Novel isocoumarin and isoquinoline derivatives

Mahmoud R. Mahmoud[a], Manal M. El-Shahawi[a]*, and Samira E. Farahat[b]

[a]*Chemistry Department, Faculty of Science, Ain Shams University, Abbassia 11 566, Cairo, Egypt*

[b]*7th of April University, Gharian, Libya*

A number of novel isoquinoline-1,3-dione derivatives have been synthesised using the readily obtainable anhydride formed from the Stobbe-type condensation of diethyl homophthalate with *p*-anisaldehyde. Primary amines form amides at the C-1 carbonyl group; recyclisation gives 4-(4-methoxybenzylidene)isoquinoline-1,3-diones.

Keywords: isocoumarins, isoquinolinediones, 2-benzopyran-1,3-diones, fused 1,2,4,5-tetrazines, 2-thiouracils

In a recent paper[1] we described the synthesis of the anhydride **1** starting from dimethyl homophthalate. Here we report on the products formed by opening of the pyrandione ring, in many cases followed by recyclisation to form isoquinoline-derived products.

Results and discussion

When the anhydride **1** was treated with primary amines such as cyclohexylamine, benzylamine, *p*-toluidine, 2-aminobenzonitrile, and 3-amino-5-methylpyrazole in refluxing ethanol, ring-opening afforded the homophthalamic acid derivatives **2a–e** rather than the isomeric products **3** (Scheme 1) This could be interpreted on the basis that interaction of the primary amines with the isocoumarin derivative **1** takes place on the benzoyl carbonyl function rather than cinnamoyl carbonyl, firstly because the benzoyl carbonyl is sterically more accessible, and secondly, that the electrophilicity of the benzoyl carbonyl function is greater than that of the cinnamoyl moiety.

Attempted cyclisation of the compounds **2a–c** using freshly distilled acetic anhydride afforded the isoquinoline derivatives **4a–c**, while in the presence of a mixture of acetic anhydride and perchloric acid at 0ºC under the conditions described by Boyd *et al.*[2-4] it yielded the homophthalisoimidium perchlorates **5a–c**. When the isoimidium salts **5a–c** were allowed to react with benzene or toluene in the presence of anhydrous aluminium chloride under Friedel-Crafts reaction conditions, they yielded the aromatic ketones **6a–c**. Compound **5a** upon treatment with benzylamine in refluxing pyridine afforded 2-[2'-(*N*-cyclohexylcarbonyl)phenyl]-*N*-benzyl-4-methoxycinnamide **7**. Furthermore, the reaction of **5a** with malononitrile gave the isoquinoline derivative **8** (Scheme 1).

Reaction of the anhydride **1** with 6-aminothiouracil in boiling pyridine yielded a product insoluble in hot pyridine which was identified as 6-[(4-methoxybenzylidene)amino] thiouracil **9**; a fraction soluble in pyridine afforded **10** upon acidification. (Scheme 2) Treatment of **10** with acetic anhydride gave the isoquinoline derivative **11**, which upon hydrazinolysis yielded the sulfur-free compound **12**.

