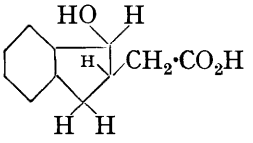
280. cis–trans-*Isomerism in Hydrindene Derivatives, and its Relation to the Walden Inversion. Part I.*

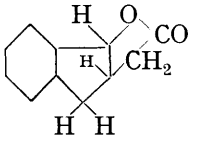
By D. H. Peacock and B. K. Menon.

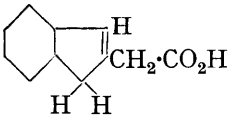
The configuration of 1-hydroxyhydrindene-2-acetic acid, whose preparation is described below, is readily determinable by the ease of lactone formation of the two isomerides, and similar considerations should apply to the corresponding amino-compounds and related lactams which we attempted to prepare in order to study the Walden inversion. Although these attempts have failed, our experiments have provided a number of examples of *cis–trans*-isomerism in the hydrindene series and of geometrical inversion in those compounds, as well as some examples of inversion at the carbon atom in the α-position to a carboxyl group. One case of *cis–trans*-isomerism in this series has already been described by Blum-Bergmann (*Annalen*, 1932, **492**, 277), who prepared methyl 1-phenylhydrindene-3-carboxylate in a solid and a liquid form; only one form of the corresponding acid was

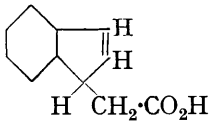
found. Geometrical inversion in the compounds now described corresponds to a Walden inversion in an ordinary, open-chain, optically active compound (cf. Noyes and Taveau, *Amer. Chem. J.*, 1906, **35**, 385).

1-Hydroxyhydrindene-2-acetic acid (I) was first prepared by one of us (D. H. P.) in 1913 from 2-bromo-1-hydroxyhydrindene (Pope and Read, J., 1912, **101**, 760), and probably has the *trans*-structure (I) because it does not readily form a lactone and on elimination of water gives an *acid* which is probably (III), since it is not identical with (IV) (Thiele

(I.) 


(II.)

(III.) 

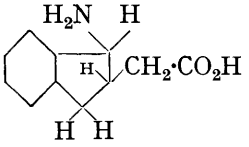

(IV.)

and Ruddiger, *Annalen*, 1906, **347**, 282). When ammonia or amines act upon 2-bromo-1-hydroxyhydrindene, the entering amino-group takes the 1-position and displaces the hydroxyl group to the 2-position (von Braun and Weissbach, *Ber.*, 1930, **63**, 3052).

The action upon (I) of hydrogen bromide and other reagents for replacing the hydroxyl group by a halogen atom gave interesting results. Hydrogen bromide in acetic acid gave the *lactone* (II) of *cis*-1-hydroxyhydrindene-2-acetic acid; this dissolved in warm sodium hydroxide solution, and on acidification the lactone was at once regenerated; we could not isolate the free acid. When (I) was heated with aqueous hydrogen bromide (saturated at 0°) in a sealed tube at 100°, it gave a small yield of the lactone (II), and as main product an unsaturated acid, probably indene-2-acetic acid (III); the same lactone was also produced by the action of aqueous hydrogen bromide under ordinary pressure, of thionyl chloride, and of phosphorus pentabromide. The methyl ester of the acid (I) gave the lactone (II) when treated with phosphorus pentabromide at 5—10° or with thionyl chloride.

When the ethyl ester of the acid (I) was treated in absolute alcohol with hydrogen bromide, it gave the bromo-ester, but this on treatment with ammonia did not give the ester or amide of the amino-acid (V) but a mixture of the lactone (II) with the *ammonium* salt of the *cis*-hydroxy-acid corresponding to the lactone (II). The bromo-ester when treated with potassium phthalimide or with sodium *p*-toluenesulphonamide gave again only the lactone (II). It might be concluded, from the ease with which the chloro- and bromo-acids are converted into the lactone, that they possess the *cis*-configuration, but we do not support this view, for it implies unproven assumptions as to the mode of replacement of the halogen.

