Isothiazoles. Part 3.[1] Cycloadditions of Diazoalkanes to 3-Dialkylaminoisothiazole 1,1-Dioxides. Competitive Ring Cleavage in 3a,4-Dihydro-6a*H*-pyrazolo[3,4-*d*]isothiazole 1,1-Dioxides: Formation of 2-Thia-3-azabicyclo[3.1.0]hex-3-ene 2,2-Dioxides and/or Pyrazoles

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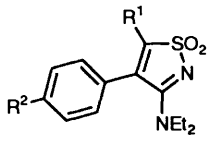
3-Dialkylaminoisothiazole 1,1-dioxides **1** readily undergo cycloadditions with diazoalkanes **2**. The reaction is characterized by high site- and regio-selectivity. Cycloadducts **3** and **4** were found to undergo straightforward thermolysis reactions at elevated temperature through two different paths characterized respectively by loss of nitrogen or sulfur dioxide and diethylcyanamide. The different transformations affording pyrazoles **6** and derivatives of the new heterocycle 2-thia-3-azabicyclo-[3.1.0]hex-3-ene 2,2-dioxide **5** are discussed.

3-Dialkylaminoisothiazole 1,1-dioxides belong to a class of heterocycles whose systematic study has started only recently. Several representatives which have an aryl substituent on C-4 are easily available by intramolecular cyclization of β-ketosulfonylamidines producing 4-hydroxy-4,5-dihydroisothiazole 1,1-dioxides which are transformed into the target compounds by treatment with thionyl chloride and dehydrochlorination.[2] These heterocyclic compounds are of general interest because they encompass the vinylsulfonamide group in a cyclic structure in which the reactivity of the double bond should be influenced by the whole of the ring so that the regiochemistry of its reactions cannot be foreseen reliably. Further, a possible practical utility is seen in their structural similarity with 3-aminobenzothiazole 1,1-dioxides which exhibit important pharmacological properties.[3,4]

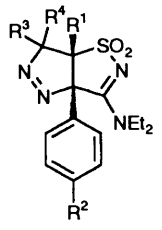
One of the many aspects of the chemistry of 3-dialkylaminoisothiazole 1,1-dioxides which raised our attention was their behaviour with 1,3-dipolar reagents. Several points needed clarification, *i.e.*, the reactivity of the electron-deficient ring in cycloaddition processes, the regioselectivity of reactions with unsymmetric dipoles and the possibility of producing unusual heterocycles which are promising substrates for further transformations.

This paper reports the reactions of some 3-diethylaminoisothiazole 1,1-dioxides with simple diazoalkanes, a synthesis of some representatives of the hitherto unknown ring 2-thia-3-azabicyclo[3.1.0]hex-3-ene 2,2-dioxide and an unusual route to substituted pyrazoles by ring cleavage of 3*a*,4-dihydro-6a*H*-pyrazolo[3,4-*d*]isothiazole 1,1-dioxides.

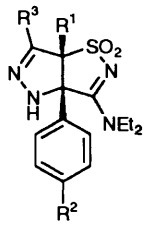


1a R^1= H, R^2= OMe
1b R^1= Me, R^2= H
1c R^1= Ph, R^2= Me

2a R^3= R^4= H
2b R^3= R^4= Me
2c R^3= Ph, R^4= H
2d R^3= CO_2Et, R^4= H



3a R^1= R^3= R^4= H, R^2= OMe
3b R^1= H, R^2= OMe, R^3= R^4= Me
3c R^1= Me, R^2= R^3= R^4= H
3d R^1= Ph, R^2= Me, R^3= R^4= H
3e R^1= Me, R^2= R^4= H, R^3= CO_2Et



4a R^1= Me, R^2= R^3= H
4b R^1= Ph, R^2= Me, R^3= H
4c R^1= H, R^2= OMe, R^3= Ph
4d R^1= H, R^2= OMe, R^3= CO_2Et
4e R^1= Me, R^2= H, R^3= CO_2Et
4f R^1= Me, R^2= H, R^3= Ph

Reactions of Isothiazole 1,1-*Dioxides* **1** *with Diazoalkanes* **2**.—The ready reaction of compounds **1a–c** with diazoalkanes **2a–d** resulted in the formation of the corresponding cycloaddition products **3** and/or **4**. Good results were obtained by performing the reaction in diethyl ether–tetrahydrofuran at room temperature. The sole exception was the treatment of isothiazole **1b** with ethyl diazoacetate **2d** which required refluxing in dichloromethane for a short time to complete the cycloaddition process. The yields were generally satisfactory.