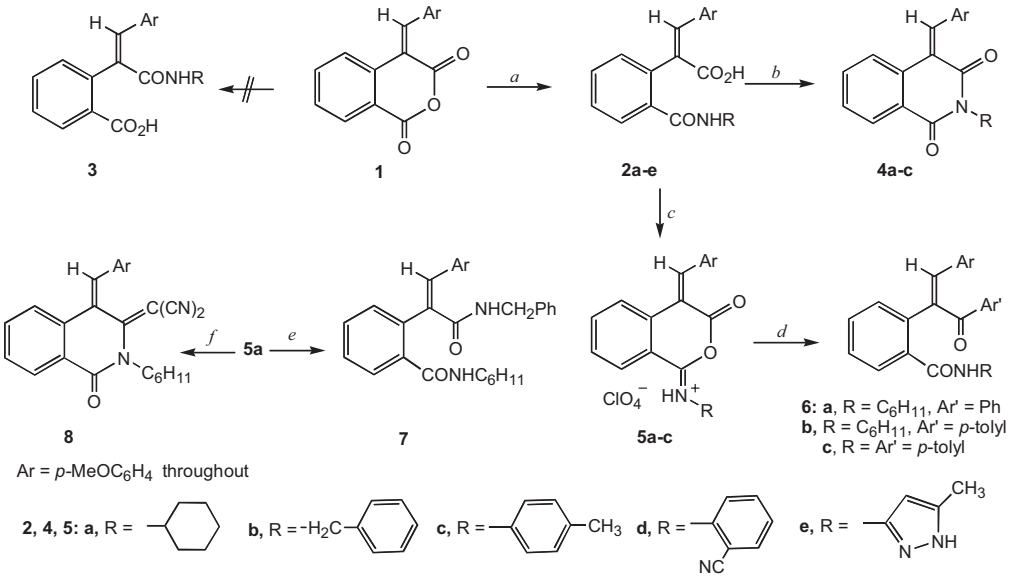
Reaction of isocoumarin derivative **1** in refluxing ethanol with the hydrazine derivative ethyl carbazate afforded the isoquinolinedione **13**, which with hydrazine in pyridine yielded the [1,2,4,5]tetrazino[2,3-*a*]isoquinoline derivative **14**. Finally, when treated with anhydrous aluminium chloride in acetylene tetrachloride under Friedel-Crafts reaction conditions compound **1** yielded the indenone derivative **15** along with the neutral keto-lactone **16**, which has been reported earlier[1] (Scheme 2).

Experimental

Equipment and settings were as reported in our earlier paper,[1] where the synthesis of the anhydride **1** is also described.

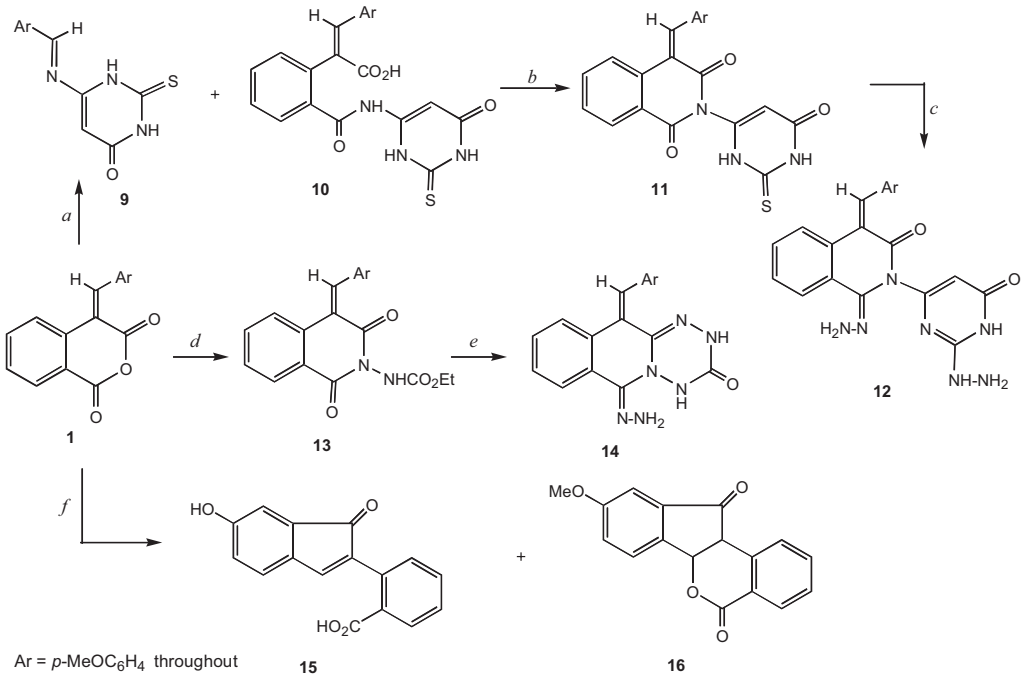
Synthesis of 2-(2-carbamoylphenyl)cinnamic acids **2a–e**. *General procedure*

A mixture of compound **1** (1.12 g, 4 mmol) and cyclohexylamine, benzylamine, *p*-toluidine or 3-amino-5-methylpyrazole (4 mmol) in absolute ethanol (20 ml) was heated under reflux for 3 h (TLC).



