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CYCLOADDITION REACTIONS OF HETEROAZADIENES: [4+2] CYCLOADDITION OF 1-THIA-3-AZABUTADIENES WITH ELECTRON-POOR DIENOPHILES.

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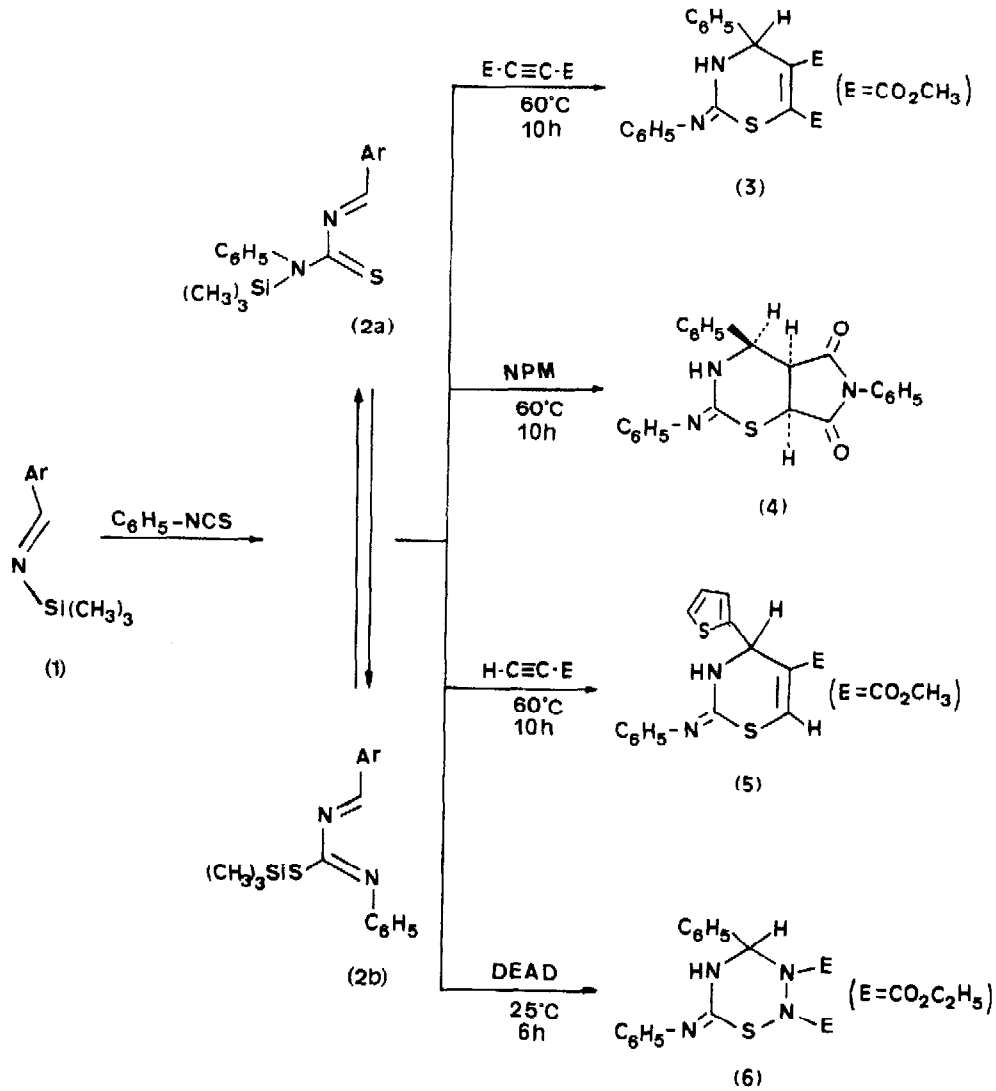
Summary. 1-Thia-3-azabutadienes cleanly undergo [4+2] cycloaddition processes with electron-poor dienophiles; the reaction is regioselective and leads exclusively to the *endo* isomer.

A great deal of attention has been recently paid to the hetero-Diels-Alder cycloaddition reactions owing to their applications in heterocyclic synthesis[1]. While a number of reports on azadienes have been released in the last years[2], studies dealing with thiaazabutadienes are mainly restricted to 4-trifluoromethyl-[3] and 4-amino-1-thia-3-azabutadienes[4] and their utility for the synthesis of cephalosporins[5]. We have shown in previous papers that heterodienes (**2**), easily made from trimethylsilyl imines (**1**) and isothiocyanates, participate in [4+2] cycloadditions with isocyanates[6] and enamines[7] through the 1,3-diazadiene tautomer (**2b**); in contrast, the 1-thia-3-azabutadiene tautomer (**2a**) has been found to be the actual species acting in the case of the intramolecular cycloaddition with unactivated alkenes[8]. We report here that heterodienes (**2**) undergo [4+2] cycloadditions to some of the most representative electron-poor dienophiles through the 1-thia-3-azabutadiene tautomer **(2a)**, exclusively.

