Synthesis of 3-Arylazo-6-oxopyridazin-5-carbonitriles: A Versatile Precursor for Condensed Arylazopyridazin-6-ones

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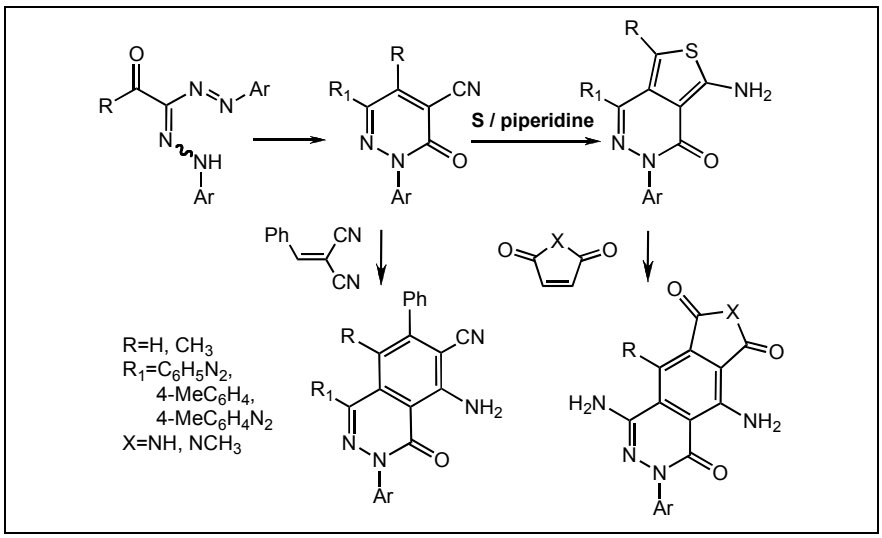

1-[2-Phenyl-1-diazenyl]-1-[2-phenylhydrazono]acetone or 1-[-2-(4-methylphenyl)-1-diazenyl]-1-[-2-(4-methylphenyl)hydrazono]-butan-2-one were produced *via* coupling the (*E*) 2-oxopropanal-1-phenyl-hydrazone or *(E)* 2-oxobutanal-1-(4-methylphenyl)hydrazone with aromatic diazonium salts. These formazanes condensed readily with ethyl cyanoacetate to yield 5-methyl-3-oxo-2-phenyl-6-phenylazo-2,3-dihydropyridazine-4-carbonitrile compound (**9a**), 5-ethyl-3-oxo-2-p-tolyl-6-p-tolylazo-2,3-dihydro-pyridazine-4-carbonitrile and/or 5-ethyl-3-oxo-2,6-di-*p*-tolyl-2,3-dihydropyridazine-4-carbonitrile that reacted with sulphur in presence of piperidine to yield the aminothienopyridazinones. The latter reacted with electron poor olefins and acetylenes to yield aminophthalazines. Compound (**9a**) reacted also with benzylidenemalononitrile to yield the arylazophthalazinone.

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INTRODUCTION

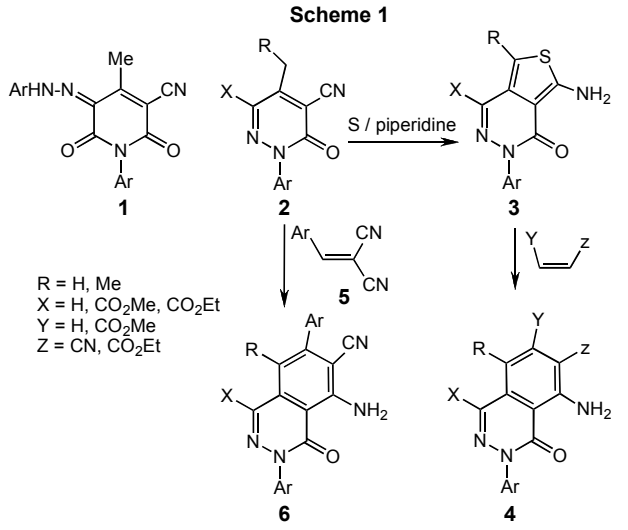
Synthesis of arylazoazoles and arylazoazines is now receiving considerable interest [1-4]. For example arylazopyridones (**1**) are extensively utilized as dyes for D2T2 printing [5,6]. However, to our knowledge, neither arylazopyridazinones nor their benzofused derivatives have yet been synthesized. In conjunction to our interest in chemistry of arylazoazoles and arylazoazines as potential dyes for D2T2 printing, we report here results of our investigations aimed at developing routes to these new classes of arylazo derivatives. In the past fifteen years, Elnagdi *et.al* [7-11] have established efficient routes to benzofused phthalazines utilizing alkyl-pyridazinyl carbonitriles as starting materials. It was reported that reacting **2** with elemental sulphur affords **3** in good yield. These thienoazenes **3** added electron poor olefins and acetylenes to yield **4**. Alternately reacting **3** with **5** has afforded **6**. Reactions of this type has been recently utilized by other groups, thus established their general nature [12-14] (Scheme 1).

