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SYNTHESIS AND ANTIMICROBIAL EVALUATION OF 2,6-BIS((E)-(2-HYDROXYNAPHTHALEN-1-YL)DIAZENYL)-1-SUBSTITUTED PHENYL-1,4-DIHYDROPYRIDINE-3,5-DICARBALDEHYDE

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ABSTRACT

Unsymmetrical and symmetrical bis (heteroaryl) azo dyes were prepared by diazotization-coupling reactions in low to good yield. A series of new azo coupled derivative of N-substituted cyclic imides were prepared by diazotization-coupling reaction. All the compounds were screened for their antimicrobial and antifungal activities. Most of the synthesized compounds have shown significant biological activity. Based on our experimental findings, the new substituted azo vinyl aldehyde derivatives containing cyclic imide moiety exhibiting excellent bactericidal and fungicidal potentials could be proposed for dyeing and antimicrobial finishing for silk, wool, cotton, and polyester fabrics. The structures of these compounds were confirmed by various analytical tools.

KEYWORDS: diazotization, coupling reaction, azo coupling, cyclic imides, biological activity.

INTRODUCTION

The structural diversity and industrial, as well as biological importance of unsymmetrical and symmetricalbis (heteroaryl) azo dyes, have made them attractive target for synthesis over many and justify continuing efforts in the development of new synthetic strategies.[1]-[5] From last few decades, the study of the chemistry of diazo compound has been given particular impacts because of their application in pigments[6]-[7], lacks[8] and dyes.[9]-[12] It has been explored and being developed as a dying and coloring agent for the textile Industries.[13]-[14]

Azo dyes also use as food color.[15]-[17] Now a day chemistry of diazo derivative synthesized using heterocyclic ring[18]-[21] exhibit a new aspect of coupling reaction.[22]-[25] Though many kinds of azo dyes have been synthesized, bis(heteroaryl) derivatives are relatively rare. Though most of the heteroaryl can act as diazotization components, bis(heteroaryl) coupling components are limited. Therefore, some novel diazo cyclic imides were synthesized from halo vinyl aldehyde derivative of cyclic imides. The series of reaction were carried out over halo vinyl aldehyde to synthesized diazo coupled product.

After the extensive literature search[26]-[28], it was observed that cyclic imides[29]-[34], halo vinyl aldehyde[35] and azo compounds[36] are the important pharmacophore, but till date enough efforts have not made to combine these three moieties as a single molecular scaffold. So, our objective was to synthesize and biological screening of a series of new compound incorporates these moieties.

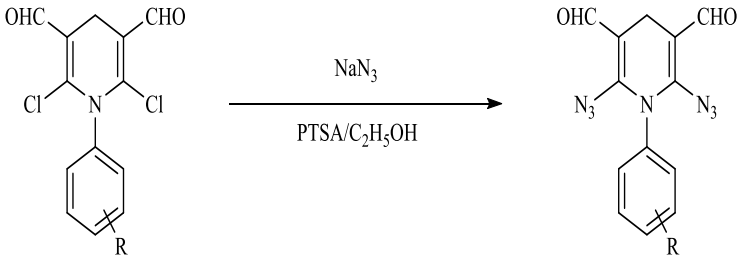
MATERIALS AND METHODS

The Melting points of all the synthesized compounds were recorded in open glass capillaries and were uncorrected. IR spectra were recorded on Lambda 7600 FTIR spectrophotometer. 1H NMR spectra were recorded on Bruker 400 MHz in DMSO-d6 using TMS as an internal standard. The reaction was monitored by TLC, which was accomplished by using pre-coated silica gel aluminum plates with the mixture of hexane: ethyl acetate as a solvent phase. Chemical purchased were used as received.

Experimental

General procedure for synthesis of 2,6-diazido-1,4-dihydro-1-substitutedphenylpyridine-3,5-dicarbaldehyde (2a-j)

In continuation of our previous work[29]-[33] a solution of 2,6-dichloro-1,4-dihydro-1-substitutedphenylpyridine-3,5-dicarbaldehyde **1a-j** (0.01 moles) in absolute ethanol (10 mL), P-toluene sulphonic acid (0.02 moles) and sodium azide (0.03 moles) were added and reaction mixture heated under reflux for time ranging between 4-6 hrs (**Scheme 1**). The refluxed mixture was added to ice cold water which precipitated compounds **2a-j**. These were filtered and recrystallized from ethanol.



