

Synthesis and Application of Monoazo Disperse Dyes Derived from Naphthalimide Derivatives on Polyester Fabrics

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ABSTRACT

New series of monoazo disperse dyes were synthesized using 6-amino-2-(4-(4-aminobenzyl)phenyl)-1H-benzo[de]isoquinoline-1,3(2H)-dione by coupling with different substituted anilines and naphthalene derivatives. The synthesized intermediates and the dyes were purified by recrystallization method. The structure of the synthesized intermediates and dyes were characterized using FTIR, ¹HNMR, MS and UV-visible spectroscopic techniques. The spectrophotometric investigation of the synthesized dyes in solvent of different polarities were carried out in order to obtain their absorption maxima and molar extinction coefficient. The wavelength of maximum absorption of all the synthesized dyes ranging from 425–591 nm and molar extinction coefficient ranging from 14,300 – 35,400 Lmol⁻¹cm⁻¹ in DMF, thus, making them suitable for use as commercial dyes. The synthesized dyes were applied on polyester fabrics using carrier exhaust dyeing method at 100°C. The colour build up and dyeing properties such as wash, light and perspiration fastness were evaluated to be very good to excellent with fastness rating of (3-5) for wash and perspiration fastness and rating of (4-6) for light fastness. The remarkable degree of brightness after washing is an indication of good affinity of the dyes on the fabrics.

Keywords: Disperse dyes, Solvatochromism, Dyeing, Polyester fabrics, Fastness properties

INTRODUCTION

Azo disperse dyes are one of the most important class of synthetic dye and widely used textile dye which covered nearly the full colour spectrum from greenish yellow to bluish green [1], [2]. They are relatively inexpensive and generally do not require numerous intermediates stages in their manufacture [3]. Disperse dyes are low molecular weight synthetic organic dyes in the range of 300-600. Majority of disperse dyes are monoazo (50%) or anthranquinone dyes (25%). The remaining dyes are based on other dye chromophores such as benzodifuranone, coumarin, methane, naphthalimide and nitrophenylamide [4]. Owing to their colour brilliance and wide range of excellent fastness properties, disperse dyes have become very popular and well known [5].

Polyester fibres are hydrophobic in nature, efficient dyeing requires the use of dyes with limited water solubility, disperse dyes are sparingly soluble in water and are almost exclusively used for cellulose diacetate fibres. The low solubility of disperse dyes enable them to transfer from water to the surface hydrophobic fibres [6]. Monoazo disperse dyes derived from naphthalimide derivatives have shown promising dyeing properties on polyester fabric.

Monoazo disperse dyes containing naphthalimide residues have been found to offer excellent thermal stability and good dyeing fastness properties [1]. The dyeing performance of disperse dyes derived from naphthalimide derivatives is influenced by several factors, including dye concentration, dyeing temperature, dyeing time, and the nature of the fibre. These dyes exhibit excellent dyeing properties, such as high colour yield, good light fastness, and wash fastness [7]. The presence of suitable substituents on the naphthalimide derivative enhances the dye's affinity for hydrophobic fibres, resulting in improved dye uptake and colour fastness. Derivatives of heterocyclic naphthalimide and 1,8-naphthalic anhydride have been researched extensively to assess their performance as intermediates for dye synthesis [8], [9].

Substitution of electron donating groups usually raises the fluorescence emission, particularly when amino and allylamino groups situated at the C-4 position [10], [11]. In the present study, a new series of monoazo disperse dyes derived from naphthalimide derivatives and their dyeing properties on polyester fabrics is being reported.

MATERIALS AND METHODS

All the chemicals used in the synthesis for this research were of commercial grade. The synthesized compounds were characterized by melting point, TLC, FTIR, ¹H NMR and GC/MS. Melting points were recorded on Gallenkamp C10127. Infra-red were recorded using Bruker-Tensor 27 Platinum ATR-FTIR Spectrophotometer, ¹H NMR were carried out on Bruker Avance FT NMR Spectrometer for ¹H NMR determination using deuterated chloroform (CDCl₃) and dimethylsulphoxide (DMSO-d₆) as solvent. The mass spectra were recorded using Agilent technologies 5975 C VL MSD spectrometer.

Synthesis of 5-Nitroacenaphthene

Acenaphthene (15.4 g, 0.1 mol) was dissolved in hot glacial acetic acid (57.2 ml) and was cooled with vigorous stirring to separate crystalline acenaphthene as fine as possible. Concentrated nitric acid (9.84 g, 0.156 mol) was added drop wise to the mixture for 1 hr at 22–27 °C and then further stirred for 1 hr at 25 °C. The solution was warmed gradually for 30 mins to 68 °C then cooled to form crystals that were filtered, washed with 1:1 acetic acid–water and water to give yellow needles [1].

Synthesis of 4-nitronaphthalic anhydride

5-Nitroacenaphthene (24.87 g, 0.125 mol) was dissolved in hot glacial acetic acid (248.75 ml), sodium dichromate (158.5 g) was added portion wise for 3 hr at 65–70 °C. The solution was warmed gradually to 98–100 °C for 30 minutes and further refluxed for 5 hr. The contents were wash out with hot water (0.6 L) and cooled to room temperature. The precipitate was filtered and washed with dilute HCl (10 %). In addition, the precipitate was boiled with 200 mL of 5 % Na₂CO₃ solution for 30 mins and filtered. The filtrate was acidified and the separated crystals dried at 120 °C for 4 hours to obtain 4-nitronaphthalene-1,8-anhydride, which was recrystallized from concentrated HNO₃ (d = 1.40 g /mL) to afford colourless needle crystals [1].

Synthesis of N-Amino- 4-nitronaphthalic anhydride

A suspension of 4-nitronaphthalic anhydride (0.02 mol, 4.86 g) and benzene -1, 4- diamine (0.03 mol, 5.55 g) was stirred under reflux for 7 hr in ethanol (102 mL). The cooled suspension was filtered out and recrystallized with ethanol to give yellow crystals.

Synthesis of 4-amino -N- substituted 1, 8- Naphthalimide

A mixture of N-Amino- 4-nitronaphthalic anhydride (a) 18 mmol, 6.88 g) and stannous chloride (90

mmol, 20.25 g) in ethanol (81 mL) was refluxed for 1 hr with hydrochloric acid (10.1 mL) until the reaction was completed. The mixture was transferred into 100ml of water and the observed precipitate was filtered out. The crude product was purified by recrystallization from ethanol as yellow crystals.

