

Diazonia Hexacyclic Aromatic Systems From bis(Bromomethyl)naphthalenes

C. K. Bradsher and J. P. Sherer

Department of Chemistry, Duke University

Starting with the appropriate bis(bromomethyl)naphthalenes, 14a,16a-diazoniaanthra[1,2-*a*]anthracene salts (**6**), and the 4a,12a- (**13**, **14**) 4a,8a- (**15**) and 8a,16a-diazoniadibenzo[*b,k*]chrysene (**16**) salts have been prepared for the first time.

A few years ago a communication from this laboratory (2) described the synthesis of three diazoniapentaphenes (e.g., **1**) from bis(bromomethyl)benzenes. These were the first examples of completely aromatic condensed benzenoid compounds having two azonia nitrogen atoms at bridgehead positions. Subsequently, other research groups have shown that the tricyclic diazoniaphenanthrene (3,4) and diazoniaanthracene (5) and heptacyclic 7,8-dihydroxy-5a,8a-diazoniaheptaphene salts (**6**) may be prepared.

The present communication deals with our efforts to prepare hexacyclic diazonia compounds starting with five bis(bromomethyl)naphthalenes. When 1,8-bis(bromomethyl)naphthalene (**2**) was allowed to react with slightly over two equivalents of 2-(1,3-dioxolan-2-yl)pyridine (**3**) and the resulting quaternary salt (**5**) heated with polyphosphoric acid, the product, isolated in 90% yield by the tribromide technique (2), was 14a,16a-diazoniaanthra[1,2-*a*]anthracene dibromide (**6**).

This dicyclization is unambiguous in the sense that in **5** each of the side chains attached to the naphthalene ring has only one adjacent position at which cyclization can occur. While the new hexacyclic derivative (**6**) has an ultraviolet absorption indicating that it is a condensed polycyclic system, comparison of the spectrum with that of the parent hydrocarbon, anthra[1,2-*a*]anthracene, is impossible since the hydrocarbon is unknown.

Another unambiguous cyclization involved the isomeric quaternary salt (**7a**, Table I) derived from 1,5-bis(bromomethyl)naphthalene, which has only one open position adjacent to each side chain. The product, believed to be 4a,12a-diazoniadibenzo[*b,k*]chrysene (**13**) bromide, has an ultraviolet absorption spectrum which is related in the usual way (7) to the parent hydrocarbon (**12**). The quaternary salt (**8a**) obtained by reaction of 1,5-bis(bromomethyl)naphthalene and the ketal (**4**) from 2-acetopyridine was more difficult to cyclize and when heated in polyphosphoric acid at 100° gave the monocyclized product (**17**) in 32% yield. Raising the cyclization

