

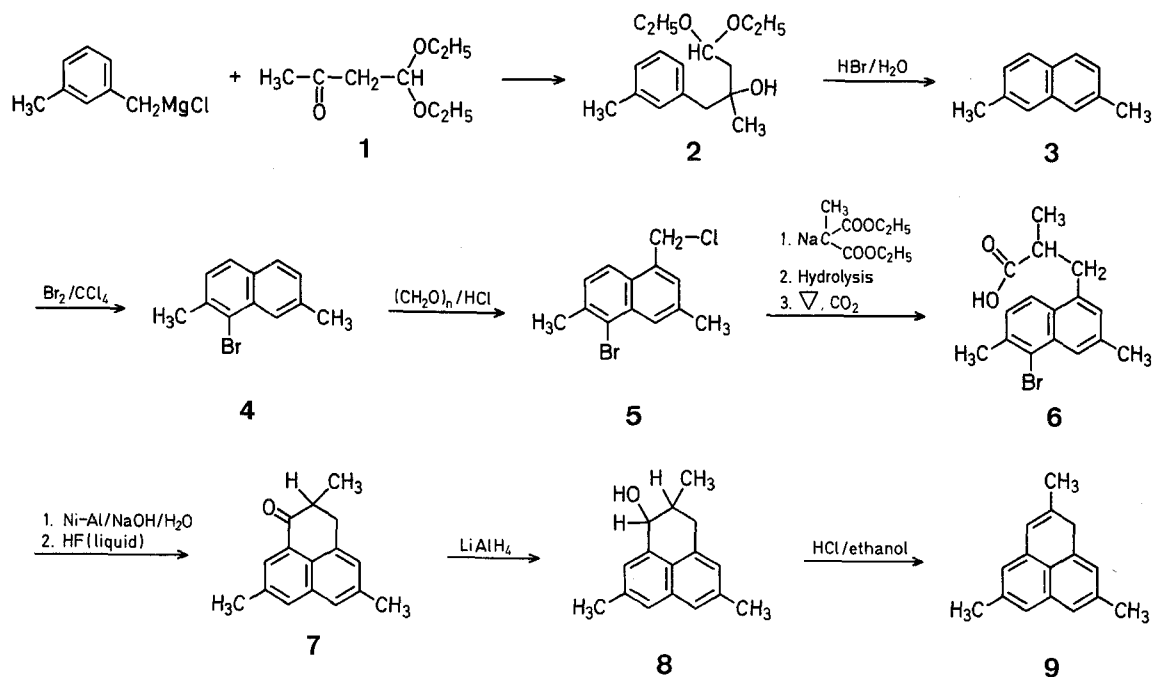
Synthesis of 2,5,8-Trimethylphenalene

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A few years ago, one of us (L.C.L.) in collaboration with Schneider and Reddoch¹ investigated the preparation of stable substituted phenalenes capable of forming symmetrical radicals (or cations) possessing threefold rotational symmetry.

The synthesis of the title compound was rendered possible by our improved synthesis of 2,7-dimethylnaphthalene. Prior to its synthesis in five steps by Baker, McOmie, and Warburton² it had always been obtained by rather tedious separation of the degradation products of terpenes. In the present work it was prepared in high yield in two steps. 3-Methylbenzylmagnesium chloride and 4,4-dimethoxybutan-2-one (**1**) gave the hydroxy-acetal **2** in 73% yield. Cyclodehydration of the latter by Bradsher's reagent resulted in an 85–90% yield of 2,7-dimethylnaphthalene (**3**) identical with the product of Baker et al.² For the synthesis of 2,4,8-trimethylphenalene (**9**) by the Fieser-Boeckelheide method, a chloromethyl group in position 4 (or 5) in 2,7-dimethylphthalene is required. It was therefore necessary to block position 1 by bromination.



Chloromethylation of the product by the method of Horn and Warren³ gave 1-bromo-2,7-dimethyl-5-chloromethylnaphthalene (**5**) rather than the 4-chloromethyl isomer because of deactivation of the ring containing bromine. Reaction with diethyl methylmalonate in the presence of sodium ethoxide gave the diester which on hydrolysis and decarboxylation led to 3-(3,6-dimethyl-5-bromo-1-naphthyl)-2-methylpropanoic acid (**6**). Hydrodebromination with Raney-Nickel alloy/aqueous base as reported by Buu-Hoi⁴ furnished 3-(3,6-dimethyl-1-naphthyl)-2-methylpropanoic acid. Cyclization in liquid hydrogen fluoride⁵ afforded 2,5,8-trimethyl-2,3-dihydrophenalene (**7**). The corresponding phenalenois (**8**) were obtained in both *cis* and *trans* forms by reduction of the ketone with lithium aluminium hydride. Finally, treatment of either isomer with alcoholic hydrogen chloride gave 2,5,8-trimethylphenalene (**9**).

