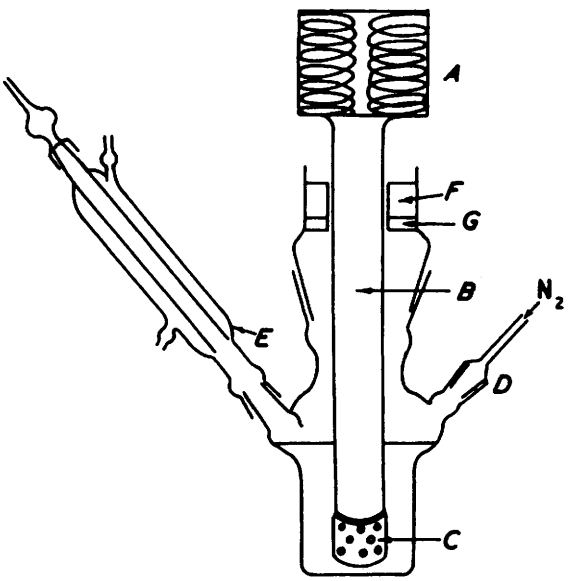
172. *Electron-donor and -acceptor Complexes with Aromatic Systems. Part IV.* An Improved Method of preparing Metal Addition Complexes with Aromatic Systems.*

By W. Slough and A. R. Ubbelohde.

Direct addition of alkali metals to aromatic molecules gives compounds whose electronic properties in the solid state depend [1] on the proportions of alkali metal to aromatic molecules M_xA_y. However, such compounds are often tedious to prepare by conventional methods,[2] and the long reaction times magnify risks of oxidation. It has been shown [3] that ethers with a high O : C ratio are desirable as solvents for efficient reaction. Suitable ethers include 1 : 4-dioxan and 1 : 2-dimethoxyethane. Even with such ethers, preparation times are undesirably long, especially for the alkali-rich complexes. In an investigation of sodium addition complexes formed by four isomeric benzoquinolines, three types of preparation have now been compared, *viz.* : (1) Direct reaction of sodium wire with the



benzoquinoline dissolved in diethyl ether. (2) Direct reaction of sodium with the isomer in boiling dimethoxyethane or dioxan. (3) Ultrasonic activation of a sodium cube, in a solution of the heterocyclic compound in diethyl ether or dimethoxyethane The ultrasonic method (3) proved to have marked advantages and is briefly described.

A diagram of the apparatus is illustrated. *A* is the Mullard magnetostrictor 25 kc. transducer head, to which was fused a stainless steel probe *B*. The length of this was adjusted to give the maximum output of energy to sodium metal contained in a stainless steel screw-on basket *C*. Nitrogen was passed in at *D* to protect the reactants, and a reflux condenser was attached at *E*. The steel probe was passed through a rubber gasket *F* which was protected from organic vapours by a Polythene disc *G*. Up to 1 kw primary power consumption was provided for, but with the compounds studied it was not convenient to use more than about 200 w. In any run sodium was introduced into *C*, and the solvent (50 ml.) then syphoned in to

* Part III, preceding paper.

[1] Holmes-Walker and Ubbelohde, *J.*, 1954, 720; Gracey and Ubbelohde, *J.*, 1955, 4089.
[2] Schlenk and Bergmann, *Annalen*, 1930, **479**, 42.
[3] Scott, Walker, and Hansley, *J. Amer. Chem. Soc.*, 1936, **58**, 2442.

a convenient level. It was verified that ultrasonic activation of the sodium showed no perceptible change in the pure solvent. On addition of about 1 g. of the benzoquinoline (phenanthridine) the characteristic red-orange colour of the sodium complex was produced immediately. After about 15 min. the solution was full of a red-brown complex. Previous preparation of this red-brown complex had shown it to contain about 1 g.-atom of sodium per mole of heterocyclic substance. Further activation up to about 45 min. produced a dark brown-black product which on isolation and analysis had the composition $Na_{1.51}C_{13}H_9N$. An analogous dark complex had the composition $Na_{1.49}C_{13}H_9N$ previously prepared without ultrasonics; this required 48 hours' reaction time in diethyl ether. Thus ultrasonic activation greatly facilitates the production of these complexes. The reaction started in the cold; no heating was required, though some warming takes place through the action of the ultrasonic waves on the liquid. The fact that the solution need not be raised to the b. p. of the solvent could be an added advantage with certain labile systems. With sluggish aromatic molecules heating to the b. p. of the solvent could further activate complex formation. Reaction could be stopped at any stage to yield complexes of intermediate composition. It seems likely that ultrasonic dispersion will prove of general benefit in reactions involving the formation of addition complexes between organic molecules and alkali metals. For other reactions involving metals where bond rupture is involved, as in Wurtz or Grignard reactions, the use of ultrasonics should likewise prove helpful for those cases where the rate-controlling step arises at the metal–solvent interface.