Scheme 1 *Reagents: a,* RNH_2/EtOH; *b*, Ac_2O; *c*, Ac_2O, $HClO_4$, 0°C; *d*, Ar'H/$AlCl_3$; *e*, $PhCH_2NH_2$/pyridine; *f*, $CH_2(CN)_2$

* Correspondent. E-mail: elshahawi31@yahoo.com



Scheme 2 *Reagents: a,* 6-amino-2-thiouracil/py; *b*, Ac_2O; *c*, $N_2H_4.H_2O$; *d*, $H_2N.NHCO_2Et$; *e*, $N_2H_4.H_2O$/py; *f*, $AlCl_3/C_2H_2Cl_4$

The solid deposited was in each case filtered off, dried and recrystallised from the indicated solvent to give **2a–e**. For the reaction with 2-aminobenzonitrile (0.47 g, 4 mmol), heating was continued for 6 h in n-butanol (20 ml), and the product was isolated at the end of the reaction by extraction into ether.

N-Cyclohexyl amide **2a**: **S**eparated from the hot solvent as white crystals (82%) (methanol), m.p. 235°C. IR: ν_{max} 3412 (OH, NH), 1706, 1642 cm^{-1} (C=O). NMR (DMSO-d_6): δ_H 12.7 (s, 1H, CO_2H), 8.0 (d, 1H, NH), 7.9–6.7 (m, 9Harom., =CH), 3.68 (s, 3H, OMe), 1.7–1.08 (two m, 11H, C_6H_{11}). MS: *m/z* (%) 380 (M + 1, 13.9), 379 (M^+, 8.9), 278 (36), 235 (21), 165 (19), 121 (100). Anal. Calcd. for $C_{23}H_{25}NO_4$ (379.46): C, 72.80; H, 6.64; N, 3.69. Found: C, 73.09; H, 6.53; N, 4.0%.

N-Benzyl amide **2b**: Product separated after cooling and slow evaporation; colourless crystals (76%) (benzene–ethanol), m.p. 150–151°C. IR: ν_{max} 3425br (OH, NH), 1690, 1656 cm^{-1} (C=O). NMR (DMSO-d_6): δ_H 12.5 (s, 1H, CO_2H), 8.1 (s, 1H, NH), 8.3–6.7 (m, 14H, arom., =CH), 4.4 (t, 2H, CH_2Ph), 3.85 (s, 3H, OMe). MS: *m/z* (%) 387 ($M^{+\cdot}$, 23.5), 280 (71.5), 235 (18.4), 165 (50),121 (45), 118 (20), 91 (100). Anal. Calcd. for $C_{24}H_{21}NO_4$ (387.44): C, 74.40; H, 5.46; N, 3.62. Found: C, 74.57; H, 5.06; N, 3.33%.

N-(4-Methylphenyl) amide **2c:** Separated after cooling and slow evaporation as white crystals (81%) (methanol), m.p. 195–196°C. IR: ν_{max} 3402 (OH, NH), 1715, 1654 cm^{-1} (C=O). NMR (DMSO-d_6): δ_H 12.8 (br. s, 1H, CO_2H), 9.6 (s, 1H, NH), 8.09–7.1 (m, 12H arom), 6.7 (s, 1H, =CH), 3.74 (s, 3H, OMe), 2.9 (s, 3H, Me-Ar). MS: *m/z* (%) 387 (M^+, 7.3), 280 (20), 235 (27), 165 (32), 107 (100). Anal. Calcd. for $C_{24}H_{21}NO_4$ (387.44): C, 74.40; H, 5.46; N, 3.62. Found: C, 74.28; H, 5.26; N, 3.76%.

