THE UTILITY OF MICHAEL CONDENSATION FOR THE SYNTHESIS OF MACROMOLECULE SURFACTANTS FROM AZO-NAPHTHOLS AS POSSIBLE ANTIMICROBIALS

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ABSTRACT

((E)-4-(pyridin-3-yl diazenyl)naphthalene-1-ol) and (4-((E)–pyridin-3-yl diazenyl)-8-((Z)-pyridin-3-yl diazenyl)naphthalene-1,5-diol) (IIIa, b) were prepared. Condensation of (IIla, b) with 2-(pyridin-4-ylmethylen) malononitrile (V) under Michael reaction conditions gave the corresponding bezoh[1]chromene and dihydrochromene[8,7-h] chromene derivatives (VIa, b). The cationic derivatives for (IIla, b) and (VIa, b) were obtained by quaternization as (IVa, b) and (VIIa, b). The structures obtained were confirmed form IR, 1H NMR, and mass spectra studies. The antimicrobial activities were also studied and have been found that; the cationic dyes (IVa, b) and (VIIa) exhibit promising results against Candida albicans.

Keywords: Pyridinyl diazenyl naphtol, cationic azo dyes, antimicrobial activity.

1. INTRODUCTION

Azo compounds are regarded as important and vital compounds in the industry of color and pigments [1], food colorant, pesticides [2], lubricating oil improvers [3], and in the medicinal and pharmaceuticals such as antineoplastic, antidiabetics, antiseptics [5, 6], antibacterial [7] and antitumor [8]. In several numbers of biological reactions such as inhibition of DNA, RNA and protein synthesis, carcinogenesis and nitrogen fixation [9, 10], the involvement of azo dyes is known. In pharmaceutical and medicinal fields, azo compounds are becoming important [11], and it has been proposed that the biological activities expressed by some Schiff bases [12, 13], might be due to azo-imine linkage which are responsible for antibacterial and pesticidal activities of different types of compounds. Electrochemical measurements showed that azo dye, 4-(phenyl diazenyl)phenyl-2-furoate(ppf), acts as corrosion inhibitor of carbon steel in saline water (SW), by suppressing simultaneously the cathodic and anodic processes via adsorption on the carbon steel surfaces [14]. Keeping in view the above-mentioned importance of azo dyes, it was conceivable to develop synthesis of macromolecule surfactant from azo naphthol. Herein, the authors have prepared some new naphthol dye and their derivatives in the form of macromolecule surfactants and study their 1H NMR, IR and mass spectroscopy. Their antimicrobial activities were also studied.

2. Material and Experimental work

2.1. General Procedure of azo-naphthols

The azo-naphthols (IIIa, b) were synthesized by diazotization of 3-amino pyredine with nitrosyl chloride and subsequent coupling with naphthalene-1-ol and naphthalene-1,5-diol respectively. Thus, (3.79 g, 0.055mol) NaNO₂ was added to (6 ml) HCl, cooled to 0°C and (4.32g, 0.05mol) 3-aminopyredine was stirred. The clear diazonium solution obtained was added under stirring at (0-5°C) to solution of coupling naphthols (0.05 mol of naphthalene-1-ol and 0.0025 mol naphthalene-1,5-diol) in 10% ac. NaOH (20 ml). The residue formed was filtered off, washed with water and dried to give the corresponding azo-naphthols.

2.1.1. ((E)-4-(pyridin-3-yl diazenyl)-naphthalene-1-ol) (IIIa), recrystallized twice from hot ethanol, yield (85%) as red solid. Mp: (209-210 °C) (lit 209.5-210 °C) [15-17].
2.1.2. (4-(E)-pyridin-3-yl diazenyl)-8-(Z)-pyridin-3-yl diazenyl)naphthalene-1,5-diol (IIIb), recrystallized from hot ethanol, yield (85%) as dark brown solid. Mp: > 300 °C.