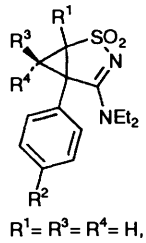
Starting from isothiazole **1a** and diazomethane **2a** a single product was formed which was identified as the 1-pyrazoline **3a** on the basis of ^{1}H NMR evidence. The spectrum shows a typical ABX pattern which is clearly associated with the proposed structure. It is worth noting that no isomers or important side-products could be identified in the reaction mixture. Compound **3b** also has the 1-pyrazoline structure (no regioisomers present). A different reaction course was observed when diazomethane **2a** was treated with isothiazoles **1b** and **1c**. A mixture of the corresponding tautomeric 1- and 2-pyrazolines was obtained in both cases, *i.e.* **3c** and **4a** and **3d** and **4b** in a ratio of 1:20 and 1:35, respectively. No difficulties were met in the complete separation of **3c** and **4a**, whereas for **3d** and **4b** only **4b** could be obtained in a pure form; **3d** was obtained in a very low yield as an uncrystallizable oil.

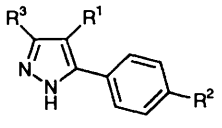
Clearly the 1-pyrazolines (**3c** and **3d**) are formed as the primary cycloadducts and tautomerize at a slower rate into the more stable 2-pyrazolines (**4a** and **4b**). This was readily confirmed since a THF solution of pure **3c** was slowly converted at room temperature into a mixture of both tautomers (**3c** and **4a**). The greater thermodynamic stability of 2-pyrazolines with respect to the corresponding 1-tautomers is well documented[5] and is enhanced by substituents on C-3 which can contribute to

the stabilization of the C=N bond. In line with this expectation only 2-pyrazolines were obtained directly from the reactions of **1a** and **1b** with phenyldiazomethane **2c** or ethyl diazoacetate **2d**. The spectral data (^{1}H NMR and ^{13}C NMR) of the cycloadducts are reported in the Experimental section.

The above results give good evidence that the cycloaddition of diazoalkanes to compounds **1** is easy and highly site- and regio-selective. The ready reaction with the C-4–C-5 double bond of the isothiazole 1,1-dioxide ring was not unexpected because the propensity of diazoalkanes to add to double bonds is well known. This reaction is favoured by electron withdrawing (EW) groups linked to the dipolarophile carbons.[6] Generally, a $HOMO_{dipole}$–$LUMO_{dipolarophile}$ control is operating and we assume that this is true also in the case of the reaction under investigation, although no calculated frontier orbital energies are at present available for the dipolarophile. It can be assumed that the reaction is completely regioselective because the same single regioisomer was isolated in every case. No other regioisomers could be detected in the crude mixture. Both the theoretical and practical results of cycloadditions of diazoalkanes to electron-deficient double bonds suggest that in most cases the simple rule holds that the dipolar carbon links to the dipolarophile site having the greater electron deficiency. In line with this, our results suggest that in the 3-aminoisothiazole 1,1-dioxide ring a charge distribution exists according to which the more electrophilic centre is located on C-5. It has to be noted that this picture also fits well with the behaviour of substrates **1** with nucleophilic reagents where addition at C-5 invariably occurs.[1] A parallel behaviour in cycloadditions with diazomethane is displayed by *N*-substituted isothiazole-3(2*H*)-one 1,1-dioxides where the above charge distribution is self-evident.[7]

Reactions of 3a,4-*Dihydro*-6aH-*pyrazolo*[3,4-d]*isothiazole* 1,1-*dioxides* **3** *and* **4**.—Both compounds **3** and **4** were found to undergo straightforward thermolysis reactions at elevated temperatures. Heating was performed both in solution by boiling in refluxing anisole (toluene was used for compound **3c** which is less stable than its congeners) and neat by maintaining the compounds at or slightly above their melting point. No important differences in chemical behaviour were observed however, as a general rule, the latter method resulted in a cleaner reaction. Cycloadducts **3a**, **3b**, **4c** and **4d** readily underwent nitrogen elimination. The corresponding 2-thia-3-azabicyclo[3.1.0]hex-3-ene 2,2-dioxides **5a–d** were produced in





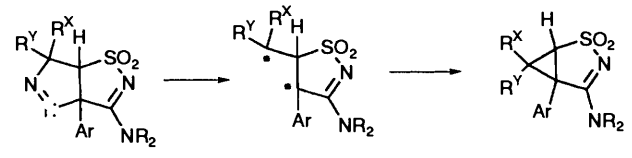
5a R^1= R^3= R^4= H, R^2= OMe
5b R^1= H, R^3= R^4= Me, R^2= OMe
5c R^1= R^4= H, R^2= OMe, R^3= Ph
5d R^1= R^4= H, R^2= OMe, R^3= CO_2Et

