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Synthesis of biologically active 3,8-dioxo-10-hydroxypyrano[2,3-*f*]quinoline and its reactions

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6-Aminocoumarin **1** on heating with malonic acid and phosphorousoxychloride in the presence of naphthalene gives 3*H*-7,8-dihydro-3,8-dioxo-10-hydroxypyrano[2,3-*f*]quinoline **2**. Compound **2** on further treatment with various acyclic, cyclic, aromatic, heterocyclic β-keto esters like ethyl acetoacetate, methyl salicylate, ethyl cyclopentanone-2-carboxylate and ethyl 2,3-dihydro-3-oxobenzofuran-2-carboxylate separately undergoes Peechman condensation to yield 3*H*,11*H*-7,8-dihydro-9-methyl-3,8,11-trioxodipyrano[2,3-*f*; 2,3-*c*]quinoline **3**, 3*H*-7,8,9,10,11,12-hexahydro-3,8,12-trioxopyrano[2,3-*f*]quinolino[3,4-*b*]pyrano[3,4-*a*]cyclopentane **4**, 3*H*,13*H*-7,8-dihydro-3,8,13-trioxopyrano[2,3-*f*]quinolino[3,4-*b*]-[1]-benzopyran **5**, and 3*H*,14*H*-7,8-dihydro-3,8,14-trioxopyrano[2,3-*f*]quinolino[3,4-*b*]pyrano[3,4-*b*]-[1]-benzofuran **6** respectively. Also the reaction of isatin, malononitrile and the compound **2** affords the corresponding spiro-[3*H*-indole-(1*H*,2*H*)-3,9-((3*H*,7*H*,8*H*)-dipyrano[2,3-*f*; 2,3-*c*]quinoline]-11-amino-10-cyano-2,3,8-trione **7**. The structures of all the compounds have been confirmed on the basis of spectral and analytical data. The above compounds have been screened for their antimicrobial activities and are found to possess significant antibacterial and antifungal activities.

Quinolones are well-known to exhibit antimalarial[1], antiviral[2], antiallergic[3], antiseptic[4], antiulcer[5] activities along with CNS depressant[6] action. Several quinolone derivatives are also active against asthama[7]. Pyranoquinolones[8] are known to act as H_1-antihistamine and also useful for cell stage preparations. Moreover, coumarins are known as potent anticoagulants[9], as well as antibacterial[10] and antifungal[11] agents. Keeping in view the biological importance of the quinolones, pyranoquinolones and the coumarins, we thought of synthesising novel pyranoquinolone compounds from 6-aminocoumarins fused at the 5,6-position of the coumarin ring.

For this purpose, 6-aminocoumarins **1a-d** were heated with malonic acid and phosphorousoxychloride in the presence of naphthalene to afford the corresponding 3*H*-7,8-dihydro-3,8-dioxo-10-hydroxypyrano[2,3-*f*]quinolines **2a-d**. The IR spectrum of **2b** in KBr showed a broad peak at 3436 cm^{-1} indicating the presence of the -OH and -NH groups, at 1721 for the C_3 carbonyl and at 1711 for the -NH-CO-group. The ^1H NMR of **2b** in DMSO-d_6 showed a singlet at δ 2.42 for the three protons of the methyl group at C_6 and a singlet at δ 6.00 and 10.65 which were D_2O exchangeable indicated the presence of the -OH and -NH groups, respectively. Its ^{13}C NMR showed the peak at δ 18.05 for the methyl group at C_6 and at δ 161.50 and 167.00 for the carbonyl group at C_3 and C_8, respectively. Mass spectrum showed M^+ at m/z 243 (17) along with other peaks at 215 (76), 187 (67), 160 (41), 132 (100).

Further, compounds **2a-d** were subjected to Peechman condensation with various acyclic, cyclic, aromatic, heterocyclic β-keto esters to afford the corresponding products.

