Formation of Cyclopropyl Ring by Action of Sodium Amide on *exo*-Methyleneammonium Ions Obtained from Rearrangement of Certain 2,6-Dimethylbenzyltrimethylammonium Ions[1]

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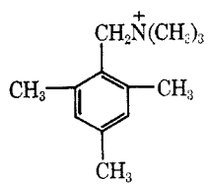
Reinvestigation (by nmr) of the structure of the product produced in the *ortho*-substitution rearrangement of the 2,4,6-trimethylbenzyltrimethylammonium ion by sodium amide in liquid ammonia, followed by two more such rearrangements of the methiodides of resulting *exo*-methyleneamines, has revealed that a cyclopropyl ring was introduced into the molecule. Similarly, two such rearrangements starting with the 2,3,5,6-tetramethylbenzyltrimethylammonium ion afforded an *exo*-methyleneamine having a cyclopropyl ring. Side reactions were observed in the latter case. Possible mechanisms are suggested.

It has previously been shown that the 2,4,6-trimethylbenzyltrimethylammonium ion (**1**) can be rearranged by sodium amide in liquid ammonia to form the *exo*-methyleneamine **2**[2] and that **2** can be converted through the methiodide **3** into another *exo*-methyleneamine **4**[3] by further treatment with this reagent. However, the methiodide **5**, prepared from **4**, was converted by this reagent into an unknown alicyclic amine that was tentatively assigned structure **6**.[3]



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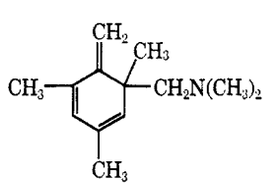

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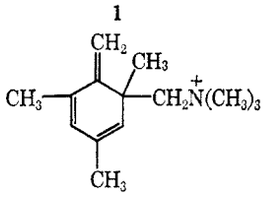

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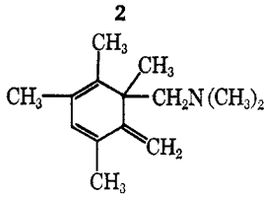

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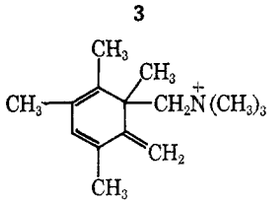

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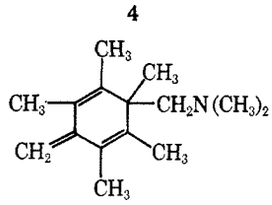

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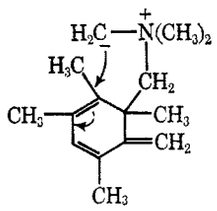
We have now obtained evidence that this last product is the *exo*-methyleneamine **9** having a cyclopropyl group. A possible mechanism for the introduction of the cyclopropyl group would involve addition of ylide **7** across the olefinic bond to form the resonance stabilized anion **8**, which undergoes an intramolecular displacement. Dreiding models indicate that ylide **7** can readily achieve a conformation favorable for such a mechanism. The last two steps might occur so rapidly that the mechanism is essentially concerted.

Structure **9** containing a cyclopropyl group was supported by analysis and by nmr, ir, and uv spectra. The nmr spectrum of **9** clearly showed an AB pattern at high field arising from the two cyclopropyl hydrogens. Other features of the spectrum were consistent with



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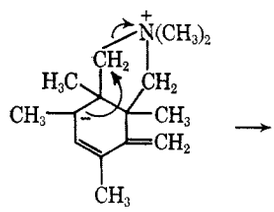

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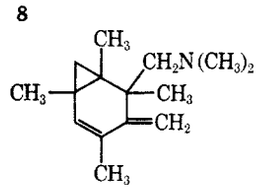


9

structure **9**. Significantly, this *exo*-methyleneamine structure, which has only two conjugated double bonds, is in agreement with the earlier reported[3] failure of this compound to undergo rearomatization on heating at 150° or on treatment with dilute hydrochloric acid, conditions that effect rearomatization of *exo*-methyleneamines having three conjugated double bonds such as **2** and **4**.

Similarly, methiodide **11**, prepared from tertiary amine **10**, was converted into an *exo*-methyleneamine having a cyclopropyl group by only two rearrangements. Thus, **11** underwent rearrangement with sodium amide in liquid ammonia to form *exo*-methyleneamine **12**, most of which was converted through its methiodide **13** into the cyclopropyl derivative **14**. However, part of **12** evidently underwent isomerization to form *exo*-methyleneamine **15** (see below), and some of **15** may have been converted through its methiodide **16** into the cyclopropyl derivative **17** (Scheme I).

Cyclopropyl derivative **17** was not isolated but olefin **23**, which must have arisen through *exo*-methyleneamine **15**, was obtained along with olefin **20** as by-products when crude *exo*-methyleneamine **12** was treated with methyl iodide followed by alkali amide in liquid ammonia to form cyclopropyl derivative **14** (see Schemes I and II).

