Journal of the Serbian Chemical Society

JSCS-info@shd.org.rs • www.shd.org.rs/JSCS

J. Serb. Chem. Soc. 85 (10) 1253–1264 (2020)
JSCS–5372

UDC 667.27+677.494.674:547.651:
677.027.625.122
Original scientific paper

Synthesis and dyeing performance of some amphiphilic naphthalimide azo disperse dyes on polyester fabrics

UMAR SALAMI AMEURU[1], MOHAMMED KABIR YAKUBU[1]*, KASALI ADEMOLA BELLO[1], PETER OBINNA NKEONYE[1] and AZIM ZIYAEI HALIMEHJANI[2]**

[1]*Department of Polymer and Textile Engineering, Ahmadu Bello University, Zaria, Nigeria and* [2]*Faculty of Chemistry, Kharazmi University, 49 Mofateh St., Tehran, Iran*

(Received 23 January, revised 24 March 2019, accepted 20 August 2020)

Abstract: A series of monoazo disperse dyes were synthesized by coupling diazotized 4-amino-*N*-dodecyl-1,8-naphthalimide with *N,N*-dialkyl anilines and naphthol derivatives. The synthesized intermediates and the dyes were characterized using FTIR, ^{1}H-NMR, ^{13}C-NMR, mass spectroscopy and elemental analysis (CHN). Visible absorption spectra of the dyes were examined in solvents of different polarities. The electronic absorption spectra cover a wavelength (λ_{max}) range of 515–535 nm in DMF at uniformly absorption intensity between 1.59–3.00×10^4 L mol^{-1} cm^{-1}. The dyes gave deep and bright intense hues of light violet, maroon, pink and neon red on polyester fabrics. The dyes generally showed good washing and perspiration rating but poor to moderate light fastness properties on woven polyester fabric and could be recommended for commercial outlets.

Keywords: 1,8-naphthalimide derivatives; azo dyes; solvatochromic effects; naphthols; fastness properties.

INTRODUCTION

Azo compounds are the most widely used class of industrial synthesized organic dyes due to their versatile applications in various fields, such as the dyeing of textiles, biological–pharmacological activities and advanced application in organic synthesis.[1–3] Most of the heterocyclic dyes are derived from diazo components containing five-membered rings with one or more nitrogen heteroatoms, with the ring being fused into another aromatic ring.[4] Azodyes containing heterocyclic rings result in brighter and often deeper shade than their benzene analogues. They are very important in applications such as disperse dyes for polyester fabrics, reprography, functional dyes and nonlinear optical systems, photodynamic therapy and lasers.[5–10] Azo dyes based on naphthalimides have a

---

*,** Corresponding authors. E-mail: (*)mkyakubu@abu.edu.ng; (**)ziyaei@khu.ac.ir

https://doi.org/10.2298/JSC190123049A

violet to blue hue. This phenomenon results from the high maximum absorption of their dyes. The strength of the electron withdrawing inductive effect of naphthalimide systems is greater than that of benzene ring systems containing nitro groups.[11]

Pioneering work on heterocyclic derivatives of naphthalimides, phenylazophthalimides and 1,8-naphthalic anhydrides has been performed to assess their role as intermediates for dye preparation.[12–15] 4-Aminonaphthalimide compounds have an amino group in their 4-position, which tends to act as a donor group, and two carbonyl groups, which act as acceptor groups. These substituents bring about a considerable bathochromic effect that led to their usefulness as the diazo component for the synthesis of azo dyes.[16] Naphthalimide derivatives have obtained great industrial importance due to their excellent fastness of some of their dyes.[17]

Aminonaphthalimides are known to produce fluorescent yellow dyes for synthetic polymer fibres. The dyes with an alkyl group in *N*-substituted naphthalimides can be converted into disperse dyes that are used in the coloration of synthetic fibres.[18]

Generally, monoazo disperse dyes derived from naphthalimides show exceptionally good thermal stability and good dyeing fastness properties.[19] However, the 4-amino-*N*-alkyl(ester)-1,8-naphthalimide derivatives of monoazo disperse dyes have relatively low heat fastness properties.

Conventional disperse dyes are hardly soluble in water due to the lack of polar groups in their structures. This leads to milling of the dye into fine particle size and addition of dispersion in water using dispersing agents during application, hence gave rise to prolong application time. In the present study, a series of monoazo disperse dyes with *in situ* incorporation of amphiphiles to enhance their solubility was synthesized. This would eliminate the milling and additions of dispersing agents associated with the application of known disperse dyes.