6a R^1= Me, R^2= H, R^3= CO_2Et
6b R^1= Ph, R^2= Me, R^3= H
6c R^1= Me, R^2= H, R^3= Ph
6d R^1= H, R^2= OMe, R^3= Ph

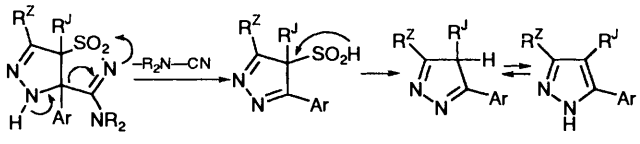
generally satisfactory yield. To our knowledge this heterocyclic ring has not been synthesized before. ^{1}H and ^{13}C NMR spectroscopy were used to confirm the structures of compounds **5**. The ^{1}H NMR and ^{13}C NMR spectra of **5a** shows a clear AMX pattern associated with 1-H and 6-H (δ_A 1.88, δ_M 2.20, δ_X 3.0; J_{AX} 5.6, J_{AM} 6.0, J_{MX} 8.4 Hz) and for **5b** we observed two singlets at δ 1.45 and 1.52 associated with 6-Me and the characteristic singlet at δ 3.28 associated with 1-H. Compounds **5c** and **5d** show a clear AB-system associated with 1-H and 6-H (δ 3.73, 3.25; δ 2.82, 3.75, respectively) where a coupling constant of about 5 Hz is consistent with a *trans* configuration.[8]

Heating compounds **4b**, **e** and **f** which have a methyl or phenyl group on the bridge carbon, resulted in a different behaviour. Instead of nitrogen, sulfur dioxide and diethylcyanamide were eliminated with cleavage of the isothiazole 1,1-dioxide ring. The pyrazoles **6b**, **a** and **c**, respectively, were produced. Their structure was easily confirmed by ^{1}H and ^{13}C NMR data and/or by comparison with the literature melting point. When compound **4a** was used as the starting material intractable tarry reaction mixture was obtained which was not investigated further. When compound **4e** was heated at its melting point it afforded, as expected, pyrazole **6a**, however, when it was heated either in refluxing anisole or dimethyl sulfoxide only a partial transformation into the tautomeric pyrazoline **3e** occurred.

The above results show that both rings of dihydropyrazolo[3,4-*d*]isothiazole 1,1-dioxides are susceptible to thermal cleavage. Two different transformation paths are possible, which are depicted in Schemes 1 and 2, respectively. In both



Scheme 1



Scheme 2

cases products are formed which are stable under the existing conditions. Which ring is cleaved easier apparently depends on the substitution pattern, more precisely on the presence of a substituent other than hydrogen on C-6*a*. It seems logical to consider the accepted diradical mechanism for nitrogen elimination from the pyrazoline ring involving the 1-tautomer.[5] A thermal isomerization step needs to be included when the 2-isomer is used as starting material (Scheme 1). It has been demonstrated that the substitution pattern on the pyrazoline is crucial for the cyclopropane formation process. Indeed, 4,4-disubstituted substrates cannot readily attain the right-angle envelope conformation which is necessary for concerted nitrogen elimination.[9,10] Evidence from molecular models shows that this hypothesis can also apply in the present case. This suggests that in compounds **3c**, **3d**, **3e**, **4a**, **4b**, **4e** and **4f**, the pyrazoline ring may be more stable to cleavage than in the less hindered ones (**3a**, **3b**, **4c**, **4d**). Accordingly, it is expected that in the former compounds the relatively high stability of the pyrazoline ring should favour the alternative cleavage of the isothiazole 1,1-dioxide ring (Scheme 2). As indicated, the transformation leading to pyrazoles occurs through an elimination reaction which should be promoted by basic catalysis. Confirmation of this was readily obtained by heating compound **4c** in the presence of a catalytical amount of diazabicycloundecene which resulted in the formation of pyrazole **6d**—only a trace amount of **5c** was obtained, which was the main product in the absence of added catalyst. This result demonstrates the possibility of controlling the course of the thermal reaction of compounds **3** and **4** directing it towards the formation of 2-thia-3-azabicyclo[3.1.0]hex-3-ene 2,2-dioxides or of pyrazoles.

