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SYNTHESIS, CHARACTERISATION AND DYEING PROPERTIES OF NEW BIFUNCTIONAL DICHLORO-S- TRIAZINYL (DCT) AZO REACTIVE DYES BASED ON 4,4'-DIAMINODIPHENYLSULPHONE. PART: 2: ON NYLON 6 FABRIC

frankiefresh72@nsuk.edu.ng

[1]Oforghor, A.O, [2]Yakubu, M .K and [3]Olua E B

[1]Nasarawa State University, Keffi, Department of Home Science and Management
[2]Ahmadu Bello University, Zaria, Department of Polymer and Textile Engineering
[3]University of Nigeria, Nsukka, Department of Home Science and Management
e-mail: frankiefresh72@nsuk. edu.ng

Abstract: A series of five new bifunctional azo reactive dyes containing two anionic Dichloro-s- triazinyl (DCT) derived from 4,4'-diaminodiphenylsulphone as a tetrazotised solution were prepared by coupling to 4-nitroanilino cyanurated acids (H-acid, J-acid, Laurent acid, Tobias acid and Gamma acid).The synthesised dyes were applied on nylon 6 fabric under typical exhaustion process and their dyeing properties were evaluated. The structures of the synthesised dyes were characterised and confirmed by melting point, UV-visible spectroscopy, FT-IR spectroscopy, 1HNMR, and MS. The percentage exhaustion and percentage fixation of the synthesised dyes on nylon 6 fabric was very good. All the synthesised dyes gave well to excellent properties to washing, light and perspiration respectively.

Key words: bifunctional azo reactive dyes, nylon 6 fabrics, exhaustion dyeing, Reactive dyes,

INTRODUCTION

Oforghor et al; (2023), Oforghor, et al; (2020), Cid et al; 2007, Ali et al; (2014) and Blanco et al; (2016) reported that reactive dyes are textile organic colourants having one or two reactive groups capable of reacting covalently between carbon and phosphorus atom of the dyes and oxygen, nitrogen or sulphur atoms of the fibre. Alan et al; (200), Patel et al; (2010) and Almasian et al; (2015) opined that reactive dyeing systems have become the most important discovery in the colouration industry in the last century. Ever since there were discovered, diminishing era for the demand of other dye class set in (Al-Degs et al; 2008, Bravo-Diaz, 2010). Reactive dyes constitute a very important class for dyeing cellulosic and polyamide fibres and a very high rate of growth is predicted in future (Ahmed, 2005, Broadbent, 2001, Clark, 2011, Patel and Kesshav, 2012).

Oforghor et al; (2023A), Oforghor, et al; (2020B) reported that the earlier dyes synthesised were however, fixed onto the cellulose by an alkaline treatment at times at a higher temperatures. Hence, as a result of this the earlier dyes form esters and ethers with cellulose. Klaus et al; (2005) and Clark, (2002). These dyes were found to have the following setbacks-lots of dyes wasted due to hydrolysis, could not be applied to cotton/polyester blends as the disperse dye meant for the polyester component decomposes at high temperature of application and due to the high alkalinity required some of the dyes could not be applied onto the substrate (Patel et al; 2002, Khosravi et al; 2005, Konstantinova and Petrova, 2002, Patel et al; 2011)

(Patel, et al; (2011), Patel, et al; (2013) reported that it is necessary to increase the fixation properties of the reactive dyes by building bifunctionality into the dye as an efficient method of improving the application

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properties of the dye. Klaus et al; (2005), Clark, (2011) opined that it is implicit that dyes with two reactive groups provides a higher fixation yield than dyes with one reactive group because if one of the two dye-fibre bonds is hydrolysed, one reactive group is still left for fixation (Patel, et al; (2013). The bifunctional azo reactive dyes are more valuable than the mono azo reactive dyes, as they are more tinctorally stable and potentially more economic than mono azo reactive dyes (Patel, et al; 2011).

Patel, et al; (2014) reported that most interest has recently shored up in the dyes containing DCT reactive groups, which give deep colours on various textile fabrics than the dyes containing only one reactive group. The curiosity implicit in this approach was to synthesised a range of high temperature dyes for exhaust dyeing with substantially improved dyeability, high exhaustion and high fixation in comparison with the conresponding conventional monofunctional azo reactive dyes-this is the most important characteristics of bifunctional azo reactive dyes (Khazaei et al; 2013)

However, the present investigation is to the Synthesis, Characterisation and dyeing properties of five new novel bifunctional dichloro-s-triazinyl (DCT) azo reactive dyes containing 1,4-diphenylenediamine as a tetrazotized component prepared by coupling to 4-nitroanilino cyanurated acids (H-acid, J-acid, Laurent acid, Tobias acid and Gamma acid). The synthesised dyes were characterised using FT-IR, UV-visible absorption spectra, and the percentage exhaustion, percentage fixation and the fastness properties (washing, light and perspiration) were assessed.