Synthesis of dyes

Sodium nitrite (1.5 mmol, 0.104 g) was slowly added with constant stirring to cold concentrated sulphuric acid (1.1 mL) at room temperature such a rate that yellow fume was not evolved. The temperature of the reaction mixture was gradually increased to 65 °C using water bath until all the sodium nitrite was dissolved. The resulting solution was then cooled to 0-5 °C and a mixture of propionic acid and glacial acetic acid (10mL, 1.5:8.5 volume ratio) was added drop wise at 5 -20 °C.

The Finely ground powder of 1.5 mmol 4-amino-N-substituted-1,8-naphthalimide was added portion wise below 10 °C, and then the mixture was further stirred for 3 hr. The obtained clear diazonium salt solution was used immediately in coupling reactions. The coupling components, 2-naphthol, 3-nitroaniline, 2,4- nitroaniline, were each dissolved with ethanol and few drops of acetic acid was added at 0-5 °C. The previously prepared diazonium solution was added over 30–40 minutes under vigorous stirring. The mixture was stirred further for 2 hours at 0-5 °C and the pH of the solution was adjusted to 4–5 using 10 % sodium acetate and stirred for 1 hr.

The resulting product was then collected by filtration, washed with warm water and then cold water and dried. The crude product was purified by recrystallization from DMSO several times. Similar procedure was used for the coupling components N, N-dimethylaniline, N, N- diethylaniline but without ethanol.

Preparation of Dye Solution

1% stock solution of each dye was prepared, a liquor ratio of 50: 1 was used, and 2% shade on the weight of the fabric. The volume required from each stock solution was calculated based on the formula in equation:

$$V = \frac{P \times W}{C}$$

where P = Percentage shade

W= Weight of the fabric

C= Percentage concentration

Procedure for Dyeing Polyester Fabric

1g of polyester fabric was weighed and soaked in a soap solution for one hour to open the fabric's pores for easier dyeing. A liquor ratio of 50:1 was used to prepare the dye bath. The required volume of dye solution was measured from the stock solution. Distilled water was then added to reach the necessary volume. The pre-soaked fabric was immersed in the dye bath at 40°C, and the dyeing process was carried out at boiling temperature (100°C) for 1hr 30mins to ensure even dyeing. Afterward, the dyed fabric was removed, thoroughly rinsed in cold water, and air-dried at room temperature. This procedure was carried out for each dye.

Reduction Clearing of the Dyed fabric

The dyed fabric was reduction cleared by stirring in an aqueous solution containing sodium dithionite (2g/l) and sodium hydroxide (2g/l) for 50 mins at 70°C. The dyed fabric was then washed with water and dried.

Fastness properties of the dyed polyester fabrics

Wash Fastness: The wash fastness test was carried out using the ISO wash fastness test No.3. The composite samples were treated with a solution containing 5g/l detergent, 2g/l sodium carbonate at Liquor Ratio 50:1 for 30mins at 60°C. The change

in colour of the dyed samples and degree of staining of the adjacent undyed fabrics were assessed using a grey scale.

Light Fastness: The test samples were exposed to Xenon arc lamp for 72 hours, after which the sample was removed and compared with the original unexposed samples. The changes in colour were assessed by using a "Blue Wool Scale". Each sample is assigned a light fastness rating based on the number of the Blue Wool Standard which shows the equivalent degree of colour change.

Fastness to Perspiration: The perspiration fastness test was carried out in both acidic and alkaline solution according to ISO-E04, 2013 by treating the dyed fabric in an acidic solution containing sodium chloride (NaCl 5g/l), disodium hydrogen orthophosphate dehydrates (Na₂HPO₄ 2.5g/l), histidine monohydrochloride monohydrate, the pH was brought to 5.5 using 0.1M acetic acid.

For the alkaline solution: (C₆H₉O₂N₃.HCl.H₂O 0.5g/l), the pH was brought to 8.0 using 0.1M sodium hydroxide (NaOH) in a liquor ratio of 20:1. The tested fabrics were rinsed, dried and rated against the grey scale for colour change.

RESULTS AND DISCUSSION**Table 1:** Physical properties of intermediates

Compounds	Molecular formula	Molecular weight (g/mol)	Melting point (°C)	Yield (%)	Colour Observed
5-nitroacenaphthene	C ₁₂ H ₉ NO ₂	199	101-102	86.2	Yellow
4-nitronaphthalic anhydride	C ₈ H ₃ NO ₅	193	231-232	70.1	Off white
6-amino-2-(4-(4-aminobenzyl)phenyl)-1H-benzo[de]isoquinoline-1,3(2H)-dione	C ₂₅ H ₁₉ N ₃ O ₂	393	276-278	68.3	Orange

Table 2: Physical properties of the dyes

Dye No:	Molecular formula	Molecular weight (g/mol)	Melting point (°C)	Yield (%)	Colour Observed
B ₁	C ₃₅ H ₂₄ N ₄ O ₃	548	176-178	74.7	Orange
B ₂	C ₃₁ H ₂₂ N ₆ O ₄	542	95-97	81.6	Yellow
B ₃	C ₃₁ H ₂₃ N ₇ O ₄	557	209-211	80.4	Yellow
B ₄	C ₃₅ H ₃₁ N ₅ O ₂	553	170-172	83.7	Orange
B ₅	C ₃₃ H ₂₇ N ₅ O ₂	525	218-220	74.6	Yellow

Table 3: FT-IR spectra of the synthesized intermediate and dyes

Dye No	Functional groups/Types of stretching vibration (cm ⁻¹)
(I _B)	3567 (N-H str.), 3022, 2937(C-H str. Aromatic, Aliphatic), 1908 (-N-C=O-str.), 1513(N=N str.), 1349(C-N str.).
B ₁	3448(O-H str.), 3072, 2901, 2803(C-H str. Aromatic, Aliphatic), 1918(-N-C=O-str.), 1519(N=N str.), 1418, 1352(C-N str.)
B ₂	3893(N-H str.), 3056, (C-H str.), 1579(-N=N-str.), 1400(N=N str.), 1400(NO ₂ str.).
B ₃	3435(N-H str.), 2976,2892(C-H str.), 1866(-N-C=O-str.), 1587(N=N str.), 1347(C-N str.).
B ₄	3426(N-H str.), 3071, 2975, 2860, (C-H str. Aromatic, Aliphatic), 1922(-N-C=O-str.), 1518(N=N str.), , 1349 (C-N str.).
B ₅	2919, 2847, (C-H str. Aromatic, Aliphatic), 1716 (-N-C=O-str.), 1463(N=N str.).

