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A New Heterocyclic System: 2*H*-1,3,2-oxaazaphosphorino[6,5-*b*]pyrido[2′,3′-*b*]indole

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The synthesis of 2-*p*-methoxyphenyl-10-ethyl-2*H*-1,3,2-oxaazaphosphorino[6,5-*b*]pyrido[2′,3′-*b*]indole-2,4-dithione has been achieved following treatment of Lawesson's reagent with 3-cyano- and 3-thiocarbamoyl-9-ethyl-α-carbolin-2-ones; the latter give rise to 2-mercapto-10-ethyl-2*H*-1,3,2-oxaazaphosphorino[6,5-*b*]pyrido[2′,3′-*b*]indole-2,4-dithione on heating with phosphorus pentasulfide.

It is known that Lawesson's reagent[†] (LR) is the best for the transformation of carbonyl groups into thiocarbonyl groups. The same transformation is known to take place for heterocyclic oxo-compounds, *e.g.*, for the synthesis of 2-pyridinethione from 2-pyridone.[1,2] Recently, we have developed a synthesis of 3-cyano-9-ethyl-α-carbolin-2-one **1** [3] and by investigating the properties of **1** we have made an attempt to obtain the corresponding α-carbolin-2-thione **2**. However, interaction of **1** with LR does not lead to **2** but instead to closure of the 1,3,2-oxaphosphorine ring (*cf.* ref. 4) with formation of tetracyclic compound **3**. The reaction of 3-cyanopyridin-2-one derivatives with LR appears to have been unknown until now. It is, however, possible to imagine the following reaction schemes for such an interaction, which are in accordance with known data on the reactions of LR with carbonyl compounds,[1] including α-cyanoketones.[1,5]

It is therefore possible to obtain four types of compounds (**A**–**D**) as a result of treating **1** with LR. The structure of the compound obtained, **3**, yield 60%, m.p. 233–236 °C (MeCN)[‡] was confirmed by chemical transformation and by spectral data. Treatment of **3** with aqueous KOH yields 93% thioamide **4**, m.p. 285 °C (decomp., 90% water–DMF), mass

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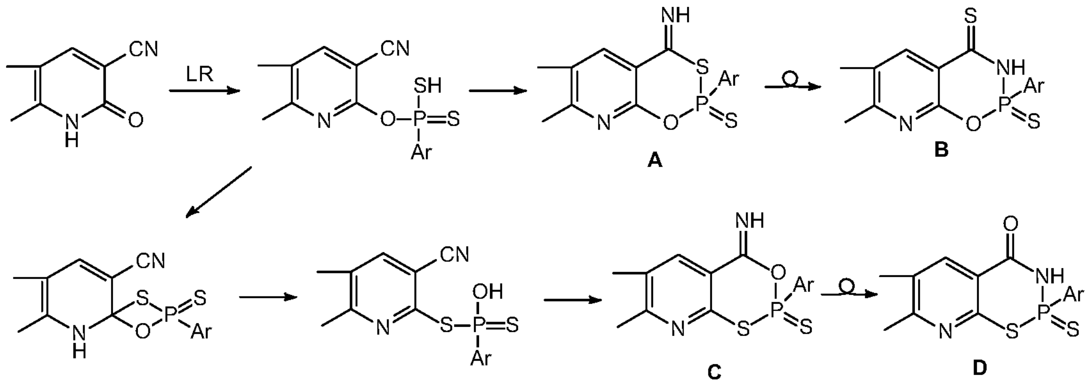
[†] 2,4-Bis(4-methoxyphenyl)-1,3-dithia-2,4-diphosphetane-2,4-disulfide.

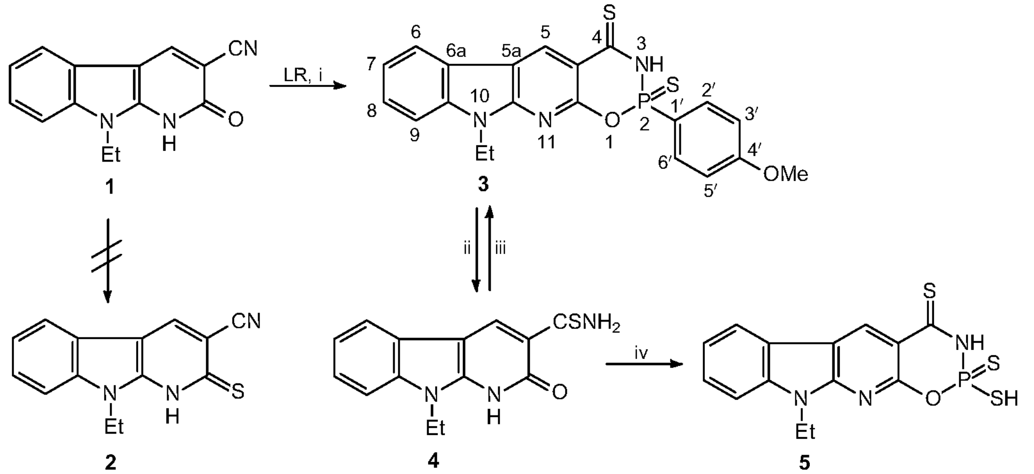
[‡] All new compounds gave the expected IR, ^{1}H NMR and mass spectra and satisfactory elemental analyses.