EXPERIMENTAL

Materials and methods

All the chemicals used in the synthesis were of commercial grade and used as received. The structures of all the newly synthesized compounds were confirmed by thin-layer chromatography (TLC), melting point, FT-IR, ^{1}H- and ^{13}C-NMR spectroscopy, mass spectra (MS) and elemental analysis (CHN). The purity of the synthesized compounds was checked by TLC using ethyl acetate–*n*-hexane (90:10 volume ratio). The TLC was performed on silica gel 60 F_{254}, 0.2 mm coated aluminium sheets. The melting points were recorded on a Barnstead electrothermal 9200 apparatus and are uncorrected. The infra-red spectra were recorded on a Perkin-Elmer Spectrum RX1 FT-IR spectrometer, ^{1}H- and ^{13}C-NMR spectra were obtained on a 300 MHz Bruker instrument using deuterated chloroform ($CDCl_3$) and dimethylsulphoxide (DMSO-d_6) as solvent. Chemical shifts are reported in parts per million (ppm) downfield from internal tetramethysilane (TMS). Elemental analyses (CHN) were recorded on Perkin–Elmer

PE 2400 series II and the mass spectra were obtained using an Agilent Technologies 5975C VL MSD mass spectrometer.

Analytical and spectral data are given in Supplementary material to this paper.

*Synthesis of 5-nitroacenaphthene (**2**)*

Acenaphthene **1** (15.4 g, 0.1 mol) was dissolved in hot glacial acetic acid (57.2 mL) and then cooled under vigorous stirring to separate as fine as possible crystalline acenaphthene. Concentrated nitric acid (65 %, *d* = 1.40 g mL^{-1}, 9.84 g) was added drop wise to this mixture over 1 h at 22–27 °C and then further stirred for 1 h at 25 °C. The solution was warmed gradually over 30 min to 68 °C then cooled to form crystals that were filtered, washed with 1:1 acetic acid–water and water to give yellow needles (yield 85 %).[20]

*Synthesis of 4-nitronaphthalene-1,8-dicarboxylic anhydride (**3**)*

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 over 3 h at 65–70 °C. The solution was warmed gradually to 98–100 °C over 30 min and further refluxed for 5 h. The reaction mixture was treated with water (0.6 L) and cooled to room temperature. The precipitate was filtered and washed with dilute HCl (10 %). In addition, the solid was boiled with 200 mL of 5 % Na_2CO_3 solution for 30 min and filtered. The filtrate was acidified and the separated crystals dried at 120 °C for 4 h to obtain 4-nitronaphthalene-1,8-dicarboxylic anhydride, which was recrystallized from concentrated HNO_3 (65 %, *d* = 1.40 g mL^{-1}) to afford colourless needle crystals (yield 74 %).[21-22]

*Synthesis of 4-nitro-*N*-dodecyl-1,8-naphthalimide (**4**)*

A suspension of 4-nitronaphthalene-1,8-dicarboxylic anhydride (0.02 mol, 4.86 g) and dodecylamine (0.03 mol, 5.55 g) in ethanol (99.5 %, 102 mL) was stirred under reflux for 7 h. The reaction mixture was cooled to precipitate. The precipitate was filtered and recrystallized from ethanol to give off-white crystals (yield 74 %).[23]

Synthesis of 4-amino N*-dodecyl-1,8-naphthalimide (**5**)*

A mixture of 4-nitro-*N*-dodecyl-1,8-naphthalimide (18 mmol, 6.88 g) and stannous chloride (90 mmol, 20.25 g) in ethanol (81 mL) was refluxed for 1 h with hydrochloric acid (36 %, 10.1 mL) until the reaction was completed. The mixture was transferred into 100 cm^3 of water and the observed precipitate was filtered. The crude product was purified by recrystalization from ethanol (99.5 %) to give orange crystals (yield 84 %).[23]