Table 4: GC-Mass Spectrometry of the intermediate and the synthesized dyes

Dye No.	Empirical formula	Experimental values of m/z fragment	Corresponding positive charge fragment	Theoretical value
I _B	C ₂₅ H ₁₉ N ₃ O ₂	55.1, 91.1,117.1, 147.1,264.4, 393.3	C ₂ NO ⁺ , C ₇ H ₇ ⁺ , C ₈ H ₇ N ⁺ , C ₈ H ₅ NO ₂ ⁺ , C ₁₁ H ₁₅ N ₂ O ₂ ⁺ , C ₁₆ H ₁₂ N ₂ O ₂ ⁺ ,M	393.44
B ₁	C ₃₅ H ₂₄ N ₄ O ₃	57.0, 111.0, 167.0, 281.0,548.0	C ₄ H ₁₀ ⁺ , C ₆ H ₈ NO ⁺ C ₁₂ H ₂₂ ⁺ , C ₁₇ H ₂₁ N ₂ O ₂ ⁺ ,M	548.59
B ₂	C ₃₁ H ₂₂ N ₆ O ₄	55.0,93.0,165.0,207.0,450.9, 542.0	C ₂ NO ⁺ , C ₇ H ₈ ⁺ , C ₁₂ H ₂₂ ⁺ , C ₁₁ H ₁₅ N ₂ O ₂ ⁺ , C ₃₀ H ₁₆ N ₃ O ₂ ⁺ ,	542.54
B ₃	C ₃₁ H ₂₃ N ₇ O ₄ ⁺	57.0, 117.0,191.0,316.2,557.3	C ₄ H ₁₀ ⁺ C ₈ H ₈ N ⁺ , C ₁₀ H ₆ N ₂ O ₂ ⁺ , C ₂₀ H ₁₆ N ₂ O ₂ ⁺ ,M	557.56
B ₄	C ₃₅ H ₃₁ N ₅ O ₂	73.0, 207.0,281.0,405.0,553.0	C ₂ H ₃ NO ₂ ⁺ , C ₁₁ H ₁₅ N ₂ O ₂ ⁺ , C ₁₇ H ₁₇ N ₂ O ₂ ⁺ , C ₂₆ H ₂₀ N ₃ O ₂ ⁺ ,M	553.65
B ₅	C ₃₃ H ₂₇ N ₅ O ₂	57.0,117.0,443.2,525.0	C ₄ H ₁₀ ⁺ , C ₈ H ₇ N ₂ ⁺ , C ₂₆ H ₂₇ N ₄ O ₃ ⁺ ,M	525.60

Acenaphthene (1) reacted with concentrated nitric acid in an acetic acid media at room temperature to give yellow crystals of 5-nitroacenaphthene after recrystallization from ethanol with a yield and melting point of 86 % and 101-102 °C respectively.

5-nitroacenaphthene (2) was oxidised using sodium dichromate and hot glacial acetic acid as the solvent under reflux condition for 5hr to give 4-naphthalic anhydride after recrystallization from nitric acid with a yield and melting point of 70.1 % and 231-232°C.

4-nitronaphthalic anhydride (3) reacted with 4,4-methylenedianiline under reflux for 7 hr in ethanoic media and recrystallized with ethanol to give yellow crystals of 4-nitro-N-substituted-1, 8-naphthalimide.

4-nitro-N-substituted-1, 8-naphthalimide (4) reacted with stannous chloride in hydrochloric acid

as a reducing agent and ethanol as solvent to give orange crystals of 4-amino -N- substituted 1, 8-Naphthalimide (6-amino-2-(4-aminophenyl)-1H-benzo[de]isoquinoline-1,3(2H)-dione) with a yield and melting point of 65.3 % and 276-278°C respectively. The reaction sequence is shown in scheme 1.

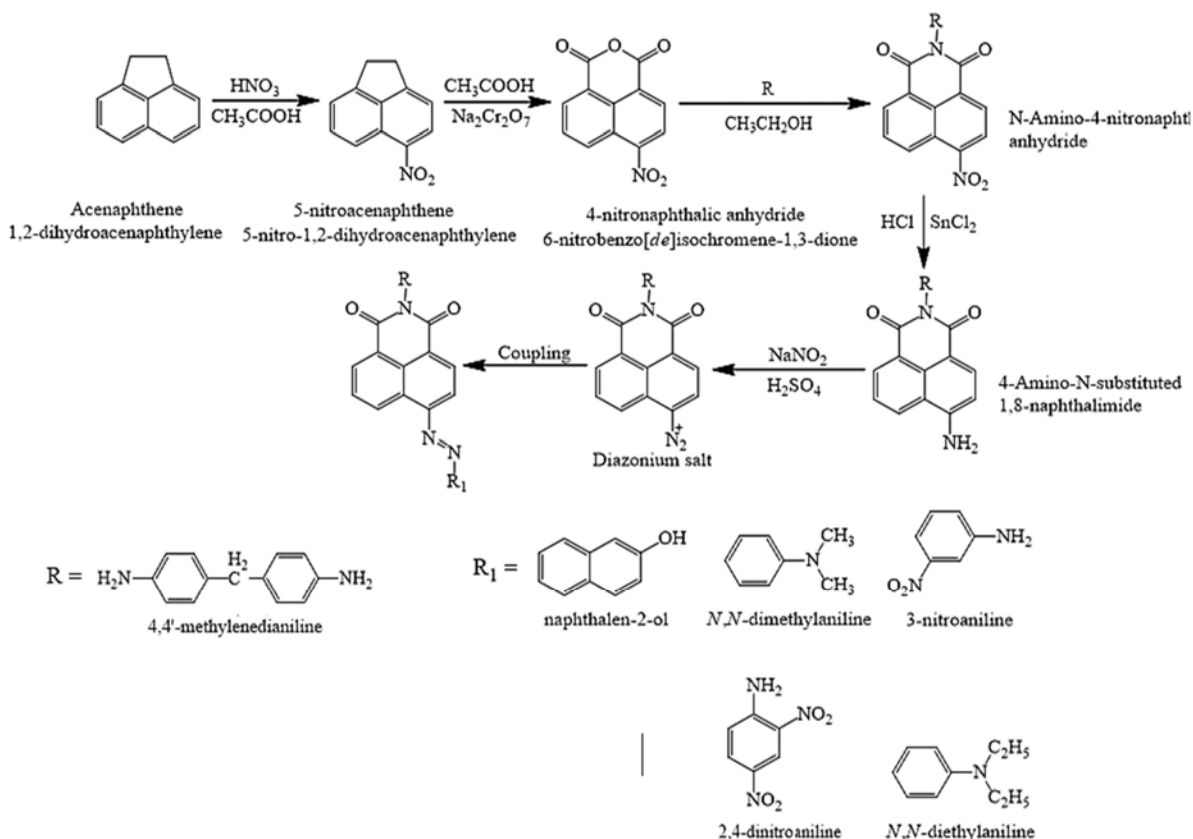
The structure of the intermediate and dyes were characterized using FTIR, ¹H NMR and mass spectroscopic techniques as shown in Table 2 and 3. The IR spectrum of the intermediate; 6-amino-2-(4-(4-aminobenzyl)phenyl)-1H-benzo[de]isoquinoline-1,3(2H)dione showed absorption signal at 3567 which indicates aromatic N-H stretch, the signal at 3022 and 2954 correspond to C-H stretch of aromatic, aliphatic. The signal at 1908 is due to carbonyl (-N-C=O-) stretch. The signal at 1513 corresponds to (- N=N-) stretch, while the signal at 1349 corresponds to (C-N) stretch. The ¹H-NMR spectrum shows peak at 9.0-