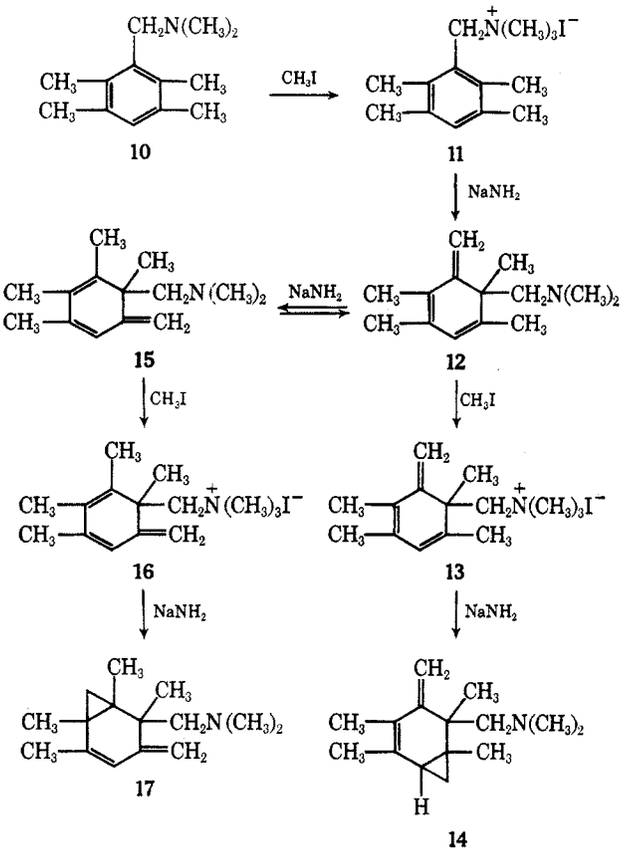
Although the cyclopropyl derivative **14** was obtained contaminated with small amounts of olefins **20** and **23**, **14** was isolated in the essentially pure condition by vpc; its structure was supported by analysis and absorption spectra. In contrast to the nmr spectrum of **9** which showed an AB system for the cyclopropyl protons, the nmr spectrum of **14** showed an ABC system. The nmr spectrum of **14** at 220 MHz showed clearly separated

(1) Supported by Army Research Office (Durham).

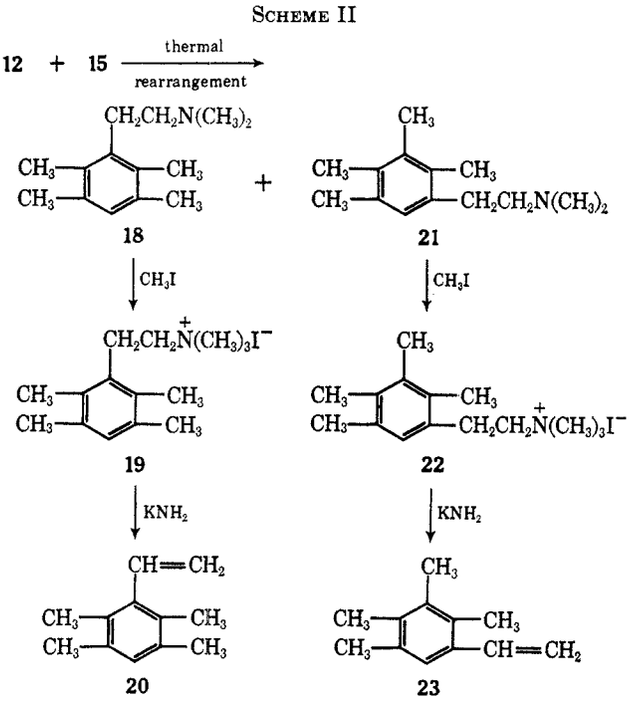
(2) C. R. Hauser and D. N. Van Eenam, *J. Amer. Chem. Soc.*, **79**, 5512 (1957).

(3) C. R. Hauser and D. N. Van Eenam, *ibid.*, **79**, 6280 (1957).

SCHEME I



SCHEME II

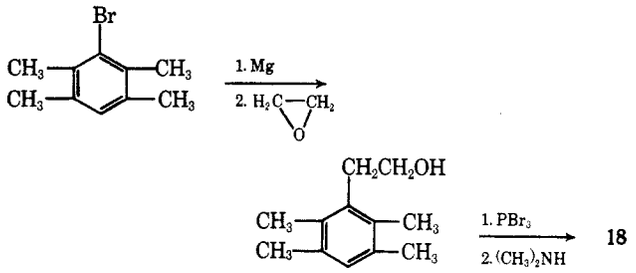


signals at high field arising from the three cyclopropyl hydrogens. Other features of the spectrum were consistent with structure **14**.

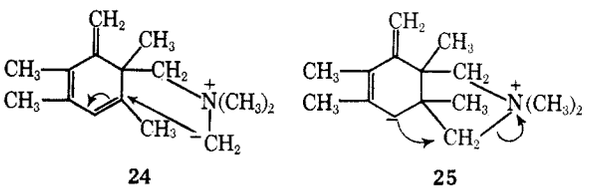
Like the cyclopropyl derivative **9** obtained from the mesityl methiodide **5** (see above), the cyclopropyl derivative **14** was found to be relatively stable toward heat and acid. Thus, **14** was recovered after distillation, after heating at 250° (vpc conditions), after standing at room temperature for more than 4 months, and after treatment with dilute hydrochloric acid.

The rearomatization of *exo*-methyleneamine **12** to form β-arylethylamine **18** was readily effected at 150–170° (see Scheme II). Although distilled *exo*-methyleneamine **12** was used in this thermal rearrangement, it was evidently contaminated with the isomeric amine **15**, since some of the β-arylethylamine **21** also appeared to be produced. Thus, treatment of the product with methyl iodide, followed by potassium amide, afforded olefins **20** and **23** in the ratio of about 4:1 (by vpc). The β-arylethylamine **18** was independently synthesized from bromodurene (Scheme III), and converted into pure olefin **20** through the methiodide **19**.