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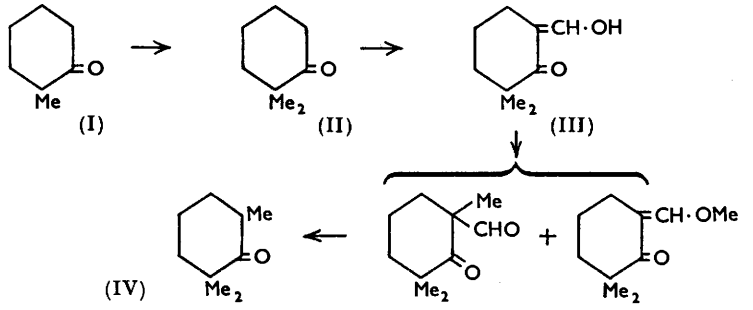
173. *The Preparation of* 2 : 2-*Dimethyl- and* 2 : 2 : 6-*Trimethyl*cyclo*hexanone.*

By F. E. KING, T. J. KING, and J. G. TOPLISS.

THE preparation of 2 : 2 : 6-trimethyl*cyclo*hexanone has been studied in connexion with the recent synthesis of (±)-ferruginol.[1] The two most satisfactory methods found in the literature are those of Sobotka and Chanley [2] and of Attenburrow *et al.*,[3] but they involve considerable fractionation of the product, the former by crystallisation of semicarbazones and the latter through an 80-plate column. The method shown by the annexed formulæ has been worked out and is believed to be convenient for moderate quantities of the ketone.



The ready accessibility of pure 6-hydroxymethylene-2 : 2-dimethyl*cyclo*hexanone (III) by the above procedure makes possible an easy synthesis of pure 2 : 2-dimethyl-*cyclo*hexanone from 2-methyl*cyclo*hexanone since the hydroxymethylene compound is hydrolysed almost quantitatively by aqueous alkali to the 2 : 2-dimethyl ketone (II).

[1] F. E. King, T. J. King, and Topliss, *Chem. and Ind.*, 1954, 108; *J.*, 1957, 573.
[2] Sobotka and Chanley, *J. Amer. Chem. Soc.*, 1949, **71**, 4136.
[3] Attenburrow, Cameron, Chapman, Evans, Hems, Jansen, and Walker, *J.*, 1952, 1094.

The over-all yield from 2-methyl*cyclo*hexanone was 44%, a considerable improvement on the hitherto known methods for the preparation of this ketone.[3, 5-8]

Experimental.—Methylation of 2-*methyl*cyclo*hexanone*. The procedure given by Haller and Cornubert [4] was modified as follows. To a mechanically stirred suspension of sodamide (49 g., 1 mol.) in dry benzene (400 c.c.) was added 2-methyl*cyclo*hexanone (140 g., 1 mol.) during ½ hr., whereupon there was a copious evolution of ammonia and the temperature rose to 60—80°. The formation of the sodio-derivative was completed by 3 hours' refluxing. The mixture was then cooled in ice, and methyl iodide (213 g., 1·2 mols.) added during 1½ hr. After being refluxed for 2 hr., the mixture was kept overnight and treated with water (450 c.c.) to remove the sodium iodide. The benzene was removed through a short fractionating column and the residue shaken mechanically with a solution of sodium metabisulphite (40 g.) in water (100 c.c.) for 1 hr. The sulphite layer was separated and the process repeated, after which the mixed ketones were washed and dried (K_2CO_3). Distillation gave the mixed 2 : 2- and 2 : 6-dimethyl*cyclo*hexanones (116 g., 72·5%), b. p. 170—171°/772 mm.

6-*Hydroxymethylene*-2 : 2-*dimethyl*cyclo*hexanone* (III). The procedure of Johnson and Posvic [5] was followed except that the dimethyl*cyclo*hexanone mixture was used instead of pure 2 : 2-dimethyl*cyclo*hexanone, and the product had b. p. 102—103°/25 mm. (yield 60—70%) (Johnson and Posvic [5] give b. p. 79—80°/11 mm.).

2 : 2 : 6-*Trimethyl*cyclo*hexanone* (IV). 6-Hydroxymethylene-2 : 2-dimethyl*cyclo*hexanone (36·7 g., 1 mol.), methyl iodide (68 g., 2 mols.), and freshly ignited potassium carbonate (66 g., 2 mols.) in dry acetone (250 c.c.) were refluxed for 36 hr.; a test portion then gave only a slowly developing violet colour with ferric chloride. Dry ether (100 c.c.) was added, and after 15 min. the precipitated potassium iodide was filtered off; 2N-hydrochloride acid (50 c.c.) was then added and the solution kept at room temperature for 6 hr. After the addition of anhydrous potassium carbonate, the mixture was stirred for 5 min. and the liquid decanted and allowed to stand over a fresh potassium carbonate for several hours. The addition of dry ether (100 c.c.) precipitated a further quantity of solid which was removed, and the filtrate was concentrated. The residue (38 g.) was shaken in ether (150 c.c.) with 2N-sodium hydroxide (3 × 25 c.c.). The ether was removed and the residue (33·9 g.) treated with 2N-hydrochloric acid (10 c.c.) in methanol (50 c.c.) for 15 hr. at room temperature. Addition of water (150 c.c.), and extraction with ether (2 × 100 c.c.), the extract being washed with 2N-sodium hydroxide (3 × 25 c.c.), gave, on evaporation of the ether, 6-formyl-2 : 2 : 6-trimethyl*cyclo*hexanone which was refluxed for 1 hr. with 15% aqueous sodium hydroxide. Extraction with ether (2 × 75 c.c.) afforded a yellow liquid (20·45 g.), b. p. 179—181°/765 mm., which when redistilled gave 2 : 2 : 6-trimethy*cyclo*hexanone (19·1 g.), b. p. 179—180°/763 mm., n_D^{17} 1·4508, in 22·3% overall yield from 2-methyl*cyclo*hexanone. The semicarbazone crystallised from ethanol as rods, m. p. 207—209°, and the oxime crystallised from aqueous ethanol in rods, m. p. 102·5—103·5°, unchanged on further recrystallisation. The m. p. (101—102°) of the oxime, as crystallised directly from the reaction mixture, was evidence of the homogeneity of the ketone. Sobotka and Chanley [2] give b. p. 178·7—179°/767 mm., n_D^{20} 1·4480, semicarbazone, m. p. 207—209°, oxime, m. p. 103°. Attenburrow *et al.* give b. p. 178°, n_D^{20} 1·4493, semicarbazone, m. p. 209—211°.