8.60 (1H) which correspond to aromatic proton in a symmetrical environment, peaks at 8.50-8.8.0ppm (4H) correspond to aromatic protons indicating a para substituted aromatic ring, peaks at 7.50-7.0ppm(2H) corresponds to aromatic protons in a hetero aromatic ring, whereas the peaks at 3.0-2.0 ppm correspond to the (5H) at the aliphatic region.

The peak at 1.0-1.5ppm (7H) showed a downfield correspond to aliphatic protons. The MS analysis showed a molecular ion[M⁺] at m/z 393.4 which is in agreement with the formula mass 393.0gmol⁻¹. The diazotization of 6-amino-2-(4-aminophenyl)-

1H-benzo[de]isoquinoline-1,3(2H)-dione was carried out using nitrosyl sulphuric acid method and coupling with various electron-rich arenes produce the dyes shown in the reaction (Scheme 1).

The structures of the dyes were characterized using FT-IR and ¹H NMR, MS and UV spectroscopic methods. The results of the characterization are shown in Table 3 and 4. Figures 2–7 showed the FT-IR and Mass spectra of some selected dyes.



Scheme 1: Synthesis of intermediates and the dyes

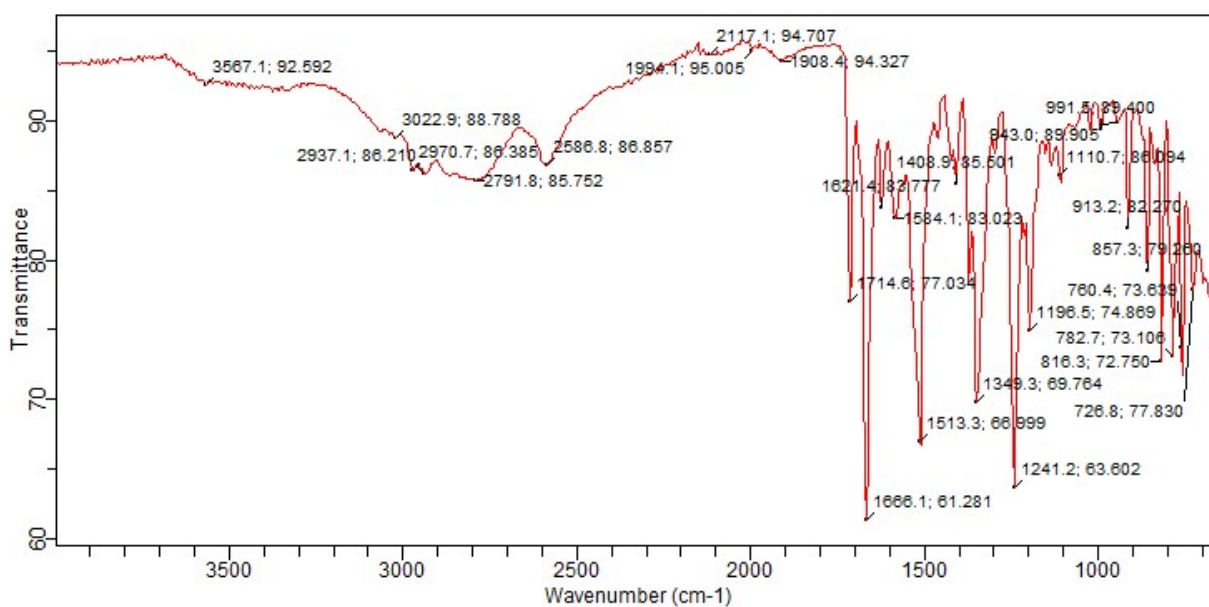


Figure 1: FTIR spectra of the Intermediate

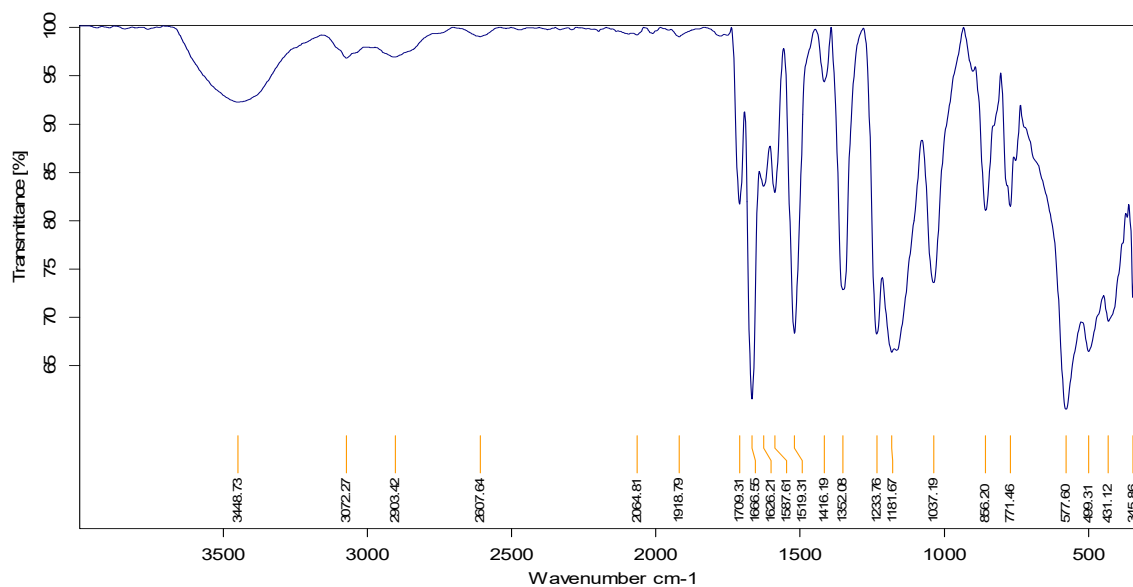


Figure 2: FTIR of dye B₁

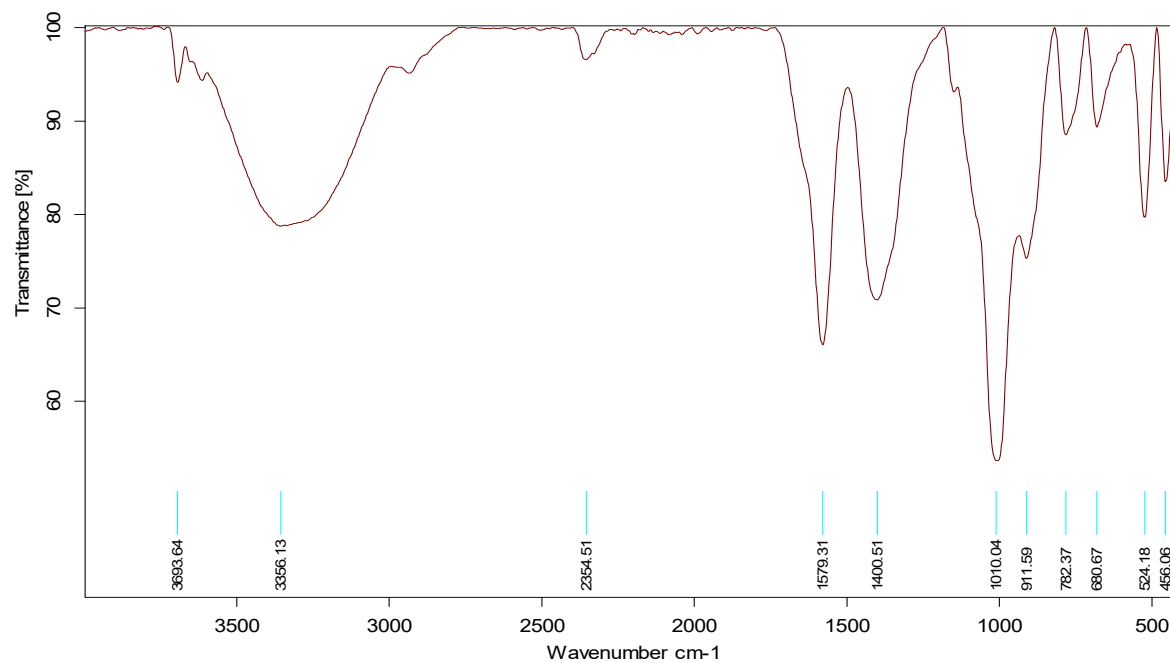


Figure 3: FTIR of dye B₂

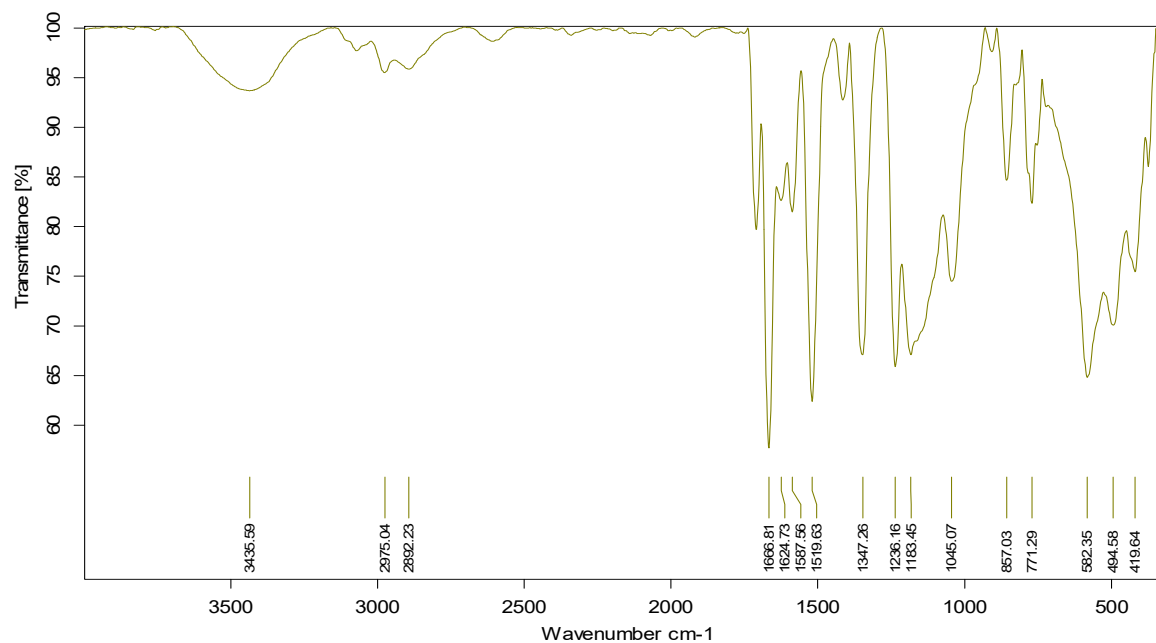


Figure 4: FTIR of dye B₃