2.0 EXPERIMENTAL

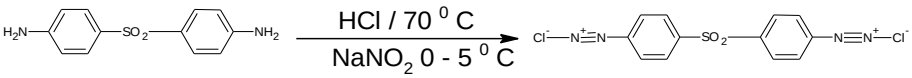
2.1 Materials

All other chemicals and solvent used in this study were of laboratory reagent grade and applied without further purification. 4,4'-diaminodiphenylsulphone, Cyanuric chloride, H-acid, J-acid, Laurent acids, Tobias acid, Gamma acid were purchased from Weifang Senya Chemical Company Limited, China. The melting points were determined by open capillary method. The IR and UV-visible absorption spectra were recorded using FT-IR (Perkin-Elmer Spectrum RXIFT-IR Spectrometer and Perkin-Elmer Lambda 25 UV-visible spectrophotometer (at the wavelength of maximum absorption (λ_{max}) at the Kharazmi University, Bureau of International Scientific Cooperation, Department of Organic Chemistry, Tehran, Iran. The already degummed and bleached nylon 6 fabric, 80 g/m2 was obtained from Chemical Processing laboratory, Department of Polymer and Textile Engineering at the Ahmadu Bello University, Zaria. Before application, the nylon 6 fabric was treated in an aqueous solution containing 2% stock concentration of detergent for 1 h at 80 °C and a 50:1 liquor ratio (LR), then washed thoroughly in water and air dried at room temperature. Applications and evaluation of fastness properties were carried out according to the standard methods in Chemical Processing laboratory, Department of Polymer and Textile Engineering at the Ahmadu Bello University, Zaria.

2.2 Methods

2.2.1 General Procedure for Tetrazotization of Intermediates

4,4'-diaminodiphenylsulphone (1.24 g, 0.005 mol) was suspended in distilled water (60 ml) and hydrochloric acid (0.36 g) was added dropwise to the well stirred suspension. The mixture was gradually heated up to 70 °C, till clear solution was obtained. The formed solution was gradually cooled to below 5 °C in an iced bath, then already cooled (0 - 5 °C) $NaNO_2$ (0.6 g in 4 mole H_2O) was added over a period of 30 mins with continuous stirring. The stirring was continued for one (1) hour, maintaining the temperature of 0 - 5 °C with positive test for nitrous acid with starch iodide paper. After completely destroying the excess of nitrous acid with the required amount of sulphamic acid, the clear tetrazonium solution at 0 - 5 °C obtained was used for next coupling reaction as shown in scheme 1 below:



Scheme 1: Tetrazotization of 4, 4'-diaminodiphenylsulphone

2.2 2. General procedure for cyanuration of H-Acid

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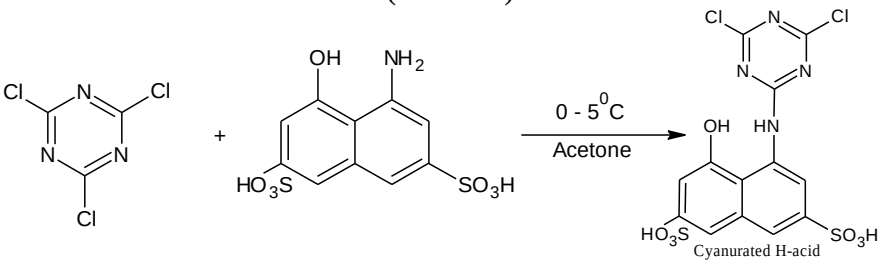
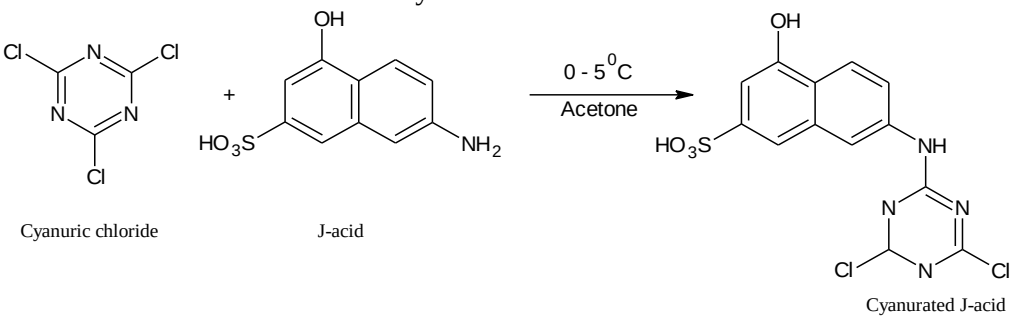
Cyanuric chloride (1.85 g, 0.01 mol) was stirred in acetone (25 ml) at a temperature below 5 ˚C for a period of an hour. A neutral solution of coupling component (3.19 g, 0.01 mole) in aqueous sodium carbonate solution (10 % w/v) was then added in small lots for an hour. The pH was maintained neutral by simultaneous addition of sodium carbonate solution (1 % w/v). The reaction mass was then stirred at 0 - 5 ˚C for further 4 hours. The cyanurated coupling component solution was used for subsequent coupling reaction as shown in scheme 2. The same procedure (method) was followed to cyanurate scheme 2b (J-acid), 2c(Laurent acid), 2d (Tobias acid) and 2e(Gamma acid) respectively.



