Reactions of 2-Aryl-2*H*-cycloheptathiazoles with Dimethyl Acetylenedicarboxylate

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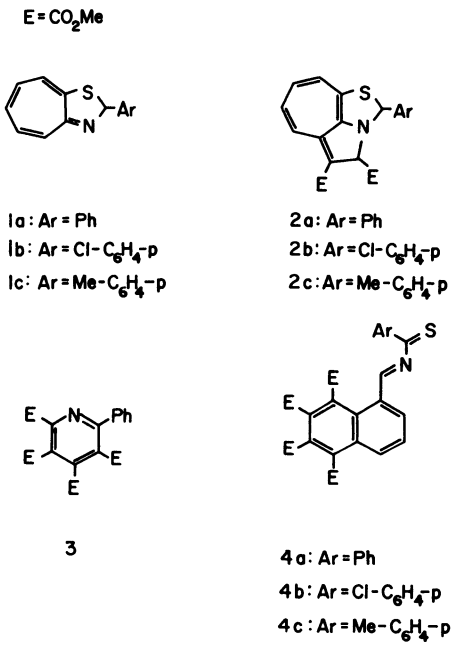
(Received September 16, 1986)

Synopsis. Reaction of 2-aryl-2*H*-cycloheptathiazoles with dimethyl acetylenedicarboxylate gave dimethyl 2-aryl-3*H*-1-thia-2a-azacyclopent[*cd*]azulene-3,4-dicarboxylate, tetramethyl 6-phenyl-2,3,4,5-pyridinetetracarboxylate, and tetramethyl 5-[(thioaroyl)iminomethyl]-1,2,3,4-naphthalenetetracarboxylate.

Concerning the cycloaddition reactions of benzothiazoles[1] and azaazulenes,[2] we have reported that the cycloaddition of 2*H*-cycloheptathiazol-2-one with acetylenic esters produced 1:1- and 1:2-cycloadducts via 1,10-dipolar intermediates.[3] Cycloadditions of 8-azaheptafulvene are also known,[4] which proceeded via similar dipolar intermediates. It is interesting to ascertain if 2-aryl-2*H*-cycloheptathiazoles, which are not fully conjugated and would be considered as substituted azaheptafulvenes, undergo a similar cycloaddition or not. We have now carried out the reaction of 2-aryl-2*H*-cycloheptathiazoles with dimethyl acetylenedicarboxylate (DMAD), and found that the reaction gave novel products in addition to the anticipated dipolar cyclization products.



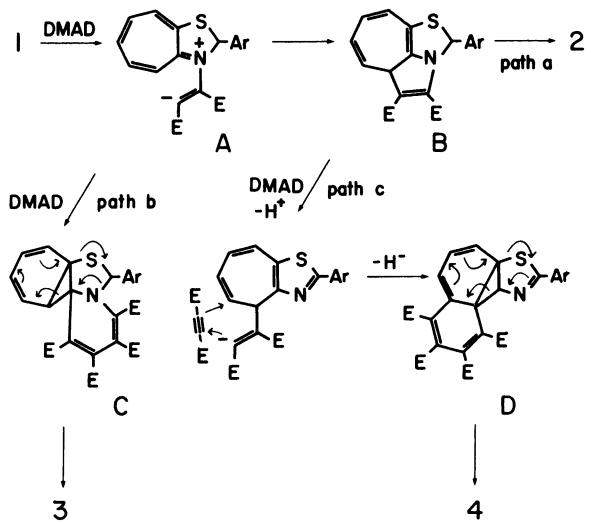
2-Aryl-2*H*-cycloheptathiazoles (**1a—c**) were prepared by the reaction of 2-aminocycloheptatrienethione (2-aminotroponethione)[5] with the corresponding aromatic aldehydes in a similar method as reported[6] for **1b**.

Treatment of **1a** with DMAD in boiling benzene gave a complex mixture, from which four products, **2a** (9%), **3** (8%), **4a** (15%), and **5a** (14%), were isolated by chromatography on silica gel. The structures of these compounds, except **5a**, were elucidated by their spectroscopic data as well as by elemental analyses.

Compound **2a** ($C_{20}H_{17}NO_4S$) was assigned to dimethyl 2-phenyl-3*H*-1-thia-2a-azacyclopent[*cd*]-azulene-3,4-dicarboxylate, which is the corresponding cycloadduct to that described before.[2,3] Its ^{1}H NMR spectrum shows two 1H-singlets at δ 5.08 and 6.10, which should be assigned to H-3 and H-2, respectively. Two ester methyl-singlets are seen at δ 2.98 and 3.72. The relatively high-field appearance of the former may be due to the shielding effect by the phenyl group at C-2. The electronic spectrum of **2a** accords with the structure as a substituted heptafulvene.