Compounds **2a-d** on condensation with an acyclic ester like the ethyl acetoacetate in PPA yielded the corresponding 3*H*,11*H*-7,8-dihydro-9-methyl-3,8,11-trioxodipyrano[2,3-*f*; 2,3-*c*]quinolines **3a-d.** The IR spectrum of **3b** in KBr showed a broad peak at 3440 cm^{-1} for -NH group, at 1724 for the C_3 and C_{11} carbonyl, at 1650 for the C_8 carbonyl group. The ^1H NMR of **3b** in DMSO-d_6 showed a singlet at δ 2.37 and 2.42 for the three protons of the methyl groups at C_6 and C_9. Only one singlet was observed at δ 10.30 (D_2O exchangeable) which indicated the presence of the -NH group; while the other singlet at δ 6.00 due to -OH group (D_2O exchangeable) seen in the ^1H NMR spectrum of **2b** was not observed in the ^1H NMR spectrum of **3b**. Its ^{13}C NMR showed the peak at δ 17.00 and 19.00 for the methyl groups at C_6 and C_9, respectively, and at δ 161.00, 161.02 and 167.50 for the carbonyl groups at C_3, C_{11} and C_8, respectively. Mass spectrum showed M^+ at m/z 309 (15) along with the other peaks at 281 (35), 253 (27), 225 (100).

Compounds **2a-d** on reaction with cyclic β-keto ester like the ethyl cyclopentanone-2-carboxylate[12] in the presence of anhydrous K_2CO_3 yielded the corresponding 3*H*-7,8,9,10,11,12-hexahydro-3,8,12-trioxopyrano[2,3-*f*]quinolino[3,4-*b*]pyrano[3,4-*a*]cyclopentanes **4a-d.** The IR spectrum of **4b** in KBr showed a broad peak at 3444 cm^{-1} indicating the presence of the -NH group, at 1724 for the C_3 and C_{12} carbonyl. The ^1H NMR of **4b** in $CDCl_3$ showed a pentate at δ 2.10 for the presence of $>CH_2$ at C_{10}, a singlet at δ 2.50 for the three protons of the methyl group at C_6, a triplet at δ 2.80 and 3.50 for the $>CH_2$ groups at C_9 and C_{11}, respectively. The singlet observed at δ 10.60 (D_2O exchangeable) proved the presence of the -NH group. Its ^{13}C NMR showed the peak at δ 18.00 for the methyl group at C_6, at δ 20.02 for the C_9 $>CH_2$, δ 30.11 for the C_{10} $>CH_2$ and at δ 35.00 for the C_{11} $>CH_2$. The carbonyl groups at C_3, C_{12} and C_8 were observed at δ 161.00, 166.00 and 168.02 respectively. Mass spectrum showed M^+ at m/z 335 (52) along with other peaks at 307 (36), 279 (27), 251 (100).

Compounds **2a-d** on condensation with aromatic and heterocyclic β-keto ester like methyl salicylate and ethyl 2,3-dihydro-3-oxobenzofuran-2-carboxylate[13] in DMF in the presence of catalytic amount of pyridine afforded the corresponding 3*H*,13*H*-7,8-dihydro-3, 8, 13-trioxopyrano[2, 3-*f*]quinolino[3,4-*b*]-[1]-benzopyrans **5a-d** and 3*H*,14*H*-7,8-dihydro-3,8,14-trioxopyrano[2,3-*f*]quinolino[3,4-*b*]pyrano[3,4-*b*]-[1]-benzofurans **6a-d** (**Scheme I**). The structures of the compounds were confirmed on the basis of spectral and analytical data.

The reaction of the indole-2,3-dione, malononitrile and the compounds **2a-d** in ethanol in the presence of catalytic amount of piperidine afforded the corresponding spiro-[3*H*-indole-(1*H*,2*H*,)-3,9-((3*H*,7*H*,8*H*)-dipyrano[2,3-*f*; 2,3-*c*]quinoline]-11-amino-10-cyano-2,3,8-triones **7a-d.** The reaction may be proceeding via Micheal adduct formation which enolises to yield the product. The IR spectrum of **7b** in KBr showed a broad peak at 3337 cm^{-1} indicating the presence of the -NH and $-NH_2$ groups, at 2211 cm^{-1} for the presence of the -CN group, at 1719 cm^{-1} for the C_3 carbonyl and at 1710 cm^{-1} for the carbonyl of the indole ring and the -NH-CO-group. The ^1H NMR of **7b** in DMSO-d_6 showed a singlet at δ 2.35 for the presence of three protons of the methyl group at C_6, and a sharp singlet observed at δ 10.58 (D_2O exchangeable) indicated the presence of the -NH group. The singlet observed at δ 11.80 and 12.50 for the proton of indole -NH and for the two protons of $-NH_2$, respectively were D_2O exchangeable. Its ^{13}C NMR showed the peak at δ 18.50 for the methyl group at C_6, the spiro carbon atom at δ 40.00 and the -CN at δ 118.00. The carbonyl groups at C_3, C_8 and that of the indole were observed at δ 161.00, 168.20 and 170.20, respectively. Mass spectrum showed M^+ at m/z 438 (18) along with the other peaks at 307 (15), 280 (23), 253 (39), 225 (21), 197 (19), 169 (100).