RESULTS AND DISCUSSION

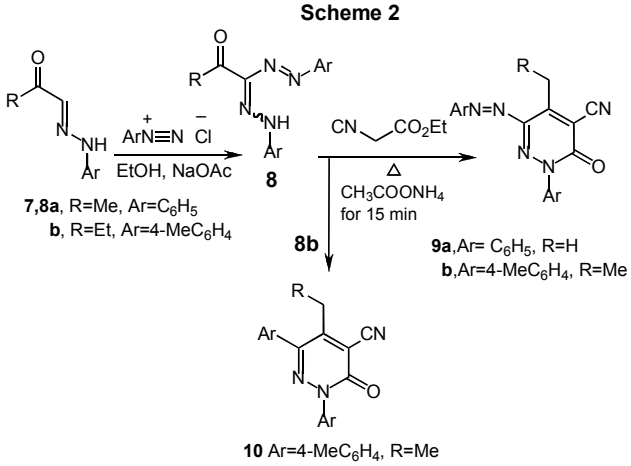
1-[2-Phenyl-1-diazenyl]-1-[2-phenylhydrazono]acetone or 1-[-2-(4-methylphenyl)-1-diazenyl]-1-[-2-(4-methyl-phenyl)hydrazono]butan-2-one (**8a,b**) could be readily obtained *via* coupling (*E*) 2-oxopropanal-1-phenyl-hydrazone or *(E)* 2-oxobutanal-1-(4-methylphenyl)hydraz-one (**7a,b**) with aromatic diazonium salts. These could be utilized as starting materials for targeted arylazo pyridazinones. As we have placed emphasis in the last few years on adopting microwave heating as a suitable substitute to conventional heating in an oil bath [15-17], we have utilized heating in a direct beam microwave oven, in this work whenever it looked feasible heating (**8a**) with ethyl cyanoacetate at 200 ºC for 15 min. in presence of ammonium acetate has afforded (**9a**) in 79% yields. However and quite unexpectedly reacting (**8b**) with the same reagent afforded (**9b**) in addition another

side product for which structure (**10**) was established based on X-ray crystal structure determination [18] (Scheme 2) (*cf*. Figure 1). Compound **10** is considered a side product as (**9**) could never yield (**10**) upon heating with ammonium acetate.

Scheme 1



Scheme 2



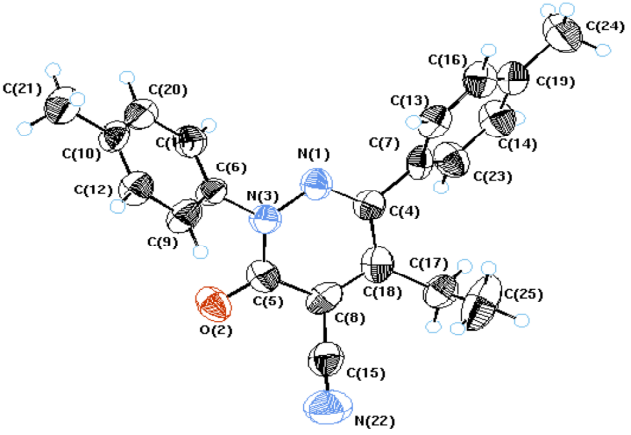
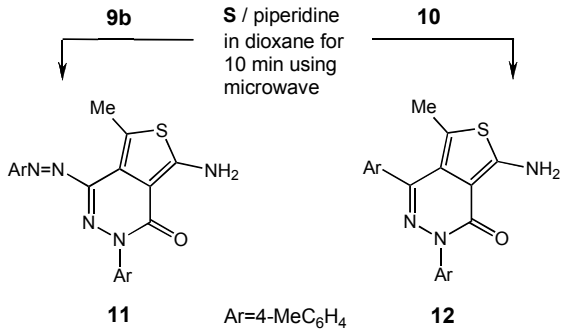


Figure 1. X-Ray crystal structure of **10**.

To our knowledge this is first example of nitrogen excision from aryldiazenyl derivatives in such system. The arylazopyridazinone (**9b**) readily reacted with elemental sulphur in presence of piperidine on heating in focused microwave at 190 ºC for 10 min in dioxane as reaction medium to yield arylazoamino thienopyridazine (**11**) in good yield. Similarly (**10**) afforded (**12**) when reacted with sulphur under the same reaction conditions. X-ray crystal structure determination of (**12**) confirm with certainly its structure [18] (Scheme 3) (*cf*. Figure 2).

Scheme 3



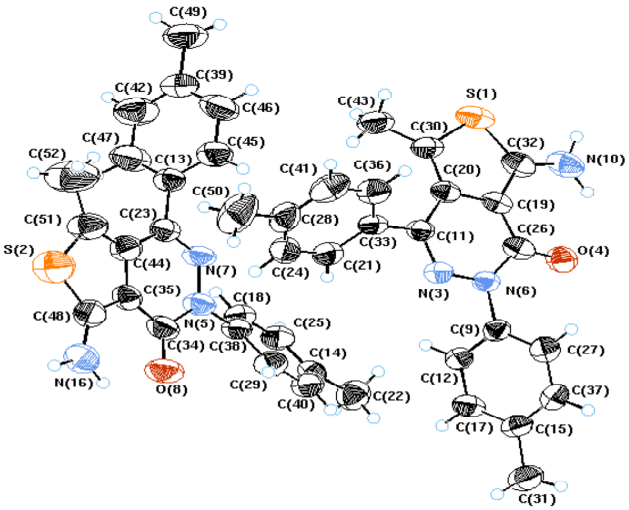


Figure 2. X-Ray crystal structure of **12**.