2 : 2-*Dimethyl*cyclo*hexanone* (II). The procedure described above for the preparation of 6-hydroxymethylene-2 : 2-dimethyl*cyclo*hexanone was followed up to the point of obtaining the solution of the hydroxymethylene compound in alkali. This solution was then steam-distilled, and the volatile ketone was extracted with ether, the ethereal solution giving 2 : 2-dimethyl*cyclo*hexanone, b. p. 170—171°/765 mm., $n_D^{18\cdot5}$ 1·4492 (semicarbazone, m. p. 199—200°; oxime, m. p. 92—93°). From 43·9 g. of dimethyl*cyclo*hexanone mixture there were obtained 26·6 g. (60·5%) of 2 : 2-dimethyl*cyclo*hexanone. The over-all yield from 2-methyl*cyclo*hexanone was 44%. Adamson, Marlow, and Simonsen [8a] give b. p. 169—170°/768 mm., n_D^{25} 1·4460. Chanley [8b] gives b. p. 170—170·5° (corr.)/761 mm., n_D^{20} 1·4482, semicarbazone, m. p. 199—201°, oxime, m. p. 93—94°. Attenburrow *et al.*[3] give b. p. 173°, n_D^{20} 1·4486.

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[4] Haller and Cornubert, *Bull. Soc. chim. France*, 1927, **41**, 367.
[5] Johnson and Posvic, *J. Amer. Chem. Soc.*, 1947, **69**, 1361.
[6] Cornforth and Robinson, *J.*, 1949, 1855.
[7] F. E. King and T. J. King, *J.*, 1954, 1373.
[8] (*a*) Adamson, Marlow, and Simonsen, *J.*, 1938, 774; (*b*) Chanley, *J. Amer. Chem. Soc.*, 1948, **70**, 246; (*c*) Elliot and Linstead, *J.*, 1938, 776; (*d*) Colonge and Duroux, *Bull. Soc. chim. France*, 1940, **7**, 459.

174. *The Preparation of 2-(5-Methyl-1-naphthyl)ethyl Bromide.*

By J. C. Bardhan, D. Nasipuri, and D. N. Mukherji.

In connection with the synthesis of polycyclic compounds [1] we required 2-(5-methyl-1-naphthyl)ethyl bromide which is best prepared in quantity as follows. 1-Chloromethyl-5-nitronaphthalene [2] on hydrogenation over collodial palladium yielded 1-amino-5-methylnaphthalene, this method being superior to that involving the sulphonation of 1-methylnaphthalene, followed by nitration and reduction of the product.[3] By the modified Sandmeyer procedure [4] the amine was smoothly converted into 1-bromo-5-methylnaphthalene,[5] the Grignard compound of which condensed with ethylene oxide, yielding 2-(5-methyl-1-naphthyl)ethyl alcohol. The latter, on treatment with phosphorus tribromide in the usual way, gave the bromide in excellent over-all yield.

Experimental.—*1-Amino-5-methylnaphthalene.* 1-Chloromethyl-5-nitronaphthalene, m. p. 98—99° (Short *et al.*,[2] m. p. 96—98°) (18 g.), acetone (100 ml.), palladium chloride (0·1 g.), gum arabic (0·1 g.), and water (5 ml.) were shaken in hydrogen until 4 mol. had been absorbed (8—10 hr.). The liquid which contained the hydrochloride of the base in suspension was evaporated and the free base liberated with aqueous ammonia. It had m. p. 76—77° (from ethanol) (Vesely *et al.*,[3] m. p. 77—78°) (Found : C, 84·2; H, 6·9. Calc. for $C_{11}H_{11}N$: C, 84·1; H, 7·0%). The benzoyl derivative had m. p. 172° (Vesely *et al.*,[3] m. p. 173—174°).

1-Bromo-5-methylnaphthalene. A solution of 1-amino-5-methylnaphthalene hydrochloride (15 g.) in concentrated hydrochloric acid (35 ml.) and water (165 ml.) was cooled in a freezing mixture and diazotised with sodium nitrite (6 g.) in water (20 ml.). The solution was mixed with a suspension of mercuric bromide (mercuric nitrate, 20 g.; sodium bromide, 30 g., water, 100 ml.) and stirring continued for 0·5 hr. more. The yellow insoluble precipitate (35—40 g.) was collected, washed with water and acetone, and dried in air. It was then mixed with twice its weight of finely powdered sodium bromide and gently heated [4] until decomposition was complete (1 hr.). After cooling, the mass was extracted with benzene, and the organic layer washed with dilute hydrochloric acid, aqueous sodium hydroxide, then with water, dried, and distilled, giving 1-bromo-5-methylnaphthalene (8 g.), b. p. 130°/4 mm., m. p. 61—62° (Vesely *et al.*,[5] 63—64°) (Found : Br, 36·5. Calc. for $C_{11}H_9Br$: Br, 36·2%).