The hydrindyl acids substituted in the α-position to the carboxyl group were next examined. They were prepared by the action of 2-bromo-1-hydroxyhydrindene upon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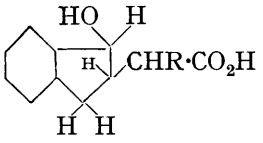
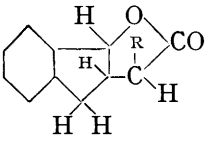
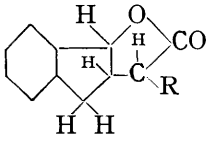

(VI; *a* and *b*.)

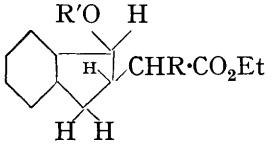

(VII*a*.)


(VII*b*.)

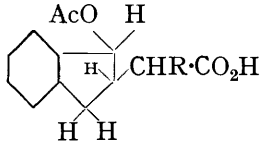
the corresponding derivatives of acetoacetic ester, followed by hydrolysis with concentrated alkali. The acids so obtained therefore had the configurations stable in alkaline solution. In this way β-*phenyl*-α-1-*hydroxyhydrindene*-2-*propionic acid* (VI; R = CH_2Ph), m. p. 164°, was obtained; as it did not readily form a lactone it was assigned the *trans*-configuration, but the configuration around the carbon atom α to the carboxyl group was, of course, unknown; this acid will be called (VI*a*). When treated similarly to the acid (I), it readily gave a *lactone* (VII*a*; R = CH_2Ph), which showed similar properties to the lactone (II).

The acid (VI*a*) was esterified and the *p*-toluenesulphonyl derivative (VIII) of the ester prepared and treated with ammonia; two products were obtained, the original acid, and a *lactone* (VII*b*), which was unchanged by treatment with hydrogen bromide or with caustic soda. Its formation was ascribed to the action of alkali on (VII*a*), and this explanation was confirmed by heating the latter with caustic soda for some hours and acidifying the solution, the lactone (VII*b*) being obtained almost quantitatively. The changes brought about may thus be summarised: The acid (VI*a*) has the *trans*-configuration with regard to the hydrindene ring, and what may be called the *a*-configuration with respect to the carbon atom α to the carboxyl group. Treatment with hydrogen bromide converts the *trans*- into the *cis*-form, but leaves the configuration round the α-carbon atom unchanged. The evidence for this is that hydrogen bromide has no action on either of the lactones (VII*a*) or (VII*b*), where the configurations of these carbon atoms differ and where, therefore, if inversion were possible it would be shown by one form or the other. The lactone (VII*a*) therefore has the *cis*-configuration with respect to the ring and the *a*-configuration of the carbon atom adjacent to the carboxyl group, a configuration which is stable to alkalis in the original *trans*-acid (VI*a*), but is unstable in the lactone and readily undergoes inversion by alkali to the *b*-configuration, giving the lactone (VII*b*). We thus see that the configuration stable in the sodium salt of the *trans*-acid is unstable in the sodium salt of the *cis*-acid. Although the inversions appeared complete, they should perhaps be described as a displacement of equilibrium in one direction or the other.

Although the two possible forms of the *cis*-lactone have thus been isolated, only one form of the *trans*-acid has been prepared. An attempt to prepare 1-hydroxyhydrindene-2-benzylmalonic acid and thence the form (VI*b*) of the corresponding acid failed, for carbon dioxide was eliminated during saponification and the product on acidification gave only the acid (VI*a*; R = CH_2Ph). What is probably the acetyl derivative of the fourth acid has, however, been prepared. The crude acid obtained in the preparation of (VI*a*; R = CH_2Ph) left an oily residue on crystallisation; this was boiled with acetic anhydride and



(VIII; R′ = *p*-$C_6H_4Me{\cdot}SO_2{\cdot}$.)