Experimental

M.p.s were determined using a Büchi 510 (capillary) apparatus or an Electrothermal 9100 apparatus. IR spectra were measured using a Jasco IR Report 100 instrument. NMR spectra were obtained either with a Bruker AC 200 or an EM-390 Varian Instrument. Chemical shifts (δ) are given in ppm and the coupling constants (J) are given in Hz. Column chromatography was performed on silica gel [Kieselgel 60–70 230 ASTM (Merck)]. Mass spectra were obtained by an electron impact ionization technique at 70 eV from a Finningan INCOS 50 instrument using the direct exposure probe (DEP).

Materials.—Diazoalkanes **2a**,[11] **2b**,[12] **2c**[13] have already been described, **2d** is commercially available.

Isothiazole 1,1-*Dioxides.*—Compound **1a** has already been described;[2] **1b** and **1c** were prepared from the corresponding 3-diethylamino-4-hydroxy-4,5-dihydroisothiazole 1,1-dioxides by treatment with thionyl chloride followed by dehydrohalogenation according to the literature.[2]

4-*Chloro*-3-*diethylamino*-5-*methyl*-4-*phenyl*-4,5-*dihydro*-*isothiazole* 1,1-*dioxide*. The reaction of the corresponding hydroxy derivative with thionyl chloride gave a mixture of two diastereoisomeric products: total yield (*cis* + *trans*) 80%. Only one of these was obtained in pure form: 40% (the other being always in mixture); m.p. 99–100 °C (Found: C, 53.2; H, 5.95; N, 8.7. $C_{14}H_{19}ClN_2O_2S$ requires C, 53.42; H, 6.04; N, 8.90%); $\delta_H(CDCl_3)$ 0.76 (3 H, t, J 7.1, Me), 1.26 (3 H, t, J 7.1, Me), 1.44 (3 H, d, J 6.8, MeC*H*), 3.00 (2 H, q, J 7.1, CH_2), 3.42–3.68 (3 H, m, CH_2 and CH) and 7.40–7.51 (5 H, m, ArH).

4-*Chloro*-3-*diethylamino*-5-*phenyl*-4-(p-*tolyl*)-4,5-*dihydroiso*-*thiazole* 1,1-*dioxide*. The reaction of the corresponding hydroxy derivative with thionyl chloride gave a mixture of two diastereomeric products: total yield (*cis* + *trans*) 82%; *cis*: m.p. 188 °C (Found: C, 61.3; H, 6.1; N, 7.2. $C_{20}H_{23}ClN_2O_2S$ requires C, 61.45; H, 5.88; N, 7.17%); $\delta_H(CDCl_3)$ 1.15 (3 H, t, J 7.1, Me), 1.38 (3 H, t, J 7.0, Me), 2.31 (3 H, s, Me), 2.90–3.00, 3.36–3.60, 3.77–3.87 (4 H, m, CH_2), 5.20 (1 H, s, 5-H) and 6.87–7.30 (9 H, m, ArH); *trans*: m.p. 200 °C (Found: C, 61.4; H, 6.0; N, 7.2. $C_{20}H_{23}ClN_2O_2S$ requires C, 61.45; H, 5.88; N, 7.17%); $\delta_H(CDCl_3)$ 0.85 (3 H, t, J 7.0, Me), 1.33 (3 H, t, J 7.0, Me), 2.40 (3 H, s, Me), 3.03–3.12 (2 H, m, CH_2N), 3.46–3.60, 3.68–3.82 (2 H, m, CH_2N), 4.69 (1 H, s, 5-H) and 7.10–7.41 (9 H, m, ArH).

3-*Diethylamino*-5-*methyl*-4-*phenylisothiazole* 1,1-*dioxide* **1b**. 70%; m.p. 147 °C (Found: C, 60.4; H, 6.7; N, 10.0, $C_{14}H_{18}N_2O_2S$ requires C, 60.40; H, 6.52; N, 10.07%); $\delta_H(CDCl_3)$ 0.84 (3 H, t, J 7.1, Me), 1.28 (3 H, t, J 7.0, Me), 1.98 (3 H, s, Me), 3.03 (2 H, q, J 7.1, CH_2), 3.61 (2 H, q, J 7.0), 7.20–7.27 (2 H, m, ArH) and 7.44–7.50 (3 H, m, ArH).

3-*Diethylamino*-5-*phenyl* 4-(*p-tolyl*)*isothiazole* 1,1-*dioxide* **1c**. 93%; m.p. 189–190 °C (Found: C, 67.6; H, 6.4; N, 7.6. $C_{20}H_{22}N_2O_2S$ requires C, 67.77; H, 6.26; N, 7.90%); $\delta_H(CDCl_3)$ 0.87 (3 H, br t, Me), 1.31 (3 H, br t, Me), 2.38 (3 H, s, Me), 3.04–3.08 (2 H, m, CH_2N), 3.63–3.66 (2 H, m, CH_2N) and 7.13–7.41 (9 H, m, ArH).