Compound **3** was identical with tetramethyl 6-phenyl-2,3,4,5-pyridinetetracarboxylate,[7,8] which was not formed in the reactions of 2*H*-cycloheptathiazol-2-one or azaazulenes.

Compound **4a** ($C_{26}H_{21}NO_8S$) was tentatively assigned to tetramethyl 5-(thiobenzoyliminomethyl)-1,2,3,4-naphthalenetetracarboxylate. In the mass spectrum, a peak at *m/z* 345 (M^+—PhCSNCH) is observed. The electronic spectrum of **1a** has several weak absorption muxima in the visible region; whereas that of **4a** does not. The ^{1}H NMR spectrum of **4a** shows a low-field resonated 1H-singlet at δ 7.67 and a 3H-multiplet at aromatic region (δ 6.85—6.95) together with four ester methyl-singlets and phenyl-multiplets. The IR spectrum of **4a** exhibits a band of medium intensity at 1630 cm^{-1} assignable to C=N in addition to the absorptions of ester carbonyls. These observations suggest that **4a** has a naphthalene nucleus and a C=N group besides four ester groups.



Scheme 1.

A yellow compound **5a** ($C_{26}H_{23}NO_2S$) was a 1:2-adduct, but the structure has not yet been elucidated.

Compounds **1b** and **1c** also reacted with DMAD to give **2b—c**, **3**, **4b—c**, and **5b—c**, respectively. From the results, no particular substituent effect was observed.

A plausible mechanism for the reaction of **1** with DMAD is shown in Scheme 1. Electrophilic attack of DMAD on the nitrogen gives the ylide intermediate **A**. A 1,10-dipolar cyclization of **A** gives **B**, and a subsequent 1,3-hydrogen shift furnishes **2** (path a). Cycloaddition of ylide **A** with DMAD gives **C**. Ring-contraction of **C** accompanied by bond cleavage affords **3** (path b). Cycloaddition of **A** with DMAD and successive rearrangement may lead to **D**, which in turn rearranges to **4** (path c).

Although the dipolar species **A** resembles to that of 2*H*-cycloheptathiazol-2-one, the reaction products differ extremely from each other. This would be associated with the difference of hybridization at C-2 carbon (sp^3 *vs.* sp^2) or the electron-attracting effect of the carbonyl group of 2*H*-cycloheptathiazol-2-one.

Experimental

Melting points are uncorrected. ^1H NMR spectra were taken with a Hitachi R-24B spectrometer (60 MHz) for solutions in $CDCl_3$ with TMS as an internal standard. Electronic spectra were measured for solutions in ethanol and IR spectra for Nujol mulls unless otherwise stated. Mass spectra were determined with a Hitachi M-80 instrument by a field desorption ionization method. Column chromatography was performed on Kieselgel 60.

Syntheses of 2-Arylcycloheptathiazoles. A mixture of 2-aminocycloheptatrienethione[5] (2.74 g, 20 mmol), benzaldehyde (2.12 g, 20 mmol), and concd hydrochloric acid (3.0 ml) in ethanol (40 ml) was refluxed for 4 h. Water (200 ml) was added, and the mixture was extracted with chloroform. The extract was washed, dried (Na_2SO_4), and evaporated. Chromatography of the residue with benzene gave **1a** (2.75 g, 61%) as yellow tar; λ_{max} 248 nm (log ε 4.19), 272 (4.04), 282 (4.03), 290 (4.01), 325 (3.78, sh), 338 (3.80), 354 (3.76), 376 (3.69), 398 (3.26, sh), 419 (3.20), 441 (3.10), 470 (2.82, sh), and 505 (2.17); ν_{max} (neat) 755 and 695 cm^{-1} (phenyl); ^1H NMR δ=6.1—6.8 (5H, m, H-4, 5, 6, 7, and 8), 7.23 (1H, s, H-2), and 7.3—7.55 (5H, m, H-phenyl); Picrate of **1a**: Yellow needles (from ethanol), mp 167—168 °C. Anal. ($C_{20}H_{14}N_4O_7S$) C, H, N.