It can be noted from bond lengths and bond angles that all nitrogens are SP^2 in character. These points to extensive delocalization of nitrogen lone pair both on ring carbon as well as C-3 (C-4 in the Figure 1). Of interest is observed elongation of C-C bonds in ethyl moiety perhaps to minimize steric interaction with *p*-tolyl at C-3, Table 1.

Inspection of bond lengths and bond angles in Table 2 may lead to conclusion that the system is not much aromatic although N1 lone pair is delocalized to some extent on ring carbonyl resulting in shorter N6—C26 and longer O4—C26 bonds while C19—C26 is typical for

single bond. The thiophene moiety is also least aromatic as indicated from single bond character between C19 and C20 and double bond character between C19 and C32.

Table 1

Selected bond lengths (Å) and bond angles (°) of compound (**10**).

N1—N3	1.363 (4)	N3—N1—C4	119.3 (3)
N1—C4	1.314 (4)	N1—N3—C5	124.9 (3)
O2—C5	1.225 (4)	N1—N3—C6	114.1 (3)
N3—C5	1.384 (4)	C5—N3—C6	121.0 (3)
N3—C6	1.452 (4)	N1—C4—C7	114.1 (3)
C4—C7	1.469 (5)	N1—C4—C18	122.2 (4)
C5—C8	1.439 (5)		
C17—C18	1.499 (5)		
C17—C25	1.521 (6)		

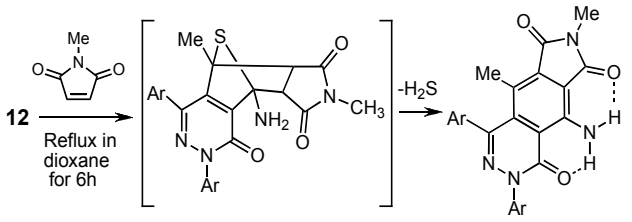
Table 2

Selected bond lengths (Å) and bond angles (°) of compound (**12**).

S1—C30	1.750 (3)	C30—S1—C32	93.9 (2)
S1—C32	1.716 (4)	N6—N3—C11	118.7 (2)
N3—N6	1.397 (3)	N3—N6—C9	113.0 (2)
N3—C11	1.302 (3)	N3—N6—C26	125.9 (3)
O4—C26	1.233 (4)	N6—C9—C12	119.9 (3)
N6—C9	1.426 (4)	S1—C30—C20	109.4 (3)
N6—C26	1.388 (4)	S1—C30—C43	117.3 (2)
N10—C32	1.336 (4)		
C19—C20	1.440 (4)		
C19—C26	1.432 (4)		
C19—C32	1.388 (4)		
C20—C30	1.361 (4)		
C30—C43	1.488 (5)		

Typical to established behaviour of thienopyridazines compounds (**12**) reacted with N-methylmaleimide in a mixture of acetic acid and dioxane to yield (**14**) *via* intermediary of *4+2* cycloadducts (**13**) that could not be isolated but is a well accepted intermediate in this type of reactions [19] (Scheme 4).

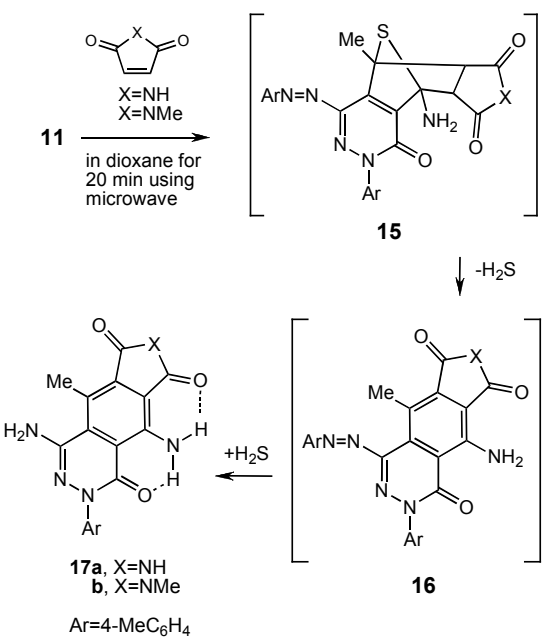
Scheme 4



13, Ar=4-MeC$_6$H$_4$ **14**, Ar=4-MeC$_6$H$_4$

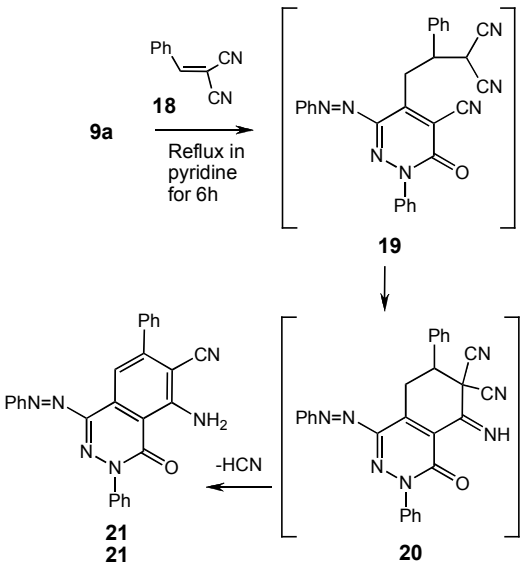
In contrast to this straightforward application of Elnagdi's synthesis of fused pyridazinones from aminothienopyridazinones [10], compound **11** reacted with maleimide and *N*-methylmaleimide in a mixture of acetic acid and dioxane, in focused microwave at 170 ºC for 20 min to yield diamino compounds **17a,b**. It is believed that hydrogen sulphide eliminated during the reaction reduced the arylazo function leading to the formation of **16**. Relieve of steric strain is perhaps more important in this case than ease of reduction. Reduction of arylazo derivatives by sodium hydrosulphide has been observed earlier [20,21] (Scheme 5).