*Procedure for the synthesis of dyes (**7a–d**)*

*(Z)-2-Dodecyl-6-((2-hydroxynaphthalen-1-yl)diazenyl)-benzo[de]isoquinoline-1,3(2*H*)--dione (**7a**).* Sodium nitrite (1.5 mmol, 0.104 g) was slowly added under constant stirring to cold concentrated sulphuric acid (98 %, 1.1 mL) at below 10 °C. The temperature of the reaction mixture was gradually increased to 65 °C using a water bath until all the sodium nitrite had dissolved. The solution was then cooled externally to 5 °C and diluted with a mixture of propionic acid and glacial acetic acid (10mL, 1.5:8.5 volume ratio). Finely ground powder of 4-amino-*N*-dodecyl-1,8-naphthalimide (1.5 mmol) was added portion wise below 10 °C, and then the mixture was stirred for 3 h. The obtained clear diazonium salt solution was used immediately in coupling reactions with 2-naphthol (1.5 mmol) dissolved in ethanol by its addition over 30–40 min under vigorous stirring. The mixture was stirred further for 2 h at 5 °C. The pH of the solution was adjusted to 4–5 using 10 % sodium acetate and stirred for 1 h. 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 to obtained dye **7a** (yield 80.9 %). The remaining DMSO was removed from the product by washing the precipitate several times with water and aqueous ethanol (50 %).

*(Z)-6-((2,3-Dihydroxnaphthalen-1-yl)diazenyl)-2-dodecyl-1*H*-benzo[de]isoquinoline-1,3(2*H*)-dione (7**b**)*. The same procedures as for **7a** were used, except that 2,3-dihydroxynaphthalene was used for the coupling.

*(Z)-6-((4-(Dimethylamino)phenyl)diazenyl)-2-dodecyl-1*H*-benzo[de]isoquinoline-1,3(2*H*)-dione (7**c**)*. The same procedures as in **7a** were used, except that *N*,*N*-dimethylaniline was used for the coupling.

*(Z)-6-((4-(Diethylamino)phenyl)diazenyl)-2-dodecyl-1*H*-benzo[de]isoquinoline-1,3(2*H*)-dione (7**d**)*. The same procedures as for **7a** were used, except that *N,N*-diethylaniline was used for the coupling.

Dyeing procedure

A KMS-IRE laboratory dyeing machine – ELITE, was used with a material to solution ratio of 1:50, 2 % shade on weight of the fabric (OWF) was used for dyeing. The dye was dissolved in DMF (5 mL) and water (45 mL) was added under constant stirring and the pH adjusted to 5 using glacial acetic acid. The dye suspension (50 mL) was transferred into a beaker provided with a lid and a screw cap. Before closing the lid and tightening the metal cap over the beaker, a wetted pattern of polyester fabric was rolled into the beaker. The beaker was then placed vertically on a rotatory carrier inside the tank and the clamp plate was firmly tightened. The rotatory carrier was then allowed to rotate in the glycerine-bath and the temperature was raised to 130 °C at a rate of 2 °C min^{-1}. The dyeing was continued for 1 h under pressure. After cooling to 70 °C, the beaker was removed from the bath. The dyed pattern was removed from the beaker|, thoroughly washed with water and dried at room temperature.

Reduction clearing

The dyed fabric was treated by stirring in an aqueous solution containing sodium dithionite (2 g L^{-1}) and sodium hydroxide (2 g L^{-1}) for 45 min at 70 °C. The fabric was then washed with water and dried.

Colour measurement

A Gretag Macbeth Colour-Eye 7000A spectrophotometer was used for colour measurement of the dyed polyester fabrics using a D65 source, 10° collection angle and small area view aperture (3 mm×8 mm).

Fastness properties of the dyed polyester fabrics

Wash fastness. The dyed samples were tested for fastness to washing treatment according to the International Standard Organization (ISO 3). The composite samples were treated with a solution containing 5 g L^{-1} detergent, 2 g L^{-1} sodium carbonate and liquor ratio 50:1 for 30 min at 60 °C. The change in colour of the tested samples and the degree of staining of the adjacent undyed fabrics were rated against the Grey scales. The grey scales are in the range 1–5, where 1 is poor and 5 is excellent.