N-(2-Cyanophenyl) amide **2d:** Separated after cooling and slow evaporation as a brown oil (72%). IR: ν_{max} 3469, 3371, 3230 (OH, NH), 2215 (C≡N), 1702, 1668 cm^{-1} (C=O). MS: *m/z* (%) 354 (M^+-CO_2), 298 (23), 253 (40), 235 (48), 165 (48), 121 (100).

N-(5-Methylpyrazol-3-yl) amide **2e:** Separated after cooling and slow evaporation as pale pink crystals (64%) (benzene–ethanol), m.p. 200–201°C. IR: ν_{max} 3279 (OH, NH), 1704, 1679 cm^{-1} (C=O). NMR (DMSO-d_6): δ_H 12.3 (br s, 1H, CO_2H), 10.3 (s, 1H, NH), 7.9 (s, 1H, NH), 7.5-7.3 (m, 9Harom, =CH), 6.2 (s, 1H, C_4-H pyrazole), 4.07 (s, 3H, OMe), 2.2 (s, 3H, Me). MS: *m/z* (%) 377 ($M^{+\cdot}$, 18), 333 (44), 256 (100), 165 (21), 121 (49). Anal. Calcd. for $C_{21}H_{19}N_3O_4$ (377.40): C, 66.83; H, 5.07; N, 11.13. Found: C, 66.51; H, 4.83; N, 10.88%.

4-Methoxybenzylideneisoquinoline-1,3(4H)-diones **4a–c**.
General procedure

The amides **2a–c** (3 mmole) was heated under reflux for two hours in freshly distilled acetic anhydride (5 ml), monitoring the progress by TLC. The reaction mixture was allowed to cool, then poured into ice-cold water and stirred for 30 min.. The solid obtained was filtered off, washed several times with water, dried and recrystallised from the indicated solvent to give **4a** and **4c**. In the case of **4b** an oil separated and was extracted (Et_2O), dried, and purified by chromatography on alumina, eluting with CH_2Cl_2.

2-Cyclohexyl compound **4a:** Orange crystals (89%) (benzene), m.p. 120–121°C. IR: ν_{max} 1765, 1731 cm^{-1} (C=O). NMR ($CDCl_3$): δ_H 7.95–6.94 (m, 9Harom, =CH), 3.87 (s, 3H, OMe), 2.03–0.85 (m, 11H, C_6H_{11}). MS: *m/z* (%) 361 (M^+, 27), 280 (100), 279 (24), 278 (31), 193 (30), 165 (88), 104 (16). Anal. Calcd. for $C_{23}H_{23}NO_3$ (361.44): C, 76.43; H, 6.14; N, 3.88. Found: C, 76.64; H, 6.23; N, 4.0%.

2-Benzyl compound **4b:** Yellow oil (76%). IR: 1773, 1701 cm^{-1} (C=O). MS: *m/z* (%) 369 (M^+, 88), 368 (28), 324 (6.3), 165 (43), 91 (100).

2-p-Tolyl compound **4c:** Yellow crystals (87%) (light petroleum ether 60–80°C), m.p. 91–92°C. IR: ν_{max} 1774, 1707 cm^{-1} (C=O). NMR ($CDCl_3$): δ_H 8.26–7.2 (m, 12Harom), 6.8 (s, 1H, =CH), 3.86 (s, 3H, OMe), 2.4 (s, 3H, CH_3-Ar). MS: *m/z* (%) 369 (M^+, 88), 368 (100), 324 (21), 165 (22), 91 (12.4). Anal. Calcd. for $C_{24}H_{19}NO_3$ (369.42): C, 78.08; H, 5.18; N, 3.73. Found: C, 78.35; H, 5.44; N, 4.0%.