Scheme 5



We traced H_2S elimination during reaction by lead acetate paper. We have also investigated possible adoption of other route, also explored by Elnagdi *et al* [10], for synthesis of phthalazines. Typical to earlier reports, arylazopyridazinones (**9a**) reacted with benzylidenemalononitrile to yield arylazophthalazinone (**21**). This is a further extension to our established phthalazine synthesis, which is believed to proceed *via* intermediacy of (**19**) and (**20**) (Scheme 6).

Scheme 6



In summary, arylazopyridazines and condensed phthalazines could be prepared *via* procedures similar to our previously described ones. A novel nitrogen molecule excision during the pyridazinones synthesis and a novel ready arylazo group reduction are reported.

EXPERIMENTAL

Melting points are uncorrected. All of the reactions under microwave irradiation were conducted in heavy-walled Pyrex tubes (capacity 10 ml) fitted with PCS cap. Microwave heating was carried out with a single mode cavity Explorer Microwave Synthesizer (CEM Corporation, NC, USA), producing continuous irradiation and equipped with simultaneous external air-cooling system. IR spectra were recorded in KBr disks using a Perkin-Elmer System 2000 FT-IR spectrophotometer. UV/Vis spectral data were recorded on UV/Vis spectrophotometer (Carry-Varian 5). ^{1}H NMR (400 MHz) and ^{13}C NMR (100 MHz) spectra were recorded on a Bruker DPX 400, super-conducting NMR spectrometer in $CDCl_3$ or DMSO as solvent and TMS as internal standard; chemical shifts are reported in δ units (ppm). Mass spectra were measured on MS 30 and MS 9 (AEI), 70 eV. Microanalyses were performed on a LECO CHNS-932 Elemental Analyzer.

Compounds **7a** and **8a** were prepared following general procedures [22,23].

Crystallographic analysis. The crystals were mounted on a glass fiber. All measurements were performed on an Enraf Nonius FR 590 diffractometer. The data were collected at a temperature of 20±1 ºC using the ω scanning technique to a maximum of a 2 θ_{max} **=** 24.09º. The structure was solved by direct Methods using SIR 92 and refined by full-materix least squares [24] Non-hydrogen atoms were refined anisotropically. Hydrogen atoms were located geometrically and were refined isotropically.

Crystal Data. $C_{21}H_{19}N_3O$ (**10**) M_r = 329.403, Triclinic, a = 9.3892 (5), b = 10.1999 (6), c = 11.1372 (8)Å, α = 104.983(2)°, β = 107.878 (2)°, γ = 108.011 (3)°, Z = 2, D_x = 1.231 Mg m^{-3}, θ_{max} = 24.09°. Full data can be obtained on request from CCDC [18]. $C_{21}H_{19}N_3OS$ (**17**) M_r = 361.467, Triclinic, a = 10.6131 (6), b = 11.8255 (7), c = 15.7381 (12)Å, α = 76.889 (2)°, β = 75.684 (3)°, γ = 79.835 (5)°, Z = 4, D_x = 1.299 Mg m^{-3}, θ_{max} = 24.15°. Full data can be obtained on request from CCDC [18].

General procedure for the preparation of compounds (7a,b). The mixture of KOH (3.5 g, 0.053 mol) in water (100 mL), ethyl acetoacetate or methyl propionyl acetate (6.5 g, 0.05 mol) was allowed to stir at rt for 24 h. The solution of KOAc was cooled to 0 ºC and concentrated hydrochloric acid (4.5 mL) in ice-water (15 mL) was added slowly with stirring, then gradually treated under stirring with a solution of aryldiazonium chloride (prepared from the corresponding aromatic amine (0.01 mol) and the appropriate quantities of both hydrochloric acid and $NaNO_2$. The mixture is made basic by addition of NaOAc (8.2 g) dissolved in water (30 mL). The solid product, so formed, was collected by filtration and crystallized from toluene.

(*E*) 2-Oxopropanal-1-phenylhydrazone (7a). Compound (**7a**) was obtained as orange crystals. Yield (1.44 g, 89%), mp 152 ºC (Lit [22], 150 ºC), ir (KBr) ν 3249, 1649 cm^{-1}; UV/Vis at λ_{max} ($CHCl_3$) = 341 nm, ^{1}H nmr (DMSO-d_6): δ 2.31 (s, 3H, CH_3), 6.93 (t, 1H, *J* = 7.4 Hz, phenyl-H), 7.17 (t, 2H, *J* = 7.7 Hz, phenyl-H), 7.24 (s, 1H, imine-H), 7.29 (d, 2H, *J* = 8 Hz, phenyl-H), 11.33 (s, 1H, NH). ms (EI) *m/z* = 162 (M$^+$, 100), 92 (10), 64 (10), *Anal. Calcd* for $C_9H_{10}N_2O$: C, 66.65; H, 6.21; N, 17.27. Found: C, 66.63; H, 6.07; N, 17.27.