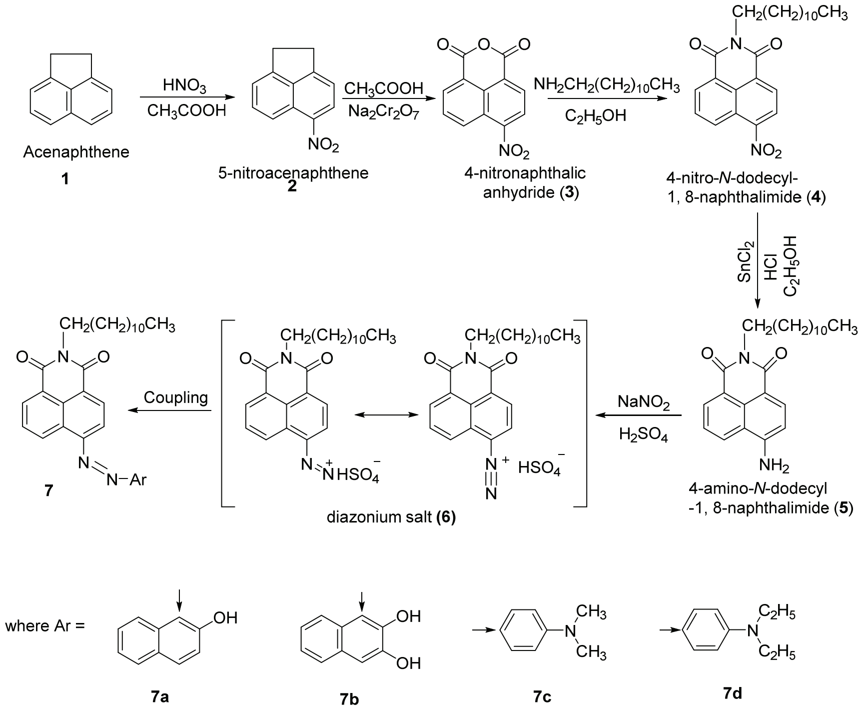
Light fastness. The photostability was evaluated by exposing the dyed fabric samples to a xenon arc lamp according to (ISO 105 B02:2014). The conditions for the test were: black panel temperature 60 °C, dry bulb temperature 43 °C, relative humidity 30 %, duration of test 48 h. After testing, the tested samples were rated against standard blue wool scale (grade 1–8) and the indications in this case are 1 is poor and 8 excellent.

Perspiration fastness. Colour fastness to perspiration was determined according to ISO 105 – EO4, 2013 by treating the dyed fabrics (10 cm× 4 cm) in an alkaline solution of freshly prepared 0.5 g L^{-1} 1-histidine monohydrochloride monohydrate, 5 g L^{-1} sodium chloride, 2.5 g L^{-1} disodium hydrogen orthophosphate and 0.1 M sodium hydroxide volume ratio of 50:1. The acid perspiration test solution contained 0.5 g L^{-1} 1-histidine monohydrochloride monohydrate, 5 g L^{-1} sodium chloride, 2.2 g L^{-1} disodium hydrogen orthophosphate and 0.1 M acetic acid solution. The tested fabric was rinsed, dried and then rated against the grey scales for colour changes.

RESULTS AND DISCUSSION

Synthesis of intermediates and the dyes

Compounds **2–5** were prepared starting from acenaphthene **1** according to the literature, as depicted in Scheme 1.[23] The structure of the intermediates and dyes were confirmed by various techniques including FT-IR, NMR, elemental analysis (CHN) and mass spectroscopy. The dyes **7a** and **7b** showed absorption band at 3387–3375 cm^{-1} due to the presence of an OH group.



Scheme 1. Synthesis of the intermediates and the dyes.

All the dyes showed absorption bands at 3106–2947 and 2922–2919 cm^{-1} due to the presence of C–H stretching vibration of aromatic C–H, methyl and methylene groups. The absorption band at 1663–1646 cm^{-1} corresponded to C=O groups. The absorption band at 1647–1604 cm^{-1} confirmed the presence of C=C groups. The signal at 1599–1579 cm^{-1} is attributed to –N=N– stretch, while the signal at 1388–1349 cm^{-1} is due to C–N. The ^{1}H-NMR spectra of the dyes displayed signals at 0.82–0.86 and 1.22–1.74 ppm for the methyl and methylene protons of the aliphatic region. The signal at 4.03–4.17 ppm shows is downfield due to *N*–CH$_2$ protons of the aliphatic group. The diazo group was substituted in the alpha position of 2-naphthol and 2,3-naphthalenediol in dyes **7a** and **7b**. Due to this, the dyes **7a** and **7b** showed signals at 16.45–16.91 ppm for OH protons in ^{1}H-NMR spectra. This amount of deshielding can be attributed to intramolecular hydrogen bonding of the diazo group and the –OH group. The aromatic protons showed signals at 6.55–8.91 ppm and the number of protons is in agreement with the aromatic protons in the structure of dyes. The presence of two signals at 6.7 and 7.9 ppm as a doublet in the ^{1}H-NMR spectra of **7c** and **7d** exactly confirms that the diazo group is substituted at the para position on the *N*,*N*-(dialkyl)aniline ring. In addition, mass analysis exactly confirmed the molar mass of the dyes.

