191. *A Synthesis of* cis- *and* trans-dl-1-iso*Propyl*cyclo*propane-1 : 2-dicarboxylic Acids.*

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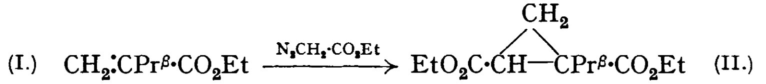
Umbellularic acid (Tutin, J., 1906, **89**, 1104) was shown by Semmler (*Ber.*, 1907, **40**, 5017; 1908, **41**, 3988) to be *d-cis*-1-*iso*propyl*cyclo*propane-1 : 2-dicarboxylic acid (II). Our attention was directed to this acid by its resemblance to norcaryophyllenic acid (compare Evans, Ramage, and Simonsen, J., 1934, 1808) and it appeared of interest to undertake its synthesis.* By adaptation of the method used by Owen and Simonsen (J., 1933, 1225) for the synthesis of homocaronic acid, *ethyl* 1-iso*propyl*cyclo*propane*-1 : 2-*dicarboxylate* was readily prepared by the condensation of ethyl α-*iso*propylacrylate (I) (Blaise and Luttringer, *Bull. Soc. chim.*, 1905, **33**, 777) with ethyl diazoacetate. Hydrolysis of the ester gave a mixture of the *cis*- and the *trans-dl*-form of the cyclic acid, in which the latter predominated. The trans-*acid*, m. p. 194—195°, was anhydrous, but the cis-*acid*, m. p. 97—98°, like umbellularic acid, crystallised from water with one molecule of water of crystallisation, which was lost at 100°, giving the anhydrous acid, m. p. 126—127°.



(I.) $\mathrm{CH_2{:}CPr^{\beta}\cdot CO_2Et} \xrightarrow{\mathrm{N_2CH_2\cdot CO_2Et}} \mathrm{EtO_2C\cdot CH{-}CPr^{\beta}\cdot CO_2Et}$ (II.) (with $\mathrm{CH_2}$ bridging CH and CPr^β)

The structure assigned by Blaise and Luttringer to the acrylic ester has been confirmed by its oxidation with ozone to ethyl dimethylpyruvate. It is apparently free from isomerides.

It is proposed to extend this method of synthesis to the higher homologues of 1-*iso*propyl*cyclo*propane-1 : 2-dicarboxylic acid.

Experimental.

Oxidation of Ethyl α-iso*Propylacrylate.*—The ester (3 g.) in carbon tetrachloride (25 c.c.) was ozonised, formaldehyde being identified in the issuing gas by the preparation of the dimedone derivative, m. p. and mixed m. p. 186°. The ozonides from three such oxidations were decomposed by water, no acetone being detected; the oil was collected in ether; after being washed with sodium carbonate solution and dried, the extract gave ethyl dimethylpyruvate (4 g.), b. p. 165—178°/769 mm. (semicarbazone, m. p. 92°). This ester was hydrolysed with methyl-alcoholic potassium hydroxide solution to dimethylpyruvic acid, b. p. 70—80°/20 mm., which was characterised by its 2 : 4-dinitrophenylhydrazone, m. p. 194—195° (compare Ramage and Simonsen, J., 1935, 535) (Found : C, 44·5; H, 4·3. Calc. : C, 44·6; H, 4·1%).

Condensation of Ethyl α-iso*Propylacrylate and Ethyl Diazoacetate.*—Ethyl diazoacetate (16 g.) was added slowly to ethyl α-*iso*propylacrylate (20 g.) at 75—80°. This temperature was maintained for 5 hours, and the mixture then heated on the water-bath until evolution of nitrogen ceased. The product from four such experiments was fractionated at 20 mm. and gave (i) b. p. 50—70° (20 g.), (ii) 120—150° (44 g.), and (iii) 190—210° (80 g.). Refractionation of (ii) gave *ethyl* 1-iso*propyl*cyclo*propane*-1 : 2-*dicarboxylate* (40 g.), b. p. 130—135°/20 mm. (Found : C, 62·7; H, 8·4. $C_{12}H_{20}O_4$ requires C, 63·2; H, 8·8%). Fraction (iii), which contained nitrogen, was heated at 150° with copper–bronze (20 g.) until evolution of nitrogen ceased; after fractionation a further quantity of the pure cyclic ester (51 g.) was obtained.

The ester (76 g.) was digested with a solution of potassium hydroxide (66 g.) in methyl alcohol (320 c.c.) for 1 hour on the water-bath, the alcohol removed, and the aqueous solution acidified. The gummy acid which separated was extracted with ether, and the solution dried and evaporated, leaving a partially crystalline residue, which was triturated with warm benzene. After filtration, the acid (31 g.; m. p. 188°, softening 160°) was recrystallised from hot water and gave dl-trans-1-iso*propyl*cyclo*propane*-1 : 2-*dicarboxylic acid* in prisms, m. p.

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* When these experiments were nearing completion we learnt that Dr. H. N. Rydon also had synthesised the *cis*