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 phosphorous oxychloride in the presence of naphthalene gives 3H-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 acetocetate, methyl salicylate, ethyl cyclopentanone-2-carboxylate and ethyl 2,3-dihydro-3-oxobenzofuran-2-carboxylate separately undergoes Pechman condensation to yield 3H,11H-7,8-dihydro-9-methyl-3,8,11-trioxo-pyrano[2,3-f]quinoline 3, 3H-7,8,9,10,11,12-hexahydro-3,8,12-trioxo-pyrano[2,3-f]quinoline 4, 3H-13H-7,8-dihydro-3,8,13-trioxo-pyrano[2,3-f]quinoline 5, and 3H,14H-7,8-dihydro-3,8,14-trioxo-pyrano[2,3-f]quinoline 6 respectively. Also the reaction of isatin, malononitrile and the compound 2 affords the corresponding spinosensitivity [3H-indole-1H,2H]-3,9-(3H,7H,8H)-dipyrylan[2,3-f; 2,3-c]quinoline;[11-amino-10-cyano]-2,3-trione. 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 antimicrobial and antifungal activities.

Quinolones are well-known to exhibit antimalarial, antiviral, antiallergic, antiseptic and antiluetic activities along with CNS depressant action. Several quinolone derivatives are also active against asthma.

Pyranopyranoquinolones are known to act as H1-antihistamine and also useful for cell stage preparations. Moreover, coumarins are known as potent anticoagulants, as well as antibacterial and antifungal agents. Keeping in view the biological importance of the quinolones, pyranopyranoquinolones and the coumarins, we thought of synthesising novel pyranopyranoquinoline 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 phosphorous oxychloride in the presence of naphthalene to afford the corresponding 3H-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 for the -NH group, at 1724 for the carbonyl group at C1, C11 and C12, 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 Pechman 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 acetocetate in PPA yielded the corresponding 3H,11H-7,8-dihydro-9-methyl-3,8,11-trioxo-pyrano[2,3-f]quinolines 3a-d. The IR spectrum of 3b in KBr showed a broad peak at 3440 cm⁻¹ for the -NH group, at 1724 for the C1 and C11 carbonyl, at 1650 for the C8 carbonyl group. The 1H NMR of 3b in DMSO-d₆ showed a singlet at δ 2.37 and 2.42 for the three protons of the methyl groups at C6 and C8. Only one singlet was observed at δ 10.30 (D₂O exchangeable) which indicated the presence of the -NH group; while the other singlet at δ 6.00 due to the -OH group (D₂O exchangeable) seen in the 1H NMR spectrum of 2b was not observed in the 1H NMR spectrum of 3b. Its 13C NMR showed the peak at δ 17.00 and 19.00 for the methyl groups at C6 and C8, respectively, and at δ 161.00, 161.02 and 167.50 for the carbonyl groups at C1, C11 and C12, 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 in the presence of anhydrous K$_2$CO$_3$ yielded the corresponding 3H-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 broad peak at 3444 pyrano[2,3-f]quinolino[3,4-b]pyrano[3,4-a]cyclopentanes 4a-d. The 1H NMR of 4b in CDCl$_3$ showed a singlet 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$_2$O 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$_1$, C$_{12}$ and C$_9$ 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 in DMF in the presence of catalytic amount of pyridine afforded the corresponding 3H,13H-7,8-dihydro-3,8,13-trioxopyrano[2,3-f]quinolino[3,4-b]-[11]-benzopyrans 5a-d and 3H,14H-7,8-dihydro-3,8,14-trioxopyrano[2,3-f]quinolino[3,4-b]pyrano[3,4-b]-[11]-benzofurans 6a-d (Scheme 1). 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-[3H-indole-(1H,2H)-3,9-((3H,7H,8H)-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$_9$ 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$_2$O 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$_2$O 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 1). 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 μg/mL to 200 μg/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**

3H-7, 8-Dihydro-3, 8-dioxo-10-hydroxypyranono[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 phosphorous oxychloride (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 pH 9 and filtered. The filtrate was acidified with conc. HCl to pH 2. The product obtained was filtered, washed with water, dried and recrystallised from ethanol.