General Procedure for the Cycloaddition Reactions of Isothiazoles **1a–c** *with Diazoalkanes* **2a–d**.—An ethereal solution (10 cm^3) of the appropriate diazoalkane **2** (1.22 mmol) was added dropwise to a solution of isothiazole **1** (1.02 mmol) in THF (10 cm^3) at room temperature. The reaction was stirred until the reactants had disappeared (TLC, AcOEt–C_6H_{14} 3:2 v/v). The solvent was evaporated and the residue was crystallized to give pure compounds.

Cycloaddition of Isothiazole Diazoalkane **2d**.—An ethereal (10 cm^3) solution of diazoalkane **2d** (1.22 mmol) was added to a suspension of isothiazole **1b** (1.02 mmol) in dichloromethane at room temperature. At the end of the addition the mixture was refluxed until the reactants had disappeared (about 4 days). The solvent was evaporated and the residue was crystallized from CH_2Cl_2–Et_2O.

3-*Diethylamino*-3a-(4-*methoxyphenyl*)-6,6a-*dihydro*-3aH-*pyrazolo*[3,4-d]*isothiazole* 1,1-*dioxide* **3a**. 83%; m.p. 142 °C (Found: C, 53.2; H, 5.8; N, 16.4. $C_{15}H_{20}N_4O_3S$ requires C, 53.55; H, 5.99; N, 16.65%); $\delta_H(CDCl_3)$ 0.86 (3 H, t, J 7, Me), 1.24 (3 H, t, J 7.1, Me), 3.38–3.87 (4 H, m, CH_2N), 3.82 (3 H, s, OMe), 3.58, 5.13 and 5.40 (3 H, ABX system, J_{AB} 20, J_{AX} 4.7, J_{BX} 9.5, 6-CH_2 and 6a-H) and 6.97–7.05 (4 H, AB system, J 9.0, ArH); $\delta_C(CDCl_3)$ 11.5, 13.0, 44.8, 45.2, 55.5, 63.5, 81.7, 111.3, 115.2–125.7, 160.2 and 162.5.

3-*Diethylamino*-3a-(4-*methoxyphenyl*)-6-*dimethyl*-6,6a-*dihydro*-3aH-*pyrazolo*[3,4-d]*isothiazole* 1,1-*dioxide* **3b**. 70%; m.p. 93 °C; $\delta_H(CDCl_3)$ 0.92 (3 H, t, J 7.0, Me), 1.26 (3 H, t, J 7.1, Me), 1.55 (3 H, s, 6-Me), 3.28 (1 H, s, 6a-H), 3.40–3.81 (4 H, m, CH_2), 3.82 (3 H, s, OMe) and 6.94–7.10 (4 H, AB system, J 9.1, ArH); m/z 336 ($M^+ - 28$).

3-*Diethylamino*-6a-*methyl*-3a-*phenyl*-6,6a-*dihydro*-3aH-*pyrazolo*[3,4-d]*isothiazole* 1,1-*dioxide* **3c**. 4%; m.p. 135–136 °C (Found: C, 56.05; H, 6.2; N, 17.3. $C_{15}H_{20}N_4O_2S$ requires C, 53.23; H, 6.29; N, 17.49%); $\delta_H(CDCl_3)$ 0.87 (3 H, t, J 7.1, Me), 0.93 (3 H, s, 6a-Me), 1.24 (3 H, t, J 7.0, Me), 3.30–3.74 (4 H, m, NCH_2), 4.49, 5.48 (2 H, AB system, J 19.9), 7.12–7.22 (2 H, m, ArH) and 7.41–7.51 (3 H, m, ArH).

3-*Diethylamino*-6a-*phenyl*-3a-(p-*tolyl*)-6,6a-*dihydro*-3aH-*pyrazolo*[3,4-d]*isothiazole* 1,1-*dioxide* **3d**. Uncrystallizable oil; $\delta_H(CDCl_3)$ 0.85 (3 H, t, J 7.1, Me), 1.25 (3 H, t, J 7.0, Me), 2.25 (3 H, s, Me), 3.00–3.20 and 3.45–3.75 (4 H, 2 × m, CH_2), 5.46, 5.85 (2 H, AB system, J 8.0, 6-H, 6a-H) and 6.90–7.30 (9 H, m, ArH).

