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Research Article

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

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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 (λ_{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.

EXPREMENTAL

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 $^{\circ}$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 ^{o}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 ^{o}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 $^{\circ}$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-(phenyldiazenyl)phenyl)-2-phenylquinazolin-4(3H)-one (3a)

MP. 97-100^{o}C; **yield**: 87%; **IR** (KBr) ν: 3457(NH), 1711 (CO), 1595 (C=N), 1501 (N=N); **^{1}H NMR** (400 MHz, DMSO-d_6) δ 12.41 (s, 1H, NH), 6.51-7.64 (m, 17H, Ar-H) ; **^{13}C NMR** (101 MHz, DMSO-d_6) 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 $C_{29}H_{18}Cl_2N_8O$ (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 ^{o}C; **yield**: 86%; **IR** (KBr) ν: 3457 (NH), 3202 (OH), 1710 (CO), 1664 (C=N), 1596 (N=N); **^{1}H NMR** (400 MHz, DMSO-d_6) δ 11.73 (s, 1H, NH), 6.76-7.92 (m, 16H, Ar-H), 5.52 (s, 1H, OH); **^{13}C NMR** (101 MHz, DMSO-d_6) 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 $C_{29}H_{18}Cl_2N_8O_2$ (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^{o}C; **yield**: 89%; **IR** (KBr) ν: 3431 (NH), 1710 (CO), 1600 (C=N), 1535 (N=N); **^{1}H NMR** (400 MHz, DMSO-d_6) δ 10.62 (s, 1H, NH), 6.39-7.91 (m, 15H, Ar-H), 2.31 (s, 6H, 2CH_3); **^{13}C NMR** (101 MHz, DMSO-d_6) 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 (CH_3); **Anal.** Calcd for $C_{31}H_{22}Cl_2N_8O$ (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 ^{o}C; **yield**: 87%; **IR** (KBr) ν: 3403 (NH), 1710 (CO), 1617 (C=N), 1552 (N=N); **^{1}H NMR** (400 MHz, DMSO-d_6) δ 10.82 (s, 1H, NH), 6.69-7.93 (m, 16H, Ar-H), 2.30 (s, 3H, CH_3); **^{13}C NMR** (101 MHz, DMSO-d_6) 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 (CH_3); **Anal.** Calcd for $C_{30}H_{20}Cl_2N_8O$ (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 $\times 10^{-5}$ 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, Najafi1 *et al*., 2009)**. Detailed information's about the procedure for dyeing of blend fabric were reported in Fig. (**1)**.

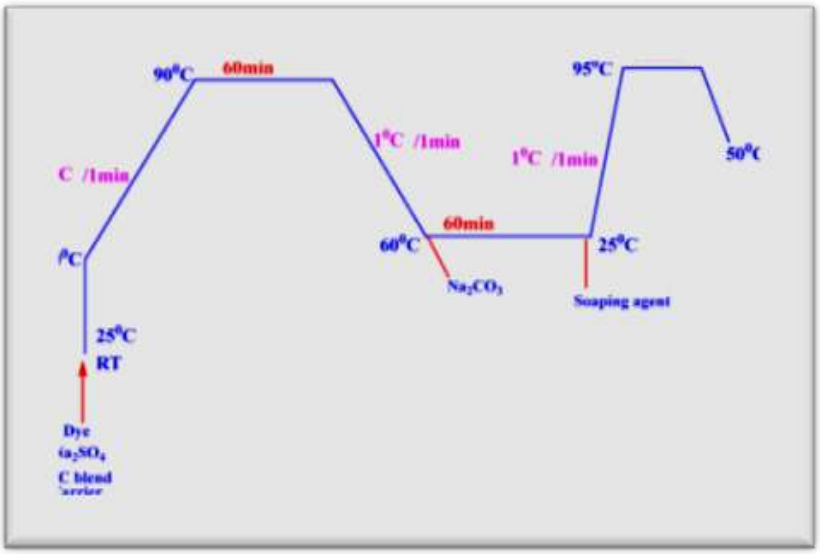


Fig. (1): One bath dyeing profile of polyester/cotton blend (70:30) fabrics with temporarily solubilized disperse-reactive dyes.