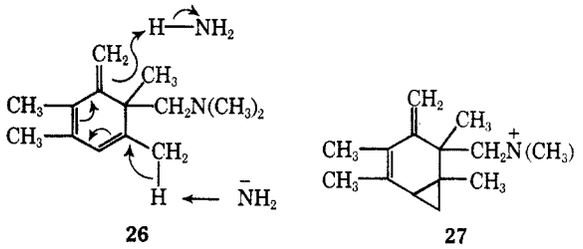
SCHEME III



The mechanism of the rearrangement of methiodide **13** to form the cyclopropyl derivative **14** (see Scheme I) may be indicated by **24** and **25**. Consideration of molecular models indicated that this mechanism is possible.



The isomerization of *exo*-methyleneamine **12** to form the isomeric *exo*-methyleneamine **15** (see Scheme I) presumably involves the amide ion catalyzed mechanism indicated in **26**. Incidentally, *exo*-methyleneamine **2** appears incapable of undergoing such a base-catalyzed isomerization and, although *exo*-methyleneamine **4** may isomerize, the process would lead only to regeneration of **4**.



The cyclopropylamine **14** was converted into its methiodide **27** but further treatment of this product with sodium amide failed to afford an isolable compound.

It should be mentioned that the present type of rearrangement of quaternary ammonium ions involving introduction of a cyclopropyl group into the molecule appears to be unprecedented in the literature. Studies are in progress on simpler models of this type of rearrangment.

Experimental Section[4]

Rearrangement of Methiodide 1 to Form *exo*-Methyleneamine 2. Conversion into Methiodide 3.—Rearrangement[2] of 1 was effected with $NaNH_2$ in liquid ammonia[5,6] to give 6-methylene-1,3,5-trimethyl-1-dimethylaminomethylcyclohexadiene-2,4 (2, 44%): bp 50–52° (0.45 mm); $n^{25}D$ 1.5120; uv λ_{max} 314 mμ (log ε 3.8); ir (neat) 3105 (C=CH_2), 1690, 1600 and 1580 cm^{-1} (C=C); nmr 5.65 (broad s, 1.0 H, C_4-H), 5.40 (broad s, 1.1 H, C_2-H), 5.22 (broad s, 1.0 H) and 5.02 (d, 0.9 H, J = 2.0 Hz, C=CH_2), 2.40 and 2.24 (AB pattern, 2.4 H, J = 13.2 Hz, CH_2N), 2.18 (s, 6.0 H, NCH_3), 1.89 (d, 2.8 H, J = 1.0 Hz, C_5-CH_3), 1.74 (d, 2.8 H, J = 1.7 Hz, C_3-CH_3), and 1.09 ppm (s, 2.7 H, C_1-CH_3).

Anal. Calcd for $C_{13}H_{21}N$: N, 7.32. Found: N, 7.29.

Methylation[3] of *exo*-methyleneamine **2** was effected with methyl iodide in acetonitrile to give *exo*-methyleneamine methiodide **3** (90%): mp 153–155° dec; ir (KBr) 3080 (C=CH_2), 1660 and 1570 cm^{-1} (C=C).

Rearrangement of *exo*-Methyleneamine Methiodide 3 to Form *exo*-Methyleneamine 4. Conversion into Methiodide 5.—Rearrangement[3] of **3** was effected with $NaNH_2$ in liquid ammonia[5,6] to afford 6-methylene-1,2,3,5-tetramethyl-1-dimethylaminomethylcyclohexadiene-2,4 (**4**, 62%): bp 65–67° (0.43–0.46 mm); $n^{25}D$ 1.5237; uv λ_{max} 319 mμ (log ε 4.0) (calcd λ_{max} 318 mμ); ir (neat) 3110 (C=CH_2), 1660, 1590 and 1570 cm^{-1} (C=C); nmr 5.63 (s, 1.0 H, C_4-H), 5.16 (s, 1.0 H) and 5.03 (d, 1.0 H, J = 2.0 Hz, C=CH_2), 2.55 and 2.25 (AB pattern, 2.1 H, J = 12.9 Hz, CH_2N), 2.13 (s, 5.9 H, NCH_3), 1.86 (s, C_5-CH_3) and 1.73 (s, C_2-CH_3 and C_3-CH_3, 9.0 H), and 1.13 ppm (s, 2.9 H, C_1-CH_3).

Anal. Calcd for $C_{14}H_{23}N$: N, 6.82. Found: N, 6.79.

Also, there was obtained from the above distillation β-isodurylethyldimethylamine (thermal isomerization product, 9%): bp 87–89° (0.36 mm); $n^{25}D$ 1.5180.

Anal. Calcd for $C_{14}H_{23}N$: N, 6.82. Found: N, 7.14.

This β-arylethylamine was evidently produced when a sample of *exo*-methyleneamine **4** was subjected to vpc at 270°, since the retention time observed was that of the aromatic compound.

Methylation[3] of *exo*-methyleneamine **4** was effected with methyl iodide in acetonitrile to give methiodide **5** (94%): mp 182–183° dec and 181–182° dec (recrystallized from acetonitrile–ether); ir (KBr) 3095 (C=CH_2), 1785, 1710, 1650, and 1570 cm^{-1} (C=C).

Anal. Calcd for $C_{15}H_{25}NI$: C, 50.23; H, 7.28; N, 4.05. Found: C, 50.49; H, 7.68; N, 3.92.