(*E*) 2-Oxobutanal-1-(4-methylphenyl)hydrazone (7b). Compound (**7b**) was obtained as orange crystals. Yield (1.26 g, 66%), mp 134-136 ºC, ir (KBr) ν 3236, 1651 cm^{-1}; UV/Vis at λ_{max} ($CHCl_3$) = 347 nm,^{1}H nmr (DMSO-d_6): δ 1.01 (t, 3H, *J* = 7.4 Hz, CH_3), 2.24 (s, 3H, CH_3), 2.75 (q, 2H, *J* = 7.4 Hz, CH_2), 7.05 (d, 2H, *J* = 8.4 Hz, [*4*-methylphenyl]-H), 7.10 (d, 2H, *J* = 8.4 Hz, [*4*-methylphenyl]-H), 7.21 (s, 1H, imine-H), 11.21 (s, 1H, NH), ^{13}C nmr (DMSO-d_6): δ 200.0, 142.0, 134.3, 131.4, 130.4, 114.4, 30.0 (CH_2), 21.3 (CH_3), 9.5 (CH_3). ms (EI) *m/z* = 190 (M$^+$, 100), 106 (60), 79 (15), 57 (22), *Anal. Calcd* for $C_{11}H_{14}N_2O$: C, 69.45; H, 7.42; N, 14.73. Found: C, 69.56; H, 7.34; N, 14.73.

General procedure for the preparation of compounds (8a,b). A solution of aryldiazonium chloride (prepared from the corresponding aromatic amine (0.01 mol) and the appropriate quantities of both hydrochloric acid and $NaNO_2$) (0.01 mol) at 0 ^{0}C was added to a solution of compound (**7a**) or (**7b**) (0.01 mol) in EtOH (50 mL) containing NaOAc (2 g). The reaction mixture was stirred at rt for 1 h and the solid product, so formed, was collected by filtration and crystallized from EtOH.

1-[2-Phenyl-1-diazenyl]-1-[2-phenylhydrazono]acetone (8a). Compound (**8a**) was obtained as red crystals. Yield (1.54 g, 58%), mp 136-138 ºC, ir (KBr) ν 3398, 1679 cm^{-1}; UV/Vis at λ_{max} ($CHCl_3$) = 443 nm, ^{1}H nmr (DMSO-d_6): δ 2.57 (s, 3H, CH_3), 7.38 (t, 2H, *J* = 7.2 Hz, phenyl-H), 7.52 (t, 4H, *J* = 7.7 Hz, phenyl-H), 7.84 (d, 4H, *J* = 7.8 phenyl-H), 14.67 (s, 1H, NH), ^{13}C nmr (DMSO-d_6): δ 193.6, 147.9, 142.0, 130.8, 129.7, 120.5, 27.4 (CH_3). ms (EI) *m/z* =266 (M$^+$, 78), 160 (25), 105 (26), 92 (100), 77 (75), 65 (52); *Anal. Calcd* for $C_{15}H_{14}N_4O$: C, 67.65; H, 5.30; N, 21.04. Found: C, 67.65; H, 5.38; N, 20.80.

1-[-2-(4-Methylphenyl)-1-diazenyl]-1-[-2-(4-methylphenyl)-hydrazono]butan-2-one (8b). Compound (**8b**) was obtained as wine red crystals. Yield (1.84 g, 60%), mp 142-144 ºC, ir (KBr) ν 3423, 1681 cm^{-1}; UV/Vis at λ_{max} ($CHCl_3$) = 455 nm, ^{1}H nmr (DMSO-d_6): δ 1.09 (t, 3H, *J* = 7.2 Hz, CH_3), 2.36 (s, 6H, [*4*-methylphenyl]-CH_3), 2.99 (q, 2H, *J* = 7.2 Hz, CH_2), 7.32 (d, 4H, *J* = 7.8 Hz, [*4*-methylphenyl]-H), 7.72 (d, 4H, *J* = 7.8 Hz, [*4*-methylphenyl]-H), 14.93 (s, 1H, NH, D_2O exchangeable), ^{13}C nmr (DMSO-d_6): δ 196.5, 145.7, 141.2, 139.5, 131.0, 120.4, 31.9 (CH_2), 21.9 ([*4*-methylphenyl]-CH_3), 9.5 (CH_3). ms (EI) *m/z*= 308 (M$^+$, 36), 132 (20), 106 (100), 91 (42), *Anal. Calcd* for $C_{18}H_{20}N_4O$: C, 70.11; H, 6.54; N, 18.17. Found: C, 70.10; H, 6.54; N, 18.12.

General procedure for the preparation of compounds (9a). A mixture of each of compounds (**8a**) (0.01mol), ethyl cyanoacetate (1.13 g, 0.01 mol), ammonium acetate (2 g) was heated with stirring at 200 ºC for 15 min, then left to cool and triturated with EtOH. The solid product, so formed, was collected by filtration and crystallized from dioxane.