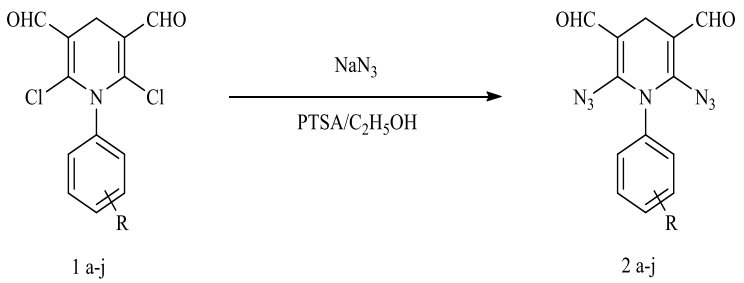
1 a-j 2 a-j

Where R a= 4H, b= 3Cl, c= 4Cl, d= 4Br, e= $2NO_2$, f= $3NO_2$, g= $4NO_2$, h= 4OH, i= $4CH_3$, j= $4OCH_3$

Scheme 1: Synthesis of 2,6-diazido-1,4-dihydro-1-substitutedphenylpyridine-3,5-dicarbaldehyde

2,6-diamino-1,4-dihydro-1-substitutedphenylpyridine-3,5-dicarbaldehyde (3a-j)

The mixture of compounds **2a-j** (0.026 moles), sodium dithionite (0.054 moles) and methanol (12mL) was refluxed for 5 hrs (**Scheme 2**). The reaction mixture was filtered and the inorganic residues were washed with methanol. The combined methanolic solution was distilled and poured over crushed ice. The resultant solids **3a-j** was filtered washed with water, dried and recrystallized using ethanol as a solvent.



1 a-j 2 a-j

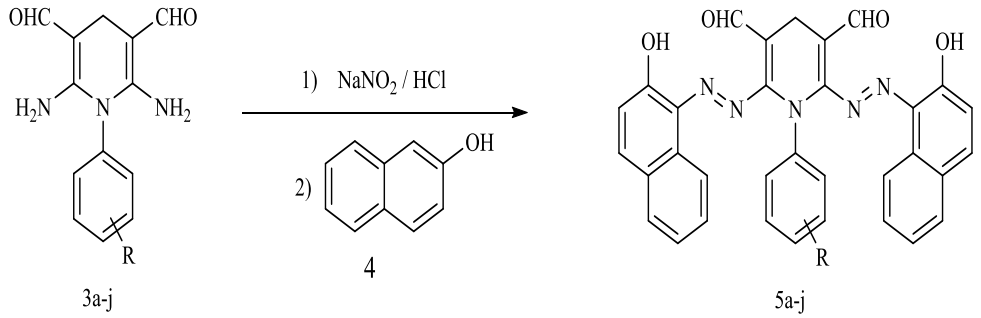
Where R a= 4H, b= 3Cl, c= 4Cl, d= 4Br, e= $2NO_2$, f= $3NO_2$, g= $4NO_2$, h= 4OH, i= $4CH_3$, j= $4OCH_3$

Scheme 2: Synthesis of 2,6-diamino-1,4-dihydro-1-substitutedphenylpyridine-3,5-dicarbaldehyde

2,6-bis((E)-(2-hydroxynaphthalen-1-yl)diazenyl)-1-substitutephenyl-1,4-dihydropyridine-3,5-dicarbaldehyde (5a-j)

Solution A was prepared by mixing **3a-j** (0.01mol) with concentrated HCl (6 mL) and water (6 mL) and cooling at a temperature below 5 °C in an ice bath. $NaNO_2$ (0.02 mol) was dissolved in water (20 mL) at 5 °C to obtain solution B. Then solution A was added drop wise to solution B at 5 °C with stirring. The mixture was then slowly added into the solution of 2-napthol **4** (0.02 mol), which was dissolved in 10% NaOH (40 mL) at 5 °C. The mixture was kept chilled in the ice bath and stirred continuously for 10 min (**Scheme 3**). The

precipitate **5a-j** formed was filtered and recrystallized from glacial acetic acid, and washed with methanol and finally dried in a vacuum oven at 70 °C for 12 hours.