3-*Diethylamino*-6a-*methyl*-3a-*phenyl*-3a,4-*dihydro*-6aH-*pyrazolo*[3,4-d]*isothiazole* 1,1-*dioxide* **4a**. 81%; m.p. 168 °C (Found: C, 56.1; H, 6.3; N, 17.5. $C_{15}H_{20}N_4O_2S$ requires C, 53.23; H, 6.29; N, 17.49%); $\delta_H(CDCl_3)$ 0.89 (3 H, t, J 7.0, Me), 1.00 (3 H, s, Me), 1.24 (3 H, t, J 7.1, Me), 2.91–3.16 (2 H, m, CH_2N), 3.39–3.66 (2 H, m, CH_2N), 6.67 (1 H, s, NH), 6.81 (1 H, s, 6-H) and 7.09–7.12, 7.38–7.47 and 7.71–7.75 (4 H, 3 × m, ArH); $\delta_C(CDCl_3)$ 11.5, 12.6, 14.8, 44.1, 44.2, 77.8, 82.1, 125.8, 126.4, 129.5, 133.9 and 166.3.

3-*Diethylamino*-6a-*phenyl*-3a-(p-*tolyl*)-3a,4-*dihydro*-6aH-*pyrazolo*[3,4-d]*isothiazole* 1,1-*dioxide* **4b**. 64%; m.p. 210 °C (Found: C, 63.9; H, 6.3; N, 13.9. $C_{21}H_{24}N_4O_2S$ requires C, 63.61; H, 6.10; N, 14.13%); $\delta_H(CDCl_3)$ 1.04 (3 H, t, J 7.0, Me), 1.31 (3 H, t, J 7.1, Me), 2.25 (3 H, s, Me), 2.97–3.17 and 3.46–3.75 (4 H, 2 × m, CH_2), 6.23 (1 H, s, NH) and 6.90–7.29 (9 H, m, ArH); $\delta_C(CDCl_3)$ 11.8, 13.1, 21.5, 43.4, 44.6, 84.4, 85.2, 127.1–128.9, 129.0, 129.8–129.9, 130.2, 139.8, 143.3 and 166.5.

3-*Diethylamino*-3a-(4-*methoxyphenyl*)-6-*phenyl*-3a,4-*dihydro*-6aH-*pyrazolo*[3,4-d]*isothiazole* 1,1-*dioxide* **4c**. 91%; m.p. 184–186 °C decomp. (Found: C, 61.4; H, 5.75; N, 13.3. $C_{21}H_{24}N_4O_3S$ requires C, 61.40; H, 5.87; N, 13.59%); $\delta_H(CDCl_3)$ 0.84 (3 H, t, J 7.0, Me), 1.24 (3 H, t, J 7.0, Me), 3.00–3.20 (2 H, m, CH_2), 3.38–3.53 and 3.63–3.73 (2 H, 2 × m, CH_2), 3.77 (3 H, t, OMe), 4.96 (1 H, s, 6a-H), 6.62 (1 H, s, NH), 6.93 and 7.30 (4 H, AB system, J 9.0, ArH), 7.25–7.40 (3 H, m, ArH) and 7.73–7.78 (2 H, m, ArH); $\delta_C(CDCl_3)$ 11.6, 12.6, 44.4, 44.7, 55.5, 80.2, 83.3, 115.3, 125.3–129.8, 131.0, 145.0, 160.0 and 165.2.

3-*Diethylamino*-6-*ethoxycarbonyl*-3a-(4-*methoxyphenyl*)-3a,4-*dihydro*-6aH-*pyrazolo*[3,4-d]*isothiazole* 1,1-*dioxide* **4d**. 88%; m.p. 176 °C decomp. (Found: C, 52.9; H, 6.3; N, 13.4. $C_{18}H_{24}N_4O_5S$ requires C, 52.96; H, 5.93; N, 13.73%); $\delta_H(CDCl_3)$ 0.76 (3 H, t, J 7.0, Me), 1.21 (3 H, t, J 7.0, Me), 1.35 (3 H, t, J 7.1, CO_2Et), 3.07–3.19 (2 H, m, CH_2), 3.42–3.53 (2 H, m, CH_2), 3.82 (3 H, s, OMe), 4.30–4.42 (2 H, m, CO_2Et),

4.72 (1 H, s, 6a-H), 6.95 (2 H, AB system, *J* 9.0, ArH), 7.24 (2 H, AB system, *J* 9.0, ArH) and 8.32 (1 H, s, NH); $\delta_C(CDCl_3)$ 11.4, 12.4, 14.2, 44.6, 45.0, 55.5, 61.9, 77.1, 84.0, 115.3, 125.6, 130.2, 133.8, 160.2, 161.5 and 164.1.