2-(5-Methyl-1-naphthyl)ethyl alcohol. To an ice-cold solution of Grignard reagent prepared from 1-bromo-5-methylnaphthalene (30 g.), activated magnesium (7·2 g.), ethyl bromide (9 ml.), and ether (300 ml.), was gradually introduced, with shaking, ethylene oxide (40 g.) in ether (100 ml.). The mixture was kept in ice over-night and the ether distilled off. The residue was decomposed with ice and hydrochloric acid, and the product was collected in ether, dried and distilled, giving the *alcohol* (22 g.), b. p. 162—163°/3 mm., 154—155°/0·5 mm. (Found : C, 83·7; H, 7·6. $C_{13}H_{14}O$ requires C, 83·9; H, 7·5%).

2-(5-Methyl-1-naphthyl)ethyl bromide. This *bromide* was prepared from the alcohol (20 g.), carbon tetrachloride (30 ml.), and phosphorus tribromide (5·2 ml.) in the usual way, and formed a colourless oil (16 g.), b. p. 149—152°/3 mm. (Found : Br, 32·3. $C_{13}H_{13}Br$ requires Br, 32·1%).

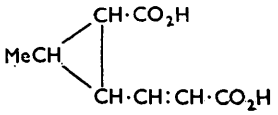
University College of Science, Calcutta. [*Received, September 10th*, 1956.]

[1] Nasipuri, Thesis, Calcutta, 1954; Bardhan and Nasipuri, *J.*, 1956, 350; Bardhan, Adhya, and Bhattacharyya, *ibid.*, p. 1346.
[2] Short and Wang, *J.*, 1950, 991.
[3] Vesely, Stursa, Olejnicek, and Rein, *Coll. Czech. Chem. Comm.*, 1929, **1**, 493; Haworth and Mavin, *J.*, 1932, 2722.
[4] Newman and Wise, *J. Amer. Chem. Soc.*, 1941, **63**, 2847; Schwechten, *Ber.*, 1932, **65**, 1605; Ruzicka and Morgeli, *Helv. Chim. Acta*, 1936, **19**, 382; Bachmann and Boatner, *J. Amer. Chem. Soc.*, 1936, **58**, 2194.
[5] Vesely, Stursa, Olejnicek, and Rein, *Coll. Czech. Chem. Com.*, 1930, **2**, 145.

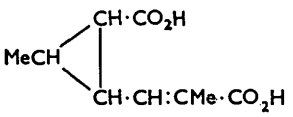
175. *The Addition of Ethyl Diazoacetate to Sorbic Esters: A Correction.*

By MARTIN G. ETTLINGER, S. H. HARPER, and FLYNT KENNEDY.

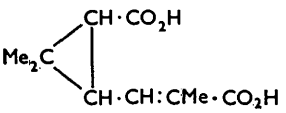
RECENTLY Harper and Reed [1] examined the addition of ethyl diazoacetate to methyl sorbate and to methyl α-methylsorbate as a route to the adduct (I) and (II), respectively, preparatory to the synthesis of chrysanthemumdicarboxylic acid (III).[2]



(I)

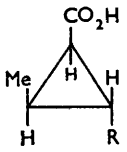


(II)

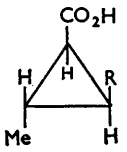


(III)

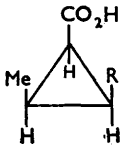
To elucidate the configurations (about the *cyclo*propane ring) of the pair of adducts (I), m. p.s 184° and 195° respectively, they were degraded to the " known " 3-methyl*cyclo*propane-1 : 2-dicarboxylic acids (IV)—(VI).



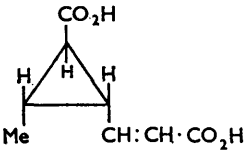
(IV); R = CO_2H



(V); R = CO_2H



(VI); R = CO_2H



(IX)

(VII); R = CH:CH·CO_2H

(VIII); R = CH:CH·CO_2H

(X); R = CH:CH·CO_2H

The identity and configurations assigned to these acids by Goss, Ingold, and Thorpe [3] being accepted, the adduct, m. p. 184°, gave the *cis-cis*-acid (VI) from which it followed that the adduct had structure (X). Similarly the adduct, m. p. 195°, gave the *trans*-3 : *cis*-2-acid (V), from which it followed that the adduct had structure (VIII). It was further concluded that addition of ethyl diazoacetate to the γδ-ethylenic bond of methyl sorbate had occurred both with and without inversion at one of the γ or the δ carbon atoms.

However, a re-examination by two of us [4] of the identity and configurations of the 3-methyl*cyclo*propane-1 : 2-dicarboxylic acids and their relation to Feist's acid, now proved to be 3-methylene*cyclo*propane-1 : *trans*-2-dicarboxylic acid,[5] has shown the above conclusions to be invalid.