Biological screening

All the above compounds **2a-d**, **3a-d**, **4a-d, 5a-d, 6a-d** and **7a-d** were screened for their antibacterial activity against *S. aureus,* and *S typhi* and antifungal against *A. niger* and *C. albicans* (**Table I**). The minimum inhibitory concentration (MIC) was determined using tube dilution method according to the standard procedure[14]. DMF was used as a blank and Ciprofloxacin and Miconazole were used as antibacterial and antifungal standards. An examination of the data reveal that all the compounds showed antimicrobial activity ranging from 50 μgm/ mL to 200 μgm/ mL.

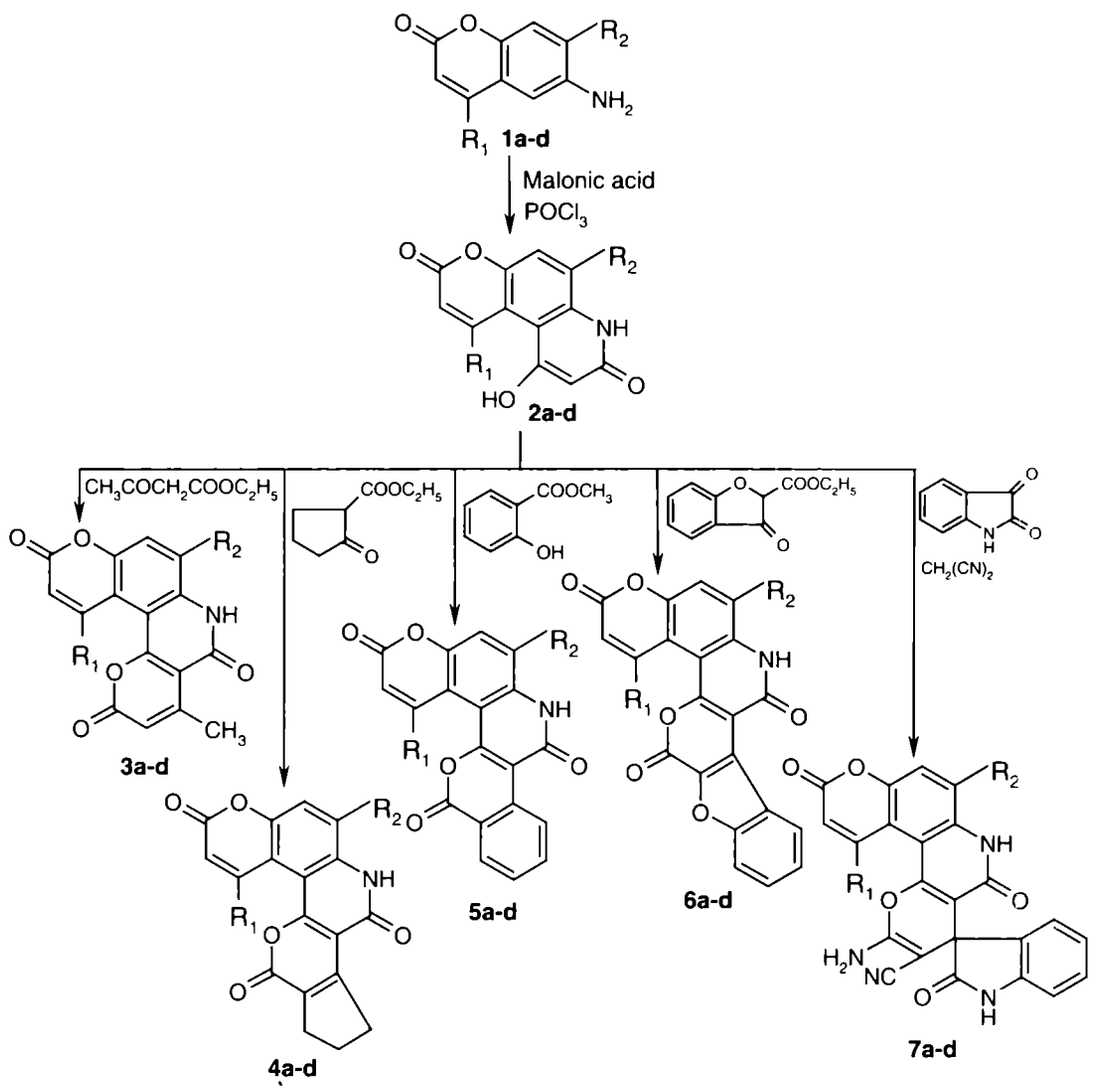
Experimental Section

Melting points were determined in open capillaries and are uncorrected. IR spectra were recorded on a Perkin-Elmer 257 spectrophotometer using KBr; ^1H NMR and ^{13}C NMR were recorded on a Bruker AMX500 MHz using TMS as an internal standard; and mass spectra on a Shimadzu GC-MS. The homogeneity of the compounds was monitored on the silica gel plates. The spots were developed in the iodine chamber. All the compounds gave satisfactory elemental analysis.

General Procedure

3*H*-7, 8-Dihydro-3, 8-dioxo-10-hydroxypyrano-[2, 3-*f*]quinoline 2a-d. To a mixture of 6-amino-coumarins **1a-d** (0.001 mole) and naphthalene (0.001 mole) was added phosphorousoxychloride (4 mL) and the mixture was heated on a water-bath for 30 min. The