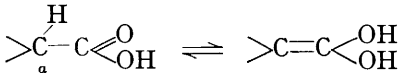
(IX*a* and *b*.)

gave an *acetoxy-acid* (IX*b*; R = CH_2Ph), m. p. 121°. The acid (VI*a*; R = CH_2Ph) when treated similarly gave an isomeric *acetoxy-acid* (IX*a*; R = CH_2Ph), m. p. 147°. When boiled with sodium hydroxide this acid regenerated the original acid (VI*a*; R = CH_2Ph), whereas on similar treatment (IX*b*) gave a mixture of (VI*a*) and an oil. It would be expected that the acid (VI*b*) if obtained as sodium salt would be readily isomerised by alkalis because the *b*-configuration is unstable to alkalis when present in a *trans*-acid. The relationship between the four acids (VI*a*), (VI*b*), (VII*a*), and (VII*b*) appears to be as follows: The solution of potassium salts obtained in the original hydrolysis probably contained (VI*a*) and (VI*b*) in equilibrium proportion, *i.e.*, with the former in excess. The oily residue from crystallisation contained all the (VI*b*) and this gave the corresponding acetyl derivative on acetylation. The acetyl derivative of (VI*b*) on treatment with alkali would then give the equilibrium mixture of (VI*a*) and (VI*b*). This explanation received confirmation from the results obtained when the two acetyl derivatives (IX*a*) and (IX*b*) were treated with hydrogen bromide; the former gave the lactone (VII*a*), and the latter the lactone (VII*b*). The lactone (VII*a*) was produced from the *trans*-acid (VI*a*), and the lactone (VII*b*) naturally corresponds to the *trans*-acid (VI*b*), from which also the acetoxy-acid (IX*b*) must be derived. Hence, derivatives of all four possible forms of this acid have been obtained. In one experiment, when the acid (VI*a*) was heated with acetic anhydride, a neutral product was obtained which dissolved in caustic soda when heated and on acidification re-formed the original acid (VI*a*). This neutral product had the correct molecular weight for the *trans*-lactone, but gave low results for carbon.

It has been established that hydrolysis of sulphonic esters frequently leads to a change of configuration which does not occur in the hydrolysis of acetic esters (cf. Phillips, J., 1923, **123**, 44; Kenyon, Phillips, and Turley, J., 1925, **127**, 399; Hückel and Frank, *Annalen*, 1930, **477**, 140). The last two authors found that treatment of cyclic sulphonic esters with dilute alkali frequently gave rise to the corresponding unsaturated hydrocarbon. The acetyl and *p*-toluenesulphonyl derivatives of the acids (I) and (VI) do not give the corresponding unsaturated acids, but the acetyl derivative is saponified to the original acid and the sulphonic ester undergoes inversion.

We have also prepared the *acids* (VI*a*; R = Me) and (VI*a*; R = *n*-Bu), but in poor yields. In both cases only one form of the *trans*-acid and of the *lactone* was obtained. The lactone of the *n*-butyl acid was unchanged when heated to 150° in a sealed tube with potassium hydroxide solution. Treatment with quinoline also failed to produce inversion.

It was suggested by Kipping and Hunter (J., 1903, **83**, 105) that the racemisation of α-substituted acids was due to the process



They showed that benzylmethylacetic acid was not racemised by heating in methyl-alcoholic solution to 170°, but did not describe the action of alkalis. Since the lactone (VII*a*) readily undergoes inversion by alkali when R = CH_2Ph, but not when R = Me or *n*-Bu, we suggest that this difference is due to the electron affinity of the benzyl group. Kipping and Hunter's suggestion involves proton expulsion from the α-carbon atom, and this process will be aided by the electron attraction of the benzyl group and retarded by the electron-repelling effect of the methyl group. Another case in which these effects act, but in the reverse direction, is in the reactivity of benzylaniline and methylaniline with benzoyl chloride (Peacock, J., 1924, **125**, 1979; 1925, **127**, 2179).