Catalytic hydrogenation of Feist's acid gives a 3-methyl*cyclo*propane-1 : 2-dicarboxylic acid, m. p. 138°, passing into a dimorphic form, m. p. 150°, which must have the *trans*-configuration (IV), postulated by Feist.[6] (The " *trans*-acid," m. p. 195°, obtained by Goss, Ingold, and Thorpe does not appear to be a 3-methyl*cyclo*propane-1 : 2-dicarboxylic

[1] Harper and Reed, *J.*, 1955, 779.
[2] Harper, Sleep, and Crombie, *Chem. and Ind.*, 1954, 1538; Crombie, Harper, and Sleep, in preparation.
[3] Goss, Ingold, and Thorpe, *J.*, 1923, **123**, 3342.
[4] Ettlinger and Kennedy, in preparation; Kennedy, Thesis, The Rice Institute, May 1956.
[5] Ettlinger, *J. Amer. Chem. Soc.*, 1952, **74**, 5805; Lloyd, Downie, and Speakman, *Chem. and Ind.*, 1954, 492; Ettlinger and Kennedy, *ibid.*, 1956, 166; Kende, *ibid.*, 1956, 437, 544; Petersen, *ibid.*, 1956, 904; Bottini and Roberts, *J. Org. Chem.*, 1956, **21**, 1169.
[6] Feist, *Annalen*, 1924, **436**, 125.

acid at all). Comparison by mixed melting points of the di-*p*-nitrobenzyl and the di-*p*-bromophenacyl esters of acid (IV) with the derivatives of the acid obtained from ozonisation of the adduct (I), m. p. 195°, showed their identity. Hence the configuration of the adduct, m. p. 195°, is not (VIII) but (VII) or (IX), of which the former appears the more probable (see below). The *trans*-3-methyl*cyclo*propane-1 : *cis*-2-dicarboxylic acid (V), m. p. 140°, results as the ester from decomposition of the pyrazoline adduct [7] of ethyl *trans*-crotonate and ethyl diazoacetate, forms an anhydride, m. p. 80°, and is interconvertible with (IV) by standard methods. Comparison of the di-*p*-nitrobenzyl ester of acid (V) with that obtained on degradation of the adduct (I), m. p. 184°, established their identity. Hence the configuration of the adduct acid, m. p. 184°, is not (X) but (VIII). [The *cis*-3-methyl*cyclo*propane-1 : *cis*-2-dicarboxylic acid (VI), m. p. 131°, is best prepared by hydrogenation of 3-methylene*cyclo*propane-1 : *cis*-2-dicarboxylic acid, readily obtained as the anhydride from Feist's acid, and can be interconverted with (IV). The acid, m. p. 108°, previously reported as (VI) [3] was probably a mixture of acids (VI) and (V)].

The stereochemistry of the addition of ethyl diazoacetate to the $\gamma\delta$-ethylenic bond of methyl sorbate can now be rationalised, for if the adduct m. p. 195°, is (VII) rather than (IX), then it and the adduct (VIII), m. p. 184°, are the normal *cis-trans* pair formed by addition without inversion of the olefinic bond. The explanations advanced by Harper and Reed [1] and by Inouye and Oyno [8] to account for the apparent inversion of the olefin are no longer necessary.

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SALISBURY, S. RHODESIA (S. H. H.). [*Received, September 18th*, 1956.]

[7] von Auwers and König, *Annalen*, 1932, **496**, 252.
[8] Inouye and Ohno, *Bull. Inst. Chem. Res., Kyoto Univ.*, 1955, **33**, 237; *Botyu-Kagaku*, 1956, **20**, 136.

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176. *The Kinetics and Mechanisms of Aromatic Halogen Substitution. Part IV.* Rates of Bromination of Benzene and of Hexadeuterobenzene by Aqueous Hypobromous Acid containing Perchloric Acid.*

By P. B. D. DE LA MARE, T. M. DUNN, and J. T. HARVEY.

FOR nitration, it has been shown by Melander [1] that hydrogen and tritium, appropriately situated in benzene, toluene, bromobenzene, or naphthalene, are replaced by the nitro-group under ordinary conditions of nitration at very nearly the same speed. Bonner, Bowyer, and Gwyn Williams [2] have found that the rates of nitration of pentadeuteronitrobenzene in 97·4% and 86·7% sulphuric acid are identical with those of nitrobenzene in the same media. These " zero isotope-effects " are interpreted as showing that the C–H bond is not broken in the rate-determining step of these aromatic nitrations.

It is desirable to establish the situation in other aromatic electrophilic substitutions. For sulphonation of bromobenzene, a moderate isotope effect has been established by

* Part III, *J.*, 1957, 131.

[1] Melander, *Arkiv Kemi*, 1950, **2**, 211.
[2] Bonner, Bowyer, and Gwyn Williams, *J.*, 1953, 2650.