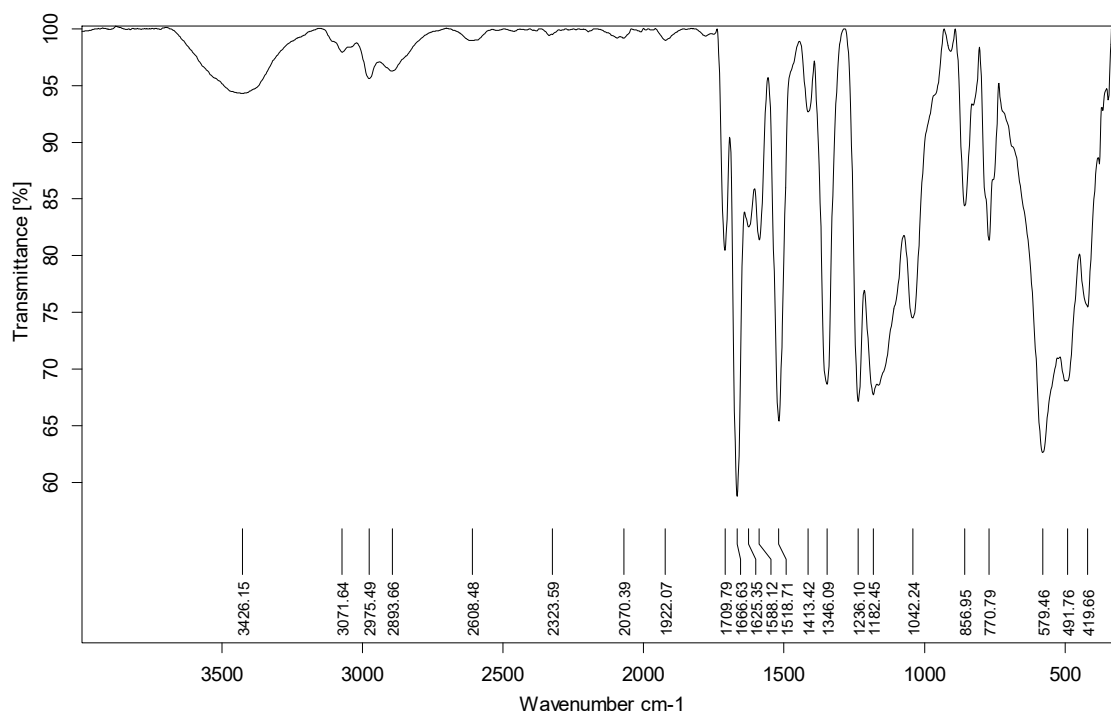


Figure 5: FTIR of dye B₄

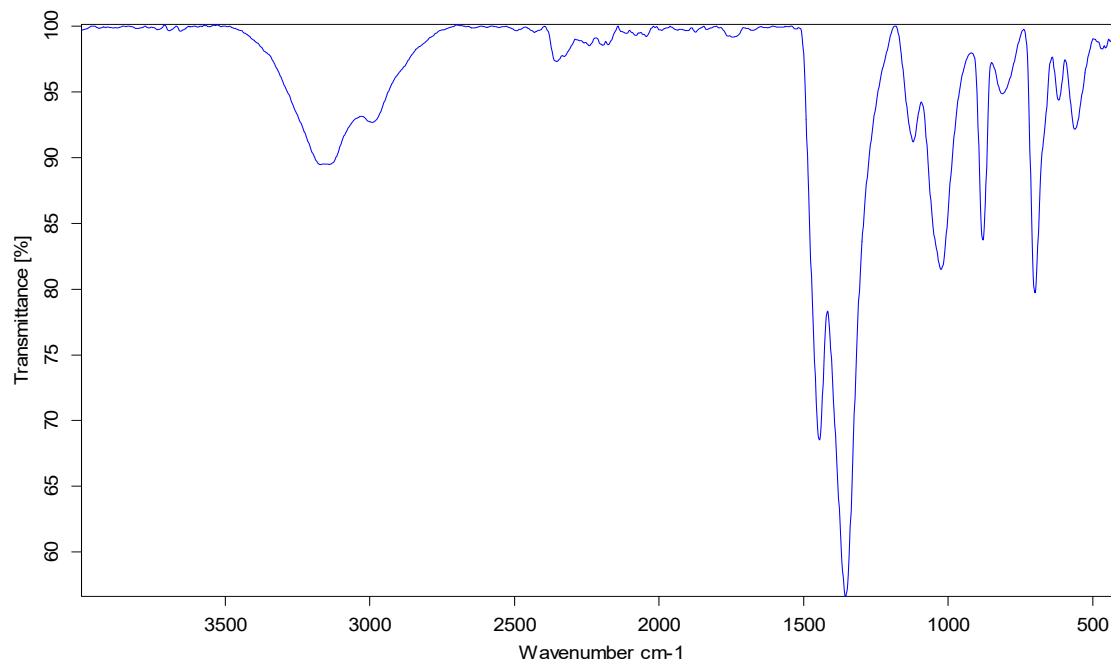
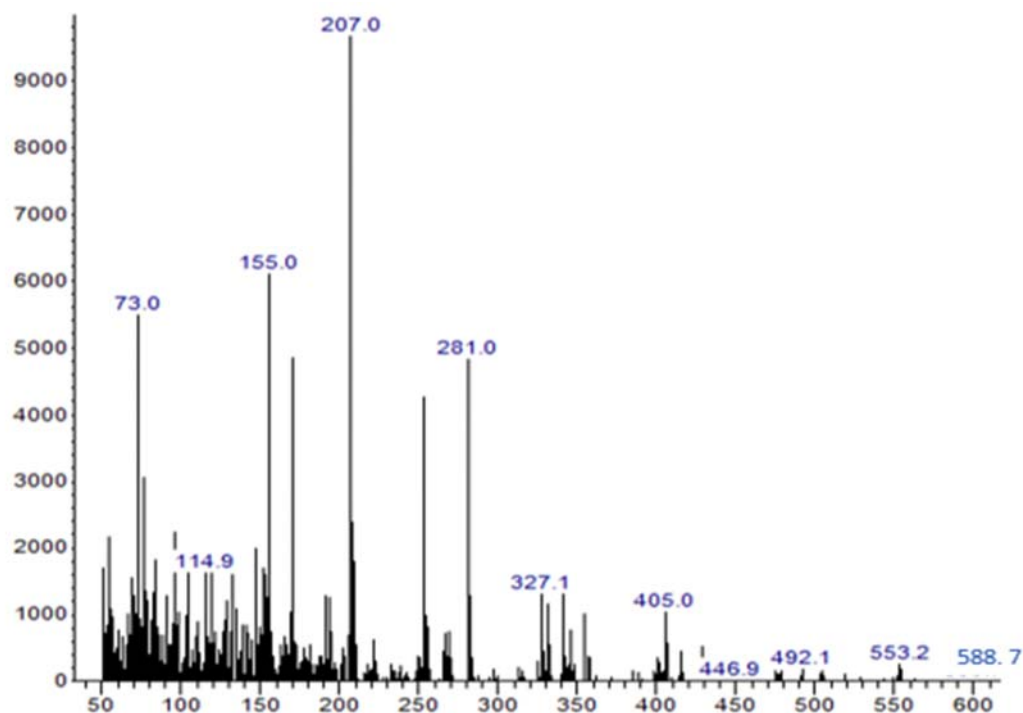


Figure 6: FTIR of dye B₅

Figure 7: MS for dye B₄

Visible Absorption Spectra and Molar Extinction Coefficient of the Dyes

The absorption spectra of the synthesized dyes were measured in solvents of different polarity in order to study their solvatochromic behaviour. The wavelength of maximum absorption and molar extinction coefficient of the dyes shown in Table 5. The wavelength of maximum absorption (λ_{max}) and extinction coefficients ranged from 445 to 498 nm and 14300 -35400 Lmol⁻¹cm⁻¹ in DMF respectively.