N-Aryl(alkyl)-4-methoxybenzylidenehomophthalisoimidium perchlorates **5a–c**. *General procedure*

Compounds **2a–c** (3 mmol) were suspended in freshly distilled acetic anhydride (5 ml) containing 3–4 drops of perchloric acid (70%) and the mixture was stirred at room temperature for a few minutes until the suspension cleared and orange crystals began to be formed. Stirring was continued while cooling the solution in an ice bath. The deposited crystals were filtered off and washed with dry ether to give **5a–c**.

N-Cyclohexyliminium salt **5a**: M.p. 111–112°C (yield 95%). IR: ν_{max} 3412br (N^+H), 1792 (C=O), 1646 cm^{-1} (C=N). MS: *m/z* (%) 361 (M^+-$HClO_4$, 26.3), 360 (37.4), 277 (87), 235 (23), 234 (33.5), 164 (73), 165 (46), 121 (100), 120 (39).

N-Benzyliminium salt **5b**: M.p. 174–175°C (yield 98%). IR: ν_{max} 3421br (N^+H), 1791 (C=O), 1659 cm^{-1} (C=N). MS: *m/z* (%) 369 (M^+-$HClO_4$, 100), 324 (9.5), 265 (10.4), 209 (8.5), 165 (29.1), 106 (7.5), 91 (48.7), 77 (18.3).

N-(4-Methylphenyl)iminium salt **5c**: M.p. 249–250°C (yield 97%). IR: ν_{max} 3446br (N^+H), 1791 (C=O), 1639 cm^{-1} (C=N). MS: *m/z* (%) 367 (M^+-$HClO_4$-2, 100), 24 (26), 268 (14), 133 (11).

2-[1'-Aryl-3'-(4-methoxyphenyl)-1'-oxoprop-2'-enyl]benzamides **6a-c**. *General procedure*

A mixture of the isoimidium perchlorate **5a** or **5c** (2 mmol) and anhydrous aluminium chloride (2 g, 0.015 mol) was stirred at room temperature for 5 h (TLC) in dry aromatic hydrocarbon (benzene or toluene) (20 ml). The reaction mixture was treated with iced

hydrochloric acid and the excess of solvent was removed by steam distillation. The solid obtained in each case was filtered off, dried and recrystallised from a suitable solvent to give **6a–c**.

N-Cyclohexyl-1'-phenyl amide **6a:** Brown crystals (61%), from light petroleum ether (80–100°C), m.p. 120–121°C. IR: ν_{max} 3422–3145w (NH), 1711, 1700 cm^{-1} (C=O). NMR ($CDCl_3$): δ_H 8.3 (s, 1H, NH), 8–7.2 (m, 13Harom), 6.6 (s, 1H, =CH), 3.8(s, 3H, OMe), 1.8–0.9 (m, 11H, C_6H_{11}). MS: *m/z* (%) 313 [M^+–R-NHCO] (4.9), 197 (5.7), 165 (7.6), 121 (100), 107 (23), 77 (16). Anal**.** Calcd. for $C_{29}H_{29}NO_3$ (439.56): C, 79.24; H, 6.65; N, 3.19. Found: C, 78.95; H, 6.38; N, 3.10%.

N-Cyclohexyl-1'-p-tolyl amide **6b:** Yellow crystals (65%) from benzene, m.p. 70–72°C. IR: ν_{max} 3166br (NH), 1716, 1698 cm^{-1} (C=O). MS: *m/z* (%) 327 (M^+-RNHCO, 100), 211 (82), 196 (18), 165 (32), 121 (86), 107 (69). Anal**.** Calcd for $C_{30}H_{31}NO_3$ (453.58): C, 79.44; H, 6.87; N, 3.09. Found: C, 79.13; H, 6.61; N, 2.99%.

