

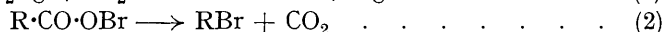
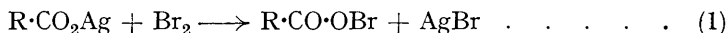
**612.** *The Conversion of Silver (+)-2-Ethylhexanoate into (+)-3-Bromoheptane.*

By D. C. ABBOTT and C. L. ARCUS.

The reaction of bromine with silver (+)-2-ethylhexanoate, from which previous investigators have obtained (±)-3-bromoheptane, has been found to yield (+)-3-bromoheptane when the silver bromide formed (a catalyst for bromine exchange) is removed at an early stage.

Attempts to repeat the conversion of silver α-phenylpropionate into 1 phenylethyl bromide (Arcus, Campbell, and Kenyon, *J.*, 1949, 1510) have not given satisfactory yields of the bromide; 1-phenylethyl α-phenylpropionate has been isolated from the products of reaction.

THE conversion of the silver salt of a carboxylic acid to an alkyl bromide by reaction with two equivalents of bromine in carbon tetrachloride has been carried out with the silver salts



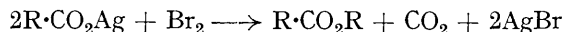
of several optically active acids. The formation of (+)-1-phenylethyl bromide by the reaction of bromine with silver (+)-α-phenylpropionate has been described (Arcus, Campbell, and Kenyon, *J.*, 1949, 1510). Bell and Smyth (*ibid.*, p. 2372) allowed bromine to react, with cooling, with silver (+)- and (–)-2-ethylhexanoate and, after 15 minutes' heating, obtained (±)-3-bromoheptane from each reaction. [Arnold and Morgan (*J. Amer. Chem. Soc.*, 1948, **70**, 4248) had earlier obtained (±)-3-bromoheptane by heating (+)- and (–)-2-ethylhexanoic acids first with silver acetate and then for 7 hours with bromine; Doering and Farber (*ibid.*, 1949, **71**, 1514) have pointed out that heating for this time with silver bromide may have racemised the 3-bromoheptane.] From silver (+)-α-benzylbutyrate Bell and Smyth obtained (–)-2-bromo-1-phenylbutane having  $[\alpha]_{5461} -2.85^\circ$  (in alcohol), but a similar experiment with silver (–)-α-benzylbutyrate gave (±)-2-bromo-1-phenylbutane.

It has been found (Arcus and Boyd, *J.*, 1951, 1580) that racemisation of (+)-1-phenylethyl bromide in solution in carbon tetrachloride is catalysed by silver bromide. Freshly prepared silver bromide effects some racemisation and the rate is greatly increased when hydrogen bromide is present. Racemisation is ascribed to bromine exchange at the surface of the silver bromide. Since bromine yields hydrogen bromide by substitution in 1-phenylethyl bromide, it was not possible to ascertain whether bromine exchange with elementary bromine takes place.

It appeared that it would be advantageous to remove the silver bromide as early as practicable and, if possible, before stage (2) commences; accordingly, silver (+)-2-ethylhexanoate was allowed to react with bromine in carbon tetrachloride, the silver bromide was removed by filtration, and the filtrate heated for completion of stage (2). Three experiments, in which the bromine was added at approximately 15°, 5°, and -15°, yielded (+)-3-bromoheptane having  $\alpha_{5893} +0.13^\circ$ ,  $+0.15^\circ$ , and  $+0.39^\circ$  [*l* 1.0; calculated for the fully-active (+)-acid] respectively.

The retention of optical activity indicates that the 3-heptyl group cannot have an extended life as a free radical or as an ion; further information cannot be deduced because the configurational relation between (+)-2-ethylhexanoic acid and (+)-3-bromoheptane is not known.

It was intended to apply this method to the reaction with silver  $\alpha$ -phenylpropionate but attempts, nine in all, by the original method and modifications of it failed to yield appreciable quantities of 1-phenylethyl bromide; the only identified product was 1-phenylethyl  $\alpha$ -phenylpropionate. The ester  $R \cdot CO_2R$ , which is probably formed according to the equation



has been reported as a product from a number of silver salt-bromine reactions (from silver butyrate, Bockemüller and Hoffmann, *Annalen*, 1935, **519**, 185; silver laurate, Lüttringhaus and Schade, *Ber.*, 1941, **74**, 1565; silver benzoate, phenylacetate, and *o*-nitrobenzoate, Oldham, *J.*, 1950, 105).

#### EXPERIMENTAL

2-Ethylhexanoic acid was prepared and resolved by the method of Kenyon and Platt (*J.*, 1939, 633); the (+)-acid of maximum rotation had b. p. 117—119°/15 mm.,  $d_4^{17} 0.908$ ,  $n_D^{25} 1.4231$ ,  $[\alpha]_{5893}^{17} +8.89^\circ$  (homogeneous), 99% optically pure by comparison with Kenyon and Platt's value.

Silver (+)- and (-)-2-ethylhexanoates were prepared, and carbon tetrachloride and bromine were dried, by methods previously described (Abbott and Arcus, *J.*, 1952, 1516).