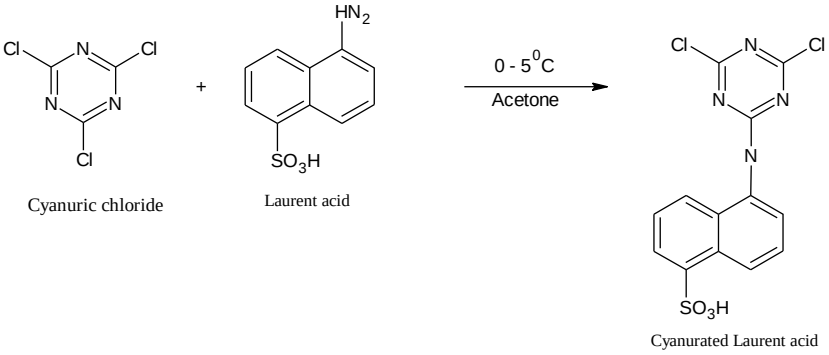
Cyanuric chloride H-acid

Scheme 2a: Cyanuration of H-acid



Cyanuric chloride J-acid

Scheme 2b: Cyanuration of J-acid



Cyanuric chloride Laurent acid

Scheme 2c: Cyanuration of Laurent acid

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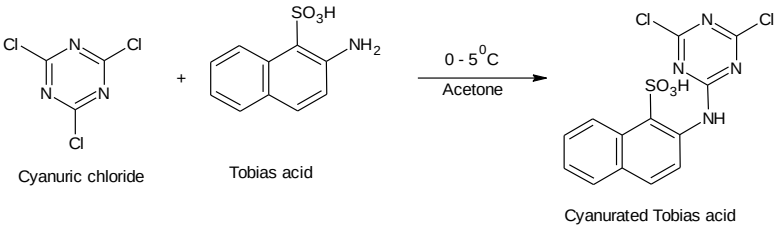
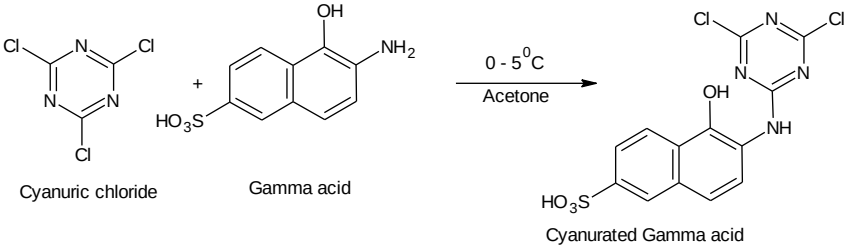


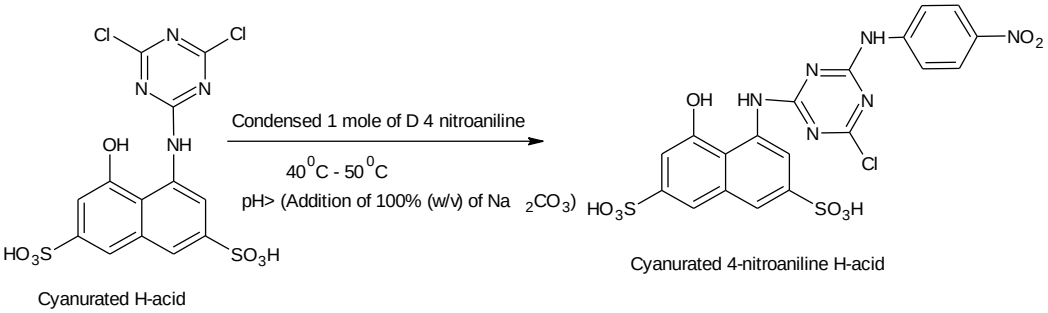
Scheme 2d: Cyanuration of Tobias acid



Scheme 2e: Cyanuration of Gamma-acid

2.2 3 General procedure for condensation of the cyanurated acids with aromatic amine

The temperature of ice-cooled well stirred solution of cyanurated H-acid, (4.67 g, 0.01 moles) was gradually raised to 45 - 50 ˚C for half an hour. To this cyanurated H-acid, 4-nitro aniline (1.39 g, 0.01 moles) was added slowly at same temperature, during a period of 30 min, maintaining the pH neutral by simultaneous addition of sodium bicarbonate solution (1 % w/v). After the addition was completed, stirring was continued for further 3 hours. The cyanurated 4- nitro anilino H-acid solution thus obtained was subsequently used for further coupling reaction as shown in scheme 3a. The same procedure (method) was followed for the condensation of cyanurated acids as shown in scheme 3b (J-acid), 3c (Laurent-acid), 3d (Tobias-acid) and 3e (Gamma-acid) respectively.



Scheme 3a: Condensation of cyanurated H-acid

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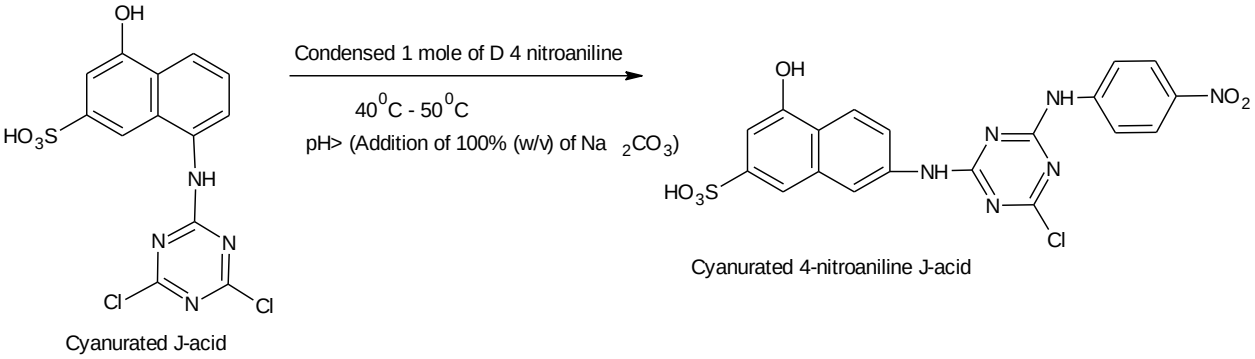
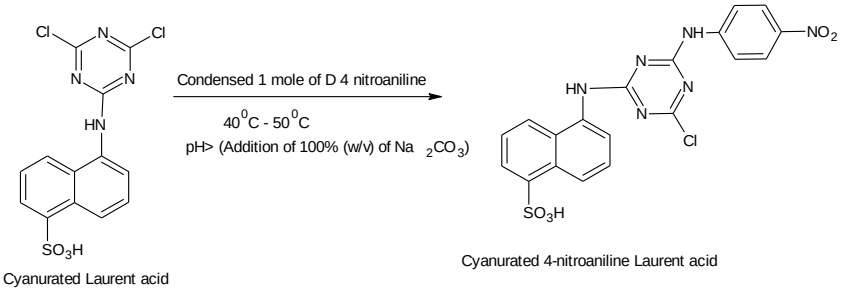