N,1'-di-p-tolyl amide **6c:** Yellow crystals (57%) from benzene, m.p. 150–151°C. IR: ν_{max} 3420 (NH), 1742, 1674 cm^{-1} (C=O). NMR ($CDCl_3$): δ_H 8.6 (s, 1H, NH), 8–7.2 (m, 16Harom), 6.7 (s, 1H, =CH), 3.83 (s, 3H, OMe), 2.1 (s, 6H, $2CH_3$-Ar). MS: *m/z* (%) 461 (M^+, 13), 429 (48), 337 (100), 260 (55), 251 (14), 164 (38.5), 118 (52.5). Anal. Calcd. for $C_{31}H_{27}NO_3$ (461.56): C, 80.67; H, 5.90; N, 3.03. Found: C, 80.44; H, 6.67; N, 3.11%.

2-[2-(N'-cyclohexylaminocarbonyl)phenyl)]-N-benzyl-4-methoxy-cinnamide (**7**)

Compound **5a** (1 g, 2 mmol) and benzylamine (0.2 g, 2 mmol) in pyridine (15 ml) were stirred at room temperature for 3 h (TLC), and then left to stand overnight. The reaction mixture was poured onto ice-cold hydrochloric acid, the yellow solid deposited was filtered off, dried and recrystallised (light petroleum ether 60–80°C) to give **7** as yellow crystals (76%), m.p. 70–72°C. IR: ν_{max} 3266, 3417 (NH), 1687, 1648 cm^{-1} (C=O). NMR ($CDCl_3$): δ_H 8.4 (br s, 2H), 7.9–7 (m, 13Harom), 6.7 (s, 1H, =CH), 5.5 (d, 2H, CH_2Ph), 3.86 (s, 3H, OMe), 1.9–1.1 (m, 11H, C_6H_{11}). MS: *m/z* (%) 469 (M + 1, 11), 342 (80.5), 234 (4), 91 (100). Anal. Calcd. for $C_{30}H_{32}N_2O_3$ (468.60): C, 76.90; H, 6.88; N, 5.98. Found: C, 77.12; H, 6.56; N, 6.18%.

2-Cyclohexyl-3-dicyanomethylene-3,4-dihydro-4-(4-methoxybenzylidene) isoquinolin-2(1H)-one (**8**)

Compound **5a** (1 g, 2 mmol) and malononitrile (0.14 ml, 2 mmol) in pyridine (15 ml) were stirred at room temperature for 3 h (TLC), and then left overnight. The reaction mixture was poured into ice-cold hydrochloric acid, and the pink solid obtained was filtered off, dried and recrystallised (benzene) to give **8** as pink crystals 50%), m.p. 80–81°C. IR: ν_{max} 2219 (C≡N), 1704 cm^{-1} (C=O). NMR ($CDCl_3$): δ_H7.8–7 (m, 9Harom + =CH), 3.8 (s, 3H, OMe), 1.87–1.1 (m, 11H, C_6H_{11}). MS: *m/z* (%) 302 (9), 261 (42), 238 (11.5). Anal. Calcd. for $C_{26}H_{23}N_3O_2$ (409.49): C, 76.26; H, 5.66; N, 10.26. Found: C, 76.45; H, 5.36; N, 9.96%.

Reaction of anhydride **1** *with 6-amino-2-thiouracil*

Compound **1** (1 g, 4 mmol) and 6-aminothiouracil (0.5 g, 4 mmol) were heated under reflux in pyridine (15 ml) for 6 h (TLC). The white solid (**9**) which separated while hot was separated by filtration. The rest of the reaction mixture in pyridine was acidified with cold dilute hydrochloric acid to precipitate **10** as a buff solid.