Where R a= 4H, b= 3Cl, c= 4Cl, d= 4Br, e= $2NO_2$, f= $3NO_2$, g= $4NO_2$, h= 4OH, i= $4CH_3$, j= $4OCH_3$

Scheme 3: Synthesis of 2,6-bis((E)-(2-hydroxynaphthalen-1-yl)diazenyl)-1-substitutedphenyl-1,4-dihydropyridine-3,5-dicarbaldehyde

2,6-bis((E)-(2-hydroxynaphthalen-1-yl)diazenyl)-1-phenyl-1,4-dihydropyridine-3,5-dicarbaldehyde 5a

Light brown; M. F.: $C_{33}H_{23}N_5O_4$; Mol. Wt.: 553.57; Percent yield: 68; Melting point (^{0}C): 192-194; FTIR (cm^{-1}): 1692 (>C=O stretch, aldehyde), 2722 (H-C=O; C-H stretch), 3236 (C-H stretch, aromatics), 1655 (-C=C- stretch), 2905 (C-H stretch, aromatics), 1528 (C-C stretch, in ring aromatics), 3411 (O-H stretch, aromatic phenol), 1506(-N=N- stretch); ^{1}HNMR (δ ppm): 3.3 (s, 2H, CH_2), 9.9 (s, 2H, CHO), 5.0 (s, 2H, Ar-OH), 7.4 -8.2 (m, 17H, Ar-H).

1-(3-chlorophenyl)-2,6-bis((E)-(2-hydroxynaphthalen-1-yl)diazenyl)-1,4-dihydropyridine-3,5-dicarbaldehyde 5b

Gray; M. F.: $C_{33}H_{22}ClN_5O_4$; Mol. Wt.: 588.01; Percent yield: 76; Melting point (^{0}C): 210-212; FTIR (cm^{-1}): 1708 (>C=O stretch, aldehyde), 2833 (H-C=O; C-H stretch), 3358 (C-H stretch, aromatics), 1642 (-C=C- stretch), 3015 (C-H stretch, aromatics), 1564 (C-C stretch, in ring aromatics), 3515 (O-H stretch, aromatic phenol), 1464 (-N=N- stretch), 734 (C-Cl stretch); ^{1}HNMR (δ ppm): 3.2 (s, 2H, CH_2), 9.8 (s, 2H, CHO), 5.1 (s, 2H, Ar-OH), 7.3 -8.1 (m, 16H, Ar-H).

1-(4-chlorophenyl)-2,6-bis((E)-(2-hydroxynaphthalen-1-yl)diazenyl)-1,4-dihydropyridine-3,5-dicarbaldehyde 5c

Yellowish brown; M. F.: $C_{33}H_{22}ClN_5O_4$; Mol. Wt.: 588.01; Percent yield: 82; Melting point (^{0}C): 228-230; FTIR (cm^{-1}): 1668 (>C=O stretch, aldehyde), 2707 (H-C=O; C-H stretch), 3272 (C-H stretch, aromatics), 1616 (-C=C- stretch), 3076 (C-H stretch, aromatics), 1577 (C-

C stretch, in ring aromatics), 3442 (O-H stretch, aromatic phenol), 1466 (-N=N- stretch), 735 (C-Cl stretch); ^{1}HNMR (δ ppm): 3.2 (s, 2H, CH_2), 9.9 (s, 2H, CHO), 4.9 (s, 2H, Ar-OH), 7.2 -8.2 (m, 16H, Ar-H).

1-(4-bromophenyl)-2,6-bis((E)-(2-hydroxynaphthalen-1-yl)diazenyl)-1,4-dihydropyridine-3,5-dicarbaldehyde 5d

Light gray; M. F.: $C_{33}H_{22}BrN_5O_4$; Mol. Wt.: 632.46 ; Percent yield: 80; Melting point (^{0}C): 172-174; FTIR (cm^{-1}): 1688 (>C=O stretch, aldehyde), 2713 (H-C=O; C-H stretch), 3242 (C-H stretch, aromatics), 1648 (-C=C- stretch), 3078 (C-H stretch, aromatics), 1476 (C-C stretch, in ring aromatics), 3589 (O-H stretch, aromatic phenol), 1478 (-N=N- stretch), 612 (C-Br stretch); ^{1}HNMR (δ ppm): 3.2 (s, 2H, CH_2), 9.8 (s, 2H, CHO), 5.1 (s, 2H, Ar-OH), 7.3-8.2 (m, 16H, Ar-H).

2,6-bis((E)-(2-hydroxynaphthalen-1-yl)diazenyl)-1-(2-nitrophenyl)-1,4-dihydropyridine-3,5-dicarbaldehyde 5e

Dark brown; M. F.: $C_{33}H_{22}N_6O_6$; Mol. Wt.: 598.56; Percent yield: 63; Melting point (^{0}C): 208-210; FTIR (cm^{-1}): 1719 (>C=O stretch, aldehyde), 2807 (H-C=O; C-H stretch), 3332 (C-H stretch, aromatics), 1681 (-C=C- stretch), 2988 (C-H stretch, aromatics), 1542 (C-C stretch, in ring aromatics), 3522 (O-H stretch, aromatic phenol), 1518 (-N=N- stretch), 1276 (N-O symmetric stretch), 1535 (N-O asymmetric stretch); ^{1}HNMR (δ ppm): 3.3 (s, 2H, CH_2), 9.9 (s, 2H, CHO), 5.1 (s, 2H, Ar-OH), 7.0-8.2 (m, 16H, Ar-H).