Cyanurated J-acid

Cyanurated 4-nitroaniline J-acid

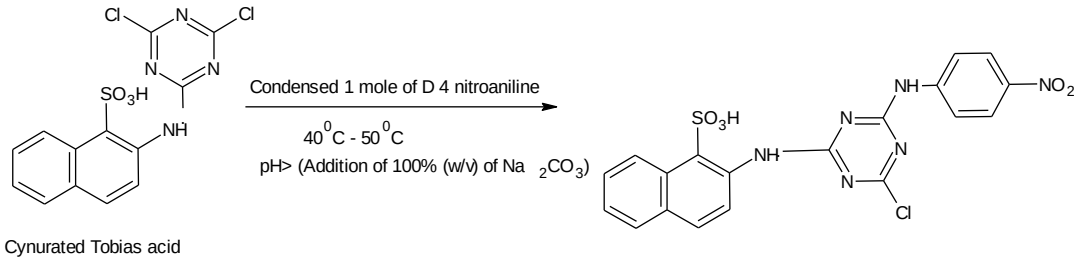
Scheme 3b: Condensation of cyanurated J-acid



Cyanurated Laurent acid

Cyanurated 4-nitroaniline Laurent acid

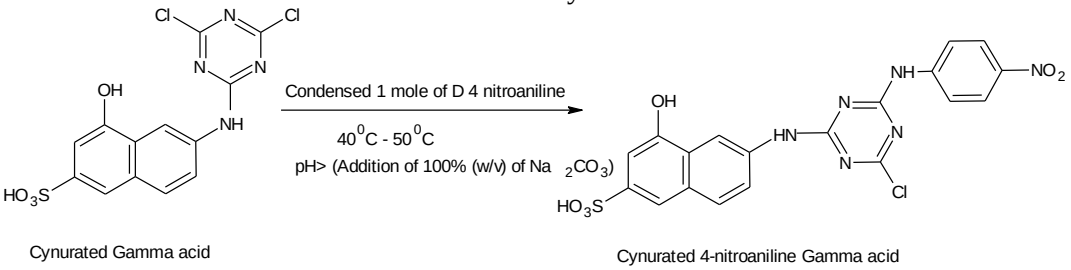
Scheme 3c: Condensation of cyanurated Laurent-acid



Cynurated Tobias acid

Cynurated 4-nitroaniline Tobias acid

Scheme 3d: Condensation of cyanurated Tobias-acid



Cynurated Gamma acid

Cynurated 4-nitroaniline Gamma acid

Scheme 3e: Condensation of cyanurated Gamma-acid

2.2 4 General procedures for synthesis of bi-functional dichlorotriazine azo reactive dyes

The synthesis of DA1 was done by adding a freshly prepared solution of tetrazotized solution of 4, 4' – Diaminodiphenylsulphone dropwise over a period of 10 – 20 minutes to the ice-cold and well stirred solution of 4-nitroanilino cyanurated H-acid. The pH 7.5 – 8.H5 was maintained by simultaneous addition of sodium carbonate

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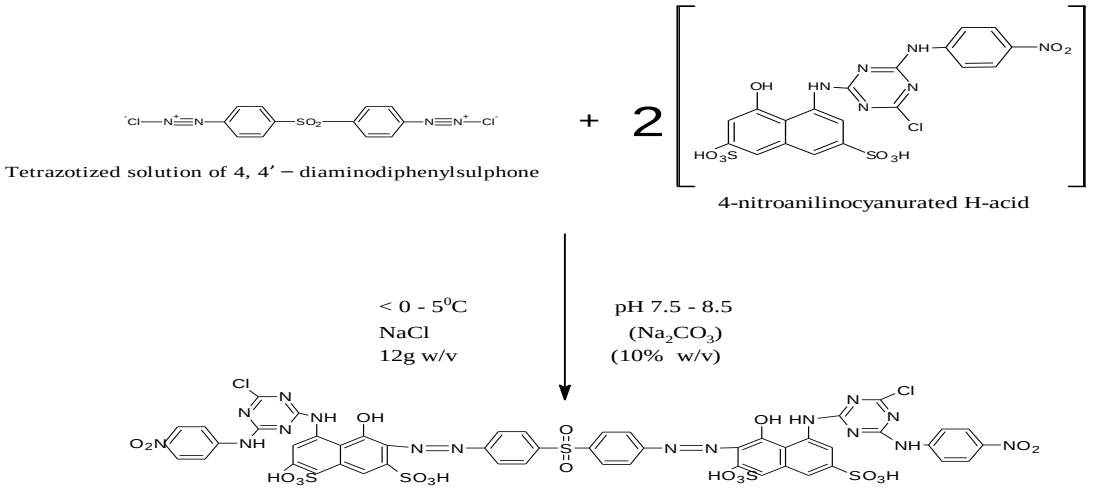
solutions (Na_2SO_3) (10 % w/v) where a purple solution was obtained. The stirring was continued to for 4hrs at a constant temperature below 0 – 5 °C for another 1 hr. The solid dye precipitates out and was filtered, washed with little amount of acetone and dried at room temperature as shown in scheme 4a below:



Scheme 4a: Synthesis of dye DA1

The same procedure (method) was followed to synthesize DA2 (J-acid), DA3 (Laurent acid), DA4 (Tobias acid) and $DD1_0$ (Gamma acid) in scheme 4b, 4c, 4d, and 4e respectively as shown in the structural formular in Table 1.

3.0 Dyeing Procedure

3.1 Dyeing of fibres

All the bifunctional dichloro-s- triazinyl (DCT) azo reactive dyes were applied on nylon 6 fabrics in 2% shade according to usual procedure (Oforghor *et al.*, 2020). After dyeing, all dyed samples were rinsed with water and air dried.

3.2 Dye exhaustion

The percentage dye exhaustion of the dyed fabrics was evaluated spectrophotometrically using Eqn 1 bellow. The variation in the hues of the dyed fabric results from both the nature and position of the substituent present on the coupler ring. The remarkable degree of levelness after washing indicates good penetration and affinity of these dyes to the fabric.

$$\% E = \left[\left(\frac{C_1 - C_2}{C_1}\right)\right] \times \frac{100}{1} \quad \text{..... (1)}$$

3.3 Dye fixation

The percentage of exhausted dye chemically bound on the fibre, also called total dye fixation ratio (%*F*), was measured by refluxing the dyed samples in 50% aqueous DMF (liquor ratio 20:1) for 10-15 min to extract the unfixed dye. This procedure was repeated until the extract was clear of the dye solution. The concentration of the extract was then measured spectrophotometrically at λ_{max} and the dye fixation ratio calculated using Eqn 2

$$\% F = \left[\left(\frac{C_1 - C_2 - C_3}{C_1 - C_2}\right)\right] \times \frac{100}{1} \quad \text{.....(2)}$$

3.4 Fastness properties test

3.4,1 Wash fastness test

The dyed samples were subjected to ISO 3 wash fastness test previously described Oforghor *et al., (*2020). The change in colour of samples and the staining of the adjacent un-dyed fabric were assessed with appropriate grey scale.

3.4.2 Light fastness test

This was carried out using a Microsal Tester Xenon arc lamp. The dyed samples were cut into 10 cm by 4 cm, placed in the machine and exposed for 48 hrs after which they were removed and the change in colour were assessed using the blue nylon 6 scale.

3.4,3 Fastness to perspiration test

The perspiration fastness of the synthesised dyes were assessed according to the conditions of ISO 105- E04 (1989) previously described Oforghor *et al., (*2020) for

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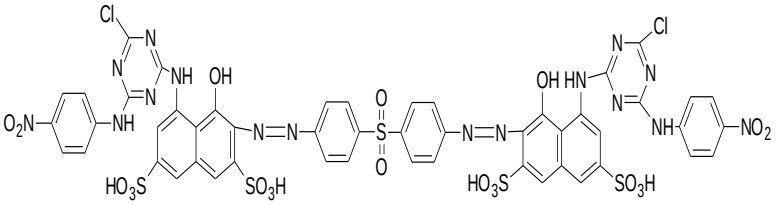
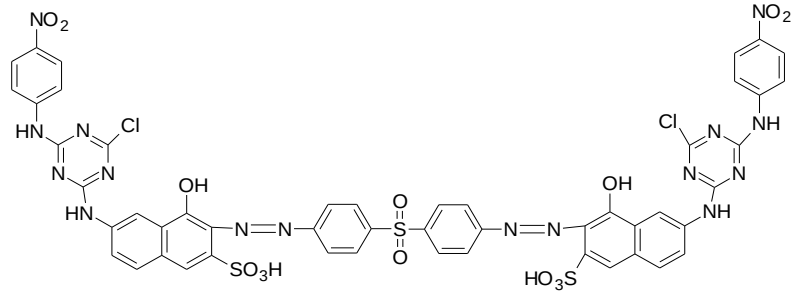
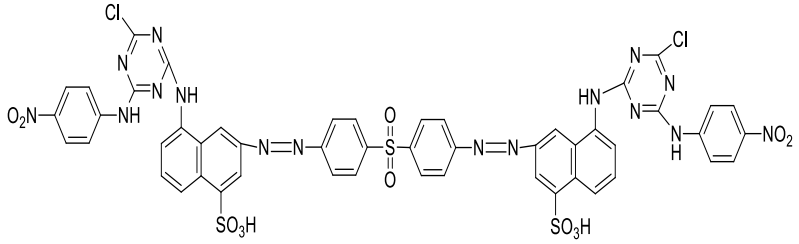
both acidic Perspiration Test and alkaline Perspiration Test