Spectral characteristics of the synthesized dyes

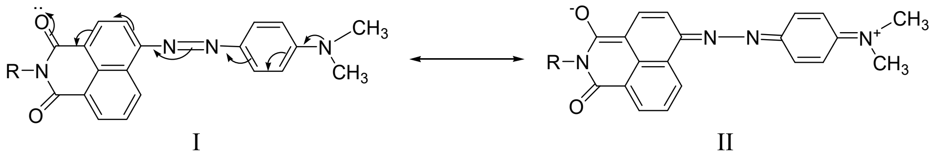
The absorption spectra of the synthesized dyes were measured in various solvents. Absorption maxima, molar extinction coefficients of each dye in various solvents are listed in Table I. Wavelengths of maximum absorption (λ_{max}) and molar extinction coefficient ranged from 515–535 nm and 1.59×10^4–3.00×10^4 L mol^{-1} cm for the synthesized dyes in DMF, respectively. The wavelength (λ_{max}) shifts in different solvents are due to solvatochromic effects resulting from changes in the dielectric constant of the solvent. In many dyes, however, the ground state is less polar than the excited state and thus, a polar solvent will tend to stabilize the excited state more than the ground state, giving rise to bathochromic shift.[24] It was observed that in chloroform, ethanol and ethanol plus a drop of HCl, the absorption spectral of the dyes did not change significantly.

TABLE I. UV–Vis spectroscopic data for the dyes

Dye	ε_{max}(DMF) 10^4 mol^{-1} cm^{-1}	λ_{max} / nm				
		DMF	Chloroform	Ethanol a	Ethanol +HCl b	Change (b–a)
7a	1.94	520	515	518	518	0
7b	2.26	515	515	512	512	0
7c	3.00	522	510	510	520	10
7d	1.59	535	525	525	530	5

Generally, the colour of naphthalimide azo dyes depends on the delocalization of electrons through the conjugated chromogen depicted by the energy difference between structures I and II, as shown in Scheme II. This agrees with Bojinov *et al.*[25]

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



Scheme II. Delocalization of electrons through the conjugated chromogen.

Dye **7a**, obtained by diazotisation of 4-amino-*N*-dodecyl-1,8-naphthalimide and coupling to 2-naphthol, absorbed at 520 nm in DMF. When the hydroxyl group was introduced into the *ortho*-position of the coupling component (2,3-dihydroxnaphthalene), the resulting dye **7b** absorbed at 515 nm in the same solvent and thus dye **7b** was hypsochromic by 5 nm when compared with dye **7a**. Dye **7c**, obtained by diazotisation of 4-amino-*N*-dodecyl-1,8-naphthalimide and coupled with *N*,*N*-dimethylaniline, absorbed at 522 nm in DMF. When the coupling component was replaced by *N,N*-diethylaniline (dye **7d**), it absorbed at 535 nm. Dye **7d** showed a bathochromic shift of 13 nm when compared with dye **7c,** which may be attributed to the higher electron donor capacity of the ethyl groups compared to the methyl groups.

Dyeing and fastness properties of the synthesized dyes

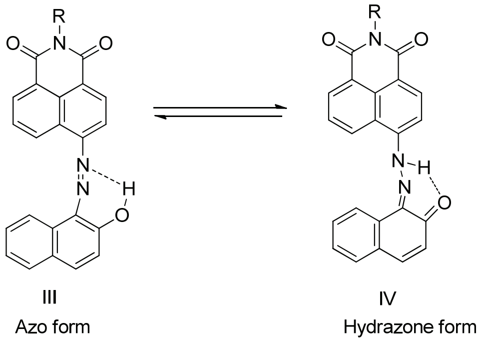
The synthesized dyes were applied to polyester fabrics using a high temperature dyeing method. Visual evaluation of the dyeing on the polyester fabrics showed that the nature of the alkyl residue in the amine group of the coupling component affects both the intensity of dyeing and the shade obtained. The highest intensity was shown by the dyes that contain methyl and ethyl groups. These substituents increase the electron density on the tertiary nitrogen atom and stabilize the polar forms, especially when there are no substituents on the phenyl ring causing steric effects.[26]

An electron donor substituent on the ring of the coupling components also considerably affects the colour of the dyeing, especially those containing a substituent in the *ortho* position to the azo band, such as dye **7a**. This phenomenon is described in terms of structures III and IV, Scheme III.

