from its biological properties, the quinazolinone nucleus has been discovered to be an essential element in a wide variety of colored products (Acharyulu et al., 2008; Patel et al., 2010; Patel et al., 2002). The quinazolinone ring's weakly delocalized electron caused these dyes to show visual absorption maxima ($\lambda_{\text{max}}$) in the yellow to orange region. It has been shown that dyes with heterocyclic moiety, such as quinazoline, produce a broad spectrum of color shades on different fiber types with very good depth and levelness (Patel et al., 2010; Patel et al., 2011). These dyes also exhibit outstanding brightness and fastness features, such as low sublimation and high heat stability (Divyesh et al., 2010). Blend fabrics have become increasingly popular because of their advantageous economic and physical characteristics. Blends of polyester and cotton offer easy-care qualities, abrasion resistance, dimensional stability, tensile strength, and crease recovery (Jeyakodi et al., 2015; Chen et al., 2019; Guruprasad et al., 2015; Seham et al., 2021).

Human exposure to ultraviolet (UV) radiation has increased due to ozone depletion, which has resulted in cataracts and skin cancer (Bernhard et al., 2020). It is crucial to shield the skin from UV radiation exposure that is too high. Because they offer easy and convenient protection against UV radiation, UV protective fabrics have drawn more attention (Vuthiganond et al., 2020). The last ten years have seen a significant development in knowledge regarding clothing-grade protective fabrics, which may shield the human body from the damaging effects of sunlight's UV rays (Youssef et al., 2014). The primary goal of the current effort was to create a number of novel reactive disperse dyes with quinazolinone moiety that included a reactive dichloro-s-triazinyl (DCT) group. This is an extension research program in our lab that is based on the synthesis of a new azo heterocyclic system. (Seham et
al., 2021; Ahmed et al., 2023; El-Borai et al., 2013; Hala et al., 2017). To get a range of shades, different coupling components were selected. These reactive disperse dyes were tested for their dyeing performance on blend fibers as well as their fastness characteristics, exhaustion, and fixation studies. Additionally, the UV protection factor of the dyed fabrics was tested, and the results demonstrated that these dyes provided excellent UV protection.

EXPERIMENTAL

Materials and instrumentation

We purchased all analytical-grade reagents from Sigma-Aldrich. Commercial polyester materials were utilized for dyeing. On Gallenkamp melting point equipment, all melting points were detected without any corrections. The KBr disc method was used to record the infrared spectra using a PerkinElmer FT-IR 1430 spectrophotometer. Using a 1.0 cm quartz cell and a SHIMADZU UV-3101PC spectrophotometer, UV-visible (UVvis) absorption spectra were recorded. A Bruker AC spectrometer (400 MHz for $^1$HNMR and 101 MHz for $^{13}$C NMR) was used to record the NMR spectra at 25 °C in DMSO d6. On a Finnigan MAT 8222 EX mass spectrometer, mass spectra were obtained at 70 eV. CTB-108, Ugolini, 1993 (dyeing machine) was used for dyeing polyester/cotton fabrics. Spectrophotometry was used to assess the levels of exhaustion of dyed fabrics. Double beam spectrophotometer (a Cecil 9200) was used for the absorption spectra measurement. Gretag Macbeth 7000 A was used to determine the dyed samples' reflectance. Thin-layer chromatography (TLC) was used to follow the progress of the reaction.

Synthesis of 3-(4-(4,6-dichloro-1,3,5-triazin-2-ylamino)phenyl)-2-phenylquinazolin-4(3H)-one (2)

Cyanuric chloride (0.97 g, 5.3 mmol) was stirred in a mixture of acetone (20 ml) and water (5 ml) for 1 h to form a fine suspension at −5 °C. A neutral solution of 3-(4-aminophenyl)-2-phenylquinazolin-4(3H)-one (1) (1.56 g, 5 mmol) in NaHCO3 solution (10%, 3 ml) was added in such a way that the temperature did not exceed above −5 °C. The reaction mixture was stirred for up to 3 h while maintaining the pH at 6.9–7.0. The solid formed was filtered, washed with water and crystallized from ethanol to give compound 2.