2a: Molecular formula C$_{12}$H$_7$NO$_4$, mp 190°C, yield 75%; IR (KBr): 3439 (-OH & -NH), 1722 (C$_7$ >C=O), 1710 (-NH-CO-), 1622, 1533, 1451, 1405 cm$^{-1}$. 

2d: Molecular formula C$_{12}$H$_7$NO$_4$, mp 190°C, yield 75%; IR (KBr): 3439 (-OH & -NH), 1710 (C$_7$ >C=O), 1700 (-NH-CO-), 1622, 1533, 1451, 1405 cm$^{-1}$. 

2b: Molecular formula C$_{12}$H$_7$NO$_4$, mp 190°C, yield 75%; IR (KBr): 3439 (-OH & -NH), 1722 (C$_7$ >C=O), 1710 (-NH-CO-), 1622, 1533, 1451, 1405 cm$^{-1}$. 

2c: Molecular formula C$_{12}$H$_7$NO$_4$, mp 190°C, yield 75%; IR (KBr): 3439 (-OH & -NH), 1722 (C$_7$ >C=O), 1710 (-NH-CO-), 1622, 1533, 1451, 1405 cm$^{-1}$. 

2d: Molecular formula C$_{12}$H$_7$NO$_4$, mp 190°C, yield 75%; IR (KBr): 3439 (-OH & -NH), 1722 (C$_7$ >C=O), 1710 (-NH-CO-), 1622, 1533, 1451, 1405 cm$^{-1}$.
2b: Molecular formula C_{13}H_{14}NO_4, mp 210°C, yield 68%; IR (KBr): 3436 (-OH & -NH), 1721 (-NH-CO-), 1711 (-NH-CO-), 1624, 1534, 1450, 1400 cm^{-1}; ¹H NMR (DMSO-d_6): δ 2.42 ppm (s, 3H, -CH_3), 6.00 (s, 1H, -OH, D_2O exchangeable), 6.42 (d, J= 9.50Hz, 1H, C-H), 7.35 (s, 1H, C-H), 7.80 (s, 1H, C-H), 8.08 (d, J= 9.50Hz, 1H, C-H), 10.30 (s, 1H, -NH, D_2O exchangeable); ¹³C NMR: δ 18.05 (C_6 -CH_3), 116.25 (C_7), 143.45 (C_8), 148.02 (C_9), 153.80 (C_10), 161.50 (C_11 >C=O), 167.00 (C_12 >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_{15}NO_4, mp 220°C, yield 65%; IR (KBr): 3433 (-OH & -NH), 1720 (C_1 >C=O), 1712 (-NH-CO-), 1625, 1531, 1452, 1403 cm^{-1}.

2d: Molecular formula C_{14}H_{15}NO_5, mp 235°C, yield 60%; IR (KBr): 3437 (-OH & -NH), 1721(C_1 >C=O), 1710(-NH-CO-), 1623, 1532,1453,1402 cm^{-1}.

3H,11H-7,8-Dihydro-9-methyl-3,8,11-trioxodipyran[2,3-f; 2,3-c]quinoline 3a-d. Mixture of 2a-d (0.001 mole) and ethyl acetooacetate (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 μg/mL) of compounds 2a-d, 3a-d, 4a-d, 5a-d, 6a-d and 7a-d.

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Ciprofloxacin Miconazole

* * * *

Note: 200 μg/mL = +, 150 μg/mL = ++, 100 μg/mL = ++++, 50 μg/mL = ++++, - = No activity up to 200 μg/mL.

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

3a: Molecular formula C₁₆H₉NO₅, mp 202°C, yield 80%; IR (KBr): 3438 (-NH), 3045, 1722 (C₃=C=O & C₁₁=C=O), 1652 (C₈=C=O), 1610, 1552, 1482, 1450, 1402 cm⁻¹.