mixture was then cooled and diluted with water. The solution was then basified with NaOH to *p*H 9 and filtered. The filtrate was acidified with conc. HCl to *p*H 2. The product obtained was filtered, washed with water, dried and recrystallised from ethanol.

2a: Molecular formula $C_{12}H_7NO_4$,, mp 190°C, yield 75%; IR (KBr): 3439 (-OH & -NH), 1722 (C_3 >C=O), 1710 (-NH-CO-), 1622, 1533, 1451, 1405 cm^{-1}.



1a, 2a, 3a, 4a, 5a, 6a, 7a: R_1= H, R_2= H.
1b, 2b, 3b, 4b, 5b, 6b, 7b: R_1= H, R_2= CH_3.
1c, 2c, 3c, 4c, 5c, 6c, 7c: R_1= CH_3, R_2= CH_3.
1d, 2d, 3d, 4d, 5d, 6d, 7d: R_1= CH_3, R_2= OCH_3.

Scheme I

2b: Molecular formula $C_{13}H_9NO_4$, mp 210°C, yield 68%; IR (KBr): 3436 (-OH & -NH), 1721 (C_3 >C=O), 1711 (-NH-CO-), 1624, 1534, 1450, 1400 cm^{-1}; ^1H NMR (DMSO-d_6): δ 2.42 ppm (s, 3H, C_6 -CH_3), 6.00 (s, 1H, -OH, D_2O exchangeable), 6.42 (d, J= 9.50Hz, 1H, C_2-H), 7.35 (s, 1H, C_9-H), 7.80 (s, 1H, C_5-H), 8.08 (d, J= 9.50Hz, 1H, C_1-H), 10.30 (s, 1H, -NH, D_2O exchangeable); ^{13}C NMR: δ 18.05 (C_6 -CH_3), 116.25 (C_2), 143.45 (C_1), 148.02 (C_{6a}), 153.80 (C_{4a}), 161.50 (C_3 >C=O), 167.00 (C_8 >C=O), 120.00 -134.00 (6Ar-C); Mass (m/z) (%): M^+ 243 (17), 215 (76), 187 (67), 160 (41), 132 (100), 104 (15), 103 (10).

2c: Molecular formula $C_{14}H_{11}NO_4$, mp 220°C, yield 65%; IR (KBr): 3433 (-OH & -NH), 1720 (C_3 >C=O), 1712 (-NH-CO-), 1625, 1531, 1452, 1403 cm^{-1}.