Experimental.

trans-1-*Hydroxyhydrindene*-2-*malonic Acid*.—Ethyl malonate (16 g.) was added to a suspension of sodium ethoxide in xylene and mixed with a solution of bromohydroxyhydrindene (21·3 g.) in benzene (50 c.c.). The mixture was boiled under reflux for 3 hours, and worked up in the usual way. The crude ester was saponified by caustic soda, and the solution, after removal of tar, evaporated to dryness, extracted with water, decolorised (charcoal), and concentrated in a vacuum desiccator; the sodium salt was precipitated by ethyl alcohol, decomposed with dilute sulphuric acid, and the solution extracted repeatedly with ether. Removal of the ether left the *acid* (8·8 g.), sparingly soluble in ether and benzene; m. p. 118° from water or alcohol–benzene (Found: C, 60·7; H, 5·6. $C_{12}H_{12}O_5$ requires C, 61·0; H, 5·1%). The lead salt was insoluble in boiling water. The yield was considerably reduced when the reaction was carried out in absolute alcohol.

trans-1-*Hydroxyhydrindene*-2-*acetic Acid* (I).—(i) This acid was obtained when the foregoing acid was heated in an oil-bath at 120—130° for 2 hours; crystallised from boiling water, dilute alcohol, or benzene–acetone, it had m. p. 131°; it was sparingly soluble in cold water and benzene, very soluble in ethyl alcohol, and soluble in ether; it was acid to litmus and readily soluble in cold sodium hydrogen carbonate solution.

(ii) Acetoacetic ester (65 g.) was added to sodium (11·5 g.) in absolute alcohol (180 c.c.), and a warm solution of bromohydroxyhydrindene (107 g.) in absolute alcohol (200 c.c.) added. Sodium bromide at once began to separate. Next day the solution was heated on a boiling water-bath until neutral (5 hours). The product when worked up gave 150 g. of crude ester. This was added gradually (1 hour) to a solution of caustic potash (150 g.) in water (200 c.c.). The solution became hot; it was heated next day for 2 hours on a water-bath, 400 c.c. of water added, and the alcohol distilled off. The turbid solution was extracted with benzene, filtered, and acidified; the crude acid readily solidified. This was dissolved in sodium bicarbonate solution, filtered from undissolved tar, and re-acidified. The crude acid (58 g.; 60%) was crystallised from boiling water (with " Nuchar ") and then from benzene–acetone (Found: C, 68·3; H, 6·3. Calc. for $C_{11}H_{12}O_3$: C, 68·7; H, 6·2%).

Lactone of cis-1-*Hydroxyhydrindene*-2-*acetic Acid* (II).—The acid (I) (4 g.) was dissolved in an acetic acid solution of hydrogen bromide (30 c.c.) and kept at 25—27° for 24 hours. The acetic

acid and hydrogen bromide were then distilled off under reduced pressure from a water-bath. The residue solidified over caustic potash in a desiccator; m. p. 73° recrystallised from light petroleum. The *lactone* was very soluble in ethyl alcohol, methyl alcohol, benzene, and ether, slowly soluble in ammonia, insoluble in sodium bicarbonate, readily soluble in caustic soda, being regenerated on acidification (Found : C, 75·95; H, 5·78. $C_{11}H_{10}O_2$ requires C, 75·9; H, 5·74%). Hydrochloric acid saturated at 0° did not affect the acid (I) during 3 days at 25—27°.

Indene-2-acetic Acid (III).—Hydrogen bromide solution saturated at 0° (25 c.c.) and the acid (I) (6 g.) heated for 6 hours at 100° gave a mixture of lactone and an *acid* melting indefinitely at 150—160° after precipitation from solution in acetic acid (Found : C, 76·3; H, 6·2. $C_{11}H_{10}O_2$ requires C, 75·9; H, 5·7%).