5-Methyl-3-oxo-2-phenyl-6-phenylazo-2,3-dihydropyridazine-4-carbonitrile (9a). Compound (**9a**) was obtained as buff crystals. Yield (2.60 g, 79%), mp. 216 ºC, ir (KBr) ν 2229, 1676 cm^{-1}; ^{1}H nmr (DMSO-d_6): δ 2.75 (s, 3H, CH_3), 7.52-7.68 (m, 8H, phenyl-H), 7.96 (d, 2H, *J* = 7.8 Hz, phenyl-H), ms (EI) *m/z* = 315 (M$^+$, 43), 105 (30), 77 (100), *Anal. Calcd* for $C_{18}H_{13}N_5O$: C, 68.56; H, 4.16; N, 22.21. Found: C, 68.15; H, 4.28; N, 21.93.

General Procedure for the Reaction of Compound 8b with Ethyl cyanoacetate. A mixture of compound (**8b**) (3.08 g, 0.01mol), ethyl cyanoacetate (1.13 g, 0.01 mol), ammonium

acetate (2 g) was heated with stirring at 200 ºC for 15 min. After cooling to room temperature, the formed precipitate was washed with EtOH, collected by filtration, and crystallized from dioxane to afford product (**9b**), the filtrate was poured onto crushed ice, the solid product, so formed, was collected by filtration and crystallized from EtOH to furnish product (**10**).

5-Ethyl-3-oxo-2-p-tolyl-6-*p*-tolylazo-2,3-dihydropyridazine-4-carbonitrile (9b). Compound (**9b**) was obtained as buff crystals. Yield (2.28 g, 64%), mp 194-196 ºC, ir (KBr) ν 2234, 1675 cm^{-1}; UV/Vis at λ_{max} ($CHCl_3$) = 325 nm, ^{1}H nmr (DMSO-d_6): δ 1.26 (t, 3H, *J* = 7.3 Hz, CH_3), 2.38 (s, 3H, [*4*-methylphenyl]-CH_3), 2.42 (s, 3H, [*4*-methylphenyl]-CH_3), 3.02 (q, 2H, *J* = 7.0 Hz, CH_2), 7.34 (d, 2H, *J* = 8.0 Hz, *p*-tolyl-H), 7.43-7.49 (m, 4H, [*4*-methylphenyl]-H), 7.84 (d, 2H, *J* = 8.0 Hz, [*4*-methylphenyl]-H), ^{13}C nmr (DMSO-d_6): δ 157.6, 155.7, 151.3, 150.1, 145.2, 139.8, 138.9, 131.3, 130.3, 126.6, 124.5, 114.8, 114.3, 25.3 (CH_2), 22.2 ([*4*-methylphenyl]-CH_3), 14.4 ([*4*-methylphenyl]-CH_3), 9.0 (CH_3). ms (EI) *m/z* = 357 (M^+, 33), 342 (15), 91 (100), 65 (17); *Anal. Calcd* for $C_{21}H_{19}N_5O$: C, 70.57; H, 5.36; N, 19.59. Found: C, 70.57; H, 5.38; N, 19.59.

5-Ethyl-3-oxo-2,6-di-*p*-tolyl-2,3-dihydropyridazine-4-carbonitrile (10). Compound (**10**) was obtained as buff crystals. Yield (0.71 g, 20%), mp 201 ºC, ir (KBr) ν 2229, 1666 cm^{-1}; UV/Vis at λ_{max} ($CHCl_3$) = 372 nm, ^{1}H nmr (DMSO-d_6): δ 1.01 (t, 3H, *J* = 7.5 Hz, CH_3), 2.36 (s, 3H, [*4*-methylphenyl]-CH_3), 2.37 (s, 3H, [*4*-methylphenyl]-CH_3), 2.67 (q, 2H, *J* = 7.5 Hz, CH_2), 7.31 (d, 4H, *J* = 7.9 Hz, [*4*-methylphenyl]-H), 7.43 (d, 2H, *J* = 7.8 Hz, [*4*-methylphenyl]-H), 7.49 (d, 2H, *J* = 8.2 Hz, [*4*-methylphenyl]-H), ^{13}C nmr (DMSO-d_6): δ 156.9, 156.5, 147.9, 139.8, 139.2, 139.0, 132.3, 130.2, 130.0, 129.6, 126.1, 114.5, 114.0, 26.3 (CH_2), 21.7 ([*4*-methylphenyl]-CH_3), 21.5 ([*4*-methylphenyl]-CH_3), 13.6 (CH_3). ms (EI) *m/z* = 329 (M^+, 100), 182 (18), 106 (22), 91 (56), *Anal. Calcd* for $C_{21}H_{19}N_3O$: C, 76.57; H, 5.81; N, 12.76. Found: C, 76.16; H, 5.83; N, 13.14.

General Procedure for the Reaction of Compounds 9b and 10 with Sulphur. A dried heavy-walled Pyrex tube containing a small stir bar was charged with compounds (**9b**) or (**10**) (0.01 mol), elemental sulphur (0.32 g, 0.01 mol)) in dioxane (2 mL) and few drops of piperidine were added. The tube containing the reaction mixture was fitted with PCS cap and then it was exposed to automated microwave irradiation at 190 ºC for 10 min. The build-up of pressure in the closed reaction vessel was carefully monitored and was found to be typically in the range 170-180 psi. After the irradiation, the reaction tube was cooled with high-pressure air through a built in system in the instrument until the temperature had fallen below 50 °C. The crude product was poured onto water, the solid product, so formed, was collected by filtration and crystallized from EtOH.