3-Hydroxy-3-methyl-4-(3-methylphenyl)-butanal Dimethyl Acetal (**2**):

3-Methylbenzylmagnesium chloride was prepared from magnesium turnings (24.0 g, 1 g-atom), 3-methylbenzyl chloride (112 g, 0.8 mol), and absolute ether (0.5 l). A solution of 4,4-dimethoxybutan-2-one (**1**) (93.0 g, 0.7 mol) in dry ether (300 ml) was added dropwise with stirring to the Grignard reagent. The reaction mixture was then heated under reflux for 30 min, cooled, and poured onto ice-cold saturated aqueous ammonium chloride (1.5 l). The ether layer was separated, washed with a little water dried (magnesium sulfate), and freed of solvent. The residue was distilled in vacuo; yield: 118 g (72%); b.p. 95–100°/0.05 torr. C₁₄H₂₂O₃ calc. C 70.59 H 9.31 (238.3) found 70.86 9.16

2,7-Dimethylnaphthalene (**3**):

A solution of the hydroxy-acetal (**2**; 78.0 g, 0.3 mol) in glacial acetic acid (320 ml) and 48% hydrobromic acid (250 ml) was heated for 1 h on the steam bath with occasional shaking. It was then stirred in an ice-bath until the oil had crystallized. The solid was filtered off with suction, washed with water, and purified by vacuum sublimation from a waterbath at 70°; yield: 46.0 g (87%); colorless plates, m.p. 95° (from ethanol) (Ref.², m.p. 96–97°).

¹H-N.M.R. (CDCl₃): δ = 7.76, 7.61, 7.50, 7.30, 7.13 (m, 6H), 2.47 ppm (s, 6H, 2CH₃).

1-Bromo-2,7-dimethylnaphthalene (**4**):

A solution of bromine (16.0 g, 0.1 mol) in carbon tetrachloride (100 ml) was added dropwise over a period of 4–5 h to 2,7-dimethylnaphthalene (15.6 g, 0.1 mol) in chloroform (100 ml). Work-up in the usual manner gave 17.6 g (74%) of product.

C₁₂H₁₁Br calc. C 61.27 H 4.71 (235.1) found 61.37 6.92

¹H-N.M.R. (CDCl₃): δ = 2.60 (s, 3H, CH₃), 2.55 ppm (s, 3H, CH₃).

1-Bromo-5-chloromethyl-2,7-dimethylnaphthalene (**5**):

In a 500-ml three-necked round bottomed flask fitted with a condenser were placed 1-bromo-2,7-dimethylnaphthalene (70.8 g, 0.3 mol), paraformaldehyde (16.5 g, 0.5 mol), glacial acetic acid (40 ml), and 85% phosphoric acid (25 ml). The mixture was vigorously stirred in a bath at 85–90° for 24 h while passing a current of anhydrous hydrogen chloride and then poured onto ice (500 g). The ether/benzene (1:1) extract was carefully washed with water, 5% sodium hydrogen carbonate, water again, and then dried with anhydrous magnesium sulfate. Solvent was distilled off and the residue was purified by bulb-to-bulb distillation; yield: 60 g (75%); b.p. 140°/0.05 torr. The product crystallized on standing; m.p. 109–110° (from hexane).

C₁₃H₁₂BrCl calc. C 55.05 H 4.26 (283.6) found 54.85 4.43

3-(5-Bromo-3,6-dimethyl-1-naphthyl)-2-methylpropanoic Acid (**6**):

Monoethyl (5-Bromo-3,6-dimethyl-1-naphthylmethyl)-methylmalonate: Diethyl methylmalonate (38.4 g, 0.2 mol) was added to a solution of sodium ethoxide (5.0 g of sodium in 80 ml anhydrous ethanol). A solution of 1-bromo-5-chloromethyl-2,7-dimethylnaphthalene (55.0 g, 0.2 mol) in anhydrous ether (375 ml) was added to the sodiummethylmalonic ester cooled in ice water. The mixture was allowed to stand at +5° for 20–24 h; the ether and alcohol were then removed under reduced pressure. The residue was treated with ice-cold dilute hydrochloric acid and extracted with ether. The residue from the ether was purified by bulb-to-bulb distillation; yield: 66.5 g (74%); b.p. 170°/0.05 torr.

C₂₁H₁₂O₄Br calc. C 58.78 H 5.88 (408.2) found 58.59 5.77

¹H-N.M.R. (CDCl₃): δ = 2.60 (s, 3H, CH₃), 4.98 ppm (s, 2H, CH₂).

