Novel Synthesis of Oxadiaza Heterocycles and Thiadiazocine Derivatives†

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Nasr K. Mohamed

Department of Chemistry, Faculty of Science, Minia University 61519, El-Minia, Egypt

Ethyl 3-benzoyldithiocarbazate **1** and ethyl dithiocarbazate **2** react with different π-acceptors to give the title products.

Dithiocarboxylic acids and esters have attracted increasing attention in recent years because of intrinsic interest in their structures and in their wide application in organic synthesis[1–5] and industry.[4–6] Recently we have reacted some sulfur compounds with π-acceptors in order to synthesize new heterocyclic compounds.[7–11] Work has also been reported[12] on the reaction of methyl dithiocarbazate and its azomethine derivatives with 2,3-dichloro-5,6-dicyano-1,4-benzoquinone (DDQ) and tetracyanoethylene (TCNE) to give bisazines and 1,2,4-thiadiazoles as well as pyridazine derivatives.[13]

The present investigation was undertaken to study the effect of the benzoyl group in ethyl 3-benzoyldithiocarbazate **1**, in terms of its behaviour compared with ethyl dithiocarbazate **2** towards some π-acceptors such as TCNE, 2,3-dicyano-1,4-naphthoquinone (DCNQ), 2-dicyanomethylideneindane-1,3-dione (CNIND), 2,3-dichloro-1,4-naphthoquinone (DCHNQ) and 3,4,5,6-tetrachloro-1,2-benzoquinone (CHL-*o*), with the aim of highlighting methods for the preparation of new heterocyclic compounds.

Mixing the ester **1** with 2 mol quiv. of TCNE in ethyl acetate gave a green colouration which changed into a brown precipitate. This behaviour may be explained by an initial formation of an unstable charge-transfer complex followed by a chemical reaction. Elimination of a molecule of H_2S from **1** furnished 2-ethylsulfanyl-5-phenyl-1,3,4-oxadiazole **3**. Dimerization of **1** in the presence of TCNE with elimination of a molecule of sulfur and another of malononitrile afforded 5-ethylsulfanyl-2-phenyl-6*H*-1,3,4-oxadiazine-6,6-dicarbonitrile **4**, which abstracted a molecule of water to give the amide derivative **5** (Scheme 1). Assignment of the structures of compounds **3–5** was based on their spectral data and combustion analysis (see Experimental section).

In a different and interesting manner, **1** reacted with CNIND to give indenooxadiazocine derivatives **11** (Scheme 2), while **2** formed an indenothiadiazepine **12** with the same acceptor. The structures proposed for **11** and **12** were confirmed by elemental and spectral analysis.

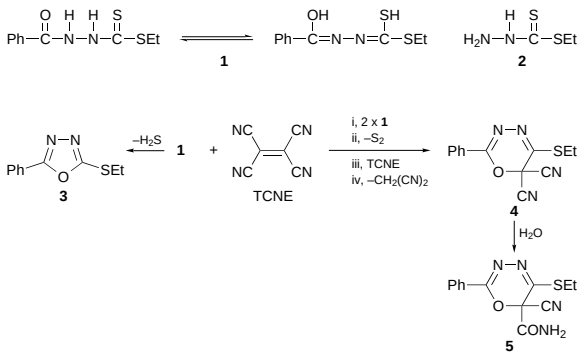
Treatment of **1** with DCNQ gave a dioxonaphthooxadiazepine derivative **14**, the structure of which was deduced on the basis of the IR, ^{1}H NMR and mass spectral data as well as by elemental analysis. The ^{13}C NMR spectrum showed two distinctive signals for the carbons in the oxadiazepine ring at 148.2 ppm for —*C*(SC_2H_5)=N and 160.3 ppm for O—*C*(Ph)=N. Similarly, **2** reacted with DCNQ to afford the benzindazole derivative **16** in high yield.

Compound **1** reacted with DCHNQ to give the 2-phenyl-5-ethylsulfanyl-1,6,3,4-oxathiadiazocine **17** (Scheme 3). In contrast, compound **1** reacted with CHL-*o* to afford compound **13**, which may be formed from **1** *via* disulfide formation and sulfur extraction followed by hydrogen abstraction (Scheme 3).