The results of the wash fastness ratings are summarized in Table II. The dyes gave good levelness and fibber penetration on polyester. The wash fastness rating is good with rating of 3 for dye **7b** and rating of 4 for dyes **7a** and **7c**. Dye **7d** gave outstanding wash rating of 5. The good wash fastness obtained on polyester may be due to the crystalline structure of the polyester that disallowed the migration of dye out of the fabric after entering the fabric:

a) To the absence of solubilising groups that renders solubility and washability of dye-out of the fabrics.

b) To the good intra-fibber diffusion of the dye molecules inside the fabric.



Scheme III. Structures III and IV.

TABLE II. Fastness properties of the synthesized dyes on polyester fabrics

Dye	Light	Fastness washing	Perspiration	
			Acid	Alkaline
7a	2	4	5	4
7b	5	3	5	4
7c	1–2	4	4	4
7d	4	5	4	5

The dyed fabrics have a poor to moderate light fastness rating, as shown in Table II. The dye **7a** and **7c** exhibited poor light fastness ratings while dye **7d** were marginally superior to the others. The dye **7b** gave a very good light fastness rating. Disperse dyes have a tendency to deposit on the fibber 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.[27] Several reports suggest that fading of azo dyes is mainly a consequence of decomposition of the –N=N– moiety, either by oxidation, reduction or photolysis.[28] 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 was polyester fabric and thus, the fading process likely occurs by oxidation.[29] 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. This agrees with the observed results (Table II) that demonstrate that the presence of a hydroxyl group in some of the synthesized dyes caused a decrease in light fastness to 2.

The introduction of polar groups can adversely affect the dyeing properties of a dye, but the hydroxyl and alkyl group appear to be particularly useful in increasing polarity without excessive undesirable side effects. A free hydroxyl group and also a short alkyl chain favour the formation of compact aggregates of dyes, which confer low surface activity, which cause a dye to spread as multilayers on the surface of the fabric; a 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.

Colour fading can be caused by the reaction between dyes on garments and the constituents of human perspiration, such as skin waste. It varies for different individuals and conditions. There are cases where more colour fading and alteration is caused, depending on the conditions under which garments are worn. Coupled with the eventual accumulation and concentration of perspiration, reaction with sunlight is regarded as the cause for such occurrences, casting an influence on certain elements in the dye structure. To forecast such occurrences, methods for examining the components of perspiration under different conditions (acid and alkaline pH values) were investigated by the standards as shown in Table II. The fastness to perspiration was generally very good both in acidic and alkaline medium with rating of 4 and 5. This may be attributed to the crystalline structure of the polyester which disallowed the migration of dye out of the fabric when it had entered the fabric.[23]

Colour measurement properties

The colour parameter of the dyed polyester fabrics are given in terms of the CIELAB value (Table III) and the following CIELAB coordinates were measured, lightness (L^*), chroma (C^*), hue angle from 0 to 360° (h), a^* value representing the degree of redness (positive) and greenness (negative) and b^* representing the degree of yellowness (positive) and blueness (negative). The K/S values are used to represent the depth of dyeing as they are proportional to the amount of colorant present in the dyed fabrics.[29] The colour hue of the dyes **7a–d** on the polyester fabrics shifted in the reddish–yellowish direction according to the positive values of a^* and b^*, respectively. The K/S values listed in the Table

TABLE III. Colorimetric and spectrophotometric data of the synthesized dyes on polyester fabrics

Dye No.	L^*	a^*	b^*	C^*	h / °	K/S
7a	44.88	49.88	10.9	51.06	12.32	8.07
7b	43.89	41.94	355.47	357.94	83.27	6.55
7c	37.03	40.89	10.76	42.28	14.74	10.71
7d	37.07	35.77	355.83	357.63	84.25	13.61

III show that amphiphilic naphthalimide disperse dyes showed the best build-up for polyester fabric and have high affinity for the polyester fabrics. The *K*/*S* values of the dyes under investigation showed that the dyes had good affinity to polyester fabrics. Dyes **7c** and **7d** were characterized by higher values of *K*/*S*, which indicates outstanding results when compared with their analogues.

CONCLUSIONS

In this research, an efficient and simple protocol for the syntheses of monoazo disperse dyes based on amphiphilic naphthalimide in good yields was developed. Data obtained by various analytical techniques proved the synthesis of the claimed novel dyestuffs. It was found that on changing the coupling components, the bathochromic and hypsochromic properties of the dyes varied, which could be related to the structure of the replaced groups. Introduction of electron donor and electron acceptor groups in the coupler had influencing effects on the bathochromic and hypsochromic properties of the dyes. The dyes were applied on polyester fabrics by the HTHP method and gave violet, maroon, pink and neon red with poor to moderate light fastness and good to very good washing and perspiration fastness properties.