2,6-bis((E)-(2-hydroxynaphthalen-1-yl)diazenyl)-1-(3-nitrophenyl)-1,4-dihydropyridine-3,5-dicarbaldehyde 5f

Reddish brown; M. F.: $C_{33}H_{22}N_6O_6$; Mol. Wt.: 598.56; Percent yield: 67; Melting point (^{0}C): 238-240; FTIR (cm^{-1}): 1682 (>C=O stretch, aldehyde), 2777 (H-C=O; C-H stretch), 3318 (C-H stretch, aromatics), 1672 (-C=C- stretch), 3112 (C-H stretch, aromatics), 1464 (C-C stretch, in ring aromatics), 3234 (O-H stretch, aromatic phenol), 1451 (-N=N- stretch), 1289 (N-O symmetric stretch), 1541 (N-O asymmetric stretch); ^{1}HNMR (δ ppm): 3.2 (s, 2H, CH_2), 9.8 (s, 2H, CHO), 5.3 (s, 2H, Ar-OH), 7.2-8.3 (m, 16H, Ar-H).

2,6-bis((E)-(2-hydroxynaphthalen-1-yl)diazenyl)-1-(4-nitrophenyl)-1,4-dihydropyridine-3,5-dicarbaldehyde 5g

Bright red; M. F.: $C_{33}H_{22}N_6O_6$; Mol. Wt.: 598.56; Percent yield: 71; Melting point (^{0}C): 266-268; FTIR (cm^{-1}): 1677 (>C=O stretch, aldehyde), 2812 (H-C=O; C-H stretch), 3288 (C-H

stretch, aromatics), 1702 (-C=C- stretch), 3074 (C-H stretch, aromatics), 1508 (C-C stretch, in ring aromatics), 3275 (O-H stretch, aromatic phenol), 1442 (-N=N- stretch), 1319 (N-O symmetric stretch), 1551 (N-O asymmetric stretch); ^{1}HNMR (δ ppm): 3.2 (s, 2H, CH_2), 9.8 (s, 2H, CHO), 5.2 (s, 2H, Ar-OH), 6.9-8.2 (m, 16H, Ar-H).

2,6-bis((E)-(2-hydroxynaphthalen-1-yl)diazenyl)-1-(4-hydroxyphenyl)-1,4-dihydropyridine-3,5-dicarbaldehyde 5h

Dark brown; M. F.: $C_{33}H_{23}N_5O_5$; Mol. Wt.: 569.56; Percent yield: 69; Melting point (^{0}C): 226-228; FTIR (cm^{-1}): 1704 (>C=O stretch, aldehyde), 2789 (H-C=O; C-H stretch), 3348 (C-H stretch, aromatics), 1638 (-C=C- stretch), 2998 (C-H stretch, aromatics), 1608 (C-C stretch, in ring aromatics), 3510, 3600 (O-H stretch, aromatic phenol), 1478 (-N=N- stretch); ^{1}HNMR (δ ppm): 3.3 (s, 2H, CH_2), 9.9 (s, 2H, CHO), 5.0 (s, 1H, Ar-H), 5.3 (s, 2H, Ar-H), 7.1-8.1 (m, 16H, Ar-H).

2,6-bis((E)-(2-hydroxynaphthalen-1-yl)diazenyl)-1-(p-tolyl)-1,4-dihydropyridine-3,5-dicarbaldehyde 5i

Violet brown; M. F.: $C_{34}H_{25}N_5O_4$; Mol. Wt.: 569.59; Percent yield: 75; Melting point (^{0}C): 206-208; FTIR (cm^{-1}): 1694 (>C=O stretch, aldehyde), 2818 (H-C=O; C-H stretch), 3255 (C-H stretch, aromatics), 1668 (-C=C- stretch), 3038 (C-H stretch, aromatics), 1487 (C-C stretch, in ring aromatics), 3545 (O-H stretch, aromatic phenol), 1503 (-N=N- stretch), 1453, 1360 (C-H bend and rock, aromatic alkyl); ^{1}HNMR (δ ppm): 3.3 (s, 2H, CH_2), 9.8 (s, 2H, CHO), 5.1 (s, 2H, Ar-OH), 7.2-8.2 (m, 16H, Ar-H), 2.2 (s, 3H, Ar-CH_3).