General procedure for the synthesis of compounds 3a-d

To a cooled solution of aromatic amines (13.7 mmol) in concentrated HCl, a solution of sodium nitrite (0.9 g, 12.7 mmol) in water was added dropwise. The diazonium salt was added with constant stirring to a cooled solution of compound 2 (3.92 g, 8.5 mmol) in sodium hydroxide (15 ml (10%)). The mixture of the reaction was agitated for two hours at 0 °C, then the
product was filtered, and crystallized from ethanol to obtain (3a-d).

(E)-3-(4-((4,6-dichloro-1,3,5-triazin-2-yl) amino)-3-(phenyldiazeyl)phenyl)-2-phenylquinazolin-4(3H)-one (3a)

MP. 97-100°C; yield: 87%; IR (KBr) v: 3457(NH), 1711 (CO), 1595 (C=N), 1501 (N=N); 1H NMR (400 MHz, DMSO-d6) δ 12.41 (s, 1H, NH), 6.51-7.64 (m, 17H, Ar-H); 13C NMR (101 MHz, DMSO-d6) δ 175.65 (C-Cl), δ 168.11 (C=N cyanuric), 161.83 (C=N quinazolinone), 151.22 (C=O), 114.44-149.11 (Ar-C); Anal. Calcd for C29H18Cl2N8O (565.42) C, 61.60%; H, 3.21%; Cl, 12.24%; N, 19.82%; Found: C, 61.41%; H, 3.11%; Cl, 12.08%; N, 19.72%

(E)-3-(4-((4,6-dichloro-1,3,5-triazin-2-yl) amino)-3-(4-hydroxyphenyl diazenyl)phenyl)-2-phenylquinazolin-4(3H)-one (3b)

MP. 205-208 °C; yield: 86%; IR (KBr) v: 3457 (NH), 3202 (OH), 1710 (CO), 1664 (C=N), 1596 (N=N); 1H NMR (400 MHz, DMSO-d6) δ 11.73 (s, 1H, NH), 6.76-7.92 (m, 16H, Ar-H), 5.52 (s, 1H, OH); 13C NMR (101 MHz, DMSO-d6) δ 180.51 (C-Cl), δ 171.78 (C=N cyanuric), 167.40 (C=N quinazolinone), 155.95 (C=O), 151.03 (C=OH), 99.97-129.33 (Ar-C); Anal. Calcd for C29H18Cl2N8O2 (581.41) C, 59.91%; H, 3.12%; Cl, 12.20%; N, 19.27%; Found: C, 59.41%; H, 2.92%; Cl, 12.06%; N, 19.17%

(E)-3-(4-((4,6-dichloro-1,3,5-triazin-2-yl) amino)-3-((3,5-dimethylphenyl)diazenyl)phenyl)-2-phenylquinazolin-4(3H)-one (3c)

MP. 180-183°C; yield: 89%; IR (KBr) v: 3431 (NH), 1710 (CO), 1600 (C=N), 1535 (N=N); 1H NMR (400 MHz, DMSO-d6) δ 10.62 (s, 1H, NH), 6.39-7.91 (m, 15H, Ar-H), 2.31 (s, 6H, 2CH3); 13C NMR (101 MHz, DMSO-d6) δ 172.12 (C-Cl), δ 160.45 (C=N cyanuric), 153.95 (C=N quinazolinone), 149.11 (C=O), 102.69-141.20 (Ar-C), 21.47 (CH3); Anal. Calcd for C31H22Cl2N8 (593.47) C, 62.74%; H, 3.74%; Cl, 11.95%; N, 18.88%; Found: C, 62.54%; H, 3.58%; Cl, 11.77%; N, 18.76%

(E)-3-(4-((4,6-dichloro-1,3,5-triazin-2-yl) amino)-3-(m-tolyldiazenyl)phenyl)-2-phenylquinazolin-4(3H)-one (3d)