Rearrangement of *exo*-Methyleneamine Methiodide 5 to Form *exo*-Methylene Bicyclic Amine 9.—To a stirred suspension of 0.255 mol of $NaNH_2$ in 300 ml of liquid ammonia[5,6] was added, during 5 min, 26.10 g of finely powdered *exo*-methyleneamine methiodide **5**. After stirring for 1 hr (color changed from deep purple-red to deep purple), the reaction mixture was decomposed with 10 g of NH_4Cl and then worked up as described previously.[3] The oily product (7.88 g) was distilled to give, after a small amount of forerun (0.30 g), 4.84 g (30%) of 3-methylene-1,2,4,6-tetramethyl-2-dimethylaminomethylbicyclo[4.1.0]heptene-4 (**9**): bp 71–72° (0.45 mm); $n^{25}D$ 1.5115; uv λ_{max} 257 mμ (log ε 4.0); ir (neat) 3113 (C=CH_2), 3060 (cyclopropylmethylene), 1760, 1665, 1640 and 1600 cm^{-1} (C=C); nmr 5.70 (broad s, 1.0 H, C_5-H), 5.03 (m, 2.1 H, C=CH_2), 2.75 and 2.55 (AB pattern, 2.2 H, J = 14.8 Hz, CH_2N), 2.35 (s, 6.0 H, NCH_3), 1.74 (d, 2.9 H, J = 1.3 Hz, C_4-CH_3), 1.19 (s, 6.0, H, C_1-CH_3 and C_6-CH_3), 0.93 (s, 3.0 H, C_2-CH_3), and 0.79 and 0.47 ppm (AB pattern, 2.0 H, J = 3.7 Hz, cyclopropyl methylene); the nmr spectrum was unchanged after the solution had stood at room temperature for 3 days.

Anal. Calcd for $C_{15}H_{25}N$: C, 82.13; H, 11.49; N, 6.39. Found: C, 81.90; H, 11.26; N, 6.52.

2,3,5,6-Tetramethylbenzyldimethylamine (10). Conversion into Methiodide 11.—Chloromethylation of durene (161 g) was effected as usual with aqueous formaldehyde, glacial acetic acid, and concentrated HCl. The crude chloromethydurene was added to a cold solution of dimethylamine (110 g) in acetonitrile (800 ml). After stirring for 3 hr at room temperature, the solvent was evaporated (steam bath) under reduced pressure. The residue was stirred with 400 ml of 20% NaOH. The liberated amine was taken up in benzene and converted into its hydrochloride salt with 500 ml of cold 10% HCl. The amine was again liberated with 300 ml of 20% NaOH and again taken up in benzene. The benzene solution was dried (Na_2CO_3) and fractionated to give 189.0 g (82%) of amine **10**: bp 135° (14 mm); nmr 6.88 (s, 0.9 H, C_4-H), 3.43 (s, 2.0 H, CH_2N), and 2.21 ppm (m, 18.0 H, C_2-CH_3, C_3-CH_3, C_5-CH_3, C_6-CH_3, and N-CH_3).

Anal. Calcd for $C_{13}H_{21}N$: C, 81.61; H, 11.06; N, 7.32. Found: C, 81.63; H, 11.42; N, 7.03.

Methylation of benzylamine **10** (186 g) was effected with methyl iodide (207 g) in acetonitrile (600 ml) to give, on stirring with anhydrous ether (1.3 l), 322.6 g (100%) of methiodide **11** as crystalline powder, mp 233–236° dec; recrystallization from dry acetonitrile afforded needles, mp 228° (darkened), 234–236° dec; ir (KBr) 3005 (aromatic C-H) and 870 cm^{-1} (pentasubstituted benzene ring).

Anal. Calcd for $C_{14}H_{24}NI$: C, 50.45; H, 7.26; N, 4.20. Found (before recrystallization): C, 50.34; H, 7.42; N, 4.07. Found (after recrystallization): C, 50.54; H, 7.40; N, 4.05.

Rearrangement of Methiodide 11 to Form *exo*-Methyleneamine 12.—To a stirred suspension of 0.45 mol of $NaNH_2$ in 500 ml of liquid ammonia[5,6] was added, during 5 min, 50.0 g (0.15 mol) of the methiodide **11** through Gooch tubing from an erlenmeyer flask (under anhydrous condition). After 2 hr (gray color changed to deep maroon), the reaction mixture was decomposed with 25 g of NH_4Cl. Anhydrous ether[7] (300 ml) was added dropwise while the liquid ammonia was evaporated on the steam bath. As soon as the ether began to reflux the reaction mixture was cooled and filtered. The solvent was removed at about 40° under reduced pressure, the last traces being removed *in vacuo* at 40°, to give 29.55 g (96% calculated as *exo*-methyleneamine **12**) of crude product (faintly yellow oil), $n^{25}D$ 1.5344. The uv and ir spectra of this crude product were almost identical with those of pure *exo*-methyleneamine **12** (see below).

Distillation of 10 g of the crude product under nitrogen through a Vigreux column gave 3.85 g (39%) of 6-methylene-1,2,4,5-tetramethyl-1-dimethylaminomethylcyclohexadiene-2,4 (**12**): bp 65–68° (0.16–0.20 mm); $n^{25}D$ 1.5259; uv λ_{max} 313[8] mμ (log ε 3.7) and 253[9] mμ (log ε 3.7); ir (neat) 3100 (C=CH_2), 1660, 1595 (sh), 1585 and 1565 cm^{-1} (sh) (C=C); nmr 5.65 (broad s, 0.9 H, C_3-H), 5.12 (s) and 4.97 (s) (1.9 H, C=CH_2), 2.53 and 2.23 (AB pattern, 2.3 H, J = 21.8 Hz, CH_2N), 3.82 (s, 6.0 H, NCH_3), 1.83 (s, 9.0 H, C_2-CH_3, C_4-CH_3 and C_5-CH_3), and 1.18 ppm (s, 2.7 H, C_1-CH_3).

Anal. Calcd for $C_{14}H_{23}N$: C, 81.89; H, 11.29; N, 6.82. Found: C, 81.79; H, 11.39; N, 6.72.