6-(4-Methoxybenzylideneamino)-2-thiouracil (**9**): Colourless crystals (20%) from dioxan, m.p. 261°C. IR: ν_{max} 3392, 3282, 3154 (NH), 1652 cm^{-1} (C=O). NMR (DMSO-d_6): δ_H 12.4 (s, 1H, NH), 11.2 (s, 1H, NH), 9.1 (s, 1H, N=CH), 8.1–7 (m, 4Harom), 6.1 (s, 1H, C_5-H), 3.9 (s, 3H, OMe). MS: *m/z* (%) 261 (M^+, 12), 260 [$(M-1)^+$, 23], 143 (96). Anal. Calcd. for $C_{12}H_{11}N_3O_2S$ (261.30): C, 55.16; H, 4.24; N, 16.08; S,12.27. Found: C, 55.41; H, 4.08; N, 15.83; S, 11.93%.

Acid amide **10:** Buff crystals (55%) (ethanol), m.p. 245–246°C. IR: ν_{max} 3400, 3181 (NH), 1705, 1689 cm^{-1} (C=O). MS: *m/z* (%) 421 [$(M-2)^+$, 9], 403 (100), 248 (6.6). Anal. Calcd. for $C_{21}H_{17}N_3O_5S$ (423.45): C, 59.57; H, 4.05; N, 9.92; S, 7.57. Found: C, 59.28; H, 3.92; N, 10.16; S, 7.71%.

4-(4-Methoxybenzylidene)-2-(4-oxo-2-thioxo-1,2,3,6-tetrahydro-pyrimidin-4-yl)-isoquinoline-1,3(4H)-dione (**11**)

Compound **10** (1 g, 2 mmol) was heated under reflux for 2 h in freshly distilled acetic anhydride (1 ml). The reaction mixture was allowed to cool and poured into ice-cold water to give a brown solid, which was collected by filtration, dried and recrystallised to give **11** as light brown crystals (85%) (dioxan), m.p. 255–256°C. IR: ν_{max} 3391, 3159 (NH), 1743, 1717 cm^{-1} (C=O). NMR (DMSO-d_6): δ_H 12.03 (s, 1H, NH), 11.1 (s, 1H, NH), 8.4-6.9 (m, 9Harom + =CH), 5.9 (s, 1H, pyrimidine C_5-H), 3.9 (s, 3H, OMe). MS: *m/z* (%) 405 (M^+, 7.8), 404 (14), 143 (100). Anal. Calcd. for $C_{21}H_{15}N_3O_4S$ (405.44): C, 62.21; H, 3.73; N, 10.36; S, 7.91. Found: C, 62.52; H, 3.95; N, 10.08; S, 7.76%

2-(2-Hydrazino-6-oxo-1,6-dihydropyrimidin-4-yl)-1-hydrazono-4-(p-methoxybenzylidene)isoquinolin-3(2H)-one (**12**)

Compound **11** (1 g, 2.5 mmol) and hydrazine hydrate (0.12 ml, 2.5 mmol) were refluxed for 3 h in pyridine (15 ml) (TLC). After cooling the reaction mixture was acidified with ice-cold hydrochloric acid, and the brown solid deposited was filtered off and recrystallised to give **12** as light brown crystals (89%) (methanol), m.p. 255–257°C. IR: ν_{max} 3185, 3065, 2927 (NH), 1700, 1650 cm^{-1} (C=O). MS: *m/z* (%) 417 (M^+, 44), 402 (86), 401 (57), 143 (100). Anal. Calcd. for $C_{21}H_{19}N_7O_3$ (417.43): C, 60.43; H, 4.59; N, 23.49. Found: C, 60.67; H, 4.40; N, 23.10%.