[§] ^{1}H NMR spectra of **4** ([^{2}H$_6$]DMSO) δ 1.30 (t, 3H, NCH$_2$C*H*$_3$), 4.43 (q, 2H, NC*H*$_2$CH$_3$), 7.20–7.40 (m, 2H), 7.60 (d, 1H), 7.99 (d, 1H) (arom. protons), 9.59 (s, 1H, 4-CH), 9.68 (weakly coupled s, 1H, NH), 11.10 (broad signal NH), 13.27 (broad signal 1H, 1-NH).



Scheme 1

spectra, m/z 271 (M^+), and the reaction of **4**[§] with LR gives rise to **3**, yield 50%. Unambiguous proof of the structure of **3** is obtained from ^{1}H NMR and ^{13}C NMR spectroscopy: ^{1}H NMR spectra ([^{2}H$_6$] DMSO): δ 1.35 (t, 3H, $\mathrm{NCH_2C}H_3$), 4.43 (q, 2H, $\mathrm{NC}H_2\mathrm{CH_3}$), 3.86 (s, 3H, OMe), 7.37 (t, 1H), 7.58 (t, 1H), 7.73 (d, 1H) and 8.32 (d, 1H, arom. protons 6,7,8,9-CH), 7.97 (q, 2H, 2′,6′-CH, $^3J_{\mathrm{H2}',6',\mathrm{P}} = 15.1$ Hz), 7.19 (q, 2H, 3′,5′-CH, $^4J_{\mathrm{H3}',5',\mathrm{P}} = 3.5$ Hz), 9.54 (s, 1H, 5-CH), 12.35 (br. d, 3-NH, $^2J_{\mathrm{NH,P}} = 15.0$ Hz). Based on these data it is possible to exclude structures **A** and **C** (spin-spin coupling of the NH-proton and the P-atom with $J_{\mathrm{NH,P}} = 15.1$ Hz for these structures is impossible). For structure **D**, δ_C(C=O) is expected to be near 150–170 ppm and for structure **B** δ_C(C=S) near 180–200 ppm, and these signals should be weakly coupled due to atom P. ^{13}C NMR for **3**: δ 14.0 ($\mathrm{NCH_2C}H_3$), 36.8 ($\mathrm{NC}H_2\mathrm{CH_3}$), 56.0 (OMe), 110.8 (9-C), 110.9 (5a-C), 114.6, 114.9 (7-C, 8-C), 114.8 (4a-C), 120.4 (6a-C), 122.0 (3′-C, 5′-C, $^3J_{\mathrm{C,P}} = 5.1$ Hz), 122.1 (1′-C, $^1J_{\mathrm{C,P}} = 154.6$ Hz), 127.8 (6-C), 134.4 (2′-C, 6′-C, $^2J_{\mathrm{C,P}} = 15.6$ Hz), 135.2 (5-C), 139.8 (9a-C), 151.9 (10a-C), 152.0 (4′-C), 164.0 (11a-C, $^2J_{\mathrm{C,P}} = 4.3$ Hz), 193.7 (C=S, $^2J_{\mathrm{C,P}} = 5.2$ Hz). Therefore, **3** has a type **B** structure and hence the decomposition of this compound in alkaline medium leading to **4** is evident. It is necessary to note that heating **3** with $\mathrm{P_2S_5}$ quantitatively yields 2-mercapto-10-ethyl-2*H*-1,3,2-oxaazaphosphorino[6,5-*b*]pyrido[2′,3′-*b*]indole-2,4-thione **5**, m.p. 234–238 °C, mass spectrum: m/z 439 (M^+), ^{1}H NMR ([^{2}H$_6$]DMSO) δ 1.36 (t, 3H, $\mathrm{NCH_2C}H_3$), 4.46 (q, 2H, $\mathrm{NC}H_2\mathrm{CH_3}$), 7.32 (t, 1H), 7.53 (t, 1H), 7.69 (d, 1H), 8.24 (d, 1H) (arom. protons), 9.40 (s, 1H, 5-CH), 11.39 (br. d, 3-NH, $^2J_{\mathrm{NH,P}} = 16$ Hz). The SH proton shares a signal with water in the solvent, $\delta \approx 6.30$ ppm.



Scheme 2 *Reagents and conditions*: i, LR, dry xylene, 130 °C, 2 h; ii, 5% aq. NaOH, 20 °C, 40 min, acidification to pH 3.5 with conc. HCl; iii, LR, dry xylene, 130 °C, 3 h.; iv, $\mathrm{P_2S_5}$, toluene, reflux for 5 h.

Thus, the synthesis of the representatives **3**, **5** of the new heterocyclic system 2*H*-1,3,2-oxaazaphosphorino[6,5-*b*]pyrido-[2′,3′-*b*]indole (1,3,2-oxaazaphosphorino[6,5-*b*]-α-carboline) has been realized.

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