MP. 93-96 °C; yield: 87%; IR (KBr) v: 3403 (NH), 1710 (CO), 1617 (C=N), 1552 (N=N); 1H NMR (400 MHz, DMSO-d6) δ 10.82 (s, 1H, NH), 6.69-7.93 (m, 16H, Ar-H), 2.30 (s, 3H, CH3); 13C NMR (101 MHz, DMSO-d6) δ 171.21 (C-Cl), δ 153.41 (C=N cyanuric), 150.12 (C=N quinazolinone), 147.47 (C=O), 99.97-146.21 (Ar-C), 20.02 (CH3); Anal. Calcd for C39H20Cl2N8O (579.44) C, 62.18%; H, 3.48%; Cl, 12.24%; N, 19.34%; Found: C, 62.06%; H, 3.28%; Cl, 12.12%; N, 19.14%.
Electronic spectral studies

Electronic spectra of the rhodanine dyes (3a-d) were studied in the UV region at molar concentration of 3 \times 10^{-5} \text{ mol/L} in Benzene and DMF.

Dyeing procedure

General procedure for dyeing of polyester/cotton fabric

The polyester/cotton fabric were dyed using the synthetic dyes as reported (Shahid et al., 2005, Najafi et al., 2009). Detailed information's about the procedure for dyeing of blend fabric were reported in Fig. (1).

Fig. (1): One bath dyeing profile of polyester/cotton blend (70:30) fabrics with temporarily solubilized disperse-reactive dyes.

Measurement for the dyeing properties

Fastness properties

According to the ISO 105-C02 (1989), ISO 105-X12 (1987), ISO 105-EO4 (1989), ISO 105-F04 and AATCC 16-2004 test methods, respectively, the colored PET fabrics fastness properties against washing, rubbing, perspiration, sublimation, and light were assessed (Abbas et al., 2020).

Colorimetric analysis

The color parameters of the dyed PET fabric were measured using a spectrophotometer (Gretag Macbeth, CE 7000 A). The following CIELAB coordinates were measured: lightness (L*), chroma (C*), the degree of redness (+ve) and greenness (-ve) (a*), and the degree of yellowness (+ve) and blueness (-ve) (b*). The color strength (K/S) values were obtained according to the Kubelka-Munk equation (AATCC, 1991) (Metwally et al., 2008).

Exhaustion study

The uptakes of the reactive disperse dyes by blend fabrics were measured by
sampling the dye bath before and after dyeing. The rate of exhaustion of the dyestuffs on blend fabrics was measured at equilibrium at 100 °C. The exhaustion rate was assessed by taking samples from the dyebath at different times during the dyeing process. The optical density of the dye bath samples was then measured spectrophotometrically at \( \lambda_{\text{max}} \) of each dye using a calibration curve previously obtained using known dye concentrations in 50% aqueous DMF and the dye exhaustion ratio was calculated using equation (1) (Cai et al., 2020):

\[
\text{% } \text{E} = \left[ 1 - \frac{C_2}{C_1} \right] \times 100 \quad \text{Equation 1}
\]

Where \( C_1 \) and \( C_2 \) are the concentrations of dye in the dyebath before and after dyeing, respectively.

**Fixation study**

Dye fixation (%F) (percentage of the exhausted dye that chemically bound on the fiber) was measured by refluxing the dyed samples in 50% aqueous DMF (liquor ratio 20:1) for 15 min to extract the unfixed dye (Ma et al., 2020). Repeat this procedure until the extract is clear. The concentration of the extract was then measured spectrophotometrically at \( \lambda_{\text{max}} \) of each dye, and the dye fixation ratio was calculated using equation (2):

\[
\text{% } \text{F} = \left( \frac{C_1 - C_2 - C_3}{C_1 - C_2} \right) \times 100 \quad \text{Equation 2}
\]

Where \( C_3 \) is the concentration of extracted dye. From the dyebath.