Also, there was obtained from the above distillation 3.17 g (32%) of β-arylethylamine **18** (contaminated with some of isomeric amine **21**), bp 82–84° (0.12–0.15 mm), $n^{25}D$ 1.5179, and 2.69 g of light brown residue. The amine **18** was identified by vpc (one peak having shoulder for **21**) and by ir and nmr spectra which were almost identical with those of **18** obtained by thermal isomerization of *exo*-methyleneamine **12** (see below).

Hydrolysis of *exo*-methyleneamine **12** (1.23 g) occurred rapidly on adding it to 30 ml of 2 *N* HCl at 0°. After stirring for 1.5 hr, the precipitate was collected, washed with water, and dried in air to give 0.67 g (75%) of pentamethylbenzene, mp 51–52°; the ir spectrum was identical with that of an authentic sample. The mixture melting point was not depressed.

Conversion of Crude *exo*-Methyleneamine 12 into Methiodide 13.—To a stirred solution of 29.25 g (0.142 mol) of freshly prepared (but not distilled) *exo*-methyleneamine **12** (containing some of *exo*-methyleneamine **15**) in 150 ml of anhydrous acetone was added, under nitrogen, 30.4 g (0.214 mol) of methyl iodide. After

(4) Melting and boiling points are uncorrected. Elemental analyses were performed by Janssen Pharmaceutica, Beerse, Belgium, and by M-H-W Laboratories, Garden City, Mich. Uv spectra were produced on a Beckman DB-G spectrophotometer in 95% ethanol. Ir spectra were produced on a Perkin-Elmer Infracord, Models 137 and 237. Nmr spectra were obtained in deuteriochloroform with Varian A-60 and superconducting 220-MHz spectrometers and signals are reported in δ units downfield from internal tetramethylsilane standard. Vpc were carried out on F & M Model 500 with a 15-ft column of silicone gum rubber 30% on 60–80 mesh Chromosorb W at 250–270° and 120–200 ml/min of helium.

(5) See C. R. Hauser, F. W. Swamer, and J. T. Adams, *Org. Reactions*, **8**, 122 (1954).

(6) Commercial anhydrous liquid ammonia was distilled and used immediately.

(7) Freshly distilled from calcium hydride after drying over calcium hydride and sodium borohydride.

(8) The intensity of this peak diminished on standing and completely disappeared after 11 days.

(9) This peak may be ascribed to a decomposition product.

1 hr, the precipitate was collected, washed with 30–50 ml of anhydrous acetone, and dried in a vacuum oven at 40° (for *ca.* 3 hr) to give 40.8 g (83%) of methiodide **13** (containing some of methiodide **16**): this white powder showed no sharp melting point, and darkened at 165–167°; mp 225–230° dec; ir (KBr) 3100 (C=CH_2), 1660 and 1585 cm^{-1} (C=C).

Anal. Calcd for $C_{15}H_{26}NI$: C, 51.88; H, 7.55; N, 4.03. Found: C, 52.12; H, 7.63; N, 3.75.

Rearrangement of *exo*-Methlenecyclohexadieneamine Methiodide 13 to Form *exo*-Methylene Bicylic Amine 14.—To a stirred suspension of 0.152 mol of $NaNH_2$ in 300 ml of liquid ammonia[5,6] was added, during a few minutes, 40.7 g (0.117 mol) of *exo*-methyleneamine methiodide **13** (containing isomeric methiodide **16**). After 30 min, the deep pink-red suspension was treated with 15 g of NH_4Cl. The resulting mixture was worked up as described above for the rearrangement of methiodide **11** to give 10.04 g (39% calculated as bicyclic amine **14**) of a pale yellow liquid, $n^{25}D$ 1.5228, which was distilled under nitrogen through a Vigreux column to afford 0.62 g of forerun, bp 51–64° (0.2 mm), and 6.08 g (24%) of 3-methylene-1,2,4,5-tetramethyl-2-dimethylaminomethylbicyclo[4.1.0]heptene-4 (**14**) as colorless oil: bp 64–67° (0.20–0.22 mm); $n^{25}D$ 1.5139; uv λ_{max} 257 mμ (log ε 4.2); ir (neat) 3110 (C=CH_2), 3068 (cyclopropyl methylene), 1645 and 1610 cm^{-1} (C=C); nmr (220 MHz)[10] 4.96 (s or d, 2.0 H, C=CH_2), 2.76 and 2.56 (AB pattern, 2.0 H, J = 14 Hz, CH_2N), 2.39 (s, 6.0 H, NCH_3), 1.89 (s, 3.0 H, C_4-CH_3), 1.73 (s, 3.0 H, C_5-CH_3), 1.12 (s, 3.0 H, C_1-CH_3), 0.96 (s, 3.0 H, C_2-CH_3), and complex ABC pattern for cyclopropyl hydrogens at 0.90 (three lines, 1.0 H, J = 4 Hz), 0.76 (four lines, 1.0 H) and 0.63 ppm (three lines, 1.0 H).

Anal. Calcd for $C_{15}H_{25}N$: C, 82.13; H, 11.49; N, 6.39. Found: C, 82.42; H, 11.62; N, 6.24.

This sample of **14** was indicated by vpc to be 92–95% pure; the sample giving the main vpc peak was collected to give pure **14** ($n^{25}D$ 1.5133). The ir and nmr spectra were identical with those of the above sample; mass spectrum[11] (mol wt 219) *m/e* (intensity) 220 (1.5), 219 (8.3), 204 (2.4), 162 (2.4), 159 (3.4), 147 (6.8), 145 (2.0), 133 (2.0), 131 (2.0), 120 (2.9), 105 (3.4), 91 (4.0), 77 (2.9), 59 (6.3), 58 (100.0), 44 (2.4), 42 (7.4), 41 (4.4), 39 (2.4), 32 (2.0), 30 (4.4), and 28 (7.4).