The λ_{max} shifts in different solvents are brought by the solvatochromic effect resulting from changes in the dielectric constant of all the dyes. The measurement of λ_{max} in chloroform, ethanol and DMF showed that λ_{max} of the molecular charge

transfer bonds exhibits a marked red shift on transfer from non-polar to solvent. This behaviour indicates that the polar excited states of the synthesized dyes stabilized by polarization interaction forces as the polarizability of the solvent is eased. It was observed that chloroform, ethanol plus a drop of HCL, the absorption spectra of the dyes did not change significantly [12].

Generally, the colour of naphthalimide azo dyes depends on the delocalization of electrons through the conjugated chromogen depicted by the energy difference between structures 1 and 2 shown below. This is in agreement with the findings of other researchers [3], [12].

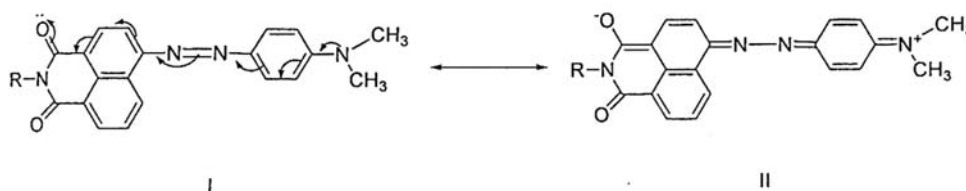


Figure 6: The energy difference

The bathochromic effect of these compounds increases when the energy difference between resonance structures is low. Contribution of the high energy stabilized structure II, could be initially enhanced by the presence of a conjugated electron acceptor (i.e. naphthalimide residue) and secondly, by an electron donor on the coupling component (i.e. dialkylamino group) which results in a

considerable bathochromic shift. Comparison of the λ_{max} of the dyes in DMF for DB₁-DB₅, in Table 5 showed that the nature of imide 1,4-diamino benzene is not very significant in the context of colour change. These findings are in accordance with those reported for azo heterocyclic and naphthalimide compounds [3], [8].

Table 5: UV-Visible and molar Extinction coefficient

Dye No:	ϵ_{max} in DMF x 10^4 (Lmol ⁻¹ cm ⁻¹)	DMF λ_{max} (nm)	Chloroform λ_{max} (nm)	Ethanol λ_{max} (nm) (a)	Ethanol + HCl λ_{max} (nm) (b)	Change in λ_{max} (nm) (b-a)
B ₁	1.43	482	463	480	480	0
B ₂	2.68	463	425	442	447	+5
B ₃	3.46	448	461	570	568	+2
B ₄	3.54	586	515	536	541	+5
B ₅	2.33	591	529	434	435	+1

Dye B₁ was obtained by coupling the intermediate; 6-amino-2-(4-(4-aminobenzyl) phenyl)-1H-benzo(de)isoquinoline-1, 3 (2H)-dione to 2-naphthol and absorbed at 482nm, when the coupling component was replaced by 3-nitroaniline gave dye B₂ and absorbed at 463nm. Dye B₂ showed a hypsochromic shift of 19nm when compared with B₁ which may be due to the presence of electron donor (NH₂) of the couple component.

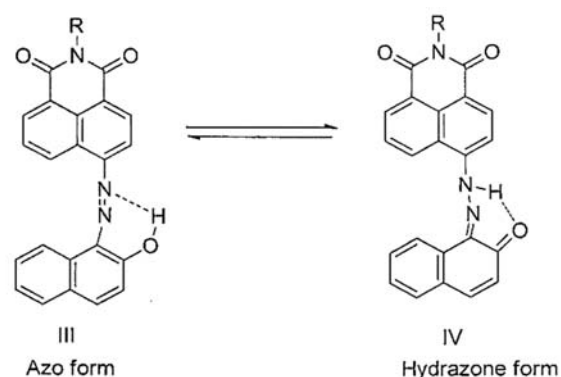
Dye B₅ was obtained by coupled intermediate with N, N-dimethylamine absorbed at 591nm in same solvent with a bathochromic shift of 53nm when compared with dye B₁. When the coupling component was replaced with N, N-diethylamine to produce B₄ and absorbed at 586nm. Dye B₄ showed bathochromic shifts by 5nm when compared with dye B₅ which may be attributed to the substituent (-CH₂) of the intermediate.

Dyeing and Fastness Properties of the Synthesized Dyes

The synthesized dyes were applied to polyester fabrics using carrier dyeing method. Visual evaluation of the dyeing on polyester fabrics showed that the nature of the alkyl residue in the amine group of the coupling component affects both the intensity of dyeing and their shade

obtained. The highest intensity is shown by the dyes which contain methyl and ethyl groups.

These substituents bring about an increase in the nucleophilic character of the tertiary nitrogen atom and the stability of polar forms especially when there are no substituents in the phenyl ring causing steric effects [1]. The electron donor substituent in the ring of the coupling components also considerably affects the colour of the dyeing especially those in an ortho position to the azo band such as dye B₁, this phenomenon is described in terms of structures III and IV.

**Figure 3: Azo and Hydrazone form structure****Table 6: Dyeing properties of the synthesized Dyes on Polyester Fabrics**

Dye No	Light Fastness	Wash Fastness	Perspiration to Acid	Alkaline
B ₁	5	4	3-4	3
B ₂	4	4	3-4	4-5
B ₃	4	3	4	5
B ₄	5	4	3	3-4
B ₅	6	4	3-4	4

The results of the wash fastness ratings are summarized in Table 6. The dyes gave good levelness and fibre penetration on polyester. The wash fastness rating is good to excellent with rating of 3 -4 for all the dyes. The good wash fastness obtained on polyester may be due:

- To the crystalline structure of the polyester which disallowed the migration of dye out of the fabric when it has entered the fabric.

- To the absence of solubilizing groups which renders solubility and washability of dye-out of the fabrics.
- To the good intra-fibre diffusion of the dye molecules inside the fabric.

All dyed fabrics shows good light fastness rating as shown in the Table 6. Disperse dyes have a tendency to deposit on the fibre surface during

dyeing as well as during cooling and therefore in order to obtain a satisfactory combination of light and sublimation fastness, a judicious choice of substituent is required [5] suggest that fading of azo dyes is mainly a consequence of decomposition of the -N=N- moiety either by oxidation, reduction or photolysis. The rates of these processes should be sensitive to the chemical structure of the dye, the type of substrate and treatment conditions. The dyed substrate employed in this study is polyester fabric, the fading process likely occurs by oxidation. The ease of oxidation of azo linkages should be a function of electron density.