3b: Molecular formula C₁₇H₁₁NO₅, mp 215°C, yield 77%; IR (KBr): 3440 (-NH), 3050, 1724 (C₃=C=O & C₁₁=C=O), 1650 (C₈=C=O), 1600, 1550, 1489, 1448, 1400 cm⁻¹; ¹H NMR (CDCl₃): δ 2.37 (s, 3H, C₆-CH₃), 2.42 (s, 3H, C₉-CH₃), 6.42 (d, J= 9.50Hz, 1H, C₂-H), 7.35 (s, 1H, C₁₀-H), 7.80 (s, 1H, C₅-H), 8.08 (d, J= 9.50Hz, 1H, C₁-H), 10.30 (s, 1H, -NH, D₂O exchangeable); ¹³C NMR: δ 17.00 (C₆-CH₃), 19.00 (C₉-CH₃), 116.30 (C₂), 143.45 (C₁), 148.20 (C₁₆), 153.75 (C₈), 161.00 (C₁₁=C=O), 161.02 (C₁₂=C=O), 167.50 (C₅=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 C₁₈H₁₃NO₅, mp 231°C, yield 72%; IR (KBr): 3439 (-NH), 3049, 1723 (C₃=C=O & C₁₁=C=O), 1651 (C₈=C=O), 1609, 1551, 1480, 1452, 1410 cm⁻¹.

3d: Molecular formula C₁₈H₁₃NO₆, mp 245°C, yield: 70%; IR (KBr): 3437 (-NH), 3047, 1722 (C₃=C=O & C₁₁=C=O), 1652 (C₈=C=O), 1607, 1549, 1485, 1451, 1405 cm⁻¹.

3H-7,8,9,10,11,12-Hexahydro-3,8,12-trioxopyrano[2,3-f]quinolin[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 K₂CO₃ (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=O & C12 >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=O & C12 >C=O), 1655, 1610, 1500, 1453, 1423 cm⁻¹. ¹H NMR (CDCl₃): δ 2.10 (p, 2H, C₁₀ >CH₂), 2.50 (s, 3H, -CH₃), 2.80 (t, 2H, C₇ >CH₂), 5.30 (t, 2H, C₁₁ >CH₂), 6.42 (d, J= 9.50Hz, 1H, C₂-H), 7.80 (s, 1H, C₆-H), 8.05 (d, J= 9.50Hz, 1H, C₇-H), 10.60 (s, 1H, -NH, D₂O exchangeable); ¹³C NMR: δ 18.00 (-CH₂), 20.02 (C₉ >CH₂), 30.11 (C₁₀ >CH₂), 35.00 (C₁₁ >CH₂), 116.20 (C₁₃), 143.44 (C₁₂), 148.25 (C₁₉), 153.79 (C₁₄), 161.00 (C₁ >C=O), 166.00 (C₁₂ >C=O), 168.02 (C₁₃ >C=O), 200.00 (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 (C₁ >C=O & C₁₂ >C=O), 1650, 1603, 1505, 1452, 1420 cm⁻¹.

4d: Molecular formula C_{20}H_{15}NO_{6}, mp >250°C, yield 66%; IR (KBr): 3442 (-NH), 3058, 1724 (C₁ >C=O & C₁₂ >C=O), 1652, 1605, 1505, 1453, 1420 cm⁻¹.

3H, 13H-7,8-Dihydro-3,8,13-trioxopyrano[2,3-f]quinoline[3,4-b]-[1]-benzofuran 5a-d. To a solution of 2a-d (0.01 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 with dilute sodium hydroxide and then with water, dried and later recrystallised from benzene.

5a: Molecular formula C_{10}H_{10}NO_{5}, mp 220°C, yield 74%; IR (KBr): 3445 (-NH), 2955, 1723 (C₁ >C=O & C₁₃ >C=O), 1652 (C₈ >C=O), 1610, 1529, 1457 cm⁻¹.