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 (λ_{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)**:

$$\% E = [1-C_2/C_1] \times 100 \quad \text{Equation 1}$$

Where C1 and C2 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 (λ_{max}) of each dye, and the dye fixation ratio was calculated using **equation (2):**

$$\%F = \frac{(C1-C2-C3)}{C1-C2} x100 \quad \text{Equation 2}$$

Where C3 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)**:

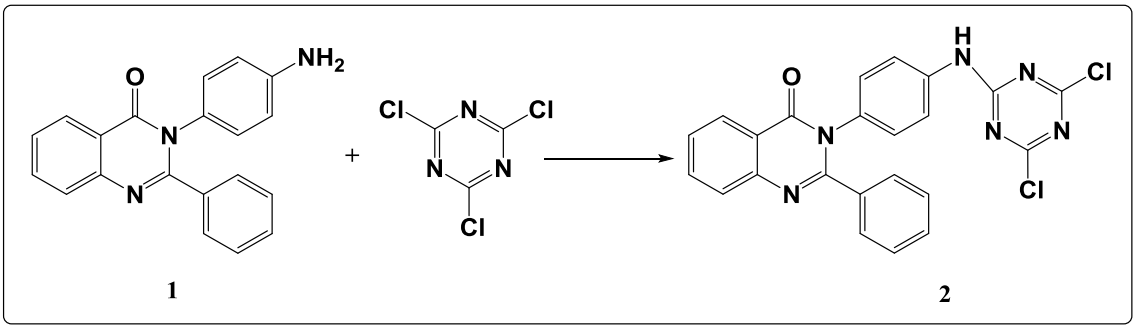
$$UPF = \frac{\text{(Med Protected Skin)}}{\text{(MED unprotected skin)}} \quad \text{..... Equation 3}$$