In a similar manner, we made the following: **1b** [41%, yellow needles (from aq ethanol), mp 80—81 °C (lit,[6] 80.5—81 °C; λ_{max} 219 nm (log ε 4.17), 227 (4.15), 247 (4.15), 270 (3.85), 279 (3.85), 290 (3.84), 342 (3.59, sh), 356 (3.67), 375 (3.59), 397 (3.21), 418 (3.23), 441 (3.15), 468 (2.90), and 500 (2.34, sh); ν_{max} 835 cm^{-1} (phenyl); ^1H NMR δ=6.0—6.8 (5H, m, H-4, 5, 6, 7, and 8), 7.10 (1H, s, H-2), and 7.30 (4H, bs, H-phenyl). Anal. ($C_{14}H_{10}ClNS$) C, H, N.]; **1c** [83%, yellow tar; λ_{max} 252 nm (log ε 4.32), 271 (4.17), 292 (4.16), 342 (3.98), 356 (4.00), 375 (3.89), 395 (3.47, sh), 421 (3.47), 445 (3.38), 471 (3.14, sh), and 503 (2.37, sh); ν_{max} (neat) 820 cm^{-1} (phenyl); ^1H NMR δ=2.33 (3H, s, Me), 6.0—7.0 (5H, m, H-4, 5, 6, 7, and 8), 7.18 (1H, s, H-2), 7.18 (2H, d, J=9 Hz, H-*m*-phenyl), 7.33 (2H, d, J=9 Hz, H-*o*-phenyl). Pycrate of **1c**: Yellow needles (from ethanol), mp 144—146 °C. Anal. ($C_{21}H_{16}N_4O_7S$) C, H, N].

Reaction of 1 with DMAD. A solution of **1a** (3.23 g, 14.4 mmol) and DMAD (6.12 g, 43.1 mmol) in dry benzene (50 ml) was refluxed for 3 h, then evaporated, and the residue chromatographed. Benzene eluted **2a** (0.48 g, 9%), which was crystallized from ethanol as yellow prisms, mp 160—161 °C; λ_{max} 223 nm (log ε 4.52), 275 (3.92), 321 (3.86), and 437 (3.52); ν_{max} 1735 and 1705 cm^{-1} (C=O); 2.90, 3.72 (each 3H, s, OMe), 5.08 (1H, bs, H-4), 6.10 (1H, s, H-2), 6.5—7.1 (3H, m, H-7, 8, and 9), and 7.25—7.7 (6H, m, H-6 and phenyl). Anal. ($C_{20}H_{17}NO_4S$) C, H, N, S. Further elution gave **3** (0.45 g, 8%), which was crystallized from ethanol as colorless prisms, mp 128—129 °C (lit,[7] mp 128—129 °C), Anal. ($C_{19}H_{17}NO_8$) C, H, N. Spectral data were described in lit. 8. Elution with benzene–chloroform (1:1) gave **4a** (1.01 g, 15%), which was crystallized from ethanol as yellow prisms, mp 206—207 °C, λ_{max} 217 nm (log ε 4.66), 321 (3.91), and 390 (3.28); ν_{max} 1750, 1725, 1710, 1700 (C=O), and 1630 cm^{-1} (C=N); ^1H NMR δ=3.02, 3.70, 3.73, 3.84 (each, 3H, s, OMe), 6.85—6.95 (3H, m, H-6, 7, and 8), 7.2—7.4 (3H, m, H-*m,p*-phenyl), 7.6—7.8 (2H, m, H-*o*-phenyl), 7.67 (1H, s, HC=N); MS *m/z* (rel intensity) 507 (M^+, 100), 345 (57). Anal. ($C_{26}H_{21}NO_8S$) C, H, N, S. Further elution gave **5a** (1.06 g, 14%), which was crystallized from ethanol as yellow prisms, mp 147—148 °C; λ_{max} 217 nm (log ε 4.59), 288 (3.83, sh), 313 (3.91), and 369 (3.83); ν_{max} 1735, 1725, 1715, 1695 cm^{-1} (C=O); ^1H NMR δ=3.38, 3.62 (each 3H, s, OMe), 3.67 (6H, s, OMe), 5.00 (1H, dd, J=1.5 and 0.5 Hz), 5.77 (1H, d, J=1.5 Hz), 6.53 (1H, d, J=0.5 Hz), 6.75—6.9 (3H, m), and 7.15—7.4 (5H, m, H-phenyl). Anal. ($C_{26}H_{23}NO_8S$) C, H, N, S.

In a similar manner, **1b** gave **2b** (3%), **3** (28%), **4b** (7%), and **5b** (10%), and **1c** gave **2c** (2%), **3** (23%), **4c** (19%), and **5c** (11%).

2b: Which could not be purified but its structure was elucidated from the ^1H NMR spectrum. ^1H NMR δ=3.03, 3.75 (each 3H, s, OMe), 5.00 (1H, bs, H-4), 6.05 (1H, s, H-2), 6.4—7.0 (3H, m, H-7, 8, and 9), and 7.1—7.5 (5H, m, H-6 and phenyl).