(5-Bromo-3,6-dimethyl-1-naphthylmethyl)-methylmalonic Acid: The above ester (66.5 g) was hydrolyzed by heating 2 h on the steam-bath with potassium hydroxide (17.0 g), water (40 ml), and ethanol (180 ml) until a sample gave a clear solution on

dilution with water. The hydrolysate was diluted to ~ 1.5 of its volume with water and acidified with 6*N* hydrochloric acid; yield of crude acid: 50 g (98%); m.p. 175° (dec.).

3-(5-Bromo-3,6-dimethyl-1-naphthyl)-2-methylpropanoic Acid: The above dibasic acid was decarboxylated by heating it above its melting point until evolution of gas ceased. The melt was dissolved in a slight excess of dilute alkali and the barely alkaline solution was filtered with the aid of carbon black. The cold filtrate was acidified with hydrochloric acid; yield of crude product: 32.0 g; m.p. 140–141°. N.E. 325 (theor. 320).

1-Oxo-2,5,8-trimethyl-2,3-dihydrophenalene (7):

3-(3,6-Dimethylnaphthyl)-2-methylpropanoic Acid: The bromo acid **6** (3.5 g) was dissolved in water (60 ml) containing sodium hydroxide (7.0 g) and treated with small portions of Raney-Nickel alloy (12 g) while stirring. After 2 h, the nickel was filtered off and the filtrate was acidified with dilute acid; yield: 2.5 g (96%); m.p. 100°.

N.E. calc. 242; found 242

With a large excess of Raney-Nickel alloy, hydrogenation of the naphthalene ring to the tetrahydro derivative occurs to some extent to give an inseparable mixture of acids.

1-Oxo-2,5,8-trimethyl-2,3-dihydrophenalene: The above acid (5 g) was added in portions to anhydrous hydrofluoric acid (25 ml) in a polyethylene bottle. Excess hydrofluoric acid was allowed to evaporate and the residue was taken up in ether. The ether solution was washed with water and dilute sodium hydrogencarbonate, then dried (K_2CO_3). Evaporation of the ether left a yellow residue which crystallized on standing; yield: 4.3 g (93%); m.p. 67° (from ethanol).

$C_{16}H_{16}O$ calc. C 85.71 H 7.20
(224.3) found 85.70 7.86

cis- and trans-1-Hydroxy-2,5,8-trimethyl-2,3-dihydrophenalene (8): A solution of ketone **7** (2.5 g) in anhydrous ether (50 ml) was added dropwise to a solution of lithium alanate (0.25 g) in benzene/anhydrous ether (40:60). Presence of benzene facilitates work-up. After the decomposition of excess hydride with methyl acetate, the reaction mixture was poured onto ice and the ether/benzene solution was freed of solvent. The residue was a mixture of the two alcohols, easily separable by pentane in which the *trans* isomer is insoluble.

cis-**8**; yield: 0.5 g; m.p. 140–141° (from ethanol).

trans-**8**; yield: 2.0 g; m.p. 150–151° (from ethanol).

$C_{16}H_{18}O$ calc. C 84.95 H 8.02
(226.3) found 85.10 8.11

2,5,8-Trimethylphenalene (9):

Compound **8** (*cis* and *trans*; 1 g) was heated on the steambath for 20 min with anhydrous ethanol (12 ml) saturated with hydrogen chloride. The solution was poured into ice water and the resultant oil was extracted with ether. The residue obtained after drying and removal of the solvent was dissolved in pentane (150 ml) and the solution was poured through alumina (Brockmann, Neutral, activity grade 1) and eluted with more pentane. Evaporation of the pentane left colorless crystals; yield: 0.6 g; m.p. 112°.

$C_{16}H_{16}$ calc. C 92.30 H 7.70
(208.3) found 92.11 7.60

2,5,8-Trimethylphenalenium Perchlorate:

A solution of tetrachloro-*o*-benzoquinone (1.0 g) and perchloric acid (0.1 ml) in ether was added to a solution of 1-hydroxy-2,3-dihydro-2,5,8-trimethylphenalene (**8**; 1.0 g) in ether. After 30 min, precipitation of reddish brown phenalenium perchlorate was complete; yield: 0.24 g; m.p. 200–201°.

$C_{16}H_{15}ClO_4$ calc. C 62.64 H 4.93
(307.5) found 62.70 4.97

1H -N.M.R. ($CDCl_3$): $\delta = 2.15$ (s, 9H, CH_3), 0.15 ppm (s, 6H_{arom}).

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¹ W. G. Schneider, A. H. Reddoch, unpublished work.

² W. Baker, J. F. W. McOmie, W. K. Warburton, *J. Chem. Soc.* **1963**, 3295.

³ D. H. S. Horn, F. L. Warren, *J. Chem. Soc.* **1946**, 144.

⁴ N. P. Buu-Hoi, N. D. Huong, N. Van Bac, *Bull. Soc. Chim. France* **1963**, 2442.