2,6-bis((E)-(2-hydroxynaphthalen-1-yl)diazenyl)-1-(4-methoxyphenyl)-1,4-dihydropyridine-3,5-dicarbaldehyde 5j

Light gray; M. F.: $C_{34}H_{25}N_5O_5$; Mol. Wt.: 583.59; Percent yield: 78; Melting point (^{0}C): 168-170; FTIR (cm^{-1}): 1722 (>C=O stretch, aldehyde), 2694 (H-C=O; C-H stretch), 3389 (C-H stretch, aromatics), 1688 (-C=C- stretch), 3122 (C-H stretch, aromatics), 1587 (C-C stretch, in ring aromatics), 3410 (O-H stretch, aromatic phenol), 1481 (-N=N- stretch), 1470, 1368 (C-H bend and rock, alkyl); ^{1}HNMR (δ ppm): 3.3 (s, 2H, CH_2), 9.9 (s, 2H, CHO), 5.1 (s, 2H, Ar-OH), 6.9-8.1 (m, 16H, Ar-H), 3.8 (s, 3H, Ar-OCH_3).

RESULTS AND DISCUSSION

Chemistry

The starting compounds of azo vinyl aldehyde **5a-j** were prepared by the reaction of **2,6-**

diazido-1,4-dihydro-1-substitutedphenylpyridine-3,5-dicarbaldehyde 2a-j using sodium dithionite. The diazo coupling reaction was carried out over **2,6-diazido-1,4-dihydro-1-substitutedphynylpyridine-3,5-dicarbaldehyde 3a-j** gives thediazonium salt, followed by the coupling reaction using 2-napthol. The series of **2,6-bis((E)-(2-hydroxynaphthalen-1-yl)diazenyl)-1-substitutephenyl-1,4-dihydropyridine-3,5-dicarbaldehyde 5a-j** were synthesized in reasonable yields. The structure of azo vinyl was confirmed by FT-IR and 1HNMR analysis.

Antimicrobial susceptibility test (5a-j)

The disc diffusion method was used to screen the antimicrobial activity. In vitro, antimicrobial activity was screened by using Mueller Hinton Agar (MHA) obtained from Hi-media. The MHA plates were prepared by pouring 15 mL of molten media into sterile Petri plates. The plates were allowed to solidify for 5 minutes and 0.1 % inoculum suspension was swabbed uniformly and the inoculum was allowed to dry for 5 minutes. The fix concentrations were loaded on 6 mm sterile discs. The loaded disc was placed on the surface of the medium and the compound was allowed to diffuse for 5 minutes and the plates were kept for incubation at 37°C for 24 hrs. At the end of incubation, inhibition zones formed around the disc were measured with the transparent ruler in millimeter. All the synthesized compounds **5a-j** were screened for their antibacterial activity against gram positive bacteria *Bacillus subtilis* (MCMB-310) and gram positive bacteria *Escherichia coli* (MCMB-301) using DMF solvent. Ampicillin was used as standard and the results were shown in the **graph 1**. The same procedure was followed for the fungus using Potato Dextrose Agar (PDA) as a nutrient medium. The antifungal activities against *Candida albicans* (NCIM-3471) and *Aspergillus niger* (NCIM- 545) strains using DMSO solvent in using Amphotericin-B as a standard revealed in the **graph 2**. All the results of the synthesized compounds were carried out by the triplicate format N=3 with Mean ± SD.

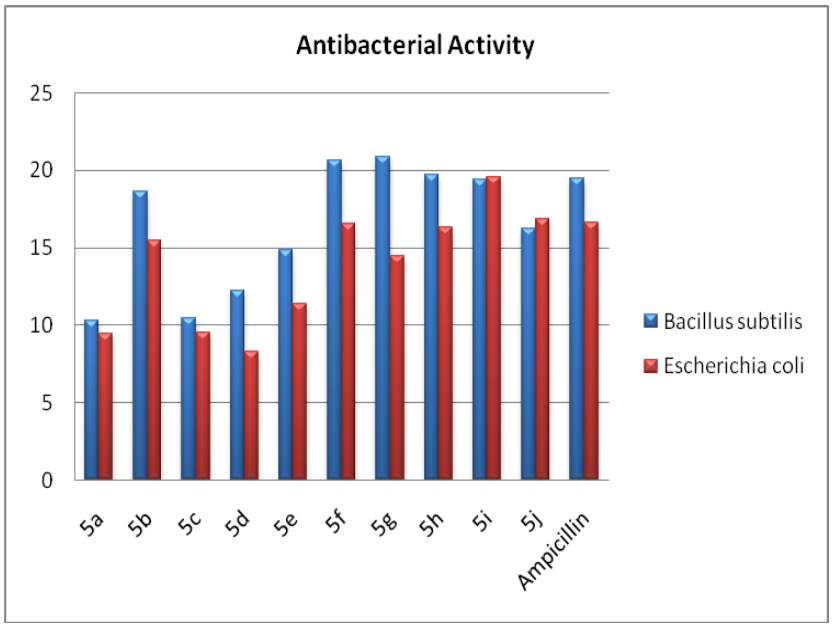
The calculated data were tabulated in **Table 1**;