4.0 Results and Discussion

Synthesis of bifunctional reactive dye

The dyes were synthesised via four steps viz cyanuration, condensation, coupling and tetrazotisation. In scheme 2, showed the cyanuration of the acids (H-acid, J-acid, Laurent acid, Tobias acid and Gamma acid) as showed in scheme 2, then followed by condensation of the cyanurated acids with 4-nitroaniline to give the corresponding cyanurated 4- nitroanilino acids as showed in scheme 3a, 3b(J-acid), 3c(Laurent acid), 3d(Tobias acid) and 3e(Gamma acid) respectively which is then coupled to the tetrazonium solution of 4,4'-diaminodiphenylsulphone (1.24 g, 0.005 mol) by the method previously described Oforghor *et al., (*2020) in small portions over 30 min at a temperature below 0-4 ºC under alkaline conditions ((Na_2SO_3) (10% w/v) to maintained pH 7.5 – 8.5) and stirring was continued for 3 – 4h at a constant temperature below 0 – 5^0C, then salted and stirred for further 1h. The solid precipitate was filtered, washed with little amount of acetone and dried at room temperature to give dye DA1 as shown in scheme 4a to give a good yield of the desired dyes as showed in scheme 4.

Table 1: Structures with IUPAC names of the synthesized bifunctional dichloro-s- triazinyl (DCT) azo reactive Dyes

Dye No.	IUPAC Name	Structures of the Synthesised Bi-functional azo reactive Dyes
DA1	3,3'-(sulfonybis(4,1-phenylene))bis(diazene-2,1-diyl))bis(5-((4-chloro-6-((4-nitrophenyl)amino)-1,3,5-triazin-2-yl)amino)-4-hydroxynapthelene-2,7-disulfonic acid)	
DA2	3,3'-(sulfonybis(4,1-phenylene))bis(diazene-2,1-diyl))bis(6-((4-chloro-6-((4-nitrophenyl)amino)-1,3,5-triazin-2-yl)amino)-4-hydroxynapthelene-2-sulfonic acid)	
DA3	3,3'-(sulfonybis(4,1-phenylene))bis(diazene-2,1-diyl))bis(5-((4-chloro-6-((4-nitrophenyl)amino)-1,3,5-triazin-2-yl)amino)napthelene-1-sulfonic acid)	

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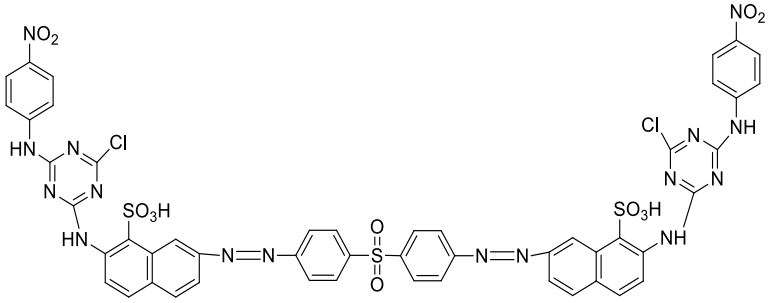
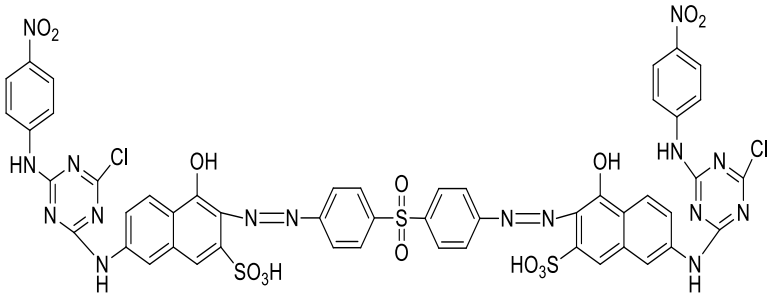
DA4	7,7'-(sulfonybis(4,1-phenylene))bis(diazene-2,1-diyl))bis(2-((4-chloro-6-((4-nitrophenyl)amino)-1,3,5-triazin-2-yl)amino)napthelene-1-sulfonic acid)	
DA5	3,3'-(sulfonybis(4,1-phenylene))bis(diazene-2,1-diyl))bis(5-((4-chloro-6-((4-nitrophenyl)amino)-1,3,5-triazin-2-yl)amino)-4-hydroxynapthelene-2-sulfonic acid)	

Table 2: Physical and spectroscopic characteristics of the synthesized bifunctional dichloro-s-triazinyl (DCT) azo reactive Dyes

Dye No.	Mol.Wt (g/mol)	Mt.Pt (ºC)	Yield (%)	DMF (λmax)	Water (λmax)	ε_{max} in DMF x$10^4$1Mol^{-1}cm^{-1}
DA1	1405.11	320-322	59	537	527	6.61
DA2	1246.08	305-308	97	510	503	3.95
DA3	1214.09	330-332	45	458	458	1.81
DA4	1214.09	310-312	79	540	403	2.09
DA5	1246.08	320-322	65	513	510	3.73