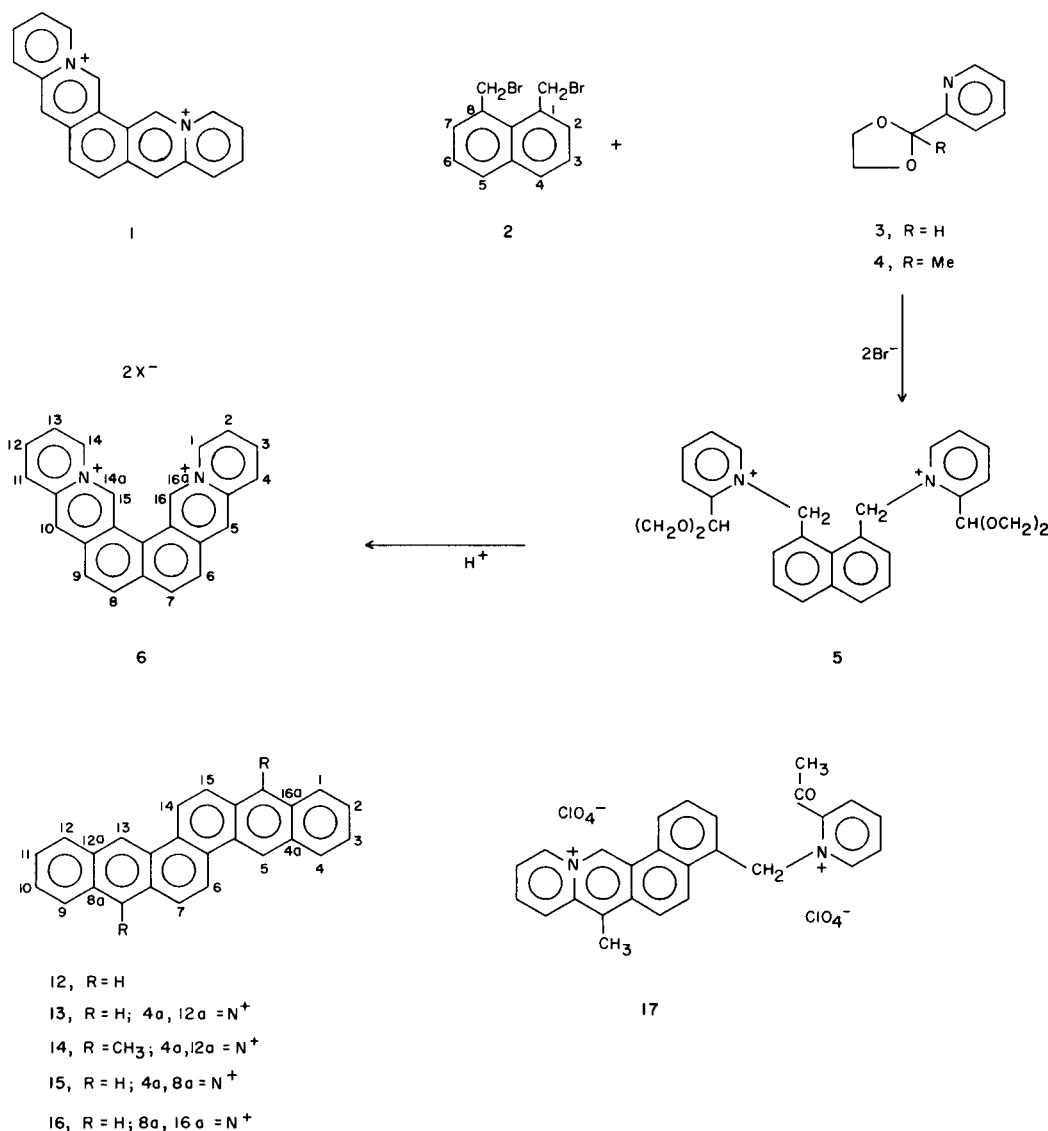
temperature to 125° afforded a good yield (91%) of the dicyclized product (**14a**).

It would be expected that the cyclization of the quaternary salt (**9a**) obtained by the reaction of 2,3-bis(bromomethyl)naphthalene with the acetal (**3**) derived from picolinaldehyde would likewise give a product of unambiguous structure. Unfortunately, no conditions were found for bringing about the cyclization.

The quaternary salt (**10**) derived from 1,6-bis(bromomethyl)naphthalene might lead to two products in that the side chain at position 6 could cyclize either into the adjacent *alpha* position (position 5) or *beta* position (position 7). The only product isolated (34% yield) is believed to be 4a,8a-diazoniadibenzo[*b,k*]chrysene bromide (**15**), formed by cyclization at the *alpha* position. The structural assignment was made by comparison of the ultraviolet spectrum of the cyclization product with that of dibenzo[*b,k*]chrysene (**12**) (8) and that of 4a,12a-diazoniadibenzo[*b,k*]chrysene bromide (**13**).

An even more ambiguous cyclization was provided by the reaction product (**11**) of 2,6-bis(bromomethyl)naphthalene with the picolinic aldehyde acetal (**3**). Each side chain has both an adjacent *alpha* and *beta* position, affording a possibility for three distinct ring systems. The most probable mode of cyclization appeared to be that involving both *alpha* positions of the naphthalene moiety, and judging from the absorption data for the product (Table II) this actually occurred.