Table 1: Antimicrobial activity of synthesized diazo compound

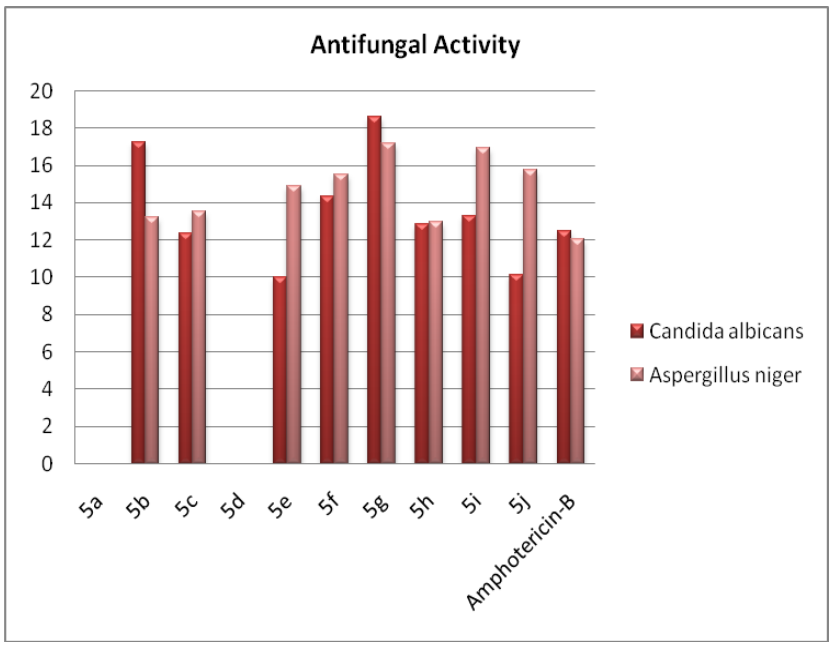
Entry	Zone diameter in mm (Mean±S.D.)			
	Bacillus subtilis	***Escherichia coli***	***Candida albicans***	***Aspergillus niger***
5a	10.28±0.22	9.44±0.29	--	--
5b	18.66±1.25	15.44±0.41	17.25 ± 0.25	13.22 ± 0.44
5c	10.43±1.42	9.53±0.55	12.38 ± 0.32	13.54 ± 0.58
5d	12.23±0.23	8.28±1.15	--	--
5e	14.86±0.34	11.35±0.54	9.99 ± 0.59	14.89 ± 0.29

5f	20.66±0.50	16.52±0.51	14.31 ± 0.33	15.51 ± 1.67
5g	20.43±0.65	14.44±0.53	18.61 ± 0.42	17.15 ± 0.21
5h	19.67±0.45	16.28±1.01	12.82 ± 0.34	12.95 ± 1.03
5i	19.43±0.71	19.52±0.13	13.30 ± 0.22	16.92 ± 1.22
5j	16.23±0.55	16.83±0.54	10.10 ± 0.54	15.73 ± 0.56
Ampicillin	19.86 ±0.14	16.63 ±0.12	--	--
Amphotericin-B	--	--	12.48 ± 0.34	12.03 ± 0.45

Keynote: Zone of inhibition measured in mm (Mean±S.D.) (N=3) ('--' means no zone of inhibition)



Graph 1: Antibacterial activities of 5a-j



Graph 2: Antifungal activities of 5a-j

CONCLUSION

An entire new series of 2,6-bis((E)-(2-hydroxynaphthalen-1-yl)diazenyl)-1-substitutephenyl-1,4-dihydropyridine-3,5-dicarbaldehyde 5a-j have been synthesized in a facile manner from 2,6-dichloro-1,4-dihydro-1-substitutedphenylpyridine-3,5-dicarbaldehyde 1a-j in good yield. Based on our experimental findings, the new substituted azo vinyl aldehyde derivatives containing cyclic imide moiety 5a-j exhibiting excellent bactericidal and fungicidal potentials could be proposed for dyeing and antimicrobial finishing for silk, wool, cotton, and polyester fabrics.