The Kubelka–Munk (*K*/*S*) value, which is representative of the colour depth of the dyed fabric, was also evaluated. The value of the coordinates *L**, *a** and *b** represent lightness/darkness, red/green and yellow/blue tones of colours, respectively. From the values of *a** and *b**, it is clear that the synthesized dyes have positive values, which indicates yellowish red colour. Most of the dyes have fairly high values of *L**, confirming their colour brilliancies. The chroma or chromatic purity (*C**) of the dyeing were equally high. The net effect of high chroma and high *L** is the good colour brilliance of the dyes.

SUPPLEMENTARY MATERIAL

Additional data are available electronically at the pages of journal website: https:// //www.shd-pub.org.rs/index.php/JSCS/index, or from the corresponding author on request.

Acknowledgements. We are grateful to the Faculty of Chemistry of Kharazmi University for supporting this work. The authors also thank the staff of the Faculty for their kind collaboration.

ИЗВОД

СИНТЕЗА НЕКИХ АМФИФИЛНИХ НАФТАЛИМИДНИХ АЗО ДИСПЕРЗНИХ БОЈА И ЊИХОВА СПОСОБНОСТ БОЈЕЊА ПОЛИЕСТАРСКИХ ВЛАКАНА

UMAR SALAMI AMEURU,[1] MOHAMMED KABIR YAKUBU[1], KASALI ADEMOLA BELLO[1], PETER OBINNA NKEONYE[1] и AZIM ZIYAEI HALIMEHJANI[2]

[1]*Department of Polymer and Textile Engineering, Ahmadu Bello University, Zaria, Nigeria и* [2]*Faculty of Chemistry, Kharazmi University, 49 Mofateh St., Tehran, Iran*

Синтетисана је серија дисперзних моноазо боја, купловањем диазонијум соли добијене из 4-амино-*N*-додецил-1, 8-нафталимида са *N*,*N*-диалкиланилинима или дериватима нафтола. Синтетисани интермедијери и боје су окарактерисани FT-IR, ^{1}H и

^{13}C-NMR спектроскопијом, масеном спектрометријом и елементалном анализом (CHN). Електронски апсорпциони спектри, у опсега таласне дужине (λ_{max}) 515–535 nm имају јединствену абсорбанцу у интервалу 1,59–3,00×10^4 L mol^{-1} cm^{-1}. Боје дају дубоке и светле интензивне нијансе љубичасте, бордо, розе и неон-црвене боје на полиестарским влакнима. Боје дају генерално добре особине приликом прања и знојења, али имају лошу до просечну постојаност на светлу на полиестарској тканини и могу бити препоручене за комерцијалну употребу.

(Примљено 23. јануара, ревидирано 24. марта 2019, прихваћено 20. августа 2020)