Action of Phosphorus Pentabromide and Thionyl Chloride on the Methyl Ester of (I).—The methyl ester of (I), prepared by standard methods, was a liquid. The ester (4 g.) was cooled in ice and water and mixed slowly (1·5 hours) with phosphorus pentabromide (10 g.) . The reaction was vigorous at first. After ½ hour, ether (30 c.c.) was added, and the ethereal solution washed with water and sodium bicarbonate. The ether was distilled off, and the residue at once crystallised; on recrystallisation from light petroleum, it had m. p. 72°, and was identical with the lactone (II). The sodium bicarbonate solution contained no bromo-acid. In another experiment, the methyl ester (4 g.) and thionyl chloride (8 g.) were left over-night at 25—27°, and then the lactone distilled under reduced pressure, b. p. 225°/25 mm.; yield 2·4 g.; m. p. 72°.

Action of Ammonia on Ethyl Bromohydrindene-2-acetate.—The *trans*-acid (I) (10 g.) was dissolved in absolute ethyl alcohol (50 c.c.), and a stream of dry hydrogen bromide passed through the boiling solution; after some hours the solution was cooled, saturated with hydrogen bromide and kept for 2 days. The alcohol was distilled off, and the residue resubmitted to this treatment. The bromo-ester was dissolved in cold saturated alcoholic ammonia (50 c.c.) and kept for 3 weeks. Crystals of the *ammonium* salt of the *cis*-acid which formed were separated and crystallised from boiling rectified spirit; 2·8 g., m. p. 158° (Found : C, 63·2; H, 7·2. $C_{11}H_{15}O_3N$ requires C, 63·2; H, 7·18%); on acidification it gave the lactone (II). From the residual solution and mother-liquors the alcohol was distilled, and the residue poured into water. An oil separated, which at once solidified on seeding with lactone (5·0 g.; m. p. 72° from light petroleum). The aqueous solution on acidification gave a further crop of the lactone.

trans-β-*Phenyl*-α-1-*hydroxyhydrindene-2-propionic Acid* (VI; R = CH_2Ph).—(i) Ethyl benzylacetoacetate (55 g.) was added to a solution of sodium (5·75 g.) in absolute alcohol (100 c.c.), and a solution of bromohydroxyhydrindene (53·25 g.) in absolute alcohol (100 c.c.) added. Next day the solution was boiled until neutral (2 hours). The ester was worked up in the usual way (yield 89 g.), added to a cold solution of potassium hydroxide (45 g.) in rectified spirit (105 c.c.), and left over-night. Next day it had turned black, and was boiled for 5 hours under reflux; the alcohol was distilled off, and water added, the resulting black oil being extracted with benzene. The aqueous solution on acidification gave a black, oily product which was treated with sodium bicarbonate, filtered from tar, and again acidified. The acid was extracted with benzene, the solution dried, and the benzene distilled. The residue crystallised (yield, 5 g. crude). When a current of hydrogen was passed through the apparatus during hydrolysis, the yield of crude *acid* was raised to 40 g. It crystallised from acetone–benzene; m. p. 164° (Found : equiv., by titration, 282·3; C, 76·4; H, 6·48. $C_{18}H_{18}O_3$ requires equiv., 282; C, 76·6; H, 6·38%); from the benzene mother-liquors an oily mixture of acids was obtained.

(ii) By a similar process from 25 g. of ethyl benzylmalonate, 35 g. of ester were obtained; this was decomposed by boiling with alcoholic potassium hydroxide, and the crude acid (3·5 g.) purified and recrystallised as before; m. p. 164°, identical with the acid obtained in (i).

cis-*Lactone* (VII*a*).—The *trans*-acid (VI*a*; R = CH_2Ph) (2 g.) was dissolved in aqueous hydrogen bromide (*d* 1·78; 20 c.c.) and heated for 2 hours on a water-bath. The hydrogen bromide was distilled off under reduced pressure, and the residue washed with sodium bicarbonate solution. The only residue solidified when stirred with alcohol; rhombohedral crystals from alcohol, m. p. 84° (Found : equiv. by titration, 259·4, 265·6; C, 82·05; H, 6·01. $C_{18}H_{16}O_2$ requires equiv., 264; C, 81·8; H, 6·06%). When the *trans*-acid (VI*a*) (2 g.) was similarly treated with an acetic acid solution (20 c.c.) of hydrogen bromide, 1·3 g. of the pure *lactone* were obtained. The *trans*-acid (2 g.) was dissolved in ether, cooled in ice, and gradually mixed with phosphorus pentabromide (6 g.). The ethereal solution was washed with water and sodium bicarbonate, and dried. On removal of the ether, 1·5 g. of the lactone were obtained. In another experiment, 1 g. of the *trans*-acid was boiled with 50% sulphuric acid; the product was 0·3 g. of lactone, m. p. 84°, and unchanged acid.