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REFERENCES

1. March J, Smith MB. *March's advanced organic chemistry: Reactions, mechanisms and structure*. 4th ed. New York: John Wiley & Sons; January 29, 2001.
2. Filimonov V, Parello J, Kutonova K, Trusova M, Postnikov P. A simple and effective synthesis of aryl Azides via Arenediazonium Tosylates. *Synthesis*, 2013; 45(19): 2706–2710. doi:10.1055/s-0033-1339648.
3. Xue D, Zhao C-J, Jia Z-H, Wang C, Xiao J. Methanol-promoted Borylation of Arylamines: A simple and green synthetic method to Arylboronic acids and Arylboronates. *Synlett*, 2014; 25(11): 1577–1584. doi:10.1055/s-0033-1339118.
4. Hojaghani S, Hosaini Sadr M, Morsali A. Sonochemical synthesis of two new copper(II) complexes with azo ligands derived from anthranilic acid and β-naphtol. *Ultrasonics Sonochemistry*, 2015; 26: 305–311. doi:10.1016/j.ultsonch.2015.02.009.
5. Carey FA, Sundberg RJ. *Advanced organic chemistry, part a: Structure and mechanisms, 4th edition*. Plenum Publishing, May 27, 2014.
6. Hunger K, Herbst W. Pigments, organic. *Ullmann's Encyclopedia of Industrial Chemistry*. June 2000. doi:10.1002/14356007.a20_371.
7. Nejati K, Rezvani Z, Seyedahmadian M. The synthesis, characterization, thermal and optical properties of copper, nickel, and vanadyl complexes derived from azo dyes. *Dyes and Pigments*, 2009; 83(3): 304–311. doi:10.1016/j.dyepig.2009.05.007.

8. Ortega-Luoni P, Vera L, Astudillo C, Guzman M, Ortega-Lopez P. Synthesis of Metallic azoderivatives of 2-amino-5-mercapto-1, 3,4-thiadiazole. *Journal of the Chilean Chemical Society*, 2007; 52(1). doi:10.4067/s0717-97072007000100015.
9. Wang M, Funabiki K, Matsui M. Synthesis and properties of bis(hetaryl)azo dyes. *Dyes and Pigments*, 2003; 57(1): 77–86. doi:10.1016/s0143-7208(03)00011-1.
10. Hallas G. Chemistry and application of leuco dyes, edited by Ramaiah Muthyala. *Journal of the Society of Dyers and Colourists*, 2008; 114(2): 65–65. doi:10.1111/j.1478-4408.1998.tb01949.x.
11. Hunger K, Mischke P, Rieper W, Raue R, Kunde K, Engel A. Azo dyes. *Ullmann's Encyclopedia of Industrial Chemistry*, September 2000. doi:10.1002/14356007.a03_245.
12. Waring DR, Hallas G. *The chemistry and application of dyes*. Plenum Press, 1990: 326.
13. Krull R, Hempel DC, Metzen P, Alfter P. Konzept zur technischen Umsetzung einer zweistufigen anoxischen und aeroben Textilabwasserbehandlung. *Chemie Ingenieur Technik*, 2000; 72(9): 1113–1114. doi:10.1002/1522-2640(200009)72:9<1113::aid-cite11130>3.0.co;2-2.
14. Oakes J, Batchelor SN, Dixon S. Azo dye location in textiles: A novel UV-vis approach. *Coloration Technology*, 2005; 121(5): 237–244. doi:10.1111/j.1478-4408.2005.tb00279.x.
15. Damodaran S, Fennema OR, Parkin K, eds. *Fennema's food chemistry*. 3rd ed. New York: Marcel Dekker; September 18, 2007.
16. Bateman B. The effects of a double blind, placebo controlled, artificial food colourings and benzoate preservative challenge on hyperactivity in a general population sample of preschool children.*Archives of Disease in Childhood*, 2004; 89(6): 506–511. doi:10.1136/adc.2003.031435.
17. Stevenson J. Rejoinder to Eigenmann PA, Haengelli CA, food colourings and preservatives--allergy and hyperactivity (Lancet 2004; 364: 823-4) and an erratum. *Archives of Disease in Childhood*, 2005; 90(8): 875–875. doi:10.1136/adc.2005.072157.
18. Clarke H, Kirner W. Methyl red. *Organic Syntheses*, 1922; 2: 47. doi:10.15227/orgsyn.002.0047.
19. Gattermann L. Untersuchungen über Diazoverbindungen. *Berichte der deutschen chemischen Gesellschaft*, 1890; 23(1): 1218–1228. doi:10.1002/cber.189002301199.
20. Sutton D. Organometallic diazo compounds. *Chemical Reviews*, 1993; 93(3): 995–1022. doi:10.1021/cr00019a008.