5b: Molecular formula C_{10}H_{10}NO_{5}, mp 237°C, yield 65%; IR (KBr): 3450 (-NH), 2950, 1725 (C₁ >C=O & C₁₃ >C=O), 1650 (C₈ >C=O), 1600, 1525, 1450 cm⁻¹. ¹H NMR (CDCl₃): δ 2.50 (s, 3H, -CH₃), 6.35 (d, J= 9.50Hz, 1H, C₂-H), 6.95 (t, 1H, C₁₀-H), 7.02 (d, J= 7.80Hz, 1H, C₁₁-H), 7.80 (s, 1H, C₇-H), 7.40 (d, J= 7.80Hz, 1H, C₁₂-H), 7.55 (t, 1H, C₁₁-H), 7.95 (d, J= 9.50Hz, 1H, C₁-H), 10.40 (s, 1H, -NH, D₂O exchangeable); ¹³C NMR: δ 18.50 (-CH₃), 101.20 (C₁₁), 116.00 (C₁₉), 120.00 (C₈ >C=O), 128.10 (C₁₃), 134.50 (C₁₂), 143.25 (C₁₅), 148.01 (C₁₂), 148.25 (C₁₉), 153.84 (C₂₄), 160.00 (C₁₃), 161.25 (C₁ >C=O), 166.07 (C₁₂ >C=O), 168.02 (C₈ >C=O), 118.00 -138.00 (8Ar-C); Mass (m/z) (%): M⁺ 385 (83), 357 (78), 329 (62), 301 (100), 273 (22).

5c: Molecular formula C_{21}H_{13}NO₂, mp 246°C, yield 63%; IR (KBr): 3441 (-NH), 3051, 1724 (C₁ >C=O & C₁₄ >C=O), 1651 (C₈ >C=O), 1551, 1496, 1451 cm⁻¹.

5d: Molecular formula C_{21}H_{13}NO₂, mp >250°C, yield 59%; IR (KBr): 3440 (-NH), 3053, 1721 (C₁ >C=O & C₁₄ >C=O), 1653 (C₈ >C=O), 1550, 1497, 1450 cm⁻¹.

Spiro-[3H-indole-(1H,2H),-3,9-((3H,7H,8H)-dipyranoyl[2,3-f: 2,3-c]quinoline)-11-amino-10-cyano-
2,3,8-trione 7a-d. A mixture of indole-2,3-dione (0.56 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_{32}H_{13}N_{4}O_{5}, mp 233°C, yield 76%; IR (KBr): 3339 (-NH & -NH$_2$), 1620, 1550, 1462, 1382 cm$^{-1}$.

7b: Molecular formula C_{24}H_{12}N_{4}O_{5}, mp 243°C, yield 73%; IR (KBr): 3337 (-NH & -NH$_2$), 2211 (-CN), 1719 (C$_1$ >C=O), 1710 (indole >C=O & -NH-CO), 1623, 1552, 1467, 1383 cm$^{-1}$; $^1$H NMR (DMSO-$d_6$) $\delta$ 2.35 (s, 3H, -CH$_3$), 4.00 (s, spiro C-atom), 11.00 (C$_{2a}$), 116.20 (C$_3$), 118.00 (-CN), 143.50 (C$_1$), 148.12 (C$_{6a}$), 153.90 (C$_{2a}$), 158.30 (C$_{12a}$), 161.00 (C$_1$ >C=O), 167.20 (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$_{18}$H$_{10}$N$_4$O$_5$, mp >250°C, yield 65%; IR (KBr): 3335 (-NH & -NH$_2$), 2214 (-CN), 1722 (C$_3$ >C=O), 1713 (indole >C=O & -NH-CO$_2$), 1624, 1553, 1466, 1381 cm$^{-1}$.

7d: Molecular formula C$_{18}$H$_{10}$N$_4$O$_5$, mp >250°C, yield 60%; IR (KBr): 3336 (-NH & -NH$_2$), 2213 (-CN), 1723 (C$_3$ >C=O), 1711 (indole >C=O & -NH-CO$_2$), 1625, 1557, 1463, 1382 cm$^{-1}$.

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References

3. Hardman G E, [Sandoz Ltd.], US Pat, 4, 109, 659, (Cl 424258; A61K3147); Chem Abstr, 93, 1990, 95134d.