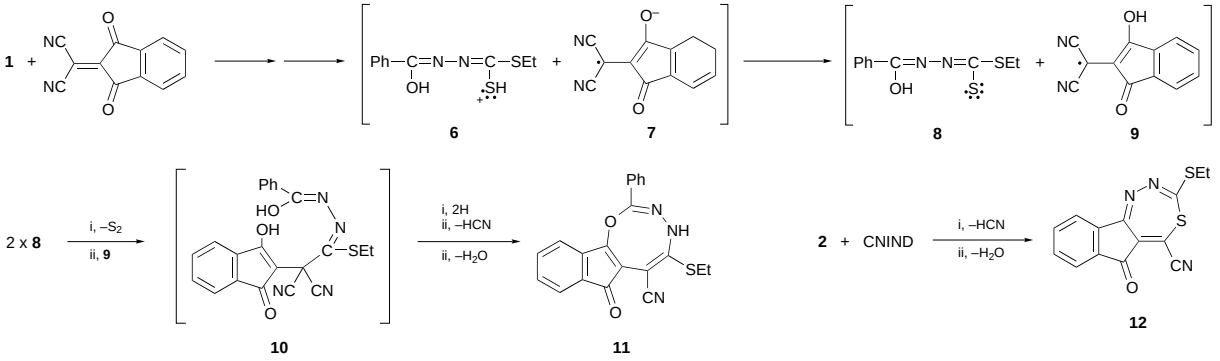
Experimental

Mps are uncorrected. IR spectra (KBr) were recorded using a Shimadzu 470 spectrophotometer. ^{1}H (100.6 MHz) and ^{13}C NMR spectra were measured on Brucker AM 400 (400 MHz) instruments using Me_4Si as internal standard. Mass spectra were recorded on a Finnigan MAT 8430 spectrometer at 70 eV. Elemental analyses were carried out by the Microanalytical Centre at Cairo University.

TCNE, DCNQ, DCHNQ and CHL-*o* were prepared and purified as reported before.[9] Ethyl dithiocarbazate and ethyl 3-benzoyldithiocarbazate were prepared according to literature procedures.[14,15]



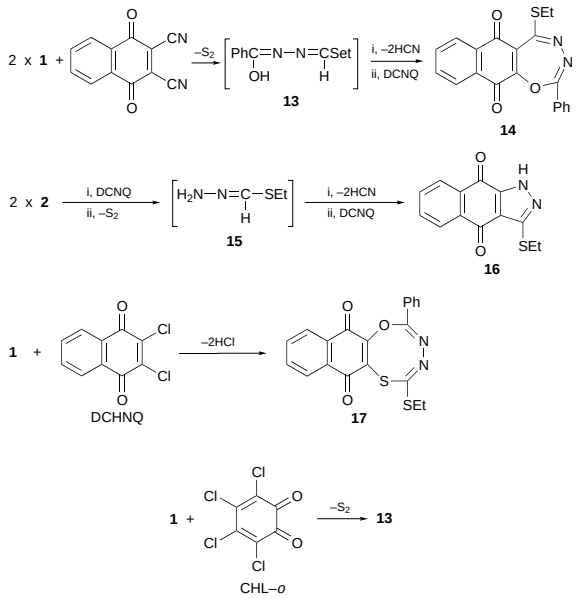
Scheme 1



Scheme 2

Reaction of Ethyl 3-Benzoyldithiocarbazate **1** *with TCNE*.—A solution of **1** (0.001 mol) in ethyl acetate (20 ml) was added to a solution of TCNE (256 mg, 0.002 mol) in the same solvent (10 ml), the reaction mixture was stirred at room temperature. The colour of the reaction mixture changed gradually during 2 h from green to

†This is a **Short Paper** as defined in the Instructions for Authors, Section 5.0 [see *J. Chem. Research (S)*, 1997, Issue 1]; there is therefore no corresponding material in *J. Chem. Research (M)*.



Scheme 3

brown. The reaction mixture was then allowed to stand for 48 h, after which a crystalline product was separated off, dried and recrystallized from a suitable solvent to give the oxadiazine derivative **4**. The filtrate was evaporated and the residue was chromatographed on preparative TLC using toluene–ethyl acetate (5:1 v/v) to give two zones, the fastest migrating one containing the oxadiazole **3** and the slowest zone containing the oxadiazine derivative **5**.

2-*Ethylsulfanyl*-5-*phenyl*-1,3,4-*oxadiazole* (**3**) (47 mg, 23%) had mp 325–327 °C, yellow crystals from ethanol; ν_{max}/cm^{-1} 2995–2840 (Ali-CH), 1630 (C═N); δ_H ([$^2H_6$]DMSO), 1.22 (t, 3 H, CH_3), 3.15 (q, 2 H, CH_2) and 7.42–7.85 (m, 5 H, Ar-H); δ_C ([$^2H_6$]DMSO), 15.1, 23.8, 127.5, 128.7, 130.2, 130.7, 135.4, 147.8 and 158.7; *m*/*z* 206 (M^+, 6%), 178 (100), 146 (12), 105 (80) and 77 (94) (Found: C, 58.37; H, 4.96; N, 13.66; S, 15.65. $C_{10}H_{10}N_2OS$ requires C, 58.23; H, 4.89; N, 13.58; S, 15.54%).