21. Gup R, Giziroglu E, Kırkan B. Synthesis and spectroscopic properties of new azo-dyes and azo-metal complexes derived from barbituric acid and aminoquinoline. *Dyes and Pigments*, 2007; 73(1): 40–46. doi:10.1016/j.dyepig.2005.10.005.
22. Koukabi N, Otokesh S, Kolvari E, Amoozadeh A. Convenient and rapid diazotization and diazo coupling reaction via aryl diazonium nanomagnetic sulfate under solvent-free conditions at room temperature. *Dyes and Pigments*, 2016; 124: 12–17. doi:10.1016/j.dyepig.2015.03.041.
23. 51.Fekri LZ, Nikpassand M. Ultrasound assisted diazotization and diazo coupling reactions using trichlorotriazine. *Russian Journal of General Chemistry*, 2014; 84(8): 1629–1633. doi:10.1134/s1070363214080313.
24. Ayyangar NR, Naik SN, Srinivasan KV. A novel synthesis of unsymmetrical azo aromatics inaccessible by diazo-coupling reaction. *Tetrahedron Letters*, 1989; 30(51): 7253–7256. doi:10.1016/s0040-4039(01)93951-6.
25. Patil MM, Rajput SS. Synthesis and Antimicrobial evaluation of some novel Diazo derivative of Cyclic Imides using Diazotization coupling reaction. *Chemical science review and letters*, 2016; 2016(517): 46–52.
26. Patai S. *Chemistry of the Diazonium and Diazo groups: Pt. 1*. Patai, ed. United Kingdom: John Wiley & Sons; March 1, 1978.
27. Patai S. *Chemistry of the Diazonium and Diazo groups: Pt. 2*. United Kingdom: John Wiley & Sons; March 1, 1978.
28. Fozooni S, Tikdari AM, Hamidian H, Khabazzadeh H. A synthesis of some new 4-arylidene-5(4H)-oxazolone azo dyes and an evaluation of their solvatochromic behaviour. *General Papers ARKIVOC*, 2008: 115–123.
29. Patil MM, Rajput SS. Succinimides: Synthesis, reaction and biological activity. *Int J Pharm Pharm Sci.*, 2014; 6(11): 8–14.
30. Abdel-Aziz AA, El-Azab AS, Attia SM, Al-Obaid AM, Al-Omar MA, El-Subbagh HI. Synthesis and biological evaluation of some novel cyclic-imides as hypoglycaemic, anti-hyperlipidemic agents. *European Journal of Medicinal Chemistry*, 2011; 46(9): 4324–4329. doi:10.1016/j.ejmech.2011.07.002.
31. Golka K, Kopps S, Myslak ZW. Carcinogenicity of azo colorants: Influence of solubility and bioavailability. *Toxicology Letters*, 2004; 151(1): 203–210. doi:10.1016/j.toxlet.2003.11.016.

32. Dhivare RS, Rajput SS. Synthesis, characterization and Antimicrobial evolution of Six Membered Cyclic Imides. *International Journal of Chemistry and Pharmaceutical Sciences*, 2015; 38: 1877–1880.
33. Dhivare RS, Rajput SS. Synthesis and antimicrobial evaluation of some novel bis-heterocyclic chalcones from cyclic imides under microwave irradiation. *Chemical science review and letters*, 2015; 2015(415): 937–944.
34. Dhivare RS, Rajput SS. Microwave assisted solvent free synthesis and antifungal evaluation of3, 5-bis-(4-hydroxy-3-methoxybenzylidene)-N- phenylpiperidine-2, 6-dionederived from N-phenyl glutarimides.*International Journal of ChemTech Research*, 2016; 9(3): 325–331.
35. Brahma S, Ray JK. Halovinyl aldehydes: Useful tools in organic synthesis. Tetrahedron., 2016; 64(13): 2883–2896. doi:10.1016/j.tet.2007.11.112.
36. Jarrahpour AA, Motamedifar M, Pakshir K, Hadi N, Zarei M. Synthesis of novel Azo Schiff bases and their antibacterial and Antifungal activities. Molecules, 2004; 9(10): 815–824. doi:10.3390/91000815.