2d: Molecular formula $C_{14}H_{11}NO_5$, mp 235°C, yield 60%; IR (KBr): 3437 (-OH & -NH), 1721(C_3 >C=O), 1710(-NH-CO-), 1623, 1532,1453,1402 cm^{-1}.

***3H*,11*H*-7,8-Dihydro-9-methyl-3,8,11-trioxodipyrano[2,3-*f*; 2,3-*c*]quinoline 3a-d.** Mixture of **2a-d** (0.001 mole) and ethyl acetoacetate (0.001 mole) in PPA were heated on a water-bath for 2 hr. The mixture was then cooled and poured into ice-cold

Table I—Biological screening data (MIC μgm/ mL) of compounds 2a-d, **3a-d, 4a-d, 5a-d, 6a-d** and **7a-d.**

Compd	Antibacterial activity		Antifungal activity	
	S. aureus	*S. typhi*	*A. niger*	*C. albicans*
2a	++	+++	++	-
2b	++	+++	+++	+
2c	+++	+++	+++	++
2d	+++	++++	++++	+++
3a	+	+	-	+
3b	++	++	+	+++
3c	+++	++	++	+++
3d	++++	+++	+++	++++
4a	-	-	-	+
4b	+	-	-	++
4c	++	+	++	++
4d	+++	++	++	+++
5a	+	-	+	-
5b	++	+	++	+
5c	++	++	++	++
5d	+++	++	+++	++
6a	-	+	-	+
6b	+	++	++	+++
6c	++	+++	++	+++
6d	+++	++++	+++	+++
7a	++	+++	++	++
7b	+++	+++	++	+++
7c	++++	++++	+++	++++
7d	++++	+++	++++	++++
Ciprofloxacin Miconazole	*	*	*	*

Note: 200 μgm/ ML = +, 150 μgm/ ML = ++, 100 μgm/ ML = +++, 50 μgm/ ML = ++++, -= No activity upto 200 μgm/ ML, * = 5 μgm/ ML.

water. The product obtained was filtered, washed well with water, dried and recrystallised from ethanol.

3a: Molecular formula $C_{16}H_9NO_5$, mp 202°C, yield 80%; IR (KBr): 3438 (-NH), 3045, 1722 (C_3 >C=O & C_{11} >C=O), 1652 (C_8 >C=O), 1610, 1552, 1482, 1450, 1402 cm^{-1}.

3b: Molecular formula $C_{17}H_{11}NO_5$, mp 215°C, yield 77%; IR (KBr): 3440 (-NH), 3050, 1724 (C_3 >C=O & C_{11} >C=O), 1650 (C_8 >C=O), 1600, 1550, 1489, 1448, 1400 cm^{-1};^{1}H NMR ($CDCl_3$): δ 2.37 (s, 3H, C_6 -CH_3), 2.42 (s, 3H, C_9 -CH_3), 6.42 (d, *J*= 9.50Hz, 1H, C_2 -H), 7.35 (s, 1H, C_{10} -H), 7.80 (s, 1H, C_5 -H), 8.08 (d, *J*= 9.50Hz, 1H, C_1 -H), 10.30 (s, 1H, -NH, D_2O exchangeable); ^{13}C NMR: δ 17.00 (C_6 -CH_3), 19.00 (C_9 -CH_3), 116.30 (C_2), 143.45 (C_1), 148.20 (C_{6a}), 153.75 (C_{4a}), 161.00 (C_3 >C=O), 161.02 (C_{11} >C=O), 167.50 (C_8 >C=O), 120.00 -138.00 (8Ar-C); Mass (m/z) (%): M^+ 309 (15), 281 (35), 253 (27), 225 (100), 197 (11), 169 (10).

3c: Molecular formula $C_{18}H_{13}NO_5$, mp 231°C, yield 72%; IR (KBr): 3439 (-NH), 3049, 1723 (C_3 >C=O & C_{11} >C=O), 1651 (C_8 >C=O), 1609, 1551, 1480, 1452, 1410 cm^{-1}.

3d: Molecular formula $C_{18}H_{13}NO_6$, mp 245°C, yield: 70%; IR (KBr): 3437 (-NH), 3047, 1722 (C_3 >C=O & C_{11} >C=O), 1652 (C_8 >C=O), 1607, 1549, 1485, 1451, 1405 cm^{-1}.