When the acid (VI*a*) (0·5 g.) was boiled with potassium hydroxide (1·5 g. in 8 c.c. water) for an hour, it was recovered unchanged on acidification.

Action of Ammonia on Ethyl β-Phenyl-α-1-p-toluenesulphonyloxyhydrindene-2-propionate (VIII).—Ethyl β-phenyl-α-1-hydroxyhydrindene-2-propionate (3 g.), prepared in the usual way, was mixed at 0—10° with *p*-toluenesulphonyl chloride (1·5 g.) and pyridine (1·1 g.) and left overnight. Next day the product was poured into water, extracted with benzene, the extract washed, and the benzene distilled off. The ester (VIII) (4 g.) was a viscous oil. It was dissolved in alcohol (50 c.c.) and saturated with ammonia at 0°. The solution was kept at room temperature for 43 hours and then heated for 5 hours at 100°. The alcohol was distilled off, and the residue dissolved in benzene and washed with dilute hydrochloric acid. Neutralisation of this extract gave no amino-acid or amino-ester. On removal of the benzene, a residue was left consisting of the original acid (m. p. 164°) and a neutral product, m. p. 102° (Found : equiv. by titration, 271·2; C, 81·7; H, 6·05. $C_{18}H_{16}O_2$ requires equiv., 264; C, 81·8; H, 6·06%); this *lactone* (VII*b*; R = CH_2Ph) was insoluble in sodium bicarbonate, but soluble in caustic soda on warming, being reprecipitated on acidification.

Action of Sodium Hydroxide on (VIII).—1 G. of the ester (VIII) was boiled with 10 c.c. of 2*N*-sodium hydroxide; the solution was acidified, extracted with benzene, and the extract washed with sodium bicarbonate solution. From the benzene solution the lactone (VII*b*), m. p. 102°, was obtained.

Conversion of Lactone (VII*a*) *into the Lactone* (VII*b*).—The lactone (1 g.) was boiled under reflux for 2 hours with potassium hydroxide (1 g.) in rectified spirit (5 c.c.), the alcohol removed, water added, the solution acidified, and extracted with ether. The extract was washed with sodium bicarbonate solution and then gave 0·75 g. of the lactone (VII*b*), m. p. 102°. Sodium ethoxide solution acted similarly.

When, however, a solution of the lactone (VII*a*) (7 g.) in absolute alcohol (100 c.c.) was saturated at 0° with hydrogen bromide, left over-night, and then heated under reflux on a boiling water-bath in a stream of hydrogen bromide, the lactone was subsequently recovered unchanged, m. p. 84°.

Condensation of 2-Bromo-1-hydrindone with Ethyl Benzylacetoacetate and with Ethyl Benzylmalonate.—2-Bromo-1-hydrindone (10 g.), prepared as described by Ishiwara (*J. pr. Chem.*, 1924, **108**, 194), was dissolved in absolute alcohol (40 c.c.) and added to a solution prepared by addition of ethyl benzylacetoacetate (11·0 g.) to a solution of sodium (1·15 g.) in absolute alcohol (20 c.c.) cooled by ice. Colourless needles at once began to separate. Next day the solution had turned black. It was boiled under reflux for one hour, the alcohol distilled off, water added, and the oil extracted with ether. On removal of the ether, the residue partly crystallised. Alcohol was added, and the crystals (3·8 g.), m. p. 158—176°, removed. The oil on hydrolysis with alcoholic caustic potash gave only a black tar. Condensation of bromohydrindone with ethyl benzylmalonate gave the same crystalline solid, and an oil which on hydrolysis gave a tar, from which a small quantity of benzylmalonic acid was isolated. The solid product was bromo-hydrindonylhydrindone (Kipping and Revis, J., 1897, **71**, 243) (Found : Br, 22·98. Calc. for $C_{18}H_{13}O_2Br$: Br, 23·4%).