5-*Ethylsulfanyl*-2-*phenyl*-6H-1,3,4-*oxadiazine*-6,6-*dicarbonitrile* (**4**) (97 mg, 36%) had mp 180–182 °C, pale yellow crystals from ethanol; ν_{max}/cm^{-1} 2980–2850 (Ali-CH), 1635 (C═N) and 2220 (CN); δ_H ([$^2H_6$]DMSO), 1.25 (t, 3 H, CH_3), 3.10 (q, 2 H, CH_2) and 7.45–8.10 (m, 5 H, Ar-H); δ_C ([$^2H_6$]DMSO), 14.7, 30.6, 118.1, 118.4, 129.30, 130.5, 131.1, 141.5, 146.2, 152.8 and 168.2; *m*/*z* 270 (M^+, 20%), 256 (11), 178 (4), 118 (4), 105 (100), 77 (58) and 64 (10) (Found: C, 57.92; H, 3.81; N, 20.78; S, 11.95. $C_{13}H_{10}N_4OS$ requires C, 57.76; H, 3.73; N, 20.73; S, 11.86%).

6-*Cyano*-5-*ethylsulfanyl*-2-*phenyl*-6H-1,3,4-*oxadiazine*-6-*carboxamide* (**5**) (54 mg, 19%) had mp 310–312 °C, yellow crystals from ethanol; ν_{max}/cm^{-1} 3400–3300 (NH_2), 2990–2840 (Ali-CH), 2215 (CN), 1710 (CO) and 1630 (C═N); δ_H ([$^2H_6$]DMSO), 1.20 (t, 3 H, CH_3), 3.20 (q, 2 H, CH_2), 7.39–7.95 (m, 5 H, Ar-H) and 8.15 (s, br, 2 H, NH_2); *m*/*z* 288 (M^+, 6), 270 (38), 238 (26), 220 (4), 193 (22), 148 (16), 177 (36) and 43 (39) (Found: C, 54.29; H, 4.29; N, 19.60; S, 11.19. $C_{13}H_{12}N_4O_2S$ requires C, 54.16; H, 4.19; N, 19.43; S, 11.12%).

Reaction of Ethyl 3-*Benzoyldithiocarbazate* (**1**) *with DCHNQ, CNIND, CHL*-o *and DCNQ*.—A solution of **1** (0.001 mol) in dry ethyl acetate (15 ml) was added to a solution of each title acceptor (0.002 mol) in dry ethyl acetate (20 ml) and the reaction mixture was then set aside for 24 h, during which time crystals of the dioxonaphthooxathiadiazocine derivative **17**, cyanoindenooxadiazocine derivative **11**, hydrazonate derivative **13** and dioxonaphthooxadiazepine derivative **14** separated and were recrystallized.

5-*Ethylsulfanyl*-7-*oxo*-2-*phenyl*-4,7-*dihydroindeno*[2,3-g]-1,3,4-*oxadiazocine*-6-*carbonitrile* (**11**) (212 mg, 57%) had mp 285–287 °C, brown crystals from ethanol; ν_{max}/cm^{-1} 3400–3250 (NH), 2995–2850 (Ali-CH), 2210 (CN), 1710 (CO) and 1635 (C═N); δ_H ([$^2H_6$]DMSO) 1.22 (t, 3 H, CH_3), 3.30 (q, 2 H, CH_2), 7.40–8.35 (m, 9 H, Ar-H) and 10.15 (s, 1 H, NH oxadiazocine ring); δ_C ([$^2H_6$]DMSO), 14.8, 28.2, 112.2, 118.6, 126.6, 127.3, 128.7, 130.3, 131.2, 133.8, 134.8, 144.1, 153.8, 162.7 and 184.6; *m*/*z* 373 (M^+, 100), 353 (6), 252 (6), 234 (4)m, 125 (18) and 77 (36) (Found: C, 67.80; H, 3.82; N, 11.33; S, 8.69. $C_{21}H_{15}N_3O_2S$ requires C, 67.54; H, 4.05; N, 11.25; S, 8.59%).

S-*Ethyl*-N,N-*phenylhydroxydihydrazonate* (**13**) (87 mg, 42%), had mp 50–52 °C, colourless crystals from ethanol; ν_{max}/cm^{-1} 3490 (OH), 2990–2850 (Ali-CH), and 1630 (C═N); δ_H ([$^2H_6$]DMSO) 1.25 (t, 3 H, CH_3), 3.25 (q, 2 H, CH_2), 4.25 (s, 1 H, OH), 6.55 (s, 1 H, CH═N) and 7.42–7.90 (m, 5 H, Ar—CH); δ_C ([$^2H_6$]DMSO), 15.3, 28.1, 122.1, 127.8, 130.1, 133.2, 162.8 and 164.1; *m*/*z* 208 (M^+, 38), 179 (36), 145 (78), 105 (100) and 77 (98) (Found: C, 58.02; H, 5.69; N, 13.68; S, 15.51. $C_{10}H_{12}N_2OS$ requires C, 57.69; H, 5.81; N, 13.45; S, 15.39%).