A suspension of the silver salt (10.0 g.) of (+)-2-ethylhexanoic acid ( $\alpha_{5893}^{25} +15.07^\circ$ , *l* 2.0, 93% optically pure) in carbon tetrachloride (100 ml.) was cooled, in ice and salt at between -10° and -15°, and a solution of bromine (6.2 g.) in carbon tetrachloride (25 ml.) was added during 15 minutes with vigorous stirring. After a further 15 minutes' stirring, the reaction mixture was filtered by suction through a sintered-glass filter in a closed apparatus. The filtrate was heated under reflux for 30 minutes, cooled, washed with aqueous sodium metabisulphite (20%; 20 ml.), with aqueous sodium carbonate (20%, 25 ml.), and with water, and dried ( $Na_2SO_4$ ). The solvent was evaporated and the product distilled: (+)-3-bromoheptane (2.5 g.), b. p. 64—70°/26 mm.,  $n_D^{25} 1.4481$ ,  $\alpha_{5893}^{21} +0.19^\circ$  (*l* 0.5), was obtained which after redistillation had b. p. 65—67°/25 mm.,  $n_D^{25} 1.4482$ ,  $\alpha_{5893}^{21} +0.18^\circ$  (*l* 0.5) (Found: C, 47.1; H, 8.8; Br, 44.6. Calc. for  $C_7H_{15}Br$ : C, 46.9; H, 8.4; Br, 44.6%).

The silver salt (8.0 g.) of (-)-2-ethylhexanoic acid ( $\alpha_{5893}^{27} -3.40^\circ$ , *l* 0.5, 82% optically pure) was allowed to react similarly for 55 minutes at 0—10°; the filtrate was not heated. (-)-3-Bromoheptane (2.7 g.), b. p. 66—68°/26 mm.,  $\alpha_{5893}^{29} -0.07^\circ$  (*l* 0.5), was obtained which after redistillation at the same b. p. had  $n_D^{25} 1.4481$ ,  $\alpha_{5893}^{20} -0.06^\circ$  (*l* 0.5) (Found: Br, 44.5%).

The silver salt (19.2 g.) of (+)-2-ethylhexanoic acid ( $\alpha_{5893}^{20} +3.74^\circ$ , *l* 0.5, 92% optically pure) was allowed to react similarly for 2½ hours at 10—15°; the filtrate was heated under reflux for 1 hour. (+)-3-Bromoheptane (4.6 g.), b. p. 65—68°/24 mm.,  $\alpha_{5893}^{25} +0.27^\circ$  (*l* 2.0), was obtained which after redistillation had b. p. 63—65°/22 mm.,  $n_D^{25} 1.4482$ ,  $\alpha_{5893}^{23} +0.06^\circ$  (*l* 0.5) (Found: Br, 44.6%).

To ( $\pm$ )- $\alpha$ -phenylpropionic acid (30 g.) was added *n*-sodium hydroxide (175 ml.); the solution

was titrated with further aqueous sodium hydroxide until just alkaline to phenolphthalein. The solution was warmed to 50° and to it was added, dropwise with stirring, a warm solution of silver nitrate (34 g.) in water (200 ml.); the precipitated silver ( $\pm$ )- $\alpha$ -phenylpropionate was washed with water, acetone, and ether and dried ( $P_2O_5$ ) in a vacuum. It (50 g.) was finely ground and re-dried.

To a well-stirred suspension of silver ( $\pm$ )- $\alpha$ -phenylpropionate (10.5 g.) in carbon tetrachloride (80 ml.), boiling under reflux on a steam-bath, a solution of bromine (6.4 g.) in carbon tetrachloride (20 ml.) was added during 15 minutes. The reaction mixture was heated until the bromine colour had disappeared ( $1\frac{1}{2}$  hours) and then for a further hour; it was allowed to cool, then filtered through a sintered-glass filter, and the filtrate treated as described above. On distillation an oil (4.0 g.) was obtained which boiled over the range 90—210°/17 mm. This product, combined with that from a similar experiment, was distilled; fractions of b. p. 90—182°/20 mm. and b. p. 182—194°/20 mm. were collected, both of which deposited crystals on cooling. These were filtered off and recrystallised from aqueous alcohol, bromine-free rhombs, m. p. 73°, of 1-phenylethyl  $\alpha$ -phenylpropionate being obtained (Found: C, 79.8; H, 6.9.  $C_{17}H_{18}O_2$  requires C, 80.3; H, 7.1%). This ester (1.1 g.) was heated with potassium hydroxide (0.5 g.) in diethylene glycol (3 ml.) and yielded an alcohol, the phenylurethane of which had m. p. 88—89° alone and when mixed with an authentic specimen (m. p. 89°) of the phenylurethane of 1-phenylethyl alcohol. The acid obtained from this hydrolysis was converted into its silver salt, which was ignited [Found: Ag, (i) 42.6, (ii) 42.4. Calc. for  $C_9H_9O_2Ag$ : Ag, 42.0%]. Various procedures—addition of undiluted bromine to the hot silver salt suspension, similar addition at room temperature, addition of bromine in carbon tetrachloride at -15°, addition of the silver salt suspension to the bromine solution at 55°—followed by heating under reflux gave little product having b. p. approximating to that of 1-phenylethyl bromide (84°/10 mm.); widely-boiling fractions were obtained from which only 1-phenylethyl  $\alpha$ -phenylpropionate was isolated.

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