First, trimethylsilyl imine (**1**) (Ar=C_6H_5) was treated with phenyl isothiocyanate in toluene at 60°C and then with dimethyl acetylenedicarboxylate (DMAD) at the same temperature to give, after aqueous work-up and column chromatography (silica gel, toluene-ether, 10:1), the cycloadduct (**3**) as a yellow oil in 92% yield[9,10].

The diene (**2**) (Ar = C_6H_5) and *N*-phenylmaleimide (NPM) reacted similarly at 60°C for 10 h to furnish the cycloadduct (**4**) (78%, m.p. 207-208°C); the reaction proved to be totally stereoselective, since solely the *endo* isomer [J(4-H-5-H) 4 Hz] was detectable in the crude mixture (^{1}H n.m.r., 300 MHz)[9,10].

The regioselectivity of the reaction was demonstrated by the formation of a single adduct (**5**) (95%, m.p. 130-131°C) [δ_H 7.7 (1H, s, 6-H)] when (**2**) (Ar = 2-thienyl) and methyl propiolate were heated in toluene at 60°C for 10 h[9,10].



Thiaazabutadienes (**2**) could also be used for the synthesis of thiatriazine derivatives by reacting with the typical dienophile diethyl azodicarboxylate (DEAD); thus, heterocycle (**6**) (90%, m.p. 145-146°C) was formed after stirring the corresponding educts at room temperature for 6 h[9,10].

The results presented here provide a preliminary insight into the potential of these heterodienes as 4_π-components in Diels-Alder reactions. It is remarkable that such systems react with dienophiles in a chemo-, regio-, and stereoselective fashion; thus, they react as 1-thia-3-aza- or 1,3-diazabutadienes in normal and inverse electron demand [4+2] cycloadditions, respectively[11,12].

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9.- Compounds (**3**)-(**6**) exist in solution as the phenylimino tautomers, according to ^{13}C n.m.r. data. See, L. M. Jackman, and T. Jen, *J. Am. Chem. Soc.,* **1975**, *97*, 2811.

10.- *Preparation of compounds* (**3**)-(**6**). A mixture of N-trimethylsilyl imine (**1**) (Ar=C_6H_5, 2-thienyl) (5.4 mmol) and phenyl isothiocyanate (730 mg, 5.4 mmol) in toluene (30 ml) was stirred and heated at 60°C overnight. The reaction mixture was cooled, the dienophile (5.4 mmol) added and stirring continued at 25-60°C for 6-10 h. The mixture was cooled, treated with water (25 ml) and extracted with CH_2Cl_2 (2 x 30ml). After removing the solvents, the resulting mixture was chromatographed [Compound (**3**), silica gel, toluene-ether, 10:1] or triturated with hexane and recrystallized from hexane-chloroform [Compounds (**4**), (**5**), (**6**)]

Selected spectroscopic data:

Compound (3) δ_H 3.7 (3H, s), 3.8 (3H, s), 5.7 (1H, s), 7.0-7.5 (11H, m) ppm.
δ_C 52.34 (q), 52.97 (q), 62.08 (d), 119.97 (d), 123.17 (d), 127.09 (d), 127.59(d), 128.21 (d), 128.63 (d), 130.52 (s), 133.15 (s), 138.55 (s), 140.80 (s), 147.76 (s), 163.16 (s), 165.26 (s) ppm.

Compound (4) δ_H 4.0 (1H, dd, J 10 Hz, 4 Hz), 4.5 (1H, d, J 10 Hz), 5.0 (1H, d, J 4 Hz), 7.1-7.8 (16H, m) ppm.

Compound (5) δ_H 3.7 (3H, s), 6.2 (1H, s), 6.8 (1H,s broad), 6.9-7.2 (8H, m), 7.7 (1H, s) ppm.
δ_C 52.11 (q), 52.84 (d), 121.14 (d), 123.66 (d), 124.41 (d), 124.60 (d), 124.82 (s), 126.40 (d), 128.88 (d), 132.05 (d), 142.93 (s), 144.23 (s), 147.99 (s), 163.37 (s) ppm.

Compound (6) δ_H 0.8 (3H, t, J 8 Hz), 1.3 (3H, t, J 8 Hz), 3.8 (2H, m), 4.3 (2H, q, J 8 Hz), 5.6 (1H, s broad), 7.0 (1H, s), 7.1-7.6 (10H, m) ppm.
δ_C 13.71 (q), 14.32 (q),63.29 (t), 63.64 (t), 69.03 (d), 120.75 (d), 123.73 (d), 127.32 (d), 127.97 (d), 128.86 (d), 138.90 (s), 139.07 (s), 145.46 (s), 154.44 (s) ppm.

11.- The analogous 1-oxa-3-azabutadiene formed by reacion of **(1)** with phenyl isocyanate[6] was recovered unchanged when treated with DMAD in refluxing toluene during 48 h.

12.- All compounds gave satisfactory spectroscopic (i.r., ^1H and ^{13}C n.m.r., and mass) and analytical data.

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