5-*Ethylsulfanyl*-2-*phenylnaphtho*[2,3-f]-1,3,4-*oxadiazepine*-6,11-*dione* (**14**) (185 mg, 52%) had mp 230–232 °C, brown crystals from ethanol; ν_{max}/cm^{-1} 2995–2860 (Ali-CH), 1705 (CO) and 1625 (C═N); δ_H ([$^2H_6$]DMSO) 1.19 (t, 3 H, CH_3), 3.20 and (q, 2 H, CH_2), 7.15–8.10 (m, 9 H, Ar-H); δ_C ([$^2H_6$]DMSO), 15.5, 27.8, 117.8, 122.5, 126.9, 129.8, 130.1, 138.4, 138.9, 148.2, 160.3 and 184.6; *m*/*z* 362 (M^+, 100), 330 (18), 314 (45), 183 (15), 155 (48) and 77 (24) (Found: C, 66.31; H, 4.02; N, 7.81; S, 8.90. $C_{20}H_{14}N_2O_3S$ requires C, 66.29; H, 3.89; N, 7.73; S, 8.85%).

5-*Ethylsulfanyl*-2-*phenylnaphtho*[2,3-b]-1,6,3,4-*oxathiadiazocine*-7,12-*dione* (**17**) (248 mg, 63%) had mp 190–192 °C, colourless crystals from methanol; ν_{max}/cm^{-1} 2940–2850 (Ali-CH), 1705 (CO) and 1630 (C═N); δ_H ([$^2H_6$]DMSO) 1.18 (t, 3 H, CH_3), 3.15 (q, 2 H, CH_2) and 7.30–7.80 (m, 9 H, Ar-H); δ_C ([$^2H_6$]DMSO), 14.3, 27.8, 126.2, 127.8, 128.9, 130.2, 131.8, 133.7, 144.3, 152.3, 155.4, 165.2, 184.7 and 185.1; *m*/*z* 394 (M^+, 100), 291 (12), 188 (10), 105 (40) and 77 (24) (Found: C, 66.83; H, 3.89; N, 7.16; S, 16.32. $C_{20}H_{14}N_2O_3S_2$ requires C, 66.90; H, 3.58; N, 7.10; S, 16.26%).

Reactions of Ethyl Dithiocarbazate **2** *with CNIND and DCNQ*.—Into a stirred solution of the title acceptor (0.002 mol) in ethyl acetate (10 ml) was added **2** (0.002 mol) in ethyl acetate (15 ml) with stirring. The reaction mixture was then allowed to stand for 73 h, during which time a crystalline product separated. Filtration, washing with ethanol and recrystallization from a suitable solvent gave **12** and **16** respectively.

3-*Ethylsulfanyl*-6-*oxo*-6H-*indeno*[2,3-e]-1,3,4-*thiadiazepine*-5-*carbonitrile* (**12**) (164 mg, 55%) had mp 240–242 °C, yellow crystals from acetonitrile; ν_{max}/cm^{-1} 2990–2840 (Ali-CH), 2220 (CN), 1710 (CO) and 1625 (C═N); δ_H ([$^2H_6$]DMSO) 1.17 (t, 3 H, CH_3), 3.55 (q, 2 H, CH_2) and 7.35–8.40 (m, 4 H, Ar-H); δ_C ([$^2H_6$]DMSO), 15.5, 30.1, 116.3, 122.3, 124.0, 126.4, 128.6, 133.4, 144.3, 150.3, 153.6, 162.1 and 184.9; *m*/*z* 299 (M^+, 18), 282 (6), 256 (100), 240 (64) and 180 (42) (Found: C, 56.25; H, 3.12; N, 14.11; S, 21.54. $C_{14}H_9N_3OS_2$ requires C, 56.17; H, 3.03; N, 14.04; S, 21.42%).

3-*Ethylsulfanyl*-1H-*benzindazole*-4,9-*dione* (**16**) (150 mg, 58%) had mp 310–312 °C, brown crystals from ethanol; ν_{max}/cm^{-1} 3340–3250 (NH), 2995–2855 (Ali-CH), 1710 (CO) and 1635 (C═N); δ_H ([$^2H_6$]DMSO) 1.21 (t, 3 H, CH_3), 3.50 (q, 2 H, CH_2), 7.25–8.10 (m, 4 H, Ar-H) and 11.50 (s, 1 H, NH pyrazole ring); *m*/*z* 258 (M^+, 100), 229 (12), 201 (6) and 160 (12) (Found: C, 60.38; H, 4.29; N, 11.09; S, 12.48. $C_{13}H_{10}N_2O_2S$ requires C, 60.45; H, 3.90; N, 10.85; S, 12.41%).

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