

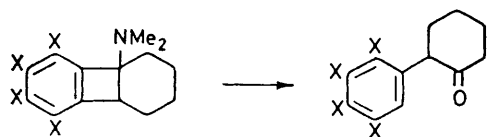
Aryne Chemistry. Part XXXV.¹ Reactions of Arynes with 1-Amino-cycloalkenes and Hydrolyses of the Adducts

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Reactions of benzyne and tetrahalogenobenzyne with 1-dialkylaminocycloalkenes afford the expected benzocyclobutene derivatives. The hydrolysis of these compounds in the presence of aqueous acid proceeds by C-aryl bond cleavage in the case of the tetrahalogeno-compounds whereas in the hydrolysis of 4b-pyrrolidin-1-yloctahydrobenzo[3.4]cyclobuta[1.2]cyclo-octene, C(4b)-C(10a) bond cleavage is observed

We have reported¹ that 4a-dimethylamino-5,6,7,8-tetrafluoro-1,2,3,4,4a,8b-hexahydrobiphenylene (1) is relatively unstable in aqueous media, being rapidly converted into 2-(2,3,4,5-tetrafluorophenyl)cyclohexanone (2). Benzocyclobutenols have been shown to undergo cleavage of the cyclobutene ring in one of two ways to afford carbonyl compounds.² The reactions of benzyne with a number of enamines have been reported but hydrolytic reactions were not mentioned.³ On the other hand certain enamines have been found to form aminocyclobutane derivatives with nitro-olefins which are hydrolysed easily to ketones in the presence of dilute mineral acids.⁴

We now report the full details of our study of enamine-aryne adducts.⁵ The reaction of tetrachlorobenzyne with 1-dimethylaminocyclohexene gave the adduct (3) in 37% yield. However, when we generated benzyne in the presence of 1-dimethylaminocyclohexene we obtained three products. These were the adduct (4) (18%), 2-phenylcyclohexanone (5) (7%), and *N*-methylaniline (3% yield). It is unusual for the nitrogen atom



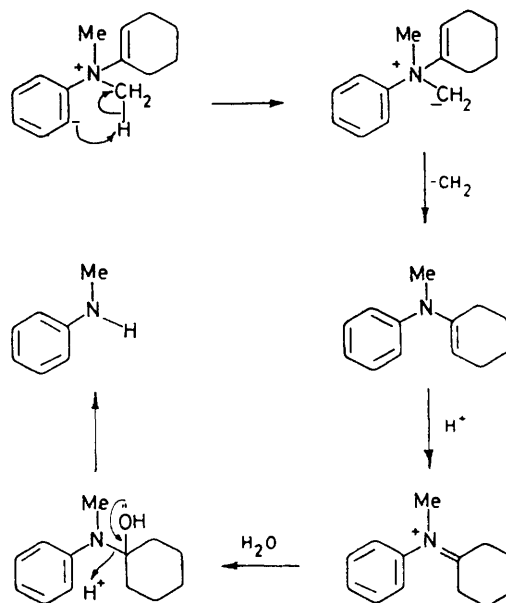
- | | |
|------------|------------|
| (1) X = F | (2) X = F |
| (3) X = Cl | (5) X = H |
| (4) X = H | (8) X = Cl |

in an enamine to function as the nucleophilic centre in reactions with electrophiles. However, we presume that the *N*-methylaniline arises by a process such as

¹ Part XXXIV, J. P. N. Brewer, H. Heaney, S. V. Ley, and T. J. Ward, preceding paper.

² M. P. Cava and K. Multh, *J. Amer. Chem. Soc.*, 1960, **82**, 652; P. Caubere, N. Dérozier, and B. Loubinoux, *Bull. Soc. chim. France*, 1971, 302; P. Caubere, G. Guillaumet, and M. S. Mourad, *Tetrahedron*, 1972, **28**, 95; P. Caubere, *Bull. Soc. chim. France*, 1967, 3451; P. Caubere and B. Loubinoux, *ibid.*, 1968, 3008, 3857; P. Caubere, G. Guillaumet, and M. S. Mourad, *Tetrahedron Letters*, 1971, 4673.

that outlined in Scheme 1. The reactions of tetrafluorobenzyne and benzyne with 1-pyrrolidinocyclo-octene



SCHEME 1

gave the expected adducts (6) and (7) in 50 and 60% yields, respectively.