Action of Ammonia on Ethyl β-Phenyl-α-1-bromohydrindene-2-propionate.—The acid (VI*a*; R = CH_2Ph) (5 g.) was dissolved in absolute alcohol (50 c.c.) and a stream of dry hydrogen bromide at room temperature passed through the solution, which was then boiled for an hour in a current of hydrogen bromide; the bromo-ester was worked up in the usual way; yield, 5·5 g. (Found : Br, 15·47%, corresponding to about 70% of the bromo-ester). This ester (5·1 g.) was added to alcoholic ammonia (6*N*, 70 c.c.) and kept at 10° for 144 hours. The alcohol and ammonia were then distilled off from a water-bath, and the residue extracted with ether. An oil (4·4 g.) which contained bromine but no nitrogen was obtained. This was heated for 6 hours with alcoholic ammonia (6*N*, 70 c.c.) at 100°. The product when worked up as before gave 1·5 g. of the lactone (VII*b*), m. p. 102°, and a neutral oil (probably a mixture of the lactones). The action of potassium phthalimide on this bromo-ester gave phthalimide, phthalic acid, the acid (VI*a*), and the lactone (VII*b*), m. p. 102°. The action of sodium *p*-toluenesulphonamide also gave this lactone, m. p. 102°, but no amino-derivative. This lactone was recovered unchanged after 2 hours' boiling with aqueous hydrogen bromide (*d* 1·78) or with an acetic acid solution of hydrogen bromide.

Acetoxy-acid (IX*b*; R = CH_2Ph).—The oil (10 g.) obtained from the mother-liquors from the crystallisation of the acid (VI*a*) was boiled for 2 hours with acetic anhydride (50 c.c.), the product poured into alcohol (50 c.c.), and left at room temperature for 2 hours. The ethyl acetate, etc., were then removed by distillation under reduced pressure, and the residue dissolved

When the acid (VI*a*) (0·5 g.) was boiled with potassium hydroxide (1·5 g. in 8 c.c. water) for an hour, it was recovered unchanged on acidification.

Action of Ammonia on Ethyl β-Phenyl-α-1-p-toluenesulphonyloxyhydrindene-2-propionate (VIII).—Ethyl β-phenyl-α-1-hydroxyhydrindene-2-propionate (3 g.), prepared in the usual way, was mixed at 0—10° with *p*-toluenesulphonyl chloride (1·5 g.) and pyridine (1·1 g.) and left overnight. Next day the product was poured into water, extracted with benzene, the extract washed, and the benzene distilled off. The ester (VIII) (4 g.) was a viscous oil. It was dissolved in alcohol (50 c.c.) and saturated with ammonia at 0°. The solution was kept at room temperature for 43 hours and then heated for 5 hours at 100°. The alcohol was distilled off, and the residue dissolved in benzene and washed with dilute hydrochloric acid. Neutralisation of this extract gave no amino-acid or amino-ester. On removal of the benzene, a residue was left consisting of the original acid (m. p. 164°) and a neutral product, m. p. 102° (Found : equiv. by titration, 271·2; C, 81·7; H, 6·05. $C_{18}H_{16}O_2$ requires equiv., 264; C, 81·8; H, 6·06%); this *lactone* (VII*b*; R = CH_2Ph) was insoluble in sodium bicarbonate, but soluble in caustic soda on warming, being reprecipitated on acidification.

Action of Sodium Hydroxide on (VIII).—1 G. of the ester (VIII) was boiled with 10 c.c. of 2*N*-sodium hydroxide; the solution was acidified, extracted with benzene, and the extract washed with sodium bicarbonate solution. From the benzene solution the lactone (VII*b*), m. p. 102°, was obtained.