Visible Absorption Spectroscopic Properties of Dye: The visible absorption spectroscopic properties of dyes were recorded in water (Table 2). The colour of the dye is affected by substituents in the coupling constituent. The visible absorption maxima of the synthesised bifunctional azo reactive dyes as recorded in Table 2 fell within the visible region (400-700 nm) of the electromagnetic spectrum. The values of the molar extinction coefficient (ε) that were determined by Beer-Lambert's law are in the range of 14324 - 85316.0 Lmol^{-1}cm^{-1} which is an indication of high absorption intensity of the synthesised bifunctional azo reactive dyes in DMF respectively. However, the synthesised bifunctional azo reactive dyes have different chromophoric functionalities, but same bridging groups and it is also apparent that the value of λ_{max} depends on the coupling components used. The presence of electron donating or electron attracting (withdrawing) groups at the suitable position of the coupler ring affects the absorption characteristics of the synthesised bifunctional azo reactive dyes (Patel *et al*., 2014). Comparing the λ_{max} of the dyes DA1, DA2, DA3, DA4, and $DD1_0$ in DMF showed that the variation in hue is due to the nature of the intermediates employed and positions of the subpstituent's on the coupler ring (Patel *et al*; 2014). Dye DA1 was synthesised by tetrazitising 4,4- diaminediphenysulphone using $NaNO_2$/HCl method and coupling with 4-nitroaniline cyanurated H-acid which absorbed at 537 nm in DMF, but when 4-nitroaniline cyanurated H-acid was replaced with 4-notrianiline cyanurated J-acid, dye DA2 was synthesised which absorbed at 510 nm, hence, there was hypsochromic shift of 27 nm when compared to dye DA1. Using 4-notrianiline cyanurated Laurent-acid as coupling component result in the synthesis of dye DA3 and

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absorbed at 458 nm in DMF and gives a hypsochromic shift of 79 nm when compared to dye DA1 and hypsochromic shift of 42 nm when compared to dye DA2. Meanwhile, replacing 4-nitroaniline cyanurated Laurent acid with Tobias acid gives dye DA4 which absorbed at 540 nm in DMF with a bathochromic shift of 3nm when compared to DA1, bathochromic shift of 30nm when compared to DA2, bathochromic shift of 82 nm when compared to DA3 respectively. Dye $DD1_0$ was by tetrazotising 4,4- diaminediphenysulphone and coupling with 4-nitroaniline cyanurated Gamma acid and absorbed at 510 nm in DMF which sifted hypsochromically with 27 nm when compared to DA1, 0 nm when compared to DA2, bathochromic shift of 42 nm when compared to DA3 and hypsochromic shift of 30nm when compared with DA4 respectively.

Table 3: FT-IR Spectroscopy of the bifunctional dichloro-s-triazinyl (DCT) Azo reactive dyes

Dye no.	**Empirical formular**	**Mol. Wt**	**Yield (%)**	**Melting point (ºC)**	**FT-IR (KBR): v (cm^{-1})**
DA1	$C_{50}H_{32}Cl_2N_{16}O_{20}S_5$	1405	59	320-322	3441 (O-H str vibr.), 3413 (N-H str vibr.), 3014(C-H str vibr.), 1711 (N=N str vibr.), 1326 (C-N str vibr), 1622 (N-H bend vibr.), 1047 (S=O str vibr.), 1326 (N=O), 730 (C-Cl str vibr.), 845 (SO_3H str vibr.)
DA2	$C_{50}H_{32}Cl_2N_{16}O_{14}S_3$	1246	97	305-308	3449 (O-H str vibr.), 3429 (N-H str vibr.), 3055-2995 (C-H str vibr.), 1597 (N=N str vibr.), 1377 (C-N str vibr.), 1651 (N-H bend vibr.), 1045 (S=O str vibr.), 1377 (N=O str vibr.), 779 (C-Cl str vibr.), 828 (SO_3H str vibr.)
DA3	$C_{50}H_{32}Cl_2N_{16}O_{12}S_3$	1214	45	330-332	3415 (O-H str vibr.), 3404 (N- H str vibr.), 3000 (C-Hstr vibr.), 1596 (N=N str vibr.), 1408 (C- N str vibr.), 1663 (N-H bend vibr.), 1066-1150 (S=O str vibr.), 1329 (N=O str vibr.), 767 -752 (C-Cl str vibr.), 853 (SO_3H str vibr.)
DA4	$C_{50}H_{32}Cl_2N_{16}O_{14}S_3$	1214	79	310-312	3489 (O-H str vibr.), 3413 (N-H str vibr.), 2985 (C-H str vibr.), 1598 (N=N str vibr.), 1598-1411 (C-N str vibr.), 1662 (N- H bend vibr.), 1053 (S=O str vibr.), 1336(N=O str vibr.), 769-751 (C-Cl str vibr.), 854-824 (SO_3H str vibr.)

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DA5	$C_{50}H_{32}Cl_2N_{16}O_{14}S_3$	1246	65	320-322	3446 (O-H str vibr.), 3416 (N-H str vibr.), 2995 (C-H str vibr.), 1600-1656 (N=N str vibr.), 1436 (C-N str vibr.), 1654 (N-H bend vibr.), 1050 (S=O str vibr.), 1365 (N=O str vibr.), 782-758(C-Cl str vibr.), 831(SO_3H str vibr.)

FT-IR spectra of all the dyes, in general showed O-H and N-H stretching vibrations in the region 3570-3588 cm-1, 3401-3418 cm-1 respectively, C-H stretching vibration at 3270-3288 cm-1, N=N stretching vibration at 1610-1629 cm-1, C-N stretching vibration at 1507-1548 cm-1, S=O stretching vibration at 1033-1168 cm-1, C-Cl stretching vibration at 709-724 cm-1, NO2 stretching vibration at 1521-1529 cm-1 (Table 3).