Berglund-Larsson and Melander;[3] and for the reactions of some diazonium ions with highly hindered naphtholsulphonic acids, Zollinger[4] has found a large isotope effect. Bonner and Wilkins[5] have observed a small, but definite, isotope effect in the cyclodehydration of 2-(2 : 4 : 6-trideuteroanilino)pent-2-en-4-one and its protium analogue, a reaction which they consider to be an intramolecular electrophilic substitution. These last observations have been interpreted as implying that the reactions follow a course which may in its simplest form be represented :

$$ArH + E \underset{v_{-1}}{\overset{v_1}{\rightleftharpoons}} ArH{\cdot}E;\ ArH{\cdot}E \xrightarrow{v_2} Products \quad . \ . \ . \ . \ . \ . \ . \ (1)$$

Here E is an electrophilic reagent; the velocity of the back-reaction (v_{-1}) is appreciable in comparison with that of the product-forming stage, v_2; and the latter reaction, which is partly rate-determining, involves in its transition state a considerable disruption of the Ar–H bond. In Zollinger's experiments, the kinetic intervention of a base in determining the velocity v_2 was demonstrated, though in principle this stage of the reaction could be either uni- or bi-molecular.

For halogenation, little has so far been established concerning the stages of the reaction following the attack of the electrophilic reagent. Reactions involving molecular halogen as the electrophilic reagent often involve complicated pre-equilibria, but on kinetic grounds it has been argued[6] that the stage of proton-loss is probably rapid and not rate-determining. Iodine-catalysed bromination of toluene and of tritiated toluene proceed with no preferential displacement of either isotope,[1] a fact which supports this view, independently of the mechanistic complications of these reactions.

Bromination involving hypobromous acid with an acid as catalyst is of some theoretical interest in that it involves[7,8] a positively charged intermediate (Br^+ or $BrOH_2^+$). The rates of bromination of benzene and of hexadeuterobenzene have now been compared, in aqueous dioxan with perchloric acid as catalyst. The reaction has the kinetic form :

$$-d[BrOH]/dt = k[ArH][BrOH][H^+] \quad . \ . \ . \ . \ . \ . \ . \ . \ (2)$$

which is consistent with reaction involving Br^+ or $BrOH_2^+$. Benzene and hexadeuterobenzene react at rates which are the same within experimental error. The stage of the reaction which involves breaking of the C–H or C–D bond is therefore, as in nitration, not rate-determining to an extent which can be detected by this criterion, and the reaction may be thought to proceed as in equation (1) ($E = Br^+$ or $BrOH_2^+$), with v_1 rate-determining, and $v_2 \gg v_{-1}$.*

Experimental.—Hexadeuterobenzene was prepared by Ingold, Raisin, and Wilson's method,[10] in which benzene is deuterated by 51% D_2SO_4 at room temperature. Four successive treatments gave a material, b. p. 79·1°, n_D^{25} 1·4950. Mass-spectrographic analysis of this material, kindly done by Dr. C. A. Bunton, showed that the sample contained at least 98·5% of C_6D_6. Subsequent infrared analysis showed the sample to contain 95% of C_6D_6 and 5% of C_6HD_5. Other materials and methods, including conventions used for calculation, have been

* A Referee has observed that Hammond's discussion[9] makes it desirable to treat this conclusion with reservation. The least categorical conclusion that can be drawn is that the breaking of the C–H bond has not made much progress in the transition state.

[3] Berglund-Larsson and Melander, *Arkiv Kemi*, 1954, **6**, 219.
[4] Zollinger, *Helv. Chim. Acta*, 1955, **38**, 1597.
[5] Bonner and Wilkins, *J.*, 1955, 2358.
[6] Robertson, *J.*, 1954, 1267; cf. Robertson, de la Mare, and Johnston, *J.*, 1943, 279.
[7] de la Mare and Harvey, *J.*, 1956, 36.
[8] Derbyshire and Waters, *J.*, 1951, 73.
[9] Hammond, *J. Amer. Chem. Soc.*, 1955, **77**, 334.
[10] Ingold, Raisin, and Wilson, *J.*, 1936, 915.

described in earlier papers. The following results illustrate a typical kinetic run. From a solution, at 25°, of hexadeuterobenzene (0·0105M), hypobromous acid (0·0014M), and perchloric acid (0·141M), all in 50% dioxan, samples (10 ml.) were removed at intervals for titration against 0·002N-sodium thiosulphate, with starch as indicator. A control, at similar concentrations, but with hexadeuterobenzene omitted, was run side by side with this measurement.

Reaction			Control		
Time (min.)	Titre (ml.)	10^2k_1 (min.$^{-1}$)	Time (min.)	Titre (ml.)	10^2k_1 (min.$^{-1}$)
0·0	14·28	—	0·0	18·72	—
3·40	11·83	5·34	3·92	18·50	0·30
7·98	9·50	5·11	7·80	18·32	0·28
11·83	7·90	5·01	11·10	18·18	0·26
15·50	6·98	4·62	15·08	18·01	0·22
19·12	6·08	4·47	19·51	18·07	0·18

The following are initial values of the second-order rate-coefficients, k_2, calculated as described earlier from the disappearance of aromatic compound and hypobromous acid, showing the dependence of rate on acidity. Corresponding experimental values for benzene [7] are included for comparison. All values refer to conditions in which the aromatic compound had concentration 0·011—0·016M, and HOBr, 0·001—0·002M in 50% dioxan at 25°.

$HClO_4$ (M)	0·066	0·088	0·111	0·141
k_2 (l. mole^{-1} min.$^{-1}$), C_6D_6	2·5	3·2	4·4	5·0
C_6H_6	2·4	3·0	4·2	5·2

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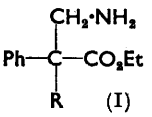
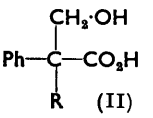
177. α-*Methyltropic Acid—A Correction.*

By R. FOSTER and H. R. ING.