2-Ethoxycarbonylamino-4-(4-methoxybenzylidene)isoquinoline-1,3(4H)-dione (**13**)

The anhydride **1** (1 g, 4 mmol) and ethyl carbazate (0.37 g, 4 mmol) were refluxed in ethanol (20 ml) for two hours (TLC). The solution was then allowed to evaporate slowly. A white solid obtained was filtered off, dried and recrystallised to give **13** as colourless crystals (70%) (ethanol/benzene), m.p. 170–171°C. IR: ν_{max} 3395, 3306 (NH), 1745, 1695 cm^{-1} (C=O). NMR (DMSO-d_6): δ_H 9.2 (s, 1H, NH), 8.0–6.7 (m, 9H, arom., =CH), 4.05 (q, 2H, $OC\underline{H}_2CH_3$), 3.98 (s, 3H, Ar-OMe) and 1.18 (t, 3H, $OCH_2C\underline{H}_3$). MS: *m/z* (%) 366 (M^+, 54), 365 [$(M-1)^+$, 60], 294 (64), 279 (57), 236 (32), 165 (75). Anal. Calcd. for $C_{20}H_{18}N_2O_5$ (366.38): C, 65.57; H, 4.95; N, 7.65. Found: C, 65.71; H, 5.05; N, 7.34%.

6-Hydrazono-11-(4-methoxybenzylidene)-6,11-dihydro-2H-[1,2,4,5] tetrazino[2,3-b]isoquinolin-3(4H)-one (**14**)

The isoquinolinedione **13** (1 g, 3 mmol) in pyridine (15 ml) was heated under reflux with hydrazine hydrate (0.14 ml, 3 mmol) for 2 h (TLC). The cooled mixture was triturated with ice-cold hydrochloric acid to give a deep brown solid, which was filtered off, dried and recrystallised (benzene) to give the fused tetrazine **14** as brown crystals (54%), m.p. 78–80°C. IR: ν_{max} 3419, 3395 (NH), 1701 cm^{-1} (C=O). MS: *m/z* (%) 348 (M^+, 7.7), 347 (26), 91 (100). Anal. Calcd. for $C_{18}H_{16}N_6O_2$ (348.37): C, 62.06; H, 4.63; N, 24.12, Found: C, 61.84; H, 4.32; N, 23.87%.

6-Hydroxy-1-oxo-1H-inden-2-yl)benzoic acid (**15**) *and 4b,10b-dihydro-2-methoxyindeno[1,2-c][2]benzopyran-6,11-dione* (**16**) *by internal Friedel–Crafts reaction*

The anhydride **1** (1 g, 4 mmol) and anhydrous aluminium chloride (1.5 g, 0.01 mole) in acetylene tetrachloride (20 ml) were stirred for 6 h. at room temperature, and then the mixture was heated on a water bath for another two hours (TLC). The reaction mixture was cooled and treated with cold dilute hydrochloric acid to give two products. The product soluble in acetylene tetrachloride was separated by steam distillation, recrystallised to give the keto-lactone[1] **16** (14%). The fraction which was precipitated and insoluble in acetylene tetrachloride was collected by filtration, dried and recrystallised from ethanol to give the acid **15** as grey crystals (57%), m.p. 291–292°C. IR: ν_{max} 3394 (OH), 1715 (C=O acid), 1681 cm^{-1} (C=O ketone). NMR (DMSO-d_6): δ_H 11.4 (s, 1H, COOH), 8.7–8 (m, 7H arom), 5.9 (s, 1H), 4.1 (br s, 1H, OH). MS: *m/z* (%) 266 (M^+, 91), 238 (100), 165 (73). Anal. Calcd. for $C_{16}H_{10}O_4$ (266.26): C, 72.18; H, 3.79. Found: C, 71.86; H, 3.66%.

Received 17 July 2007; accepted 22 February 2008
Paper 06/4750A doi: 10.3184/030823408X296212

References

1 M.R. Mahmoud, M.M. El-Shahawi and S.E. Farahat, *J. Chem. Res*., 2008, 59.
2 G.V. Boyd and R.L. Monteil, *J. Chem. Soc. Perkin Trans. 1*, 1978, 1338.
3 A.E. Baydar and G.V. Boyd, *J. Chem. Soc. Perkin Trans. 1*, 1981, 2871.
4 A.E. Baydar and G.V. Boyd, *J. Chem. Soc. Perkin Trans. 1*, 1987, 1360.