Table 4: Mass Spectroscopy data for bifunctional triazine azo reactive dyes DA1 – $DD1_0$

Dye No.	Empirical formular	Experimental values of m/z fragment	Corresponding positive charge fragment	Theoretical value
DA1	$C_{50}H_{32}Cl_2N_{16}O_{20}S_5$	46.0, 76.0, 114.1, 248.2, 318.1, 1405.1	NO_2^+, $C_6H_4^+$, $C_3ClN_3^+$, $C_{12}H_{12}N_2O_2S^+$, $C_{10}H_8NO_7S_2^+$, M	1405
DA2	$C_{50}H_{32}Cl_2N_{16}O_{14}S_3$	46.0, 76.0, 114.1, 248.1, 239.2, 1246.2	NO_2^+, $C_6H_4^+$, $C_3ClN_3^+$, $C_{12}H_{12}N_2O_2S^+$, $C_{10}H_9NO_4S^+$, M	1246
DA3	$C_{50}H_{32}Cl_2N_{16}O_{12}S_3$	46.0, 76.0, 114.1, 223.1, 248.1, 1214.3	NO_2^+, $C_6H_4^+$, $C_3ClN_3^+$, $C_{12}H_{12}N_2O_2S^+$, $C_{10}H_9NO_3S^+$, M	1214
DA4	$C_{50}H_{32}Cl_2N_{16}O_{14}S_3$	46.0, 76.0, 114.1, 223.1, 248.1, 1214.3	NO_2^+, $C_6H_4^+$, $C_3ClN_3^+$, $C_{12}H_{12}N_2O_2S^+$, $C_{10}H_9NO_3S^+$, M	1214
DA5	$C_{50}H_{32}Cl_2N_{16}O_{14}S_3$	46.0, 76.0, 114.1, 248.1, 239.1, 1246.2	NO_2^+, $C_6H_4^+$, $C_3ClN_3^+$, $C_{12}H_{12}N_2O_2S^+$, $C_{10}H_9NO_4S^+$, M	1246

The mass spectrum MS for dyes DA1 –DA5 analysis revealed all the fragmentation pattern of NO_2^+, $C_6H_4^+$, $C_3ClN_3^+$, $C_{12}H_{12}N_2O_2S^+$, $C_{10}H_8NO_7S_2$ respectively. All these differences observed arise due to bridging groups, chromophores, coupling components and reactive systems.

Table 5: Exhaustion and fixation study of the dichloro-s-triazinyl DCT reactive dyes on nylon 6 fabric

		Exhaustion (%)	Fixation (%)
Dye No.	Shade on nylon 6	Nylon 6	Nylon 6
DA1	Light yellow	70	90
DA2	Orange	75	92
DA3	Yellow	69	85
DA4	Light yellow	72	92
DA5	Light orange	68	87

The percentage exhaustion of 2% dyeing on nylon 6 fabric showed from 75% to 72%, The percentage fixation of 2% dyeing on nylon 6 fabric showed from 85% to 92 (Table 5).

Table 6: Fastness performance properties of the bifunctional dichloro-s-triazinyl (DCT) Azo Reactive dyes on nylon 6 fabric

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Dye No			Perspiration fastness	
	Wash fastness Nylon 6	**Light fastness Nylon 6**	**Alkaline Nylon 6**	**Acidic Nylon 6**
	cc	Cc	Cc	Cc
DA1	5	4-5	4	3-4
DA2	3-4	5	4-5	4-5
DA3	4	3-4	4-5	4
DA4	3	4	4	4-5
DA5	4-5	5-6	4	4

cc = colour change
1=poor, 2=fair, 3=fairly good, 4=good, 5=excellent –wash fastness
1=poor, 2=slight, 3=moderate, 4=fair, 5=good, 6=very good, 7=excellent, 8=outstanding light fatness
1=much change (poor) 2=considerable change (fair), 3=noticeable change (fairly good), 4=slight change (good), 5=negligible (excellent) –Perspiration fastnes
The wash fastness, light fastness and perspiration fastness were studied according to Oforghor et al, (2020). The wash fastness of all the dyes showed good to excellent on nylon 6 fabrics. The light fastness of all the dyes showed moderate to good on nylon 6 fabrics and the perspiration fastness (acidic and alkaline) of all the dyes showed good to excellent perspiration fastness on nylon 6 fabrics (Table 6).

CONCLUSION

New bifunctional dichloro-s-triazinyl (DCT) azo reactive dyes based on 4, 4-diaminodiphenylsulphone has been successfully synthesised. 4, 4-diaminodiphenylsulphone was tetrazotized and coupled with cyanurated 4-nitroanilino R' acids (H-acid, J-acid, Laurent acid, Tobias acid and Gamma acid) coupling components to give the corresponding bifunctional dichloro-s-triazinyl (DCT) azo reactive dyes (DA1-DD1$_0$). These dyes gave pink, orange, brown and yellow shade on nylon 6 fabrics. The dyes gave better light fastness and seem to have good dyeing performance on nylon 6 fabrics. The exhaustion and fixation performance of these dyes are very satisfactory. The remarkable degree of levelness after washing indicates the good penetration and affinity of the dyes to nylon 6 fabrics.

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