7-Amino-5-methyl-2-p-tolyl-4-*p*-tolylazo-2*H*-thieno[3,4-*d*]-pyridazin-1-one (11). Compound (**11**) was obtained as wine red crystals. Yield (3.43 g, 88%), mp 208 ºC, ir (KBr) ν 3322, 3278, 1642 cm^{-1}; UV/Vis at λ_{max} ($CHCl_3$) = 453 nm, ^{1}H nmr (DMSO-d_6): δ 2.33 (s, 3H, CH_3), 2.41 (s, 3H, [*4*-methylphenyl]-CH_3), 2.45 (s, 3H, [*4*-methylphenyl]-CH_3), 7.22 (d, 2H, *J* = 7.6 Hz, [*4*-methylphenyl]-H), 7.37 (d, 2H, *J* = 7.7 Hz, [*4*-methylphenyl]-H), 7.41 (d, 2H, *J* = 7.9 Hz, [*4*-methylphenyl]-H), 7.51 (s, 2H, NH_2, D_2O exchangeable), 7.81 (d, 2H, *J* = 7.7 Hz, [*4*-methylphenyl]-H), ^{13}C nmr (DMSO-d_6): δ 161.2, 159.5, 150.9, 150.4, 144.2, 139.1, 137.1, 131.0, 129.6, 126.7, 124.1, 122.5, 116.6, 105.0, 22.0 ([*4*-methylphenyl]-CH_3), 21.5 ([*4*-methylphenyl]-CH_3), 15.2 (CH_3). ms (EI) *m/z*= 389 (M^+, 100), 270 (30), 106 (60), 91 (80); *Anal. Calcd* for $C_{21}H_{19}N_5OS$: C, 64.76; H, 4.92; N, 17.98; S, 8.23. Found: C, 65.08; H, 5.06; N, 17.91; S, 8.22.

7-Amino-5-methyl-2,4-di-*p*-tolyl-2*H*-thieno[3,4-*d*]pyridazin-1-one (12). Compound (**12**) was obtained as buff crystals. Yield (3.25 g, 90%), mp 202-204 ºC, ir (KBr) ν 3421, 3276, 1631 cm^{-1}; UV/Vis at λ_{max} ($CHCl_3$) = 372 nm, ^{1}H nmr (DMSO-d_6): δ 1.82 (s, 3H, CH_3), 2.32 (s, 3H, [*4*-methylphenyl]-CH_3), 2.37 (s, 3H, [*4*-methylphenyl]-CH_3), 7.19 (d, 2H, *J* = 8.0 Hz, [*4*-methylphenyl]-H), 7.27 (d, 2H, *J* = 7.7 Hz, [*4*-methylphenyl]-H), 7.33 (d, 2H, *J* = 7.7 Hz, [*4*-methylphenyl]-H), 7.40-7.42 (m, 4H, [*4*-methylphenyl]-H, NH_2, D_2O exchangeable), ^{13}C nmr (DMSO-d_6): δ 160.2, 159.5, 145.7, 139.7, 139.2, 136.5, 134.6, 130.2, 129.7, 129.6, 126.4, 125.4, 116.5, 105.4, 21.9 ([*4*-methylphenyl]-CH_3), 21.6 ([*4*-methylphenyl]-CH_3), 13.8 (CH_3). ms (EI) *m/z*= 361 (M^+, 100), 329 (22), 91 (20), *Anal. Calcd* for $C_{21}H_{19}N_3OS$: C, 69.78; H, 5.30; N, 11.63; S, 8.87. Found: C, 69.28; H, 5.48; N, 11.83; S, 8.94.

9-Amino-5,7-dimethyl-2,4-di-*p*-tolyl-2*H*-pyrrolo[3,4-*g*]-phthalazine-1,6,8-trione (14). A solution of compound (**12**) (3.61 g, 0.01mol), *N*-methylmaleimide (1.11 g, 0.01mol), in dioxane (10 mL) and few drops of acetic acid was refluxed for 6 h. The solvent was evaporated then washed with EtOH. The solid products, so formed, were collected by filtration and crystallized from dioxane. Compound (**14**) was obtained as bright yellow crystals. Yield (3.42 g, 78%), mp 265-267 ºC, ir (KBr) ν 3305, 1749, 1691 cm^{-1}; UV/Vis at λ_{max} ($CHCl_3$) = 470 nm, ^{1}H nmr (DMSO-d_6): δ 2.11 (s, 3H, CH_3), 2.42 (s, 3H, [*4*-methylphenyl]-CH_3), 2.44 (s, 3H, [*4*-methylphenyl]-CH_3), 3.17 (s, 3H, NCH_3), 7.06 (brs, 1H, NH, D_2O exchangeable), 7.26-7.30 (m, 6H, [*4*-methylphenyl]-H), 7.52 (d, 2H, *J* = 8.0 Hz, [*4*-methylphenyl]-H), 9.09 (brs, 1H, NH, D_2O exchangeable), ms (EI) *m/z*= 438 (M^+, 100), 291 (16), 91 (17), *Anal. Calcd* for $C_{26}H_{22}N_4O_3$: C, 71.22; H, 5.06; N, 12.78. Found: C, 71.21; H, 5.06; N, 12.80.