**Ultraviolet protective factor (UPF), UV-A and UV-B transmission**

The UPF and ultraviolet radiation (UV-R) transmission through dyed sample is measured on a spectrophotometer (Labsphere UPF TesterV- 2000F Fabric Analyzer). % transmission of UV-A, UV-B rays and UPF were measured as per AATCC 183–2010. Ultraviolet protective factor measures the effectiveness of textile fabrics in protecting the human skin from ultraviolet radiations. It is expressed as the ratio of the time required for the skin to show redness (erythema) with and without protection, under constant exposure to sunlight (Joseph et al., 2016). The UPF is calculated using the following equation (3) Louris et al., 2018; Mishra et al., 2019):

\[
\text{UPF} = \frac{(\text{Med Protected Skin})}{(\text{MED unprotected skin})} \quad \text{Equation 3}
\]

Where, MED is the minimal erythemal dose or quantity of radiant energy needed to produce the first detectable reddening of skin after 22 ± 2 hours of continuous exposure.

**RESULTS AND DISCUSSION**

**Synthesis and characterization**

The reaction of neutral solution of starting compound 3-((4-aminophenyl)-2-phenylquinazolin-4(3H)-one (1) with Cyanuric chloride dissolved in a mixture of acetone and water led to formation of 3-(4-(4,6-dichloro-1,3,5-triazin-2-ylamino)phenyl)-2-phenylquinazolin-4(3H)-one (2) as shown in scheme (1).
The synthesized reactive azo dyes 3a-d is shown in Scheme (2). The diazonium salts of different aromatic amines coupled with compound 2 in basic medium to give the corresponding reactive azo compounds 3a-d in a good yield. The structures of reactive dyes were confirmed by means of FT-IR, $^1$H NMR, $^{13}$C NMR and elemental analyses. The FT-IR spectra of reactive dyes 3a-d showed characteristic bands at 3403-3457 cm$^{-1}$ and 1501-1596 cm$^{-1}$ due to the NH stretching vibration and the azo group (N=N) bending vibration, respectively. Additionally, a strong band at 1710-1711 cm$^{-1}$ corresponding to the C=O group of the quinazolinone moiety and an absorption band at 1595-1664 cm$^{-1}$ due to the C=N stretching vibration of the quinazolinone moiety were observed. In addition compound 3b showed characteristic band at 3202 cm$^{-1}$ due to the OH stretching. The $^1$H NMR spectra of reactive dyes 3a-d exhibited a singlet signal at $\delta$ 10.62–12.41 ppm due to NH proton which was exchangeable with D$_2$O. The OH proton of reactive dye 3b revealed as a singlet signal at $\delta$ 5.52 ppm which was exchangeable with D$_2$O. The $^{13}$C NMR spectral data of dyes 3a-d showed signals at $\delta$ 171.21–180.51 ppm due to C-Cl, signals at $\delta$ 153.41–171.78 ppm due to C=N (cyanuric), signals at $\delta$ 150.12–167.40 ppm and $\delta$ 147.47–155.95 due to C=N(quinazolinone) and C=O respectively. Finally, the elemental analysis was in accord with the predicted structures.
Visible absorption spectroscopic properties of dyes 3a–d

Because of their higher polarity, especially in the excited state, heterocyclic-based azo disperse dyes generally have a stronger bathochromic effect than their benzenoid analogues, with larger solvatochromic effects (Yazdanbakhsh et al., 2010, Athira et al., 2019). The electronic absorption spectra of dyes 3a–d were measured at room temperature and quantified at a concentration of $10^{-5}$ mol/L using DMF, a dipolar aprotic solvent, and benzene, a nonpolar solvent. Table (1) and Fig. (2) provide an overview of the results for $\lambda_{\text{max}}$ and molar absorptivity ($\varepsilon$). All dyes showed only one absorption maximum in the visible region in the range...
of 352–436 nm because of the presence of electronic transitions in the conjugate system consisting of phenyl rings, heterocyclic moieties, and theazo group, which may be classified as the $\pi-\pi^*$ transition type, all dyes displayed only one absorption maximum in the visible region in the range of 352–436 nm. Overall, it was discovered that the dye absorption maxima were influenced by the substituents’ nature on phenyl moieties, position, as well as the diazo component.