The new hexacyclic diazonia compounds (**13-16**) are high melting (> 400°), and yellow or yellow-orange in color. Addition of a bicarbonate solution to an aqueous solution of one of the salts gives a blue color which quickly turns brown. Even polar solvents attack the aromatic diazonia compounds producing dark-colored material. This may be avoided by a small quantity of a mineral acid to the solvent used for crystallization.



EXPERIMENTAL

Elemental analyses were carried out by Dr. Ing. A. Schoeller, Kronach, Germany, and Janssen Pharmaceutica, Beerse, Belgium. Melting points were determined in capillaries using a Mel-Temp melting block and are uncorrected. Ultraviolet absorption spectra were measured in water using 1 cm. quartz cells with the Cary Model 14 spectrophotometer.

bis(Bromomethyl)naphthalenes.

The 1,8-bis(bromomethyl)naphthalene was prepared from naphthalic anhydride as previously described (9). 1,5-bis(bromomethyl)naphthalene, m.p. 215-216° (Lit. (10) 212°) was prepared by the action of phosphorus tribromide on 1,5-bis(hydroxymethyl)naphthalene (11). The 2,3-bis(bromomethyl)-, the 1,6-bis(bromomethyl)- and 2,6-bis(bromomethyl)naphthalenes were prepared by methods described in the literature (12, 10, 13).

Quaternization Reactions.

The bis(bromomethyl)naphthalene 3.14 g. (0.01 mole) was

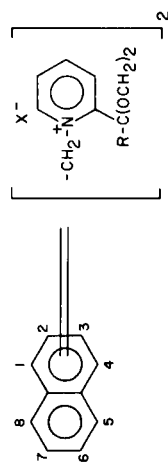
heated on the steam bath with 3.5 g. (0.023 mole) of 2-(1,3-dioxolan-2-yl)pyridine (3) (14) or 3.5 g. (0.021 mole) of 2-(2-methyl-1,3-dioxolan-2-yl)pyridine (4) (14) and 5 ml. of tetramethylene sulfone until a homogeneous solution was obtained. The resulting mixture was allowed to stand at room temperature in a stoppered flask for the specified time (Table I). The solid mass was then broken up, washed with ethyl acetate and then recrystallized from methanol-ethyl acetate affording colorless crystals. Perchlorate salts were prepared by addition of a 35% solution of perchloric acid to an aqueous solution of the bromide.

Cyclization Reactions.

The bis(1-methylene-2-[1,3-dioxolan-2-yl]pyridinium)naphthalene bromides (Table I) were suspended in 10-20 times their weight of polyphosphoric acid and the mixture heated on the steam bath and stirred for the period indicated (Table II). The solution was then cooled, an equal volume of crushed ice added, and the solution heated on the steam bath for 1 hour. The resulting solution was cooled and a solution of one volume of bromide in three volumes of 48% hydrobromic acid was added