Anal. Calcd for $C_{15}H_{25}N$: C, 82.13; H, 11.49; N, 6.39. Found: C, 82.23; H, 11.49; N, 6.12.

The forerun mentioned above was found by vpc to consist of vinyldurene **20** (40%), isomeric vinyl compound **23** (3%), and *exo*-methylene bicyclic amine **14** (45%); the two former vpc peaks were collected to give pure **20** and **23**. Pure compound **20**, mp and mmp 34.5–35.5°, gave ir and nmr spectra that were identical with those of independently synthesized **20** (see below).

Anal. Calcd for $C_{12}H_{16}$: C, 89.94; H, 10.06. Found: C, 89.99; H, 10.18.

Pure compound **23** was a colorless liquid: ir (neat) 3090 (C=CH_2), 1625 and 1560 (C=C), and 876 cm^{-1} (pentasubstituted benzene ring); nmr 7.13 (s, C_6-H) and 7.02 (X portion of ABX pattern, vinyl αH, 2.2 H), 5.35 (center of AB portion of ABX pattern, J_{gem} = 1.9 Hz, 2.3 H, vinyl βH), and 2.25 ppm (d, 12.0 H, C_2-CH_3, C_3-CH_3, C_4-CH_3, and C_5-CH_3).

Anal. Calcd for $C_{12}H_{16}$: C, 89.94; H, 10.06. Found: C, 89.64; H, 9.96.

When the rearrangement was repeated using 0.166 mol of $NaNH_2$ and 47.40 g (0.127 mol) of the crude methiodide **13** (containing isomeric methiodide **16**), there was obtained 11.10 g (37% calculated as bicyclic amine **14**), which was distilled to give 2.49 g of forerun, bp 54–70° (0.20–0.30 mm), and 5.76 g of **14** (19%, 85–87% pure by vpc), bp 71–74° (0.26–0.30 mm), $n^{25}D$ 1.5185; the ir and nmr spectra were identical with those of the above sample. The forerun was found by vpc to consist of vinyldurene **20** (50%), isomeric vinyl compound **23** (30%), and *exo*-methyleneamine **14** (20%); the two former peaks were collected and identified by ir and nmr.

Treatment of a pure sample of bicyclic amine **14** with dilute HCl and then with NaOH solution gave the recovered bicyclic amine **14**.

Thermal Isomerization of Crude *exo*-Methylamine 12 to Form β-Arylethyldimethylamines 18 and 21. Conversion into Olefins 20 and 23.—A 10-g sample of crude *exo*-methyleneamine **12**, bp 65–68° (0.16–0.20 mm), was heated at 150–170° (Wood's metal bath) for 5 hr. After cooling to room temperature, the mixture was filtered. The filtrate was distilled to give 6.10 g (61%) of β-durylethyldimethylamine (**18**), contaminated with some of its isomeric amine **21** (the vpc showed one peak for **18** with shoulder for **21**): bp 92.5–93° (0.30–0.35 mm); $n^{25}D$ 1.5170; ir (neat, strong peak) 3000–2700, 1460, 1045, 1037 and 860 cm^{-1}; nmr 6.84 (s, 0.8 H, aromatic) and 3.05–1.67 ppm (m, 22.0 H, others); also, the retention time in vpc was same as that of the above sample.

Anal. Calcd for $C_{14}H_{23}N$: C, 81.89; H, 11.29; N, 6.82. Found: C, 81.98; H, 11.54; N, 6.69.

Methylation of 4.30 g (0.02 mol) of a mixture of isomeric β-arylethylamines **18** and **21** was effected at 0° under nitrogen with 5.70 g (0.04 mol) of methyl iodide in 30 ml of dry acetonitrile. After 30 min, the reaction mixture was treated with 100 ml of anhydrous ether (stirred for 4 hr) to precipitate 7.00 g (96%) of a mixture of isomeric methiodides **19** and **22** (dried *in vacuo*): mp 267–269° dec; mmp with the authentic **19** 271–274° dec (mp 282–285°, see below).

Anal. Calcd for $C_{15}H_{26}NI$: C, 51.87; H, 7.55; N, 4.03. Found: C, 51.98; H, 7.44; N, 4.06.

β elimination was effected by adding 5.90 g (0.017 mol) of this mixture of methiodides **19** and **22** to 0.02 mol of KNH_2 in 150 ml of liquid ammonia.[5,6] After stirring for 30 min, the gray suspension was decomposed with 1 g of NH_4Cl, and the liquid ammonia was replaced by 200 ml of anhydrous ether.[7] The resulting mixture was worked up to give 2.11 g (78%) of a mixture of isomeric 2,3,5,6-tetramethylstyrene (**20**) and 2,3,4,5-tetramethylstyrene (**23**), bp 64–68° (0.40–0.45 mm); the composition of this mixture of **20** and **23** was 79 and 21%, respectively (by vpc).

Anal. Calcd for $C_{12}H_{16}$: C, 89.94; H, 10.06. Found: C, 89.74; H, 10.09.

The two components of this mixture of isomeric olefins were separated by vpc, and samples were collected. Olefin **20** was identified by mp and mmp 34.5–35.5°, and by ir and nmr spectra which were identical with those of independently synthesized olefin **20** (see below).

Anal. Calcd for $C_{12}H_{16}$: C, 89.94; H, 10.06. Found: C, 89.99; H, 10.18.