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

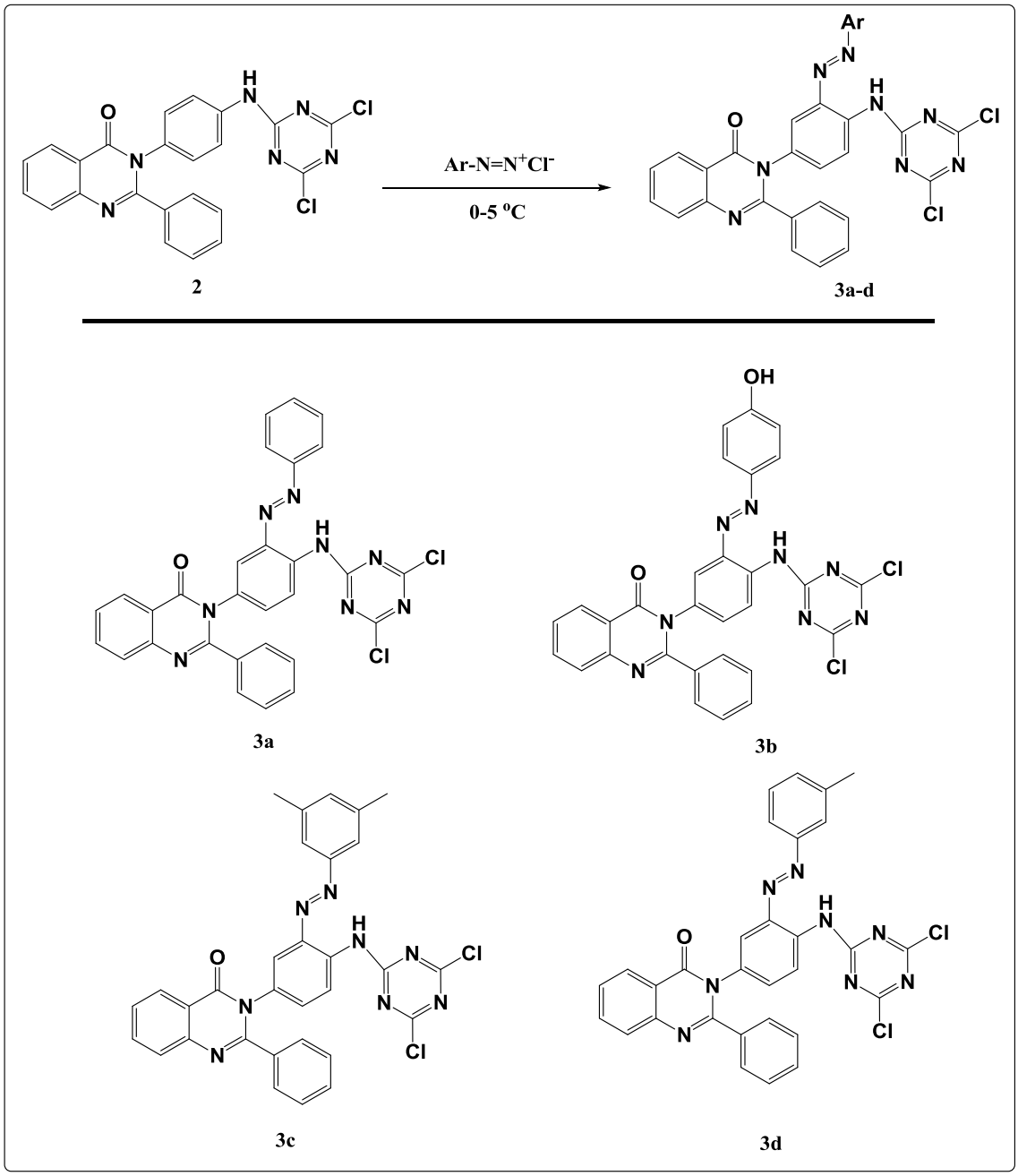
Synthesis and characterization

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).



Scheme (1). Synthesis pathway of compound **2**

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 δ 10.62–12.41 ppm due to NH proton which was exchangeable with D_2O. The OH proton of reactive dye **3b** revealed as a singlet signal at δ 5.52 ppm which was exchangeable with D_2O. The ^{13}C NMR spectral data of dyes **3a-d** showed signals at δ 171.21–180.51 ppm due to C-Cl, signals at δ 153.41–171.78 ppm due to C=N (cyanuric), signals at δ 150.12–167.40 ppm and δ 147.47–155.95 due to C=N(quinazolinone) and C=O respectively. Finally, the elemental analysis was in accord with the predicted structures.



Scheme (2). Synthesis pathway of compound **3a-d**

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 λmax and molar absorptivity (ε). 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 the azo group, which may be classified as the π–π* 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 π 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 λ_{max} was 3b > 3c > 3d > 3a respectively. The λ_{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

No.	Absorption λ_{max} (nm) (Benzene)	ε	Absorption λ_{max} (nm) (DMF)	ε
3a	345	1132	413	1176
3b	385	1456	436	3234
3c	365	1378	428	2310
3d	352	1256	421	2212

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.

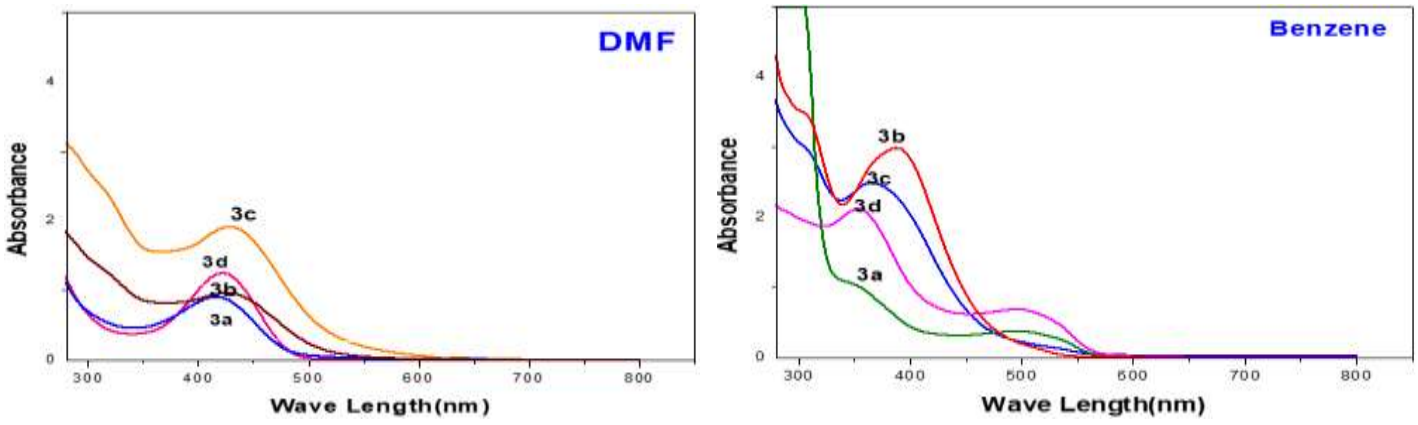


Fig. (2): Absorption spectra of dyes 3a-d in DMF and Benzene (3×10^{-5} M)