**Solvent effect on the absorption spectra**

Table (2) demonstrates that the dyes 3a-d were more sensitive to polar aprotic solvents than nonpolar solvents. All dyes displayed maximum sensitivity in DMF because of its polar and alkaline properties, which explain most solute-solvent interactions.

**Substituent effects on the absorption spectra**

Because dyes 3a-d contains $\pi$ electrons, they can be subjected to UV–vis absorption measurements to determine the electron shell state. The main difference between dyes is the nature of the substituents on the phenyl moiety, i.e., OH group in 3b, 2-CH$_3$ in 3c, CH$_3$ in 3d and H in 3a. As shown in Table (1) and Figs. (2&3), the order of $\lambda_{\text{max}}$ was 3b > 3c > 3d > 3a respectively. The $\lambda_{\text{max}}$ of dye 3b (436, and 385 nm) was higher than that of dye 3c, 3d and 3a, which is due to the bathochromic shift of the absorption band caused by the presence of the electron-withdrawing OH group respectively. This result showed that the absorption bands show bathochromic or hypsochromic shifts, respectively, as the conjugation in the dye molecules increases or decreases. The impact of the structural alterations in the phenyl nucleus will most likely determine how much of this shift occurs.

**Table (1): Absorption spectra of dyes 3a-d**

<table>
<thead>
<tr>
<th>No.</th>
<th>Absorption $\lambda_{\text{max}}$ (nm) (Benzene)</th>
<th>$\varepsilon$</th>
<th>Absorption $\lambda_{\text{max}}$ (nm) (DMF)</th>
<th>$\varepsilon$</th>
</tr>
</thead>
<tbody>
<tr>
<td>3a</td>
<td>345</td>
<td>1132</td>
<td>413</td>
<td>1176</td>
</tr>
<tr>
<td>3b</td>
<td>385</td>
<td>1456</td>
<td>436</td>
<td>3234</td>
</tr>
<tr>
<td>3c</td>
<td>365</td>
<td>1378</td>
<td>428</td>
<td>2310</td>
</tr>
<tr>
<td>3d</td>
<td>352</td>
<td>1256</td>
<td>421</td>
<td>2212</td>
</tr>
</tbody>
</table>

**Dyeing properties of the dyes on polyester fabrics**

**Assessment of fastness properties**

Blend fabrics were dyed using synthetic dyes at a concentration of 2% (owf). The resulting hues on the fabrics ranged from yellow to dark brown (Table 2). The fastness qualities of the dyes on mix were assessed, as indicated in Tables (3). Synthetic dyes have very good to excellent washing fastness values (3–4, 4-5), which can be explained by the dyes' low water solubility and good intra-fabric diffusion. A notable levelness upon washing demonstrated strong penetration and affinity of these dyes, and the presence of hydrophobic groups (C=O) in the chemical structures of the dyes clearly inhibits dye
molecules from migrating back from the fiber to the washing solution bath, and a remarkable degree of levelness after washing indicated good penetration and affinity of these dyes to the fabric. Fastness to acid and alkaline perspiration could be very good to excellent (3-4, 4–5); these results indicate the stability of the dyes. Furthermore, due to adequate diffusion of dyes molecule into the fabrics, the rubbing fastness (wet and dry) is very good to excellent values (4–5). All the synthesized dyes show very good to excellent fastness to light (5–6, 6). From the results we concluded that the dyes revealed approximately similar results of fastness properties for fabrics. The high ratings of fastness properties could be referred to the covalent binding linkages between the dye and the fiber and strong dye-dye interaction energy that can prevent dye molecules from transferring to the fiber surface.