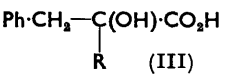
IN a recent paper on " Some new tropine derivatives " [1] we assumed that the acid obtained by the action of nitrous acid on ethyl β-amino-α-methyl-α-phenylpropionate (I; R = Me), and subsequent hydrolysis of the hydroxy-ester, was α-methyltropic acid (II; R = Me). At the time we were unaware that Zaugg [2] had shown that the acid obtained by Burtner and Cusic [3] in a similar way from ethyl β-amino-αα-diphenylpropionate (I; R = Ph) was not, as these authors naturally thought, α-phenyltropic acid (II; R = Ph) but α-benzylmandelic acid (III; R = Ph), produced by molecular rearrangement during the reaction of the amino-ester with nitrous acid. When Dr. Zaugg kindly drew our attention to his proof [2] of the structure of Burtner and Cusic's acid it seemed probable that a similar



(I)



(II)



(III)

rearrangement had occurred during our synthesis and that our supposed α-methyltropic acid (m. p. 98°) was really α-benzyl-lactic acid (III; R = Me), originally synthesized by Gabriel and Michael,[4] who recorded m. p. 97—99°. We repeated Gabriel and Michael's

[1] *J.*, 1956, 938.
[2] Zaugg, *J. Amer. Chem. Soc.*, 1950, **72**, 3001.
[3] Burtner and Cusic, *J. Amer. Chem. Soc.*, 1943, **65**, 262.
[4] Gabriel and Michael, *Ber.*, 1879, **12**, 814.

synthesis, using somewhat simpler conditions, and found that both α-benzyl-lactic acid and a mixture of it with our supposed α-methyltropic acid melted sharply at 98°. There is, therefore, no doubt that our acid, m. p. 98°, is α-benzyl-lactic acid and that the ethyl, tropine, and ψ-tropine esters described in our paper [1] as α-methyltropates are really α-benzyl-lactates.

Experimental.—The bisulphite compound from benzyl methyl ketone (25 g.) was suspended in water (150 ml.), and a saturated solution of potassium cyanide (12 g.) added dropwise with stirring at 0—5°. The oily cyanohydrin was separated (in ether) and hydrolysed by boiling 5N-hydrochloric acid (200 ml.) for 3 hr. A small amount of dark oil was separated (in benzene) and α-benzyl-lactic acid extracted with ether and crystallized three times from benzene; it formed feathery needles, m. p. 98° (Found: C, 66·5; H, 6·7. Calc. for $C_{10}H_{12}O$: C, 66·7; H, 6·7%).

We are grateful to Dr. H. E. Zaugg for drawing our attention to his work and giving us the opportunity of correcting our error ourselves.

DEPARTMENT OF PHARMACOLOGY, OXFORD. [*Received, October 3rd*, 1956.]

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178. *The Cholestane-2 : 3-diols.*

By H. B. HENBEST and M. SMITH.

INCIDENTALLY to other work, the four cholestane-2 : 3-diols have been prepared, three of them apparently for the first time. The methods used were similar to those employed for the preparation of similar diols in the sapogenin series; [1,2,3] the configurations of the cholestane compounds can be assigned by analogy.

Experimental.—Cholestane-2β : 3α-diol. This was prepared by Marker and Plambeck's method.[4] The purified compound had m. p. 197—200°, $[\alpha]_D$ +42°; the earlier authors record m. p. 201°.

Cholestane-2α : 3α-diol. A mixture of cholest-2-ene (1·3 g.) in dry benzene (50 c.c.) and osmium tetroxide (1 g.) in dry pyridine (50 c.c.) was kept at 20° for 90 hr. The solvent was evaporated under reduced pressure and the residue was heated under reflux for 4 hr. in a mixture of mannitol (7·5 g.), potassium hydroxide (7·5 g.), ethanol (75 c.c.), benzene (30 c.c.), and water (15 c.c.). The product was isolated with benzene and crystallised from aqueous methanol, to give material, m. p. 196—209°. The pure 2α : 3α-*diol* had m. p. 212—214°, $[\alpha]_D$ +32° (Found: C, 80·2; H, 12·05. $C_{27}H_{48}O_2$ requires C, 80·15; H, 11·95%).

Cholestane-2β : 3β-diol. Silver acetate (2·3 g.), and then iodine (1·39 g. in portions), were added to a stirred solution of cholest-2-ene (2·03 g.) in acetic acid (350 c.c.). When the iodine had dissolved, water (0·1 c.c.) was added and the mixture was stirred at 95° for 20 hr. Sodium chloride (0·15 g.) in water (1 c.c.) was added to the cooled mixture, which was then filtered, and the filtrate evaporated under reduced pressure. The residue was hydrolysed by potassium hydroxide (2 g.) in methanol (100 c.c.) at 20° overnight, the product being isolated with chloroform and chromatographed on alumina (300 g.). Material eluted with ether–methanol (49 : 1) was discarded; the product (1·43 g.) eluted with ether–methanol (19 : 1) was crystallised from methanol, to give the 2β : 3β-*diol*, m. p. 174—177°, $[\alpha]_D$ +43° (Found: C, 80·2; H, 12·0%).