3-*Diethylamino*-6-*ethoxycarbonyl*-6a-*methyl*-3a-*phenyl*-3a,4-*dihydro*-6aH-*pyrazolo*[3,4-d]*isothiazole* 1,1-*dioxide* **4e**. 67%; m.p. 181–183 °C; $\delta_H(CDCl_3)$ 0.84 (3 H, t, *J* 7.0, Me), 1.20–1.27 (6 H, m, Me), 1.36 (3 H, t, *J* 7.1, Me), 2.97–3.15 (2 H, m, CH_2), 3.35–3.63 (2 H, m, CH_2), 4.36 (2 H, q, *J* 7.1, CH_2), 7.00–7.04 (1 H, m, ArH), 7.39–7.51 (4 H, m, ArH) and 7.61 (1 H, s, NH); *m/z* 393 ($M^+ + 1$) and 230 ($M^+ - 162$, 100%).

3-*Diethylamino*-6a-*methyl*-3a,6-*diphenyl*-3a,4-*dihydro*-6aH-*pyrazolo*[3,4-d]*isothiazole* 1,1-*dioxide* **4f**. 60%; m.p. 190 °C decomp. (Found: C, 63.4; H, 6.0; N, 14.4. $C_{21}H_{24}N_4O_2S$ requires C, 63.61; H, 6.10; N, 14.13%); $\delta_H(CDCl_3)$ 0.91 (3 H, t, *J* 7.1, Me), 1.15 (3 H, s, 6a-Me), 1.38 (3 H, t, *J* 7.0, Me), 2.89–3.13 (2 H, m, CH_2), 3.36–3.50 and 3.66–3.80 (2 H, 2 × m, CH_2), 6.46 (1 H, s, NH), 7.05–7.10 (1 H, m, ArH), 7.33–7.59 (7 H, m, ArH) and 7.88–7.92 (2 H, m, ArH); $\delta_C(CDCl_3)$ 11.6, 12.5, 16.5, 43.9, 44.4, 80.7, 86.1, 125.6–130.1, 135.8, 149.6 and 165.6.

General Procedure for Pyrolysis of Cycloadducts **3a**, **b** *and* **4b**–**f**.—The cycloadduct (100 mg) was refluxed in anisole (5 cm^3) until the reactant disappeared. The solvent was evaporated and the residue was crystallized from CH_2Cl_2–Et_2O. In some cases chromatographic purification of the residue (AcOEt–C_6H_{14} 2:3) was performed. Alternatively, the cycloadducts were heated at their melting points and when the reactant was completely transformed the residue was purified as above.

4-*Diethylamino*-5-(4-*methoxyphenyl*)-2-*thia*-3-*azabicyclo*-[3.1.0]*hex*-3-*ene* 2,2-*dioxide* **5a**. Yield (pyrolysis in solution) 35%; yield (pyrolysis at m.p.) 78%; m.p. 138 °C (Found: C, 58.2; H, 6.53; N, 9.0. $C_{14}H_{20}N_2O_3S$ requires C, 58.42; H, 6.54; N, 9.09%); $\delta_H(CDCl_3)$ 0.65 (3 H, t, *J* 7.1, Me), 1.20 (3 H, t, *J* 7.1, Me), 1.88 and 2.20 (2 H, AMX system, J_{AX} 5.6, J_{AM} 6.0, J_{MX} 8.5, 6-CH_2), 2.95–3.60 (5 H, m, CH_2N and 1-H), 3.85 (3 H, s, OMe) and 6.90 and 7.25 (4 H, AB system, *J* 8.5, ArH); $\delta_C(CDCl_3)$ 11.8, 12.5, 22.2, 40.7, 43.6, 43.8, 45.0, 55.4, 114.8, 126.1, 129.7, 159.8 and 167.5.

4-*Diethylamino*-5-(4-*methoxyphenyl*)-6-*dimethyl*-2-*thia*-3-*azabicyclo*[3.1.0]*hex*-3-*ene* 2,2-*dioxide* **5b**. Yield (pyrolysis in solution) 46%; yield (pyrolysis at m.p.) 74%; m.p. 146 °C (Found: C, 60.7; H, 7.6; N, 8.3. $C_{17}H_{24}N_2O_3S$ requires C, 60.69; H, 7.19; N, 8.33%); $\delta_H(CDCl_3)$ 0.40 (3 H, t, *J* 7.1, Me), 1.17 (3 H, t, *J* 7.1, Me), 1.45 (3 H, s, Me), 1.52 (3 H, s, Me), 2.86–3.26 (2 H, m, CH_2), 3.28 (1 H, s, 1-H), 3.44–3.63 (2 H, m, CH_2), 3.80 (3 H, s, OMe) and 6.87 and 7.35 (4 H, AB system, ArH).