All dyes revealed higher color yields due to their increased substantively to the fiber. And a remarkable level of levelness upon washing suggested that these dyes had strong affinity and penetration into the fabric. The dyes’ durability is demonstrated by their very good to excellent fastness to acid and alkaline sweat (3–4, 4-5). Furthermore, the rubbing fastness (both wet and dry) is very good to excellent values (3–4, 4-5), as a result of the dyes’ molecules diffusing into the materials sufficiently. Every synthetic dye exhibits very good to excellent light fastness (5-6, 6). We deduced from the data that the dyes showed roughly comparable fastness property values for fabrics. The covalent binding connections between the dye and the fiber as well as the potent dye-dye interaction energy that can inhibit dye bleed could be the cause of the high ratings for fastness properties. All dyes revealed higher color yields due to their increased substantivity to the fiber.

**Fig. (2):** Absorption spectra of dyes 3a-d in DMF and Benzene (3×10⁻⁵ M)
**Table (2): Shade of fabric samples dyed with 3a-d at 2% owf level**

<table>
<thead>
<tr>
<th>Blend fabrics</th>
<th>3a</th>
<th>3b</th>
<th>3c</th>
<th>3d</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>![Image]</td>
<td>![Image]</td>
<td>![Image]</td>
<td>![Image]</td>
</tr>
</tbody>
</table>

**Table (3): Fastness properties of dyed blend fabrics using dyes 3a-d (2% o.w.f).**

<table>
<thead>
<tr>
<th>Dyes. No</th>
<th>Washing</th>
<th>Perspiration</th>
<th>Rubbing</th>
<th>Light</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Acidic</td>
<td>Alkaline</td>
<td>Dry</td>
</tr>
<tr>
<td></td>
<td>SC</td>
<td>Alt</td>
<td>SC</td>
<td>Alt</td>
</tr>
<tr>
<td>3a</td>
<td>3-4</td>
<td>4-5</td>
<td>4-5</td>
<td>3-4</td>
</tr>
<tr>
<td>3b</td>
<td>4-5</td>
<td>4-5</td>
<td>4-5</td>
<td>3-4</td>
</tr>
<tr>
<td>3c</td>
<td>4-5</td>
<td>4-5</td>
<td>4-5</td>
<td>3-4</td>
</tr>
<tr>
<td>3d</td>
<td>4-5</td>
<td>3-4</td>
<td>4-5</td>
<td>3-4</td>
</tr>
</tbody>
</table>

SC, staining on cotton; Alt, color change of dyed sample.

**Color assessment**

The synthetic dyes 3a–d were applied to blend fabrics, and the results showed that these dyes had visual shades ranging from yellow to dark brown. Furthermore, the presence of chromophores in their structures gave these dyes good depth and leveling qualities. The color coordinates show that the dyes have a good affinity for blend fabrics with a good degree of brightness, evenness, and depth of color. On blend fabrics, the dye's lightness or darkness is determined by comparing the significantly (54.88–69.43) on blend fabrics, as indicated by the L* values. The blend fabrics displayed excellent dye absorption as evidenced by their bright shade (high C* value) (59.44–67.24). Because all synthetic dyes have positive a* and positive b*, the dyed fabrics have yellow-red hues. The dyed polyester fabrics' K/S value at the absorption maximum ranges from 13.11 to 10.25. The dyestuffs used in the investigation demonstrated good affinity blend fabrics with acceptable K/S values and satisfactory color yields (Table 4, Fig.(3). All of the dyed fabrics' visual observations showed that the leveling qualities of each dye were excellent. Values of L* (positive denotes lightness, and negative denotes darkness). The color lightness value (L*) of dyes 3a–d varies
Table (4): Colorimetric data of the dyed blend fabrics using dyes 3a-d (2% o.w.f)