REFERENCES

1. A. A. Fadda, H. A. Etman, F. A. Amer, M. Barghout, K. S. Mohamed, *J. Chem. Technol. Biotechnol.* **61** (1994) 343 (https://doi.org/10.1002/jctb.280610410)
2. M. M. M. Raposo, A. M. R. C. Sousa, A. M. C. Fonseca, G. Kirsch, *Tetrahedron* **61** (2005) 8249 (https://doi.org/10.1016/j.tet.2005.06.039)
3. M. R. Yazdanbakhsh, A. Ghanadzadeh, E. Moradi, *J. Mol. Liq.* **136** (2007) 165 (https://doi.org/10.1016/j.molliq.2007.03.005)
4. M. A.Weaver, L. Shuttleworth, *Dyes Pigm.* **3** (1982) 81 (https://doi.org/10.1016/0143-7208(82)80016-8)
5. J. A. Mielczarski, G. M. Atenas, E. Mielczarski, *Appl. Catal., B* **56** (2000) 289 (https://doi.org/10.1016/j.apcatb.2004.09.017)
6. H. R. Maradiya, V. S. Patel, *J. Braz. Chem. Soc.* **12** (2001) 710 (http://dx.doi.org/10.1590/S0103-50532001000600004)
7. L. C. Abbott, S. N. Batchelor, J. Oakes, B. C. Gilbert, A. C. Whitwood, J. R. L. Smith, J. N. Moore, *J. Phys. Chem., A* **109** (2005) 2894 (https://pubs.acs.org/doi/abs/10.1021/jp045216s)
8. P. C. Tsai, I. J. Wang, *Dyes Pigm.* **74** (2007) 578 (https://doi.org/10.1016/j.dyepig.2006.03.022)
9. A. C. Razus, L. Birzan, N. M. Surugiu, A. C. Corbu, F. Chiraleu, *Dyes Pigm.* **74** (2007) 26 (https://doi.org/10.1016/j.dyepig.2006.01.041)
10. M. M. M. Raposo, M. C. R. Castro, A. M. C. Fonseca, P. Schellenberg, M. Belsley, *Tetrahedron* **67** (2011) 5189 (https://doi.org/10.1016/j.tet.2011.05.053)
11. J. Griffiths, *Color and Constitution of Organic Molecules*. Academic Press, London, 1976, p. 32 (https://doi.org/10.1002/col.5080030213)
12. A. T. Peters, M. J. Bide, *Dyes Pigm.* **7** (1986) 237 (https://doi.org/10.1016/0143-7208(86)85012-4)
13. A. R. Khosravi, S. Moradian, K. Gharanjig, F. Afshar Taromi, *J. Chin. Chem. Soc.* **52** (2005) 495 (https://doi.org/10.1002/jccs.200500071)
14. K. Gharanjig, M. Arami, S. Rouhani, H. Bahrami, B. Movassagh, N. Mahmoodi, *J. Chin. Chem. Soc.* **54** (2007) 1021 (https://doi.org/10.1002/jccs.200700147)
15. P. Parvizi, A. R. Khosravi, S. Moradian, K. Gharanjig, *J. Chin. Chem. Soc.* **56** (2009) 1035 (https://doi.org/10.1002/jccs.200900150)
16. A. Khosravi, S. Mordian, K. Gharanjig, F. AfsharTaromi, *Dyes Pigm.***69** (2006) 79 (https://doi.org/10.1016/j.dyepig.2005.02.007)
17. T. Konstantinova, A. Spirieva, T. Petkova, *Dyes Pigm.* **45** (2000) 125 (https://doi.org/10.1016/S0143-7208(00)00014-0)
18. R. Stolarski, *Fibres Text. East. Eur.* **17** (2009) 91.
19. J. Szadowski, K. Wojciechowski, W. Malinowski, *Color Technol.* **101** (1985) 105 (https://doi.org/10.1111/j.1478-4408.1985.tb01013.x)

20. M. Okazaki, T. Tanaka, S. Taniguchi, *Yuki Gosei Kagaku Kyokaishi* **14** (1957) 344 (https://doi.org/10.5059/yukigoseikyokaishi.14.344)
21. M. Okazaki, Y. Suhara, M. Fujiyama, *Yuki Gosei Kagaku Kyokaishi* **14** (1956) 394 (https://doi.org/10.5059/yukigoseikyokaishi.14.394)
22. M. Dong, Y. W. Wang, Y. Peng, *Org. Lett.* **12** (2010) 5310 (https://doi.org/10.1021/ol1024585)
23. U. S. Ameuru, M. K. Yakubu, K. A. Bello, P. O. Nkeonye, A. Ziyaei Halimehjani, *Dyes Pigm*. **157** (2018)190 (https://doi.org/10.1016/j.dyepig.2018.04.050)
24. R. M. Abd El-Aal, A. I. Koraierm, *J. Chin.Chem. Soc.* **47** (2000) 389 (https://doi.org/10.1002/jccs.200000052)
25. V. Bojinov, G. Ivanova, J. M. Chovelon, I. Grabchev, *Dyes Pigm*. **58** (2003) 65 (https://doi.org/10.1016/S0143-7208(03)00036-6)
26. K. Wojciechowski, *Dyes Pigm*. **12** (1990) 273 (https://doi.org/10.1016/0143-7208(90)85018-J)
27. A. Datyner, *J. Soc. Dye Colourist* **94** (1978) 256 (https://doi.org/10.1111/j.1478-4408.1978.tb03417.x)
28. A. M. Al-Etaibi, M. A. El-Apasery, M. R. Ibrahim, N. A. Al-Awadi, *Molecules* **17** (2012) 13891 (https://doi.org/10.3390/molecules171213891)
29. H. R. Chipalkatti, N. F. Desai, C. H. Giles, N. Macaulay, *J. Soc. Dye Colourist* **70** (1954) 487 (https://doi.org/10.1111/j.1478-4408.1954.tb02006.x)
30. J. Wang, H. Asnes, *J. Soc. Dyers Col.***107** (1991) 314 (https://doi.org/10.1111/j.1478-4408.1991.tb01364.x).