4-*Diethylamino*-5-(4-*methoxyphenyl*)-6-*phenyl*-2-*thia*-3-*azabicyclo*[3.1.0]*hex*-3-*ene* 2,2-*dioxide* **5c**. (Pyrolysis in anisole solution gave only tarry products); yield (pyrolysis at m.p.) 65%; m.p. 132–135 °C; $\delta_H(CDCl_3)$ 0.51 (3 H, t, *J* 7.0, Me), 1.22 (3 H, t, *J* 7.1, Me), 3.05–3.20 (1 H, m, CH_2), 3.25 (1 H, AB system, *J* 5.8, 6-H), 3.29–3.51 (3 H, m, CH_2), 3.73 (1 H, AB system, *J* 5.8, 1-H), 3.74 (3 H, s, OMe), 6.68 (4 H, AB system, *J* 8.5, ArH), 6.98–7.24 (2 H, m, ArH) and 7.30–7.31 (3 H, m, ArH); *m/z* 385 ($M^+ + 1$) and 320 ($M^+ - 64$, 100%).

4-*Diethylamino*-6-*ethoxycarbonyl*-5-(4-*methoxyphenyl*)-2-*thia*-3-*azabicyclo*[3.1.0]*hex*-3-*ene* 2,2-*dioxide* **5d**. Yield (pyrolysis in solution) 83%; yield (pyrolysis at m.p.) 70%; m.p. 162 °C (Found: C, 57.5; H, 7.05; N, 7.7. $C_{17}H_{24}N_2O_5S$ requires C, 56.82; H, 6.36; N, 7.37%); $\delta_H(CDCl_3)$ 0.50 (3 H, t, *J* 7.1, Me), 1.18 (3 H, t, *J* 7.1, Me), 1.22 (3 H, t, *J* 7.1, Me), 2.82 and 3.75 (2 H, AB system, *J* 5.1), 3.00–3.25 (2 H, m, CH_2), 3.30–3.60 (2 H, m, CH_2), 3.83 (3 H, s, OMe), 4.15–4.30 (2 H, m, CH_2) and 6.85–7.18 (2 H, AB system, *J* 8.8, ArH); $\delta_C(CDCl_3)$ 11.6, 12.4, 14.1, 35.6, 44.1, 45.1, 45.8, 46.4, 55.5, 62.4, 114.5, 122.7, 131.1, 160, 165.2 and 165.9.

Ethyl 4-*methyl*-5-*phenylpyrazole*-3-*carboxylate* **6a**. Yield (pyrolysis at m.p.) 41%; m.p. 102 °C (lit.,[14] 102–103 °C); $\delta_H(CDCl_3)$ 1.42 (3 H, t, *J* 7.1, OEt), 2.45 (3 H, s, Me), 4.42 (2 H, q, *J* 7.0, OEt), 7.40–7.51 (3 H, m, ArH), 7.56–7.62 (2 H, m, ArH) and 10.7 (1 H, s, NH).

4-*Phenyl*-5-(p-*tolyl*)*pyrazole* **6b**. (Pyrolysis in anisole solution gave only tarry products); yield (pyrolysis at m.p.) 32%; oil; $\delta_H(CDCl_3)$ 2.38 (3 H, s, Me), 7.13–7.38 (9 H, m, ArH) and 7.67 (1 H, s, CH); *m/z* 234 (M^+, 100%).

4-*Methyl*-3,5-*diphenylpyrazole* **6c**. (Pyrolysis in anisole solution gave only tarry products); yield (pyrolysis at m.p.) 70%; m.p. 225 °C (lit.,[15] 223–224 °C); $\delta_H(CDCl_3)$ 2.29 (3 H, s, Me), 7.36–7.67 (10 H, m, ArH) and 3.10 (1 H, s, NH).

5-(4-*Methoxyphenyl*)-3-*phenylpyrazole* **6d**. (Pyrolysis in anisole solution gave only tarry products); yield (pyrolysis at m.p.) 31%; m.p. 158–160 °C (lit.,[16] 155–156 °C) (Found: C, 75.6; H, 5.1; N, 11.05. $C_{16}H_{14}N_2O$ requires C, 76.78; H, 5.64; N, 11.20%); $\delta_H(CDCl_3)$ 3.82 (3 H, s, OMe), 6.72 (1 H, s, CH), 6.88 (2 H, d, *J* 8.8, ArH), 7.33–7.37 (3 H, m, ArH), 7.62 (2 H, d, *J* 8.8, ArH), 7.68–7.25 (2 H, dd, ArH) and 11.6 (1 H, br s, NH).

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