Conversion of Lactone (VII*a*) *into the Lactone* (VII*b*).—The lactone (1 g.) was boiled under reflux for 2 hours with potassium hydroxide (1 g.) in rectified spirit (5 c.c.), the alcohol removed, water added, the solution acidified, and extracted with ether. The extract was washed with sodium bicarbonate solution and then gave 0·75 g. of the lactone (VII*b*), m. p. 102°. Sodium ethoxide solution acted similarly.

When, however, a solution of the lactone (VII*a*) (7 g.) in absolute alcohol (100 c.c.) was saturated at 0° with hydrogen bromide, left over-night, and then heated under reflux on a boiling water-bath in a stream of hydrogen bromide, the lactone was subsequently recovered unchanged, m. p. 84°.

Condensation of 2-Bromo-1-hydrindone with Ethyl Benzylacetoacetate and with Ethyl Benzylmalonate.—2-Bromo-1-hydrindone (10 g.), prepared as described by Ishiwara (*J. pr. Chem.*, 1924, **108**, 194), was dissolved in absolute alcohol (40 c.c.) and added to a solution prepared by addition of ethyl benzylacetoacetate (11·0 g.) to a solution of sodium (1·15 g.) in absolute alcohol (20 c.c.) cooled by ice. Colourless needles at once began to separate. Next day the solution had turned black. It was boiled under reflux for one hour, the alcohol distilled off, water added, and the oil extracted with ether. On removal of the ether, the residue partly crystallised. Alcohol was added, and the crystals (3·8 g.), m. p. 158—176°, removed. The oil on hydrolysis with alcoholic caustic potash gave only a black tar. Condensation of bromohydrindone with ethyl benzylmalonate gave the same crystalline solid, and an oil which on hydrolysis gave a tar, from which a small quantity of benzylmalonic acid was isolated. The solid product was bromo-hydrindonylhydrindone (Kipping and Revis, J., 1897, **71**, 243) (Found : Br, 22·98. Calc. for $C_{18}H_{13}O_2Br$: Br, 23·4%).

Action of Ammonia on Ethyl β-Phenyl-α-1-bromohydrindene-2-propionate.—The acid (VI*a*; R = CH_2Ph) (5 g.) was dissolved in absolute alcohol (50 c.c.) and a stream of dry hydrogen bromide at room temperature passed through the solution, which was then boiled for an hour in a current of hydrogen bromide; the bromo-ester was worked up in the usual way; yield, 5·5 g. (Found : Br, 15·47%, corresponding to about 70% of the bromo-ester). This ester (5·1 g.) was added to alcoholic ammonia (6*N*, 70 c.c.) and kept at 10° for 144 hours. The alcohol and ammonia were then distilled off from a water-bath, and the residue extracted with ether. An oil (4·4 g.) which contained bromine but no nitrogen was obtained. This was heated for 6 hours with alcoholic ammonia (6*N*, 70 c.c.) at 100°. The product when worked up as before gave 1·5 g. of the lactone (VII*b*), m. p. 102°, and a neutral oil (probably a mixture of the lactones). The action of potassium phthalimide on this bromo-ester gave phthalimide, phthalic acid, the acid (VI*a*), and the lactone (VII*b*), m. p. 102°. The action of sodium *p*-toluenesulphonamide also gave this lactone, m. p. 102°, but no amino-derivative. This lactone was recovered unchanged after 2 hours' boiling with aqueous hydrogen bromide (*d* 1·78) or with an acetic acid solution of hydrogen bromide.

Acetoxy-acid (IX*b*; R = CH_2Ph).—The oil (10 g.) obtained from the mother-liquors from the crystallisation of the acid (VI*a*) was boiled for 2 hours with acetic anhydride (50 c.c.), the product poured into alcohol (50 c.c.), and left at room temperature for 2 hours. The ethyl acetate, etc., were then removed by distillation under reduced pressure, and the residue dissolved