<table>
<thead>
<tr>
<th>Dye</th>
<th>L*</th>
<th>a*</th>
<th>b*</th>
<th>C*</th>
<th>h0</th>
<th>K/S</th>
<th>D. Ex.* (%)</th>
<th>D. Fx.* (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3a</td>
<td>60.59</td>
<td>9.10</td>
<td>32.55</td>
<td>64.78</td>
<td>39.11</td>
<td>13.11</td>
<td>97</td>
<td>85</td>
</tr>
<tr>
<td>3b</td>
<td>69.43</td>
<td>11.92</td>
<td>22.80</td>
<td>66.89</td>
<td>30.24</td>
<td>12.67</td>
<td>94</td>
<td>80</td>
</tr>
<tr>
<td>3c</td>
<td>66.19</td>
<td>9.52</td>
<td>29.65</td>
<td>67.24</td>
<td>29.67</td>
<td>11.81</td>
<td>95</td>
<td>84</td>
</tr>
<tr>
<td>3d</td>
<td>54.88</td>
<td>17.07</td>
<td>21.03</td>
<td>59.44</td>
<td>22.90</td>
<td>10.25</td>
<td>92</td>
<td>82</td>
</tr>
</tbody>
</table>

(a) D. Ex. Meaning Degree of Exhaustion (%), (b) D. Fx. = Degree of Fixation (%).

Exhaustion and fixation study
Through pre- and post-dyeing dyebath sampling, the amount of dye absorbed by the fiber was determined. Equation (1) was utilized to calculate the absorbance of the diluted dye solution in ethanol-water (4:1, v/v) by measuring the dye's $\lambda_{\text{max}}$. Comparative dyeing properties blend fabrics with recently developed dyes had somewhat higher primary fixation and exhaustion. Between 92% and 97% of the dyes 3a–d were exhausted. Dyes 3a–d had a fixation rate of 80%–85%. The exhaustion values are influenced by the diffusion rate, fabric structure, and dye molecules. Under the specified dyeing conditions, the dye molecule diffuses quickly throughout the fabric, leading to a high rate of substantivity and strong dye attraction with the fabric. This suggests that the fabrics and the dyes are compatible as well. Additionally, after washing, these
dyes showed an extraordinary level of levelness because of the accumulation of polar groups, demonstrating strong diffusion and excellent affinities between the dyes and the fabric. The degree of exhaustion and fixation value of a dye molecule are enhanced by the addition of a reactive group, like a triazine ring, which increases substantivity toward fibers (Faisal et al., 2020; Sakr et al., 2020) Table (4) and Fig.(4).

**Fig. (4):** Percentages exhaustion and fixation of dyes 3a-d on blend fabrics

**Ultraviolet protection factor**

Because textiles can reflect, absorb, and scatter UV rays and lessen the amount of radiation that passes through them, they can shield the skin from damaging UV radiation. The UV protection factor of a textile material is used to quantify the level of UV protection it offers. Table 5 and Figure 5 provide a summary of the UV protection factor results. They demonstrate that dyed blend has an excellent UV protection factor rating, with values in the 54.22–72.79 range. This means that the transmittance percentage blocks approximately 100% of the UV radiation in the UV-B range of 290–315 nm and the UV-A range of 315–400 nm. As a result, textile materials are exceptionally protected from UV light by all synthetic dyes. Blend fabrics have higher UV protection factor values, which could be attributed to the compact structure of the fabric and a higher percentage of dye exhaustion.
Table (5): Ultraviolet Protection Factor Rating

<table>
<thead>
<tr>
<th>Dyes No.</th>
<th>UPF Range</th>
<th>Protection category</th>
<th>Effective UV-R Transmission (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>UV-B&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>3a</td>
<td>68.34</td>
<td>Excellent</td>
<td>0.02</td>
</tr>
<tr>
<td>3b</td>
<td>72.79</td>
<td>Excellent</td>
<td>0.07</td>
</tr>
<tr>
<td>3c</td>
<td>59.19</td>
<td>Excellent</td>
<td>0.01</td>
</tr>
<tr>
<td>3d</td>
<td>54.22</td>
<td>Excellent</td>
<td>0.08</td>
</tr>
</tbody>
</table>