Cholestane-2α : 3β-diol. Cholestane-2β : 3β-diol (0·15 g.) was added to a solution of sodium (0·7 g.) in ethanol (17 c.c.), and the mixture heated at 180° for 24 hr. Isolation with ether followed by crystallisation from methanol afforded the 2α : 3β-*diol*, m. p. 212—214°, $[\alpha]_D$ +28°

[1] Pataki, Rosenkranz, and Djerassi, *J. Amer. Chem. Soc.*, 1951, **73**, 5375.
[2] Herran, Rosenkranz, and Sondheimer, *ibid.*, 1954, **76**, 5531.
[3] Klass, Fieser, and Fieser, *ibid.*, 1955, **77**, 3829.
[4] Marker and Plambeck, *ibid.*, 1939, **61**, 1332.

(Found : C, 79·2; H, 12·2%). The m. p. was depressed to 205° on admixture with the 2α : 3α-diol which has the same m. p.; the infrared absorption spectra were also different in detail. The 2α : 3α-diol was also isomerised to the 2α : 3β-diol on similar treatment with sodium ethoxide.

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THE UNIVERSITY, MANCHESTER, 13. [*Received, October 3rd*, 1956.]

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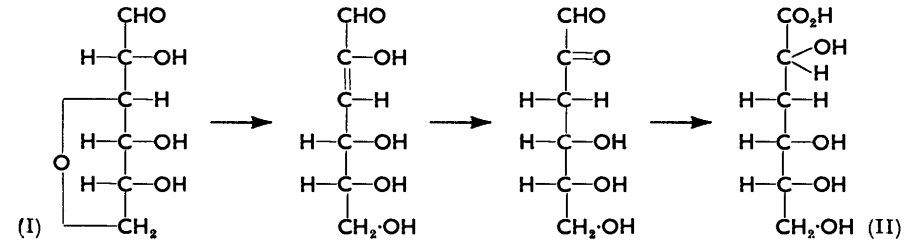
179. *The Degradation of Carbohydrates by Alkali. Part XIV.** 3 : 6-*Anhydro*-D-*glucose.*

By W. M. CORBETT and J. KENNER.

IT would be expected from the earlier work of this series that the 3 : 6-anhydrohexoses would undergo degradation by lime-water. This has been confirmed for 3 : 6-anhydro-D-glucose (I) which eventually gives one equivalent of acid. The acids have been isolated as their calcium salts and separated into the salts of 3-deoxy-D-gluconic and 3-deoxy-D-mannonic acid (D-*gluco*metasaccharinic acids; II).



Experimental.—3 : 6-Anhydro-D-glucose, prepared from mono-*O*-*iso*propylidene-D-glucose as described by Ohle *et al.*,[1] had m. p. 116—119°, $[\alpha]_D^{20}$ +51·8° (*c*, 1·39 in water). A solution (100 ml.) of 3 : 6-anhydro-D-glucose (0·3418 g.) in oxygen-free 0·04N-lime-water was maintained at 25°. Samples were withdrawn periodically and the consumption of alkali estimated by back titration. The equivalents of acid produced are given in the following table :

Degradation of 3 : 6-*anhydro*-D-*glucose by lime-water at* 25°.

Time (hr.)	0·25	0·5	1	2	5	7	24	48	72	144	168	216
Acid (equiv.) ...	0·024	0·028	0·033	0·064	0·163	0·207	0·502	0·748	0·879	0·993	1·015	1·015

Paper chromatograms of the samples, when developed in butanol–pyridine–water (6 : 4 : 3) and sprayed with silver nitrate,[2] indicated the presence of two components. The slower component was revealed as a pale brown streak originating from the starting line and resembled streaks produced by calcium salts of an organic polyhydroxy-acid, whilst the faster component was revealed as a brown spot whose R_F value was similar to that of 3 : 6-anhydro-D-glucose. The intensity of the former increased and of the latter decreased as the reaction progressed.

A solution (500 ml.) of 3 : 6-anhydro-D-glucose (1·85 g.) in oxygen-free lime-water was maintained at 25° for 7 days. The excess of calcium hydroxide was then removed as the carbonate, and the filtered solution concentrated to a residue (2·37 g.). On addition of ethyl

* Part XIII, *J.*, 1956, 2921.

[1] Ohle, Vargha, and Erlbach, *Ber.*, 1928, **61**, 1214.

[2] Trevelyan, Procter, and Harrison, *Nature*, 1950, **166**, 144.

alcohol (3·5 ml.) to a solution of the residue in water (3·5 ml.), cubic crystals of calcium 3-deoxy-D-mannonate (0·75 g.) separated. The crystals, $[\alpha]_D^{23}$ −21·3° (*c*, 3·0 in water), were converted into 3-deoxy-D-mannonolactone, m. p. 89·5—91·5° undepressed in admixture with an authentic sample. Further addition of alcohol (5 ml.) to the aqueous ethanol solution of the calcium salts gave calcium 3-deoxy-D-gluconate (0·74 g.), $[\alpha]_D^{23}$ −6·7° (*c*, 3·0 in water). This was converted *via* the free acid into the brucine salt, m. p. 145—150° undepressed in admixture with an authentic specimen.

This work forms part of the programme of fundamental research undertaken by the Council of the British Rayon Research Association.

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