3*H*-7,8,9,10,11,12-Hexahydro-3,8,12-trioxopyrano[2,3-*f*]quinolino[3,4-*b*] pyrano[3,4-*a*]cyclopentane 4a-d. A mixture of **2a-d** (0.001 mole) and ethyl cyclopentanone-2-carboxylate (0.01 mole) and anhydrous K_2CO_3 (25 mgm) was heated on an oil-bath at 175-80°C for 3 hr. The resultant mixture was cooled and treated with pet. ether (40-80° or 60-80°)

or *n*-hexane. The product separated was filtered, washed with hot water to remove potassium salts and recrystallised from acetic acid.

4a: Molecular formula $C_{18}H_{11}NO_5$, mp 212°C, yield 69%; IR (KBr): 3442 (-NH), 3060, 1722 (C_3 >C=O & C_{12} >C=O), 1651, 1600, 1502, 1450, 1420 cm^{-1}.

4b: Molecular formula $C_{19}H_{13}NO_5$, mp 223°C, yield 70%; IR (KBr): 3444 (-NH), 3069, 1724 (C_3 >C=O & C_{12} >C=O), 1655, 1610, 1500, 1453, 1423 cm^{-1}; ^1H NMR ($CDCl_3$): δ 2.10 (p, 2H, C_{10} $>CH_2$), 2.50 (s, 3H, $-CH_3$), 2.80 (t, 2H, $C_9>CH_2$), 3.50 (t, 2H, $C_{11}>CH_2$), 6.42 (d, *J*= 9.50Hz, 1H, C_2-H), 7.80 (s, 1H, C_5-H), 8.05 (d, *J*= 9.50Hz, 1H, C_1-H), 10.60 (s, 1H, -NH, D_2O exchangeable); ^{13}C NMR: δ 18.00 ($-CH_3$), 20.02 (C_9 $>CH_2$), 30.11 (C_{10} $>CH_2$), 35.00 (C_{11} $>CH_2$), 116.20 (C_2), 143.44 (C_1), 148.25 (C_{6a}), 153.79 (C_{4a}), 161.00 (C_3 >C=O), 166.00 (C_{12} >C=O), 168.02 (C_8 >C=O), 120.00 -138.00 (8Ar-C); Mass (m/z) (%): M^+ 335 (52), 307 (36), 279 (27), 251 (100), 223 (17).

4c: Molecular formula $C_{20}H_{15}NO_5$, mp 239°C, yield 63%; IR (KBr): 3440 (-NH), 3059, 1723 (C_3 >C=O & C_{12} >C=O), 1650, 1603, 1505, 1452, 1421 cm^{-1}.

4d: Molecular formula $C_{20}H_{15}NO_6$, mp >250°C, yield 66%; IR (KBr): 3442 (-NH), 3058, 1724 (C_3 >C=O & C_{12} >C=O), 1652, 1605, 1505, 1453, 1420 cm^{-1}.

3*H*, 13*H*-7,8-Dihydro-3,8,13-trioxopyrano[2,3-*f*]quinolino[3,4-*b*]-[1]-benzopyran 5a-d. To a solution of **2a-d** (0.001 mole) in DMF (3 mL) and catalytic amount of pyridine (0.5 mL) was added methyl salicylate (0.002 mole) and the mixture was refluxed at 160-70°C for 4 hr. The mixture was then cooled and poured into crushed ice and water containing a little conc. HCl. The product obtained was filtered, washed initially with dilute sodium bicarbonate and then with dilute sodium hydroxide and finally with water. It was then recrystallised from ethanol.

5a: Molecular formula $C_{19}H_9NO_5$, mp 220°C, yield 74%; IR (KBr): 3445 (-NH), 2955, 1723 (C_3 >C=O & C_{13} >C=O), 1652 (C_8 >C=O), 1610, 1529, 1457 cm^{-1}.