Protection Category: Good (14-24), Very good (25-39), Excellent (40-50), UV-B<sup>a</sup>: Transmittance (mean transmittance percentage in the range 290-315 nm), UV-A<sup>b</sup>: Transmittance (mean transmittance percentage in the range 315-400 nm)

Fig. (5): Results for ultraviolet protection factor (UPF Value) for dyed blend fabric

Conclusion
In conclusion, four new quinazolinone reactive disperse dyes were successfully synthesized using Quinazolinone, various substituted primary aromatic amines and the 1,3,5-trichlorotriazine (cyanuric chloride) group. Using elemental analysis techniques and spectroscopic data, the structure of the synthesized dyes was established. Blend fabrics were successfully dyed using the synthetic dyes. The colorfastness data for dyed fabrics 3a–d revealed very good to excellent fastness to light (5–6 and 6), as well as very good to excellent fastness on the polyester fibers (3–4 and 4-5) to washing, rubbing, and perspiration. Additionally, the color coordinates show
that the dyes have a good affinity for blend fabrics with excellent brightness and color depth. The exhaustion values (ranging from 92% to 97%) are excellent. Additionally, these dyes have excellent fixation (range: 80% to 85%), which suggests that the dyes have excellent solubility and attraction to the fabric. Additionally, these dyes demonstrated an incredible level of evenness, demonstrating excellent fabric affinity as well as good diffusion and penetration. Due to the blend fabric's compact structure and higher percentage of dye exhaustion, the synthesized dyes exhibit excellent UV protection factor value in addition to their performance properties.

References


Noser et al., (2023) “Reactive Dyes for Various Fibers” Fibers and Polymers 11(4), 537-544


Ma, W., Du, S., Yan, S., Yu, X and Zhang, Z.ZS. (2020) “Salt-free dyeing of modified cotton through graft polymerization with highly enhanced dye fixation and good strength properties”. Polymija 12:462


Nasab, R.R., Hassanzadeh, F., Khodarahmi, G.A., Rostami, M., Mirzaei, M and
New class of azo reactive disperse dyes based on quinazolinone moieties


فئة جديدة من الأصباغ المختلطة النشطة الأزروية القائمة على حلقة الكينازولينون: التحضير والتحضير والصبغة على الأقمشة المخلوطة مع الحماية من الأشعة فوق البنفسجية
أحمد تصير، عادل سليم، سهام عبد اللطيف، اسماء صقر
قسم الكيمياء- كلية العلوم- جامعة طنطا

تصف هذه الدراسة تقنية فعالة وبسيطة لتخليق أربعة أصباغ مشتقة تفاعلية جديدة للكينازولينون، والتي تشمل مجموعة 1,3,5- ثلاثي كلوروبريترترین (كلوريد البيتاوروك) من الكينازولينون والعديد من الأمينات العطرية الأولية المستقبلة. تم تأكيده بنية الأصباغ وتوضيحها عن طريق التحليل الطيفي الكتلي، والأشعة فوق البنفسجية المرئية، والFT-IR، H-NMR، وNMR-C13. كانت القيم النظرية لجميع الألوان المنتجة والبيانات المرصودة متوافقة جيدًا مع التركيب الكيميائي المقترح. يتم تحديد خصائص صبغ القماش، وتمثيل اللون، واستنفاذ الصبغة وتبنيها، وخصائص الثبات. أثبتت هذه الأصباغ نجاحها في صباغة الأقمشة المخلوطة، والتي تتكون من 70% بوليستر و30% قطن. لقد أسفرت البيانات اللونية والاستنفاذ، وتحقيقات التثبيت عن نتائج مثيرة. تتمتع هذه الأصباغ بميزة سهولة تصنيعها نسبة، ومن الممكن توسيع نطاقها، مما يفضل تطبيقات الصبغة الصناعية. بالإضافة إلى ذلك، تم فحص عامل الحماية من الأشعة فوق البنفسجية للأقمشة المصبغة، وأظهرت النتائج أن هذه الأصباغ توفر حماية متميزة من الأشعة فوق البنفسجية.