4b: Yellow needles (from cyclohexane–dichloromethane), mp 221—222 °C; λ_{max} 219 nm (log ε 4.58), 321 (3.83), and 392 (3.17); ν_{max} 1750, 1740, 1720, 1705 (C=O), and 1625 cm^{-1} (C=N); ^1H NMR δ=3.10, 3.69, 3.72, 3.83 (each 3H, s, OMe), 6.75—7.0 (3H, m, H-6, 7, and 8), 7.27 (2H, d, J=9 Hz, H-*m*-phenyl), 7.67 (1H, s, HC=N), and 7.70 (2H, d, J=9 Hz, H-*o*-phenyl); MS *m/z* 541 (M^+). Anal. ($C_{26}H_{20}ClNO_8S$) C, H, N, S.

5b: Yellow needles (from ethanol), mp 177—179 °C; λ_{max} 221 nm (log ε 4.52), 282 (3.79), 313 (3.87), and 367 (3.79); ν_{max} 1735, 1720, 1715, and 1685 cm^{-1} (C=O); ^1H NMR δ=3.50, 3.69 (each 3H, s, OMe), 3.72 (6H, s, OMe), 5.03 (1H, dd, J=1.5 and 0.5 Hz), 5.71 (1H, d, J=1.5 Hz), 6.57 (1H, d, J=0.5 Hz), 6.8—7.1 (3H, m), and 7.30 (4H, bs, H-phenyl). Anal. ($C_{26}H_{22}ClNO_8S$) C, H, N, S.

2c: Which could not be purified but its structure was elucidated from the ^1H NMR spectrum. ^1H NMR δ=2.30 (3H, s, Me), 3.00, 3.73 (each 3H, s, OMe), 5.00 (1H, bs, H-4), 6.07 (1H, s, H-2), 6.35—7.0 (3H, m, H-7, 8, and 9), 7.2—7.6 (5H, m, H-6 and phenyl).

4c: Yellow prisms (from ethanol), mp 247—249 °C; λ_{max} 217 nm (log ε 4.70), 322 (3.92), and 395 (3.28); ν_{max} 1755, 1725, 1720, 1705 (C=O), and 1630 cm^{-1} (C=N); ^1H NMR δ=2.33 (3H, s, Me), 3.06, 3.72, 3.75, 3.85 (each 3H, s, OMe), 6.85—7.05 (3H, m, H-6, 7, and 8), 7.12 (2H, d, J=9 Hz, H-*m*-phenyl), 7.67 (2H, d, J=9 Hz, H-*o*-phenyl), and 7.72 (1H, s, HC=N); MS *m/z* (rel intensity) 521 (M^+, 16), 462 (100), 404 (68), 359 (18). Anal. ($C_{27}H_{23}NO_8S$) C, H, N, S.

5c: Yellow needles (from ethanol), mp 125.5—126 °C; λ_{max} 220 nm (log ε 4.55), 288 (3.77, sh), 314 (3.87), and 369 (3.80); ν_{max} 1735, 1725, 1715, and 1690 cm^{-1} (C=O); ^1H NMR δ=2.33 (3H, s, Me), 3.44, 3.66 (each 3H, s, OMe), 3.70 (3H, s, OMe), 5.02 (1H, dd, J=1.5 and 0.5 Hz), 5.80 (1H, d, J=1.5 Hz), 6.58 (1H, d, J=0.5 Hz), 6.8—7.05 (3H, m), and 7.15 (4H, bs, H-phenyl). Anal. ($C_{27}H_{25}NO_8S$) C, H, N.

References

1) R. M. Acheson, *Lect. Heterocyclic Chem.*, **6**, 59 (1982).
2) T. Nishiwaki and N. Abe, *Heterocycles*, **15**, 547 (1981).
3) N. Abe, T. Nishiwaki, and M. Shigematsu, *J. Chem. Soc., Perkin Trans. 1*, **1982**, 2881.
4) T. Iwasaki, S. Kajigaeshi, and S. Kanemasa, *Bull. Chem. Soc. Jpn.*, **51**, 229 (1978).
5) N. Soma, J. Nakazawa, T. Watanabe, Y. Sato, and G. Sunagawa, *Chem. Pharm. Bull.*, **13**, 819 (1965).
6) W. R. Brasen and R. E. Benson, *J. Am. Chem. Soc.*, **83**, 3135 (1961).
7) R. Huisgen and K. Herbig, *Liebigs Ann. Chem.*, **688**, 98 (1965).
8) N. Abe, T. Nishiwaki, and K. Ikeda, *Bull. Chem. Soc. Jpn.*, **55**, 2464 (1982).