Therefore, electron donating substituents on this moiety should increase the fading rate while electron withdrawing groups should decrease the rate. The introduction of polar groups can adversely affect the dyeing properties of a dye but the hydroxyalkyl group appears to be particularly useful in increasing polarity without excessive undesirable side effects. The free hydroxyl group and also short alkyl chain favour formation of compact aggregates of dyes, which confers low surface activity and this causes dye to spread as multilayer on the surface of the fabric; the multilayer is less susceptible to fading. This may account for why the dyes from N, N-dimethylaniline and N, N-diethylaniline have acceptable results in light fastness.

In attempting to trace the relationships between chemical structure and light fastness, it was observed by [6], that there is no absolute value for the light fastness of a dye. The rating obtained for a given colourant in any fading test depends on many factors, the most important of which are concentration and or degree of aggregation of dye within the fabric, nature of fabric in which dye is dispersed, the characteristics of the incident radiation, molecular structure and substantivity.

Colour fading and alteration can be caused by the reaction between dyes on garments and the constituents of human perspiration, such as skin waster. It varies for different individuals and conditions. There are cases where more colour fading and alteration is caused, depending the condition under which the garments are used. In Table 6, the fastness to perspiration was good both in acidic and alkaline medium with rating of (3-4). This may be attributed to the crystalline structure of the polyester which disallowed the migration of the dye out of the fabric when it has entered the fabric.

CONCLUSION

A new series of monoazo disperse dyes based on naphthalimide derivatives have been synthesized in

good yields. The structures of the intermediate and the dyes were confirmed using FTIR, ¹HNMR, Mass and UV-visible spectroscopic techniques. It was found that introducing electron donor and acceptor group into the coupler ring has an influencing effect on the bathochromic and hypsochromic properties of the dyes. The synthesized dyes were applied on Polyester using carrier dyeing method at 100°C. The colour build up and dyeing properties like wash fastness, light fastness and perspiration fastness showed good to excellent results with fastness rating of (3-5) for wash and perspiration fastness and rating of (4-6) for light fastness. The remarkable degree of brightness after washing is an indication of good affinity of the dyes on the fabrics.

REFERENCES

- [1] Ameuru, U.S., Yakubu, M.K., Bello K.A., Nkeonye P.O. and Halimehjani A.Z. (2019). Synthesis and Application of Monoazo disperse dyes derived from 4-amino-N-hexadecyl-1,8-naphthalimide and their dyeing properties on polyester fabrics, 5, pp. 1 – 10.
- [2] Behect B. (2017). Colour concept in textiles: A review. *Journal of Textile Engineering & Fashion Technology*.
- [3] Khosravi, A., Mordian, S., Gharanjig, K. and Afshar Taromi, F. (2006). Synthesis and Spectroscopic studies of some Naphthalimide Based Disperse Azo Dyestuffs for Dyeing of Polyester Fibres, *Dye and Pigments*, 69, pp. 79-92.
- [4] Shaki, H., Gharanjig, K. and Khosravi A. (2014). Spectral, dyeing and antimicrobial properties of some monoazo naphthalimide dyes on polyamide, *Indian Journal of Fibre and Textile Research*, Vol. 40, pp. 425-430.
- [5] Al-Etaibi A and El-Asasery, MA. (2020) comprehensive review on the synthesis and versatile applications of biologically active pyridone- based disperse dyes. *International Journal of Environmental Research and Public Health*.
- [6] Maradiya, H.R. (2010). Synthesis and Dyeing performance of some Novel Thiazole Azo Disperse Dyes. *Journal of the Saudi Chemical Society*. 14, pp. 77-81.
- [7] Otutu, J. O. (2013). Synthesis and application of azo dyes derived from 2-amino-1,3,4-thiadiazole-2-thiol on polyester fibre, *Inter. J. Res. Rev. Appl. Sci.*, 15, 292-296.
- [8] Gharanjig, K., Arami, M., Rouhani, S., Bahrami, H., Movassagh, B. and Mahmoodi, N. (2007). Synthesis and

- Characterization of Novel Monoazo N-ester-1, 8 naphthalimide Disperse Dyestuffs Journal of Chinese Chemical Society 1021 54, (<https://doi.org/10.1002/jccs.200700147>).
- [9] Parvizi, P., Khosravi, A.R., Moradian, S. and Gharanjig, K Journal of Chemical Society 56 (2009) 1035 (<https://doi.org/10.1002/jccs.200900150>).
- [10] Bojinov, V.B. and Konstantinova, T.N. (2007). Fluorescent 4-(2, 2, 6, 6-tetramethylpiperidin-4-ylamino)-1,8-naphthalimide pH chemosensor based on photoinduced electron transfer', Sensor Actuat. B – Chem., 123, 869–876.
- [11] Akgun, H., Karamekoglu, I., Berk B., Kurnaz, I., Sarıbıyık, G., Oktem, S., and Kocagoz, T. (2012). Synthesis and antimycobacterial activity of some phthalimide derivatives', Bioorg. Med. Chem., 20:4149–4154.
- [12] Ameuru, U.S., Yakubu, M.K., Bello, K.A., Nkeonye, P.O. and Halimehjani, A.Z. (2018). Synthesis of disperse dyes derived from 4-amino-N-decyl-1, 8-naphthalimide and their dyeing properties on polyester fabrics. Dyes Pigm. 157 190 (<https://doi.org/10.1016/j.dyepig.2018.04.050>).
- [13] Ukanah, P. S., Gadimoh, S., Salisu, Z. M., Suleiman, M. A., Sulai: nan, I. A., Chibuzo Anakor, N. C., Umar, I. S., Lawal, O. M. and Oddy-Obi, LC. (2020). Influence of selected mordants and mordanting techniques on eco-friendly dyeing of cellulosic fabric using natural flavonoid dye extracted from onion outer scale, *Nigerian Journal a/Textiles*, vol. 6, Pp. 19-25.
- [14] Koh, J. and Greaves, A. J. (2013). Synthesis and application of an alkali-clearable azo disperse dye containing a fluorosulfonyl group and analysis of its alkali hydrolysis kinetics, *Dyes and Pigment*, 50(2): 117-126, ISSN 0143-7208.
- [15] Joonseok Koh (2011). Dyeing with Disperse Dyes Textile Dyeing, Prof. Peter Hauser (Ed.), SBN 978-953.
- [16] Karst, D., Nama, D., Yang, Y. (2007). Effect of disperse dye structure and dye adoption onto PLA fibre. *Journal of Colloid Interface Scientific*, 310, 106-111. doi:10.1016/j.jcis.2007.01.037