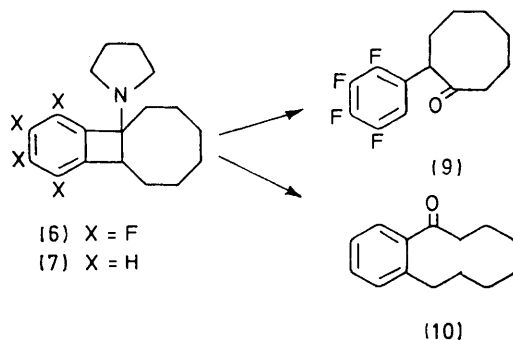
Although satisfactory elemental analyses were obtained for the cycloadducts, the tetrafluoro-compounds undergo hydrolysis in a moist atmosphere. When compounds (1) and (3) were heated in aqueous ethanol containing acid they were rapidly converted into the corresponding 2-arylcyclohexanone derivatives (2) and

³ M. E. Kuehne, *J. Amer. Chem. Soc.*, 1962, **84**, 837; D. J. Keyton, G. W. Griffin, M. E. Kuehne, and C. E. Bayha, *Tetrahedron Letters*, 1969, 4163; T. Kametani, S. Noguchi, I. Agata, T. Aono, K. Kigasawa, M. Hiiragi, T. Hayasaka, and O. Kusama, *J. Chem. Soc. (C)*, 1971, 1047; T. Kametani, K. Kigasawa, M. Hiiragi, T. Hayasaka, and O. Kusama, *ibid.*, p. 1051.

⁴ M. E. Kuehne and L. Foley, *J. Org. Chem.*, 1965, **30**, 4280.

⁵ Preliminary communication, H. Heaney and S. V. Ley, *Chem. Comm.*, 1970, 1184.

(8) in good yield. On the other hand compound (4) was stable under similar conditions. Although a similar cleavage reaction occurred in the acidic hydrolysis of compound (6), the hydrolysis proceeded by a different pathway in the reaction of compound (7) to give the octahydrobenzocyclodecenone (10).



SCHEME 2

We conclude that the ability of the tetrahalogenoaryl residue to stabilise negative charge is probably responsible for the differences in the stability of the various compounds studied. A number of mechanisms could operate in these reactions. Unfortunately we are unable to comment critically on these mechanisms; deuteriolysis reactions gave inconclusive results owing to multiple incorporation of deuterium atoms.

EXPERIMENTAL

For the general methods used see ref. 1.

Reaction of Tetrachlorobenzene with 1-Dimethylaminocyclohexene.—1-Dimethylaminocyclohexene (5 g, 0.04 mol) was added to ethereal pentachlorophenyl-lithium⁶ [from hexachlorobenzene (5.7 g, 0.02 mol)] at -70° . After the mixture had warmed to room temperature the solution was heated under reflux for 4 h and water (100 ml) was then added. The ethereal layer was extracted with aqueous 2N-hydrochloric acid (4×25 ml) and the extracts were immediately neutralised with solid sodium carbonate and re-extracted with ether. Evaporation gave 5,6,7,8-tetrachloro-4a-dimethylamino-1,2,3,4,4a,8b-hexahydrobiphenylene (3) (2.5 g, 37%), m.p. $79-79.5^{\circ}$ (from light petroleum) (Found: C, 49.9; H, 4.5; N, 4.0. $C_{14}H_{15}Cl_4N$ requires C, 49.6; H, 4.5; N, 4.15%; τ ($CDCl_3$) 6.37 (1H, t, $|J|$ 4.5 Hz), 7.68 (6H, s), and 7.7-9.0 (8H, m).

Reaction of Benzene with 1-Dimethylaminocyclohexene.—1-Bromo-2-fluorobenzene (3.5 g, 0.02 mol) in tetrahydrofuran (30 ml) was added dropwise to a solution of 1-dimethylaminocyclohexene (7.5 g, 0.06 mol) in tetrahydrofuran (5 ml) and magnesium turnings (0.485 g, 0.02 g atom) at a rate such that the solution boiled. The mixture was then heated under reflux for 2 h, cooled, and evaporated. The oily residue was taken into ether, washed with water, and extracted with aqueous 2N-hydrochloric acid (4×25 ml). The organic phase gave, after removal of ether and cyclohexanone, 2-phenylcyclohexanone (5) (240 mg, 7%),

⁶ M. D. Rausch, F. E. Tibbetts, and H. B. Gordon, *J. Organometallic Chem.*, 1966, **5**, 493.

m.p. $54-56^{\circ}$ (from aqueous ethanol) (lit.,⁷ $50-53^{\circ}$); τ (CCl_4) 2.7-3.2 (5H, m), 6.4-6.8 (1H, m), and 7.5-8.8 (8H, m).

The combined acidic extracts were neutralised with solid sodium carbonate and extracted with ether to afford an oil which gave, after preparative layer chromatography, (a) *N*-methylaniline (123 mg, 3%) (identical with an authentic sample by i.r. and 1H n.m.r. spectroscopy) and (b) 4a-dimethylamino-1,2,3,4,4a,8b-hexahydrobiphenylene (4) (750 mg, 18%), b.p. 120° at 3 mmHg (Found: C, 83.0; H, 9.6; N, 6.9%; M^+ , 201. $C_{14}H_{19}N$ requires C, 83.55; H, 9.5; N, 6.95%; M , 201); τ (CCl_4) 2.9 (4H, m), 6.45 (1H, t, $|J|$ 4 Hz), 7.72 (6H, s), and 8.0-9.0 (8H, m).

Reactions of Arynes with 1-Pyrrolidin-1-ylcyclo-octene.—In analogous reactions we obtained 1,2,3,4-tetrafluoro-4b,5,6,7,8,9,10,10a-octahydro-4b-pyrrolidin-1-ylbenzo[3,4]-cyclobuta[1,2]cyclo-octene (6) (50%), m.p. $52-54^{\circ}$ (from light petroleum) (Found: C, 66.05; H, 6.5; N, 4.2%; M^+ , 327. $C_{18}H_{21}F_4N$ requires C, 66.1; H, 6.45; N, 4.3%; M , 327); τ (CCl_4) 6.4-6.7 (1H, m), 7.0-7.7 (4H, m), and 7.9-8.7 (16H, m). The ketone (9) was not detected by g.l.c. in the neutral layer.

Similarly we obtained 4b,5,6,7,8,9,10,10a-octahydro-4b-pyrrolidin-1-ylbenzo[3,4]cyclobuta[1,2]cyclo-octene (7) (60%), m.p. $68.5-69^{\circ}$ (from hexane) (Found: C, 84.75; H, 9.95; N, 5.35%; M^+ , 255. $C_{18}H_{25}N$ requires C, 84.65; H, 9.85; N, 5.5%; M , 255); τ (CCl_4) 3.03 (4H, m), 6.52 (1H, t), 7.1-7.6 (4H, m), and 8.0-9.0 (16H, m).

Hydrolysis of the Adduct (3).—Compound (3) (400 mg) was dissolved in aqueous ethanol (10 ml; 75%) containing hydrochloric acid (2 drops) and was heated under reflux for 6 h. Removal of the solvent gave 2-(2,3,4,5-tetrachlorophenyl)-cyclohexanone (8) (98 mg, 96%), m.p. $118-118.5^{\circ}$ (from hexane) (Found: C, 46.15; H, 3.35. $C_{12}H_{10}Cl_4O$ requires C, 46.15; H, 3.2%; τ ($CDCl_3$) 2.79 (1H, s), 5.73-6.1 (1H, m), and 7.3-8.4 (8H, m).

Similarly compound (1)¹ gave compound (2),¹ m.p. and mixed m.p. 95° (lit.,¹ 95°) (99%), but compound (4) was recovered unchanged.

Hydrolysis of the Adduct (6).—By a similar procedure this gave 2-(2,3,4,5-tetrafluorophenyl)cyclo-octanone (9) (76%), m.p. $51.5-52^{\circ}$ (from hexane) (Found: C, 61.5; H, 5.15%; M^+ , 274. $C_{14}H_{14}F_4O$ requires C, 61.3; H, 5.15%; M , 274); τ (CCl_4) 2.58-3.08 (1H, m), 5.64 (1H, t), 7.3-7.65 (2H, m), and 7.65-9.0 (10H, m).

Hydrolysis of the Adduct (7).—After 8 h this gave starting material (5%) and 7,8,9,10,11,12-hexahydrobenzocyclo-dec-5-one (10) (94%), m.p. $52-53^{\circ}$ (from hexane) (lit.,⁸ b.p. $156-160^{\circ}$ at 11 mmHg) (Found: C, 83.3; H, 9.0%; M^+ , 202. Calc. for $C_{14}H_{18}O$: C, 83.15; H, 9.0%; M , 202); τ 2.81 (4H, m), 7.0-7.4 (4H, m), and 8.0-9.4 (10H, m); λ_{max} (cyclohexane) 214 (ϵ 16,150), 235 (7570), and 276 (1040) nm.

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⁷ Heilbron and Bunbury, 'Dictionary of Organic Compounds,' Eyre and Spottiswoode, London, 1953.

⁸ R. Huisgen, I. Ugi, E. Rauenbusch, V. Vossius, and H. Oertel, *Chem. Ber.*, 1957, **90**, 1947.