TABLE I

Bis-(1-Methylene-2-(1,3-dioxolan-2-yl)pyridinium)naphthalene Salts



| No. | R | Subst. | Time Days | Anion X | Yield, % | M.P., °C. | Formula | C | | H | | N | |
|-----|----|--------|-----------|------------------|----------|---------------------|--|--------|-------|--------|-------|--------|-------|
| | | | | | | | | Calcd. | Found | Calcd. | Found | Calcd. | Found |
| 5a | H | 1,8 | 2 | Br | 81 (a) | 136-138 (b) (c) | C ₂₈ H ₂₈ Br ₂ N ₂ O ₄ ·½H ₂ O | 53.77 | 53.97 | 4.67 | 4.69 | 4.48 | 4.47 |
| 5b | H | 1,8 | — | ClO ₄ | — | >400 (d) (e) (f) | C ₂₈ H ₂₈ Cl ₂ N ₂ O ₁₂ | 51.31 | 51.31 | 4.31 | 4.49 | 4.28 | 4.50 |
| 7a | H | 1,5 | 4 | Br | 89 | 172-174 (d) (g) | C ₂₈ H ₂₈ Br ₂ N ₂ O ₄ ·H ₂ O | 53.01 | 53.12 | 4.77 | 4.61 | 4.42 | 4.28 |
| 7b | H | 1,5 | — | ClO ₄ | — | 236-238 (c) | C ₂₈ H ₂₈ Cl ₂ N ₂ O ₁₂ | 51.31 | 51.34 | 4.31 | 4.20 | 4.28 | 4.42 |
| 8a | Me | 1,5 | 9 | Br | 81 | 187-189 (e) | C ₃₀ H ₃₂ Br ₂ N ₂ O ₄ | 55.91 | 55.52 | 5.01 | 4.96 | 4.35 | 4.37 |
| 8b | Me | 1,5 | — | ClO ₄ | — | 226 (d) (g) | C ₃₀ H ₃₂ Cl ₂ N ₂ O ₁₂ | 52.71 | 52.96 | 4.72 | 4.98 | 4.10 | 4.23 |
| 8c | Me | 1,5 | 3/4 (h) | I | 69 | 173-174 (b) (d) (g) | C ₃₀ H ₃₂ I ₂ N ₂ O ₄ | 48.79 | 48.88 | 4.37 | 4.20 | 3.79 | 3.95 |
| 9a | H | 2,3 | 20 | Br | 90 | 146-147 (e) | C ₂₈ H ₂₈ Br ₂ N ₂ O ₄ ·H ₂ O | 53.01 | 53.16 | 4.77 | 4.76 | 4.42 | 4.60 |
| 9b | H | 2,3 | — | ClO ₄ | — | 220-221 (d) (e) (i) | C ₂₈ H ₂₈ Cl ₂ N ₂ O ₁₂ | 51.31 | 51.23 | 4.31 | 4.18 | 4.28 | 4.44 |
| 10b | H | 1,6 | 20 | ClO ₄ | 80 (j) | 212.2-213.5 | C ₂₈ H ₂₈ Cl ₂ N ₂ O ₁₂ | 51.31 | 51.64 | 4.31 | 4.24 | 4.28 | 4.40 |
| 11a | H | 2,6 | 22 (k) | Br | 93 | 196-197 (d) (e) | C ₂₈ H ₂₈ Br ₂ N ₂ O ₄ | 54.56 | 54.15 | 4.58 | 4.58 | 4.55 | 4.53 |
| 11b | H | 2,6 | — | ClO ₄ | — | 251-253 (d) (e) (i) | C ₂₈ H ₂₈ Cl ₂ N ₂ O ₁₂ | 51.31 | 51.38 | 4.31 | 4.33 | 4.28 | 4.47 |

(a) Using dimethylformamide as a solvent. Only 55% yield was obtained in tetramethylenesulfone. (b) Light yellow. (c) Needles. (d) With decomposition. (e) Prisms. (f) From methanol-acetonitrile. (g) Microcrystalline powder. (h) 1,8-bis(Iodomethyl)naphthalene was heated at 100° with the ketal 4. (i) From acetonitrile-ethyl acetate. (j) The quaternization product (bromide, 10a) would not crystallize and one-fifth of the product was converted to the solid perchlorate to determine the yield and to provide a sample for analysis. The crude bromide was used in our cyclization experiments. (k) Quaternization yields in solvents other than tetramethylene sulfone: dimethylformamide, 25°, 68%; ethylene carbonate, 25°, 88%; acetone, 56°, 85%; no solvent, 100° for 3 hours, 69%. Not only did tetramethylene sulfone give a better yield, but also a purer product.