Olefin **23** was obtained as an oil; the ir and nmr spectra were identical with those of the above sample collected by vpc.

Independent Synthesis of β-Arylethylamine 18 and Olefin 20.—To a cold, stirred solution of the Grignard reagent prepared from 21.3 g (0.10 mol) of bromodurene and 2.56 g (0.105 g-atom) of magnesium turnings in 60 ml of tetrahydrofuran[12] (THF) was added, during 10 min, 9 g (0.20 mol) of ethylene oxide in 30 ml of THF.[12] After stirring for 6 hr at room temperature, the reaction mixture was hydrolyzed with 90 ml of 10% HCl and worked up to give, after recrystallization from methanol–water, 14.40 g (81%) of β-hydroxyethyldurene (bulky leaflets): mp 97–102 and 105–106° after another recrystallization; ir (KBr) 3260 (broad, OH), 1040 or 1020 (CO), and 860 cm^{-1} (pentasubstituted benzene ring); nmr 6.81 (s, 0.9 H, C_4-H), 3.90–2.83 (m of A_2B_2 type, 4.2 H, CH_2CH_2), 2.23 (s, 1.20 H, C_2-CH_3, C_3-CH_3, C_5-CH_3 and C_6-CH_3), and 2.16 ppm (s, 0.9 H, –OH).

Anal. Calcd for $C_{12}H_{18}O$: C, 80.85; H, 10.18. Found: C, 81.29; H, 10.34.

To 12.40 g (0.07 mol) of this alcohol (mp 97–102°) in 50 ml of anhydrous benzene was added 16.25 g (0.06 mol) of PBr_3 in 30 ml of anhydrous benzene (ice bath), and the mixture was stirred overnight at room temperature. The solution was concentrated and the residue was stirred with methanol to give, on slowly evaporating the solvent in a hood, 8.86 g (53%) of β-bromoethyldurene (bulky glittering leaflets), mp 54–56°, and 6.79 g (41%), mp 59–60°, after recrystallization from methanol: ir (KBr) 868 (pentasubstituted benzene ring) and 756 cm^{-1} (C-Br ?); nmr 6.96 (s, 0.8 H, C_4-H), 3.33 (broad s, 3.6 H, CH_2CH_2) and 2.22 ppm (s, 12.0 H, C_2-CH_3, C_3-CH_3, C_5-CH_3 and C_6-CH_3).

Anal. Calcd for $C_{12}H_{17}Br$: C, 59.76; H, 7.11. Found: C, 59.73; H, 7.08.

A solution of 14.5 g of this bromide (mp 54–60°) and 40 g of anhydrous dimethylamine in 70 ml of methanol was allowed to stand in the dark at room temperature for 10 days (stoppered flask). The solvent was evaporated, and the residual salt was treated with 90 ml of 40% NaOH. To an ethereal solution of the liberated amine was added 200 ml of 6 *N* HCl to precipitate

(10) We thank E. I. du Pont de Nemours and Co., Inc., for determination of this spectrum.

(11) We thank Dr. David Rosenthal for this determination, which was done at the Research Triangle Mass Spectrometry Center supported by Special Facility Grant No. FR-00330-01, National Institutes of Health.

(12) Freshly distilled from lithium aluminum hydride.

the amine salt. This salt was treated with NaOH to give 9.42 g (76%) of β-durylethyldimethylamine (**18**): bp 93° (0.26 mm) (solidified on cooling in an ice bath); $n^{25}D$ 1.5165; ir (neat, strong peak) 3000–2700, 1460, 1045, 1035, 1015, 864, and 857 cm^{-1}; nmr 6.82 (s, 0.8 H, aromatic) and 3.18–2.10 (m, 22.0 H, others).

Anal. Calcd for $C_{14}H_{23}N$: C, 81.89; H, 11.29; N, 6.82. Found: C, 81.82; H, 11.05; N, 6.90.

Methylation of 4.30 g (0.02 mol) of this amine was effected with 5.70 g (0.04 mol) of methyl iodide in acetonitrile to give 7.14 g (98%) of methiodide **19**, mp 282–285° dec.

Anal. Calcd for $C_{15}H_{26}NI$: C, 51.87; H, 7.55; N, 4.03. Found: C, 52.11; H, 7.44; N, 4.06.

β elimination was effected by adding 5.90 g (0.017 mol) of this methiodide **19** to 0.02 mol of KNH_2 in 150 ml of liquid ammonia[5,6] to give 2.11 g (78%) of 2,3,5,6-tetramethylstyrene (**20**): bp 51–52° (0.12–0.15 mm); mp 34.5–35.5°; ir (neat) 3080 (C=CH_2), 1625 and 1600 (C=C), and 866 cm^{-1} (pentasubstituted benzene ring); nmr 6.89 (s, C_4-H) and 6.74 (X portion of ABX pattern, vinyl αH, 2.1 H), 5.31 (center of AB portion of ABX pattern, J_{gem} = 2.4 Hz, vinyl βH), and 2.20 ppm (d, 12.0 H, C_2-CH_3, C_3-CH_3, C_5-CH_3 and C_6-CH_3).

Anal. Calcd for $C_{12}H_{16}$: C, 89.94; H, 10.06. Found: C, 89.88; H, 10.02.

Conversion of *exo*-Methylene Bicyclic Amine 14 into Methiodide 27. Treatment with Sodium Amide.—Methylation of 3.92 g (0.0179 mol) of this amine was effected with 5.10 g (0.0358 mol) of methyl iodide in dry acetone (stirred for 3.5 hr) to give 2.10 g (33%) of methiodide **27** (white powder): mp 224–226° dec; ir (KBr) 3010 (C=CH_2), 3070 (cyclopropyl methylene), 1810 (C-H), 1635, 1600 and 1575 cm^{-1} (C=C).