Table (2): Shade of fabric samples dyed with **3a-d** at 2% owf level

	3a	3b	3c	3d
Blend fabrics				

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

Dyes. No	Washing		Perspiration				Rubbing		Light
			Acidic		Alkaline				
	SC	Alt	SC	Alt	SC	Alt	Dry	Wet	
3a	**3-4**	**4-5**	**4-5**	**4-5**	**3-4**	**4-5**	**4-5**	**4-5**	**6**
3b	**4-5**	**4-5**	**4-5**	**3-4**	**4-5**	**3-4**	**4-5**	**4-5**	**5-6**
3c	**4-5**	**4-5**	**3-4**	**4-5**	**3-4**	**4-5**	**4-5**	**3-4**	**5-6**
3d	**4-5**	**3-4**	**4-5**	**3-4**	**4-5**	**4-5**	**4-5**	**4-5**	**6**

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)

Dye	L*	a*	b*	C*	h^0	K/S	D. Ex.[a] (%)	D. Fx.[b] (%)
3a	60.59	9.10	32.55	64.78	39.11	13.11	97	85
3b	69.43	11.92	22.80	66.89	30.24	12.67	94	80
3c	66.19	9.52	29.65	67.24	29.67	11.81	95	84
3d	54.88	17.07	21.03	59.44	22.90	10.25	92	82

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

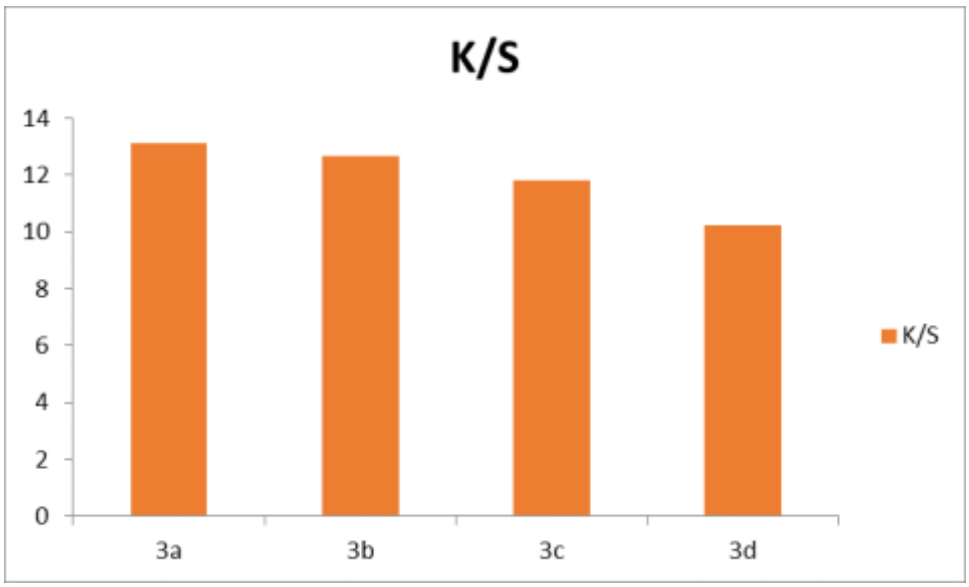


Fig. (3): K/S values of dyed blend fabrics

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 λ_{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).

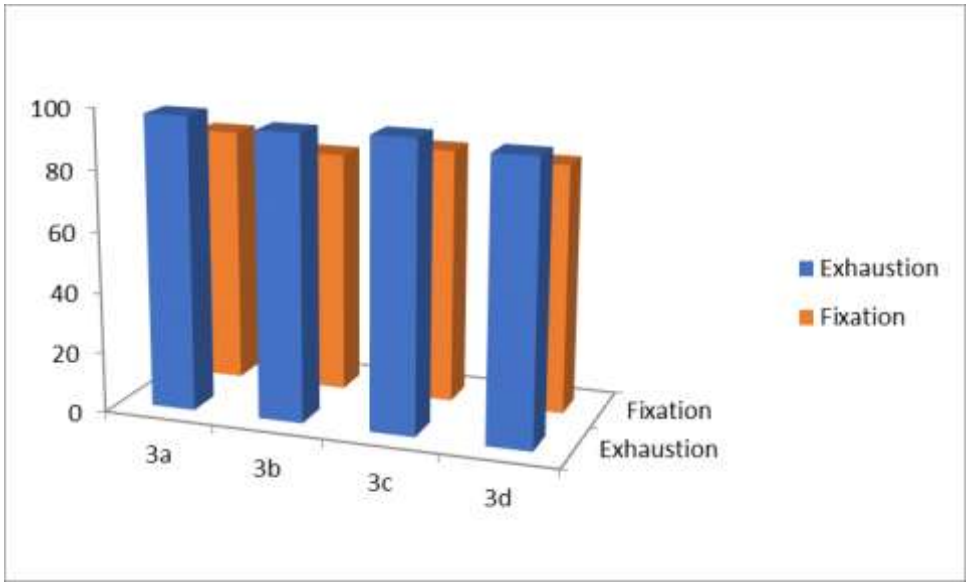


Fig. (4): Percentages exhaustion and fixation of dyes **3a-d** on blend fabrics

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

Dyes No.	UPF Range	Protection category	Effective UV-R Transmission (%)	
			UV-B[a]	UV-A[b]
3a	68.34	Excellent	0.02	0.01
3b	72.79	Excellent	0.07	0.09
3c	59.19	Excellent	0.01	0.07
3d	54.22	Excellent	0.08	0.05