TABLE II
Diazonia Derivatives of Dibenzo[*b,k*]chrysenes

| Compd. No. | R | N ⁺ at Positions | X ⁻ | Time Hr. | Yield, % | Starting Cpd. | Formula | Anal. | | λ max (mμ), H ₂ O (log ε) |
|------------|----|-----------------------------|------------------|----------|----------------|---------------|---|----------------|--------------|---|
| | | | | | | | | Calcd. C | Found H N | |
| 13 | H | 4a, 12a | Br | 24 | 85 (a) (b) (c) | 7a | C ₂₄ H ₁₆ Br ₂ N ₂ | 58.56 58.75 | 3.28 3.32 | 255sh (4.52), 271 (4.78), 293 (4.87) 304.5 (4.89), 332sh (3.93), 367sh (3.98), 385 (4.33), 406.5 (4.56), 434 (4.36). 245sh (4.38), 260sh (4.53), 267sh (4.59), 276 (4.81), 297 (4.83), 309 (4.82), 337.5sh (3.50), 373sh (3.83), 393 (4.28) 415 (4.59), 441 (4.43). |
| 14a | Me | 4a, 12a | Br | 17 (d) | 91 (e) (f) | 8a | C ₂₆ N ₂ OBr ₂ N ₂ | 60.02 59.89 | 3.87 3.85 | 251sh (4.44), 272 (4.68), 290sh (4.66), 299 (4.73), 311 (4.79), 350 (4.00), 370sh (4.00), 388sh (4.27), 397.5sh (4.38), 409 (4.48), 416.5sh (4.47), 439sh (4.03). |
| 14b | Me | 4a, 12a | ClO ₄ | — | — (e) (f) | | C ₂₆ H ₂₀ Cl ₂ N ₂ O ₈ | 55.82 55.67 | 3.60 3.72 | 234 (4.28), 241sh (4.25), 269 (4.70), 277 (4.68), 310 (4.63), 324 (4.83), 342.51sh (4.06), 369 (4.13), 389 (4.26), 407 (3.82), 433 (4.08), 461 (4.22). |
| 15a | H | 4a, 8a | Br | 3 | 34 (g) (e) (h) | 10a | C ₂₄ H ₁₆ Br ₂ N ₂ ·4H ₂ O | 58.03 58.12 | 3.35 3.42 | |
| 15b | H | 4a, 8a | ClO ₄ | — | — (e) (f) | | C ₂₄ H ₁₆ Cl ₂ N ₂ O ₈ | 54.25 54.40 | 3.04 3.00 | |
| 16a | H | 8a, 16a | Br | 24 | 54 (i) (e) (f) | 11a | C ₂₄ H ₁₆ Br ₂ N ₂ ·4H ₂ O | 58.03 57.69 | 3.35 3.60 | |
| 16b | H | 8a, 16a | ClO ₄ | — | — (e) (f) | | C ₂₄ H ₁₆ Cl ₂ N ₂ O ₈ | 54.25 54.15 | 3.04 3.13 | |

(a) Dark yellow. (b) Irregular crystals. (c) From acidified water-ethanol. The perchlorate, m.p. > 400° exploded on heating and did not give satisfactory carbon and hydrogen analyses. (d) At 120-130°. (e) Yellow. (f) Needles. (g) Overall yield from 1,6-bis(bromomethyl)naphthalene. The intermediate bromide was not obtained in a crystalline condition. (h) Microcrystalline powder. (i) If the starting material (**11a**) was refluxed for 24 hours in a mixture containing 20 ml. of 48% hydrobromic acid and 40 ml. of acetic acid a 70% yield of **16b** was obtained.

until no further precipitation occurred. The tribromide salt was collected, washed with cold water then dissolved in 1:1 acetone-water solution. The mixture was concentrated and the bromide which crystallized was purified by recrystallization. The salts melted above 400° usually with decomposition. Further details concerning the formation of diazoniadibenzo[*b,k*]chrysenes will be found in Table II.

14a,16a-Diazoniaanthra[1,2-*a*]anthracene Dibromide (6).