5b: Molecular formula $C_{20}H_{11}NO_5$, mp 237°C, yield 65%; IR (KBr): 3450 (-NH), 2950, 1725 (C_3 >C=O & C_{13} >C=O), 1650 (C_8 >C=O), 1600, 1525, 1450 cm^{-1}; ^1H NMR ($CDCl_3$): δ 2.50 (s, 3H, $-CH_3$), 6.35 (d, *J*= 9.50Hz, 1H, C_2-H), 6.95 (t, 1H, C_{10}-H), 7.02 (d, *J*= 7.80Hz, 1H, C_9-H), 7.80 (s, 1H, C_5-H), 7.40 (d, *J*= 7.80Hz, 1H, C_{12}-H), 7.55 (t, 1H, C_{11}-H), 7.95 (d, *J*= 9.50Hz, 1H, C_1-H), 10.40 (s, 1H, -NH, D_2O exchangeable); ^{13}C NMR: δ 18.50 ($-CH_3$), 111.00 (C_{8a}), 112 (C_{8a}'), 116.10 (C_2), 143.44 (C_1), 148.10 (C_{6a}), 153.00 (C_{14a}), 153.90 (C_{4a} & C_{12a}), 161.00 (C_3 >C=O), 162.20 (C_{13} >C=O), 168.20 (C_8 >C=O), 120.00 -138.00 (8Ar-C); Mass (m/z) (%): M^+ 345 (59), 317 (67), 289 (37), 261 (100), 233 (15).

5c: Molecular formula $C_{21}H_{13}NO_5$, mp 247°C, yield 60 %; IR (KBr): 3447 (-NH), 2957, 1722 (C_3 >C=O & C_{13} >C=O), 1651 (C_8 >C=O), 1607, 1530, 1453 cm^{-1}.

5d: Molecular formula $C_{21}H_{13}NO_6$, mp >250°C, yield 62%; IR (KBr): 3442 (-NH), 2953, 1723 (C_3 >C=O & C_{13} >C=O), 1650 (C_8 >C=O), 1609, 1532, 1454 cm^{-1}.

3*H*,14*H*-7,8-Dihydro-3,8,14-trioxopyrano[2,3-*f*]-quinolino[3,4-*b*]pyrano[3,4-*b*]-[1]-benzofuran 6a-d. A mixture of **2a-d** (0.01 mole) and ethyl 2,3-dihydro-3-oxobenzofuran-2-carboxylate (0.01 mole) was refluxed in DMF (15 mL) on an oil-bath at 160°C in the presence of catalytic amount of pyridine (2 mL). The solution was then cooled and poured into crushed ice and water containing a little amount of conc. HCl. The product separated was filtered, washed with dilute sodium hydroxide and then with water, dried and later recrystallised from benzene.

6a: Molecular formula $C_{21}H_9NO_6$, mp 221°C, yield 71%; IR (KBr): 3439 (-NH), 3050, 1723 (C_3 >C=O & C_{14} >C=O), 1652 (C_7 >C=O), 1549, 1495, 1449 cm^{-1}.

6b: Molecular formula $C_{22}H_{11}NO_6$, mp 234°C, yield 68%; IR (KBr): 3438 (-NH), 3051, 1725 (C_3 >C=O & C_{14} >C=O), 1654 (C_7 >C=O), 1542, 1490, 1448 cm^{-1}; ^1H NMR (DMSO-d_6): δ 2.45 (s, 3H, $-CH_3$), 6.45 (d, *J*= 9.50Hz, 1H, C_2-H), 6.95 (d, *J*= 7.50Hz, 1H, C_9-H), 7.10 (t, 1H, C_{10}-H), 7.30 (t, 1H, C_{11}-H), 7.60 (d, *J*= 7.50Hz, 1H, C_9-H), 7.80 (s, 1H, C_5-H), 8.10 (d, *J*= 9.50Hz, 1H, C_1-H), 10.65 (s, 1H, -NH, D_2O exchangeable); ^{13}C NMR: δ 18.50 ($-CH_3$), 111 (C_{8a} & C_{8a}''), 113 (C_{8a}'), 116.00 (C_2), 143.25 (C_1), 148.01 (C_{12a} & C_{15a}), 148.25 (C_{6a}), 153.84 (C_{4a}), 160.00 (C_{13a}), 161.25 (C_3 >C=O), 166.07 (C_{14} >C=O), 168.02 (C_8 >C=O), 118.00 -138.00 (8Ar-C); Mass (m/z) (%): M^+ 385 (83), 357 (78), 329 (62), 301 (100), 273 (22).