Anal. Calcd for $C_{16}H_{28}NI$: N, 3.88. Found: N, 3.56.

To a stirred suspension of 0.0175 mol of $NaNH_2$ in 70 ml of liquid ammonia[5,6] was added 2.10 g (0.0058 mol) of methiodide **27**. After 3 hr, the deep orange-red mixture was decomposed with NH_4Cl, and the liquid ammonia was replaced by 50 ml of anhydrous ether.[7] The resulting mixture was worked up, but no isolable product was obtained in appreciable amount.

Registry No.—Sodium amide, 12125-45-0; **2**, 19990-87-5; **3**, 19990-88-6; **4**, 6968-88-3; β-isodurylethyldimethylamine, 5336-63-0; **5**, 19990-91-1; **9**, 19990-92-2; **10**, 19990-93-3; **11**, 19990-94-4; **12**, 19990-95-5; **13**, 19990-96-6; **14**, 19990-97-7; **18**, 19990-98-8; **19**, 19990-99-9; **20**, 2039-91-0; **21**, 19991-01-6; **22**, 19991-02-7; **23**, 3937-22-2; β-hydroxyethyldurene, 19991-04-9; β-bromoethyldurene, 19991-05-0; **27**, 19991-06-1.

Aminolyses of Sulfinic Acid Derivatives[1]

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A series of alkane- and arenesulfinamides was prepared from the corresponding sulfinyl chloride. Treatment of the chlorolysis product of dithiodiglycolic acid with morpholine produced 4-morpholinosulfinylacetomorpholide (**1**). Dimorpholide **1** was a stable, water-soluble, and slightly acidic substance. The infrared spectrum resembled that of the simple alkanesulfinamides in the region of 1500–650 cm^{-1}. However, between 3000 and 2500 cm^{-1} the spectrum exhibited a series of bands characteristic of amine salts. In addition, there were two strong bands at 1630 and 1610 cm^{-1} assignable to conjugated C=C stretching and C=O stretching vibrations. The ultraviolet spectrum of **1** exhibited one maximum at 273 mμ (ε 14,000) which did not shift in the presence of base. From a consideration of the spectral data and the saltlike physical properties of compound **1**, it appears that its structure is best represented by the betaine resonance hybrid **1a** ↔ **1b**. Under controlled conditions, oxidation of 3,3′-dithiodipropionic acid by chlorine led to 1,2-oxathiolan-5-one 2-oxide (**3**), which upon aminolysis with aromatic amines gave sulfonyl dipropionamides **5**. The structure of **3** was confirmed by molecular weight determinations (Rast method), saponification equivalent, alkaline permanganate oxidation, and elementary analysis. Mechanisms for the formation of **3** and its aminolysis products are presented.

In a search for agents capable of reconstituting reduced keratin, a process involving mild oxidation of thiol to disulfide groups, our attention turned to the little known class of sulfinamides $RSONR^1R^2$. Several years ago, Smith and Grasley[3] reported, as part of their work relating to antiradiation drugs, the oxidation of 2-aminoethanethiol to its disulfide in the presence of certain arenesulfinamides.

$$RSONR_2 + 2R'SH \longrightarrow R'SSR' + RSNR_2 + H_2O$$

While arenesulfinamides have been known for some time,[4] amides derived from alkanesulfinic acids became accessible only after a facile method for the synthesis of alkanesulfinyl chlorides had been discovered.[5] Douglass and Farah[6] reported the aminolysis of methanesulfinyl chloride with several aromatic amines, and Moriarty[7] more recently applied this method to the synthesis of a few N,N-dialkylalkanesulfinamides, the first members of this class of compounds.[8]

The sulfinamides prepared in our laboratories by amonolysis and aminolysis of a variety of arene- and alkanesulfinyl chlorides are listed in Table I. In general, the sulfinamides obtained were unpleasant smelling, colorless liquids, distillable at low pressures. They were soluble in most organic solvents; the lower molecular weight derivatives and those containing morpholine groups were unstable and discolorized gradually on exposure to air. The sulfinamides were rapidly oxidized by alkaline permanganate, but the corresponding sulfonamides expected as end products of the oxidation[6] could not be isolated. The infrared (ir) spectra of the sulfinamides showed strong absorptions at 1070 and 1010 cm^{-1} assignable to S=O stretching vibrations.[9]

(1) Presented at the 150th National Meeting of The American Chemical Society, Atlantic City, N. J., Sept 1965.

(2) Ethicon, Inc., Somerville, N. J.

(3) W. T. Smith, Jr. and M. Grasley, Abstract, the 141st National Meeting of the American Chemical Society, Washington, D. C., March 1962, p 36N.

(4) L. C. Raidord and S. E. Hazlet, *J. Amer. Chem. Soc.*, **57**, 2172 (1935).

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(6) I. B. Douglass and B. S. Farah, *J. Org. Chem.*, **23**, 805 (1958).

(7) R. M. Moriarty, *Tetrahedron Lett.*, No. 10509 (1964).

(8) The use of a number of N,N-dialkylsulfinamides as bird repellants without claiming or describing a method of preparation has been disclosed: L. D. Goodhue, R. P. Louthan, and K. E. Cantrel, U. S. Patent 2,955,980 (1960).

(9) L. J. Bellamy, "The Infra-red Spectra of Complex Molecules," 2nd ed, John Wiley & Sons, Inc., New York, N. Y., 1958, pp 350–364.