General Procedure for The Preparation of Compounds (17a,b). A dried heavy-walled Pyrex tube containing a small stir bar was charged with each of maleimide, or *N*-methylmaleimide (0.01 mol), compounds (**11**) (3.89 g, 0.01 mol), in dioxane (2 mL) and few drops of acetic acid were added. The tube containing the reaction mixture was fitted with PCS cap and then it was exposed to automated microwave irradiation at 170 ºC for 20 min. The build-up of pressure in the closed reaction vessel was carefully monitored and was found to be typically in the range 80-85 psi. After the irradiation, the reaction tube was cooled with high-pressure air through an inbuilt system in the instrument until the temperature had fallen below 50 ºC. The solvent was evaporated then washed with ethanol. The solid products, so formed, were collected by filtration and crystallized from dioxane.

4,9-Diamino-5-methyl-2-*p*-tolyl-2*H*-pyrrolo[3,4-*g*]phthalazine-1,6,8-trione (17a). Compound (**17a**) was obtained as orange crystals. Yield (3.04 g, 87%), mp 307-309 ºC, ir (KBr) ν 3442, 3310, 3210, 1752, 1705, 1645 cm^{-1}; UV/Vis at λ_{max} ($CHCl_3$) = 473 nm, ^{1}H nmr (DMSO-d_6): δ 2.35 (s, 3H, CH_3), 2.93 (s, 3H, [*4*-methylphenyl]-CH_3), 5.71 (s, 2H, NH_2, D_2O exchangeable), 7.05 (brs, 1H, NH, D_2O exchangeable), 7.25 (d, 2H, *J* = 8.0 Hz, [*4*-methylphenyl]-H), 7.47 (d, 2H, *J* = 8.0 Hz, [*4*-methylphenyl]-H), 9.08 (brs, 1H, NH, D_2O exchangeable), 11.33 (brs, 1H, NH, D_2O exchangeable), ^{13}C nmr (DMSO-d_6): δ 170.7, 170.3, 160.1, 148.6, 147.2, 139.7, 137.6, 134.9, 132.9, 129.8, 126.5, 122.0, 118.7, 111.5, 21.7 (*p*-tolyl-CH_3), 15.8 (CH_3). ms (EI) *m/z*= 349 (M^+, 100), 242 (40), 106 (22), *Anal.*

Calcd for $C_{18}H_{15}N_5O_3$: C, 61.89; H, 4.33; N, 20.05. Found: C, 61.86; H, 4.44; N, 20.30.

4,9-Diamino-5,7-dimethyl-2-*p*-tolyl-2*H*-pyrrolo[3,4-*g*]-phthalazine-1,6,8-trione (17b). Compound (**17b**) was obtained as orange crystals. Yield (3.06 g, 84%), mp 308-310 ºC, ir (KBr) ν 3434, 3294, 3193, 1748, 1698, 1646 cm^{-1}; UV/Vis at λ_{max} ($CHCl_3$) = 470 nm, ^1H nmr ($CDCl_3$): δ 2.42 (s, 3H, CH_3), 3.10 (s, 3H, [*4*-methylphenyl]-CH_3), 3.17 (s, 3H, NCH_3), 4.59 (s, 2H, NH_2, D_2O exchangeable), 7.04 (s, 1H, NH, D_2O exchangeable), 7.29 (d, 2H, *J* = 7.9 Hz, [*4*-methylphenyl]-H), 7.48 (d, 2H, *J* = 7.8 Hz, [*4*-methylphenyl]-H), 9.35 (s, 1H, NH, D_2O exchangeable), ^{13}C nmr ($CDCl_3$): δ 169.3, 169.0, 160.1, 148.5, 146.9, 139.7, 137.6, 134.2, 132.8, 129.8, 126.5, 122.1, 118.9, 110.7, 24.6 (NCH_3), 21.7 ([*4*-methylphenyl]-CH_3), 16.0 (CH_3). ms (EI) *m/z*= 363 (M^+, 100), 259 (56), 107 (15), *Anal. Calcd* for $C_{19}H_{17}N_5O_3$: C, 62.80; H, 4.72; N, 19.27. Found: C, 62.79; H, 4.76; N, 19.13.

5-Amino-4-oxo-3,7-diphenyl-1-phenylazo-3,4-dihydro-phthalazine-6-carbonitrile (21). A solution of compound (**9a**) (3.16 g, 0.01 mol) in pyridine (3 mL) was treated with benzylidenemalononitrile (1.54 g, 0.01mol). The reaction mixture was refluxed for 6 h, then poured onto water and acidified with dilute hydrochloric acid. The solid product obtained was crystallized from dioxane. Compound (**21**) was obtained as brown crystals. Yield (3.10 g, 70%), mp 293-295 ºC, ir (KBr) ν 3418, 3340, 2206, 1659 cm^{-1}; UV/Vis at λ_{max} ($CHCl_3$) = 394 nm, ^1H nmr ($CDCl_3$): δ 7.22-7.73 (m, 15H, phenyl-H and NH_2), 7.85 (d, 1H, *J* = 8 Hz, phenyl-H), 7.98- 8.02 (m, 2H, phenyl-H). ms (EI) *m/z*= 442 (M^+, 20), 403 (80), 361 (32), 312 (30), 119 (62), 93 (100), 77 (40), *Anal. Calcd* for $C_{27}H_{18}N_6O$: C, 73.29; H, 4.10; N, 18.99. Found: C, 72.97; H, 4.65; N, 18.73.

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