6c: Molecular formula $C_{23}H_{13}NO_6$, mp 246°C, yield 63%; IR (KBr): 3441 (-NH), 3051, 1724 (C_3 >C=O & C_{14} >C=O), 1651 (C_7 >C=O), 1551, 1496, 1451 cm^{-1}.

6d: Molecular formula $C_{23}H_{13}NO_7$, mp >250°C, yield 59%; IR (KBr): 3440 (-NH), 3053, 1721 (C_3 >C=O & C_{14} >C=O), 1653 (C_7 >C=O), 1550, 1497, 1450 cm^{-1}.

Spiro-[3*H*-indole-(1*H*,2*H*,)-3,9-((3*H*,7*H*,8*H*)-dipyrano[2,3-*f*; 2,3-*c*]quinoline)-11-amino-10-cyano-

2,3,8-trione 7a-d. A mixture of indole-2,3-dione (0.01 mole) and malononitrile (0.01 mole) in ethanol (30 mL) was refluxed in the presence of catalytic amount of piperidine (0.5 mL) for 1 hr. To this, compound **2a-d** (0.01 mole) was added and the refluxing was continued further for 22 hr. The reaction mixture was half concentrated, cooled and poured into crushed ice and water containing a little conc. HCl. The solid product obtained was filtered, washed with water and recrystallised from ethanol.

7a: Molecular formula $C_{23}H_{12}N_4O_5$, mp 233°C, yield 76%; IR (KBr,): 3339 (-NH & $-NH_2$), 2210 (-CN), 1720 (C_3 >C=O), 1712 (indole >C=O & -NH-CO-), 1623, 1552, 1465, 1382 cm^{-1}.

7b: Molecular formula $C_{24}H_{14}N_4O_5$, mp 243°C, yield 73%; IR (KBr): 3337 (-NH & $-NH_2$), 2211 (-CN), 1719 (C_3 >C=O), 1710 (indole >C=O & -NH-CO-), 1620, 1550, 1467, 1383 cm^{-1}; ^1H NMR (DMSO-d_6) δ 2.35 (s, 3H, $-CH_3$), 6.41 (d, *J*= 9.50Hz, 1H, C_2-H), 6.85 (d, *J*= 7.50Hz, 1H, $C_{4'}$-H), 7.10 (t, 1H, $C_{5'}$-H), 7.30 (t, 1H, $C_{6'}$-H), 7.60 (d, *J*= 7.50Hz, 1H, $C_{7'}$-H), 7.85 (s, 1H, $C_{5'}$-H), 8.10 (d, *J*= 9.50Hz, 1H, C_1-H), 10.58 (s, 1H, -NH, D_2O exchangeable), 11.80 (s, 1H, indole -NH, D_2O exchangeable), 12.50 (s, 2H, $-NH_2$, D_2O exchangeable); ^{13}C NMR: δ 18.50 ($-CH_3$), 40.00 (spiro C-atom), 111.00 (C_{8a}), 116.20 (C_2), 118.00 (-CN), 143.50 (C_1), 148.12 (C_{6a}), 153.90 (C_{4a}), 153.90 (C_{12a}), 161.00 (C_3 >C=O), 168.20 (C_8 >C=O), 170.20 (indole >C=O), 122.00 -138.00 (11Ar-C); Mass (m/z) (%): M^+ 438 (18), 307 (15), 280 (23), 253 (39), 225 (21), 197 (19), 170 (79), 169 (100), 142 (52), 131 (27), 114 (23).

7c: Molecular formula $C_{25}H_{16}N_4O_5$, mp >250°C, yield 65%; IR (KBr): 3335 (-NH & $-NH_2$), 2214 (-CN), 1722 (C_3 >C=O), 1713 (indole >C=O & -NH-CO-), 1624, 1553, 1466, 1381 cm^{-1}.

7d: Molecular formula $C_{25}H_{16}N_4O_6$, mp >250°C, yield 60%; IR (KBr): 3336 (-NH & $-NH_2$), 2213 (-CN), 1723 (C_3 >C=O), 1711 (indole >C=O & -NH-CO-), 1625, 1557, 1463, 1382 cm^{-1}.

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