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

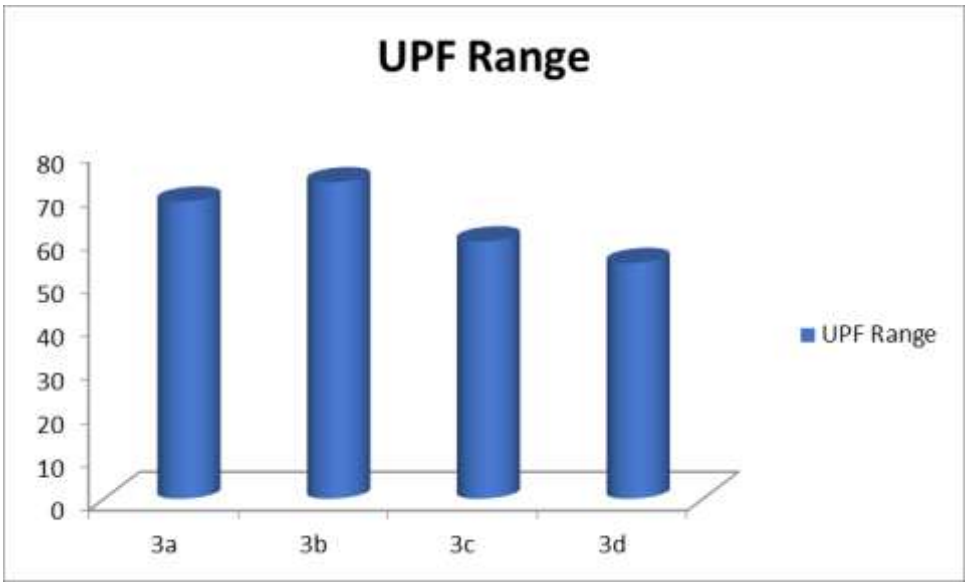


Fig. (5): Results for ultraviolet protection factor (UPF Value) for dyed blend fabric

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.

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فئة جديدة من الأصباغ المنتشرة النشطة الآزوية القائمة على حلقة الكينازولينون: التحضير والتوصيف والصباغة على الأقمشة المخلوطة مع الحماية من الأشعة فوق البنفسجية

أحمد نصير* ، عادل سليم ، سهام عبداللطيف ، اسماء صقر

قسم الكيمياء- كلية العلوم- جامعة طنطا

تصف هذه الدراسة تقنية فعالة وبسيطة لتخليق أربعة أصباغ مشتتة تفاعلية جديدة للكينازولينون، والتي تشمل مجموعة ١،٣،٥- ثلاثي كلوروتريازين (كلوريد السيانوريك) من الكينازولينون والعديد من الأمينات العطرية الأولية المستبدلة. تم تأكيد بنية الأصباغ وتوضيحها عن طريق التحليل الطيفي الكتلي، والأشعة فوق البنفسجية المرئية، وFT-IR، وH-NMR، وNMR-C١٣ ، وتحليل CHN. كانت القيم النظرية لجميع الألوان المنتجة والبيانات المرصودة متوافقة جيدًا مع التركيب الكيميائي المقترح. يتم تحديد خصائص صبغ القماش، وتمثيل اللون، واستنفاد الصبغة وتثبيتها، وخصائص الثبات. أثبتت هذه الأصباغ نجاحها في صباغة الأقمشة المخلوطة، والتي تتكون من ٧٠% بوليستر و٣٠% قطن. لقد أسفرت البيانات اللونية، والاستنفاد، وتحقيقات التثبيت عن نتائج باهرة. تتمتع هذه الأصباغ بميزة سهولة تصنيعها نسبيًا، ومن الممكن توسيع نطاقها، مما يفضل تطبيقات الصباغة الصناعية. بالإضافة إلى ذلك، تم فحص عامل الحماية من الأشعة فوق البنفسجية للأقمشة المصبوغة، وأظهرت النتائج أن هذه الأصباغ توفر حماية متميزة من الأشعة فوق البنفسجية.