IIIb: IR (νmax, cm⁻¹): 3441.1, 3337.8, 3043, 1596.3, 1558.7 (vs). ¹HNMR (DMSO-d6): (δ, ppm): 7.014, 6.993 (1H, d, J=8.4 Hz), 7.63, 7.612, 7.594 (2H, t, J=7.2 Hz); 7.757, 7739.720 (1H, t, J=7.2 Hz), 8.025, 8.003 (1H, d, J=8.8 Hz), 8.238, 8.219 (2H, d, J=7.6 Hz), 8.637 (1H,s), 8.66,8.847 (1H, d, J=7.6 Hz) and 9.107 (1H, s, 2-Py)

UV c.f (Table 1, fig. 1) λ max (278, 427 and 565 nm)

2.1.3. Synthesis of 2-(Pyridin-4-ylmethylene)malononitrile (V)

Solution of 4-pyridinecarboxaldehyde (5 g, 0.047 mol) in 50 ml (EtOH; H2O) was stirred at room temperature, and then followed by adding malononitrile solution (3.08 g, 0.047 mol) for (15 min.). The mixture was reflux until precipitation complete (time reaction is 1hr). The corresponding solid product filtered off; Mp: 100-101°C [18].

V: IR (νmax, cm⁻¹): 3426(br), 3046.44, 2952, 2930.59, 2232.08, 2191.8, 1609.08 and 1546.82

¹HNMR (DMSO-d6), 400 MHz: (δ, ppm): 7.55(1H, s, PyCH=), 8.474 – 8.747(4H, m, Py-H)

Ms (m/z, %): 155(M⁺, 10.79), 103, (11.12), 78(78.56), 77(24.41), 52(35.91), 51(100), c.f scheme 6

2.1.4. Synthesis of ((E)-2-amino–6-(pyridin-3-yl diazenyl)–4-(pyridin-4-yl)-4H-benzo[h]chromene-3-carbonitrile (VIIa).

To solution of 2-(pyridin-4-ylmethylene)malononitrile (1.55 g, 0.01 mol) in EtOH (30 ml) was treated with (E)-4-(pyridin-3-yl diazenyl)naphthalen-1-ol (2.49 g, 0.01 mol) followed by few drops of piperidine (0.5 ml). The reaction mixture was heated until precipitation (the reaction time 6hrs). The solid product which formed was collected by filtration and recrystallized from EtOH to produce the expected yield as dark red. Mp: 170 °C

VIIa: IR (νmax, cm⁻¹): 3380.3(br), 3059.6, 2934.7, 2232.08, 2191.8, 1609.08 and 1546.82

¹HNMR (DMSO-d6) 400 MHz: (δ, ppm): 6.998(C=H), 7.074(2H, NH), 7.421, 7.441, 7.461 (2H, dd, J₁=J₂= 8Hz), 7.568, 7.579 (2H, d, J=4.4 Hz ) (7.681, 7.701,7.734)(1H, dd, J₁=8 and J₂= 13.2Hz), 7.811(1H, s),8.199,8.222(1H, d, J=9.2 Hz), 8.5(1H,s),8.772, 8.808(1H, d, J=14.4 Hz), 8.882, 8.898(1H, d, J=6.4 Hz), 9.008(1H, s), 11.843(1H,s)

UV c.f (Table 1, fig. 1) λ max (266, 367, 476 and 584 nm)

2.1.5. Synthesis of 3,9-diamino–5-((E)-pyridin-3-yl diazenyl)–11-((Z)-pyridin-3-yl diazenyl)-1,7-di(pyridin-4-yl)-1,7–dihydrochromeno[8,7-h]chromene-2,8-dicarboni- trile (VIIb)

To a solution of 2-(pyridin-4-ylmethylene) malononitrile (3.1 g, 0.02 mol) in EtOH (30 ml) was treated with 4-((E)-pyridin-3-yl diazenyl)–8-((Z)pyridin-3-yl diazenyl) naphthalene-1,5-diol (3.7 g, 0.01 mol) followed by few drops of piperidine (0.5 ml). The reaction mixture was heated until precipitation (the reaction time 6hrs). The solid product which formed was collected by filtration and recrystallized from EtOH to produce the expected yield. Mp: >300°C
2.2. Quaternary salt (surfactants)

2.2.1. Synthesis of (E)–1-dodecyl-3-((4-hydroxynaphthalen-1-yl)diazene yl) pyridin-1-ium bromide (IVa).

A mixture of (E)-4-(pyridin-3-ylidiazenu) naphthalen-1-ol (2.49 g, 0.01 mol) and 1-bromododecane (2.49 g, 0.01 mol) in ethanol was refluxed for 48 h to produce the quaternary product. The mixture was allowed to cool and the obtained red solid precipitate was further purified by diethyl ether, dioxane then recrystallized from ethanol.

IVa: IR ($\nu_{max}$, cm$^{-1}$): 3420.1(br), 3282.96, 1632.35(m), 1548.75 (vs) 

1H NMR (DMSO-d$_6$) 400 MHz: (δ, ppm): 7.0947(3H, CH$_3$), 1.162(20H, 10CH$_2$), 4.6908(2H, N-CH$_2$), 6.0808, 7.1281, 7.257, 7.383, 7.5684, 7.6957, 8.0174, 8.2452, 8.6196 and 9.0945(11H, Ar-H, OH).

Ms (m/z, %): 498(M$^+$), 284(100), 170(54.47), 143(22.42), 115(44.3), 114(44.3), 89(8.75), 78(73.99), 64(75.29), 43(47.51), 40(54.96). (Scheme 5)

UV c.f (Table 1, fig. 1) $\lambda$ max (260 and 412 nm)

2.2.2. Synthesis of 3-(3-(E)-4,8-dihydroxy-5-((Z)-(1-dodecyl-pyridin-1-iumbromide-3-yl)diazenu)naphthalen-1-yl)diazenuy)-1-dodecylpyridin-1-ium bromide (IVb).

A mixture of 4-(E)-pyridin-3-ylidiazenu)-8-((Z)-pyridin-3-ylidiazenu) naphtalene-1,5-diol (3.7 g, 0.01 mol) and 1-bromododecane (4.98g, 0.02 mol) in ethanol was refluxed for 48 h to produce the quaternary product. The mixture was allowed to cool and the obtained solid precipitate was further purified by diethyl ether, dioxane then recrystallized from ethanol.

IVb: IR ($\nu_{max}$, cm$^{-1}$): 3384.62, 3187.09, 3057.95, 2924.30 (vs), 2853.54( aliph C-H), 1629.1, 1592.09, 1458.57(s) 

1H NMR (DMSO-d$_6$) 400 MHz: (δ, ppm): 0.8436, 0.8608(d, 6H, 2CH$_3$, $J$=6.88 Hz), 1.0826, 1.0651(4H, d, 2CH$_2$), $J$=7 Hz , 1.2417(m, 32H, 16 CH$_2$), 4.4347, 4.4171, 4.3994(2d, 4H, * N-CH$_2$), $J$=7.04 and $J$=7.08Hz), 7.0198(1H, s), 7.1476(1H, s), 7.135((1H, s), 7.4986, 7.5358(2H, d, $J$=14.88 Hz), 8.033(1H, s), 8.1088(1H, s), 8.1659, 8.1519(2H, d, $J$=5.6 Hz), 8.975(1H, s), 9.3249, 9.3122 (2H, d, $J$=6.88 Hz), 9.7318(1H, s), 10.732(1H, s).

UV c.f (Table 1, fig. 1) $\lambda$ max (268, 440 and 563 nm)
2.2.4. Synthesis of 4,4'-(3,9-diamino-2,8-dicyano-5-(Z)-(1-dodecylpyridin-1-ium-3-yl)diazeyln)-11-(E)-(1-dodecylpyridin-1-ium-4-yl)diazeyln)-1,7-dihydrochromeno[8,7-h]1,7-diylih(1-dodecylpyridin-1-ium)bromide (VIIb).

A mixture of 3,9-diamino-5-((E)-pyridine-3-yl)diazeyln)-11-(Z)-(pyridin-3-yl)diazeyln)-1,7-di(pyridin-4-yl)-1,7-dihydrochromeno[8,7-h]chromene-2,8-dicarbonitrile (6.8 g, 0.01 mol) and 1-bromododecane (9.96 g, 0.04 mol) in ethanol was refluxed for 96 hrs. To produce the quaternary product the mixture was allowed to cool and the obtained solid precipitate was further purified by diethyl ether, dioxane then recrystallized from ethanol.

VIIb: IR (ν max, cm⁻¹): 3385.03, 2955.42, 2924.46, 2853.58, 2194.4(CN), 1633.09, 1588.34, 1462.97

¹H NMR (DMSO-d₆) 400 MHz: (δ, ppm): 0.851(12H, s, 4CH₃), 1.2358, 1.6639 – 1.9194 (88H, 2m, 44CH₂), 4.4103 and 4.6304(2H, 2s, C₃H, 1,7), 6.8761(4H, s, 2NH₂), 7.0663, 7.1945(2H, 2s, H-6,12, Ar), 7.3217 – 8.9236(16H, m, H-Py).

UV c.f (Table 1, fig. 1) λ max (272 and 567 nm)

2.3. Antimicrobial activity

The standardized disc–agar diffusion method (Bauer – Kirby 1966 & CLSI 2006) [19] was followed to determine the activity of the synthesized compounds against the tested microorganisms.

2.3.1. Test Organisms

Cultures of the following microorganisms were used in the test: Gram-positive bacteria: Staphylococcus aureus (ATCC 25923) and Bacillus subtilis (ATCC 6635), Gram-negative bacteria: Escherichia coli (ATCC 25922) and Salmonella typhimurium (ATCC 14028), Yeast: Candida albicans (ATCC 10231) and Fungus: Aspergillus fumigatus.

2.3.2. Detecting the possibility of antimicrobial potential:

2.3.2.1. Preparation of tested compound

The tested compounds were dissolved in dimethyl formamide (DMF) solvent and prepared in concentration of 100 mg/ml and then 10 μl of each preparation was dropped on disk of 6 mm in diameter. The concentration
became 1mg/disk. In the case of insoluble compounds, the compounds were suspended in DMF and subsequently treated.

2.3.2.2. Testing for anti-bacterial and yeasts activity:

Bacterial cultures were grown in nutrient broth medium at 30 °C. After 16 h of growth, each microorganism, at a concentration of 10³ cells/ml, was inoculated on the surface of Mueller-Hinton agar plates using sterile cotton swab. Next, uniform size paper discs (6 mm diameter) were impregnated with an equal volume (10 µl) of the specified concentration of the dissolved compounds and carefully placed on the surface of each pollination plate. The plates were incubated in the upright position at 36°C for 24 hours. Three replicates were carried out for each extract against each tested organism. Simultaneously, addition of the respective solvent instead the dissolved compound was surfed as negative controls. After incubation, the diameters of the growth inhibition zones formed around the disc were measured in millimeter with transparent ruler, averaged and the mean values were tabulated.

2.3.2.3. Testing for anti-fungal activity:

The active vaccine was prepared for experiments by transferring several bacterial rings from cultures farms to the sterilized distilled water (SDW) tubes test that were stirred and diluted with sterile distilled water to achieve a corresponding visual density of 2.0 x10⁵ spore/ml. inoculum of 0.1 % suspension was swabbed uniformly and the inoculum was allowed to dry for 5 minutes then the same procedure was followed as described above.

2.3.2.4. Standard references:

The antibiotic, chloramphenicol was used as standard reference in the case of Gram – negative bacteria, Cephalothin was used as standard reference in the case of Gram – positive bacteria and cycloheximide was used as standard reference in the case of yeasts and fungi.
3. RESULT AND DISCUSSION

Diazotization of 3-amino pyridine (I) and coupling with 1-naphthol and/or 1,5-dihydroxy naphthalene (IIa, b) gave the corresponding azo compounds in the form of ((E)-4-(pyridin-3-yl diazenyl)naphthalen-1-ol) [15-17] and (4-(E)-pyridin-3-yl diazenyl) –8-((Z)-pyridin-3-yl diazenyl)naphthalen-1,5-diol) (IIIa, b) respectively (scheme 1).

Alkylation of (IIIa, b) with dodecyl bromide in boiling ethanol afforded the corresponding mono and di cationic surfactants (Va, b) respectively (scheme 2).

Condensation of ((E)-4-(pyridin-3-yl diazenyl) naphthalen-1-ol) and (4-((E)-pyridin-3-yl diazenyl)-8-((Z)-pyridin-3-yl diazenyl)naphthalene-1,5-diol) (IIIa, b) with 4-pyridinylmethylene malononitrile [18] in ethanol/piperidine afforded the corresponding ((E)-2-amino-6-(pyridin-3-yl diazenyl)-4-(pyridin-4-yl)-4H-benzo[h]chromene-3-carbonitrile and 3,9-diamino-5-((E)-pyridin-3-yl diazenyl)-11-((Z)-pyridin-3-yl diazenyl)-1,7-di(pyridin-4-yl)-1,7-dihydrochromeno[8,7- h]chromene-2,8-dicarbonitrile (Vla, b) respectively (scheme 3).

The structures of Vla, b has been assigned as reaction product on the basis of spectral data. These data were in assignment with obtained structures. The IR (νmax cm⁻¹) spectrum of Vla displayed absorption at 3380.3 (br) and 2193.5 corresponding to NH2 and CN groups. Its 1HNMR spectrum exhibited C-H signal at 6.998, NH2 at 7.074 – 7.125 and complex pattern at δ 7.253 – 9.179 ppm region owing to aromatic of pyridine protons. Its mass spectra
showed molecular ion peak at m/z= 404(M⁺, 8.96%) together with base peak at m/z= 298 (scheme 7). The IR spectrum (vmax, cm⁻¹) of VIb showed absorption NH₂ at 3430.1 (br) and CN at 2192.2 cm⁻¹. Its ¹HNMR (δ ppm): 6.4 (S, 2H), 6.925(br, 2NH₂), two doublet at 6.972, 6.99, 7.011 (J₁ = 8.8 Hz, J₂ = 7.2 Hz) 7.182, 7.272, 7.272 (br) and set of multiplets at 7.378 – 8.80 for pyridine protons as two singlet signals at 9.06, 9.12 for naphthalene protons. Its mass showed (m/z, %) at 680 (14.25) (M⁺, M⁺¹) together base peak at 343 (scheme 8).

Quaternization of benzo[h] chromene derivatives (VIa, b) with dodecyl bromide was successful and corresponding 4,6-di(1-dodecylpyridinium)-4H-benzo[h]chromene and 1,5,7,11-tetra(1-dodecylpyridinium)-1,7-dihydrochromeno[8,7-h]chromine derivatives VIIa, b was obtained respectively (Scheme 4). The structures of dicationic and tetracationic pyridine compound VIIa, b was supported by IR (vmax, cm⁻¹) for VIIa 3415.79 (NH₂), 2195.78 (CN) and for VIIb 3385.03 (NH₂), 2194.4 (CN) and ¹HNMR (δ ppm): for VIIa, displayed the presence of singlet signal at

![Scheme 2](image)

Scheme 2

![Scheme 3](image)

(Scheme 3)

![Scheme 4](image)

Scheme 4
4.7106 ppm attributed to H-4 protons and broad signal at 6.6449 – 6.6607 ppm for the amino protons. Also, HNMR for VIIb showed the appearance of two singlet signals at \( \delta \) 4.4103 and 4.6304 ppm due to 2C-H at position 1,7 and broad signal at 6.8761 ppm due to amino protons in addition to singlet signals at 7.066 – 7.1945 attributable to aromatic protons at positions besides aliphatic and pyridinium protons.

**UV-Visible (Table 1; fig. 1)**

The absorption maxima (\( \lambda_{\text{max}} \)) of the dyes show one of them in the UV range due to (\( \pi-\pi^* \)) transition of C=C in the aromatic moiety and another absorption maxima, lies in the visible region due to (\( \pi-\pi^* \)) of azo linkage N=N of dyes. There is bathochromic shift in case of IIIa, IIIb, and VIa to VIIb the presence of two hydroxyl groups in dis azo dye. It was found that highest bathochromic shift is shown in case of IVa to IVb and in case of VIIa to VIIIb which may be attributed to the electron releasing capacity of diol and from monocationic to dicatonic and from dicatonic to tetracatonic dyes.

**Biological activity (table 2)**

The results obtained indicated that compound IVa showed maximum activity (mean zone diameter mm) 43 toward Candida albicans (ATCC 10231), while compound IVb shows mean zone diameter 40 mm and for derivative VIIb, 36 while compound VIIa has the same value of control (cyclohexamid). The tested compounds show lower the effect than the control for Gram-positive, Gram-negative bacteria and the compound VIIb showed no effect. Thus, it is obvious that the monocationic dye IVa exhibit higher effect than dicationic dye IVb and tetracationic dye contains fused dihydrochromene[8, 7-h]chromene VIa, VIIb than dicatonic dye containing benzo[h]chromene, VIIa nucleus against Candida albicans (ATCC 10231).

The promising results indicate that hydrophilic balance of the cationic surfactant (IVa, b and VIIb) has a key role in biological efficiency against Candida albicans. Since the azo and carbonyl group which has electron withdrawing effect to positive nitrogen in pyridinium, lead to a more positive quaternary nitrogen atom , which increases the affinity to Candida albicans c.f. Table 2.

**4. CONCLUSION**

Anew naphthol azo dyes (IIIa, b) were synthesized and underwent cyclic condensation with 2-(Pyridin-4-ylmethylene)malononitrile (V) to give the corresponding benzo[h]chromene and dihydrochromene[8,7-h]chromene derivatives (VIa, b). The macromolecule surfactants (IVa, b) and (VIIa, b) were prepared. The antimicrobial activities were also studied. The cationic dyes (IVa, b) and tetracationic dye (VIIa) gave promising results against Candida albicans.

| compounds | \( \lambda \) nm | \( \epsilon \) M\(^{-1}\)cm\(^{-1} \) | compounds | \( \lambda \) nm | \( \epsilon \) M\(^{-1}\)cm\(^{-1} \) |
|-----------|------------------|-------------------|-----------|------------------|-------------------|
| IIIa      | 279              | 12110             | VIa       | 278              | 17920             |
|           | 427              | 14740             |           | 426              | 15670             |
|           | 565              | 1490              |           |                  |                   |
| IIIb      | 266              | 17290             | VIIb      | 272              | 24220             |
|           | 367              | 9490              |           | 272              | 30000             |
|           | 476              | 9430              |           | 437              | 14300             |
|           | 584              | 4980              |           | 567              | 4670              |
| IVa       | 260              | 1810              | VIa       | 278              | 17920             |
|           | 412              | 920               |           | 426              | 15670             |
|           | 268              | 23390             | VIIa      | 272              | 30000             |
|           | 440              | 10590             |           | 437              | 14300             |
|           | 563              | 5820              |           | 567              | 4670              |

**UV-Vis spectra of compounds (Table 1)**
UV-Vis spectra of compounds (fig. 1)

### Mean* of zone diameter, nearest whole mm.

| Sample | Gram - positive bacteria | Gram - negative bacteria | Yeasts and Fungi** |
|--------|--------------------------|--------------------------|--------------------|
|        | *Staphylococcus aureus* (ATCC 25923) | *Bacillus subtilis* (ATCC 6635) | *Salmonella typhimurium* (ATCC 14028) | *Escherichia coli* (ATCC 25922) | *Candida albicans* (ATCC 10231) | *Aspergillus fumigatus* |
| IIIa   | -                        | -                        | -                  | -                  | -                  | -                  |
| IIIb   | -                        | -                        | -                  | -                  | -                  | -                  |
| VIa    | 14                       | 16                       | 9                  | 16                 | 18                 | -                  |
| VIb    | -                        | -                        | -                  | -                  | -                  | 17                 |
| IVa    | 23                       | 23                       | 12                 | 24                 | 43                 | 12                 |
| IVb    | 27                       | 24                       | 11                 | 26                 | 40                 | -                  |
| VIIa   | 18                       | 20                       | 11                 | 23                 | 35                 | -                  |
| VIIb   | 29                       | 27                       | 22                 | 21                 | 36                 | -                  |
| Control #   | 35                       | 35                       | 36                 | 38                 | 35                 | 37                 |

**Antimicrobial activity of prepared compound (Table 2)**

* = Calculate from 3 values. ** = identified on the basis of routine cultural, morphological and microscopical characteristics.

– = No effect. #: Chloramphenicol in the case of Gram-positive bacteria, Cephalothin in the case of Gram-negative bacteria and cycloheximide in the case of fungi.
REFERENCES

[1] M. U. Schmidt, J. Brüning, D. Wirth and M. Bolte, (2008) “Two azo pigments based on napththol”, Acta Cryst. 64, 474-477

[2] H. Kumar, R. P. Chaudhary, (2010) “Pesticidal studies of azo based heterocyclic Schiff base and its transition metal complexes”, Arch. Appl. Sci. Res. 2 (10): 407-413

[3] S.M. Mahdi, R.I. Aliway, (2015) “Preparation and identification of a new azo-chalcone ligand (VACAN) and its complexes with some diveral transition metal ions” INJC, 15(2), 191-213.

[4] J.L. Zhang, H. Cheo, B.J. Dezube, M. Farzan, P.L. Sharma, X.C. Zhou, L.B. Chen, M. Ono, S. Gillies, Y. Wu, J.G. Sodroski, C.S. Crumpacker, (1998) “The Bis-Azo Compound FP-21399 Inhibits HIV-1 Replication by Preventing Viral Entry”; VIROLOGY, 244, 530-541

[5] B. V. Girish and V. Z. Raksha, (2011) “Synthesis of Novel Acidic Mono Azo and an Investigation of their Use within the Textile Industry”, Turk. J. Chem., 26, 897-903.

[6] H. G Garg and C. Prakh, (1972) “Preparation of 4-arylamino phenol”, Act. Cryst. 1, 1082-1086.

[7] C. Park, J. Lim, Y. Lee, B. Lee, S. Kim, J. Lee and S. Kim, (2007) “Optimization and Morphology for Decolorization of Reactive Black 5 by Funalia trogii”, Enz. Micro. Technol., 40, 1758-1764.

[8] O. A. Oluwabunmi, E. A. Alice, A. moanta, A. Samide, C. Ionescu, B. Tutunaru, A. Dobriteşcu, et al, (2013) “Synthesis and characterization of an azo – dye: 4 - (phenyl-diazenyl) phenyl – 2 - furoate. Electrochemical and XPS study of its adsorption and inhibitive properties on corrosion of steel in salin water”, Intr. J. Electrochemical Sci. 8 (1): 780-796

[9] S. H. Eltiawi, Y. M. Issa, (1978) “Studies on Azo Compounds. VI. Relation between the Molecular Structure and Absorption Spectra of 3-Pyridylazo Dyes”, Kolorizitkai: Erteshto, 1, 20, 37-41.

[10] L. Antonov, V. Denva, S. Simeonov, V. Kurteva, D. Nedeltchev, J. Wirz, (2009) “Exploiting tautomerism for switching and signaling “, Angew. Chem. Int. Ed, 48,7875-7878.

[11] S. M. Mahdi, M. A. Amrollahi, F. Bulgarian, (2015) “A facile catalyst-free Knoevenagel condensation of pyridinecarbaldehydes and active methylene compounds”, Chemical Communication, 41, 1-7, 12.

[12] P. S. Patel, M. V. Hathi (2010) “Studies on Synthesis and Dyeing Performance of Disperse Azo Dyes supported Schiff Base of Ninhydrin and 3-amino phenol”, J. Chem. Pharm. Res. 2(6):78-85

[13] A. moanta, A. Samide, C. Ionescu, B. Tutunaru, A. Dobriteşcu, et al, (2013) “Synthesis and characterization of an azo – dye: 4 - (phenyl-diazenyl) phenyl – 2 - furoate. Electrochemical and XPS study of its adsorption and inhibitive properties on corrosion of steel in salin water”, Intr. J. Electrochemical Sci. 8 (1): 780-796

[14] S. H. Eltiawi, Y. M. Issa, (1978) “Studies on Azo Compounds. VI. Relation between the Molecular Structure and Absorption Spectra of 3-Pyridylazo Dyes”, Kolorizitkai: Erteshto, 1, 20, 37-41.

[15] L. Antonov, V. Denva, S. Simeonov, V. Kurteva, D. Nedeltchev, J. Wirz, (2009) “Exploiting tautomerism for switching and signaling “, Angew. Chem. Int. Ed, 48,7875-7878.

[16] B. K. Vanya, A. L. Lubenov, L. Sh. Boris, P. N. Rositsa and M. F. Katharina, (2018) “Betttia Bases from 4-(3-pyridyazo)-1-naphththol: Synthesis, Coordination Behaviour and Unusual Substitution Reactions “, Chem. Scl. 3,12017-12021.

[17] M. H. Moemeni, M. A. Amrollahi, F. Bulgarian, (2015) “A facile catalyst-free Knoevenagel condensation of pyridinecarbaldehydes and active methylene compounds”, Chemical Communication, 41, 1-7, 12.

[18] A. W. Bauer, W. W. M. Kirby, J. C. Sherris, M. Turck, (1966) “Antibiotic susceptibility testing by a consistent single disc method” American Journal of Clinical Pathology,45,493-496.

اليكانت

استكمال تأثيتك مايكول تشبيب جزيرة كبيرة ذات نشاط سطحي من الأزوناتول والمتوافق لها نشاط ضد

الفيروسات

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