The cyclization of 1,8-bis(1-methylene-2-[1,3-dioxolan-2-yl]-pyridinium bromide)naphthalene (5a) was carried out for 2 hours essentially as described in the preceding paragraph, affording yellow orange needles, m.p. > 400° dec. from acidified water-acetonitrile solution, yield (90%).

Anal. Calcd. for C₂₄H₁₆Br₂N₂: C, 58.56; H, 3.28; N, 5.70. Found: C, 58.34; H, 2.96; N, 5.80.

The perchlorate crystallized from acidified water-acetonitrile as long golden needles, m.p. > 400° dec.

Anal. Calcd. for C₂₄H₁₆Cl₂N₂O₈: C, 54.25; H, 3.04; N, 5.27. Found: C, 54.59; H, 2.88; N, 5.61.

4-(1-Methylene-2-acetylpyridinium)-7-methylbenz[*h*]acridizinium Perchlorate (17).

A solution of 0.87 g. of 1,5-bis(1-methylene-2-[2-methyl-1,3-dioxolan-2-yl]pyridinium)naphthalene bromide (8a) in 15 g. of polyphosphoric acid was heated and stirred for 19 hours. The solution was diluted in the usual way, heated, filtered and cooled. To the cold diluted solution, 35% perchloric acid was added and the resulting precipitate crystallized from methanol-ethyl acetate. The resulting yellow powder m.p. > 400°; 0.25 g. (32%), had a strong absorption in the infrared at 5.85 μ (carbonyl) and in solution exhibited a blue fluorescence, u.v. max (95% ethanol) 232.5 mμ (log ε 4.53), 270sh (4.56), 274 (4.57), 306 (4.32), 318.5 (4.39), 344 (3.85), 360 (4.07), 379 (4.36), 399 (5.11).

Anal. Calcd. for C₂₆H₂₂Cl₂N₂O₉: C, 54.08; H, 3.84; N, 4.85. Found: C, 54.20; H, 3.86; N, 5.15.

REFERENCES

- (1) This investigation was supported by a research grant CA-05509 of the National Cancer Institute of the National Institutes of Health.
- (2) C. K. Bradsher and J. C. Parham, *J. Org. Chem.*, **29**, 856 (1964).
- (3) I. C. Calder and W. H. F. Sasse, *Tetrahedron Letters*, 3871 (1964).
- (4) D. H. Corr and E. E. Glover, *Chem. Ind. (London)*, 847 (1965).
- (5) E. E. Glover and G. H. Morris, *J. Chem. Soc.*, 3885 (1965).
- (6) D. L. Diels, J. B. Miller and D. D. Reynolds, *J. Org. Chem.*, **29**, 2640 (1964).
- (7) The main differences between the spectrum of the parent hydrocarbon and that of an azonia derivative are a loss of fine structure, a bathochromic shift of the long wavelength bands and an increase in intensity of these same bands. A qualitatively similar effect has been seen in comparison of polycyclic hydrocarbons with their aza derivatives. G. M. Badger, R. S. Pearce, and R. Pettit, *J. Chem. Soc.*, 3199 (1951).
- (8) E. Clar, H. Wallenstein, and R. Avenarius, *Ber.*, **62**, 950 (1929).
- (9) W. J. Mitchell, R. D. Topsom and J. Vaughan, *J. Chem. Soc.*, 2562 (1962).
- (10) W. Ried and H. Boden, *Chem. Ber.*, **91**, 1981 (1958).
- (11) G. Lock and E. Walter, *ibid.*, **75B**, 1158 (1942).
- (12) W. Werner, *J. Org. Chem.*, **17**, 523 (1952).
- (13) J. Diekmann, W. R. Hertler and R. E. Benson, *ibid.*, **28**, 2719 (1963).
- (14) C. K. Bradsher and J. C. Parham, *ibid.*, **28**, 83 (1963).

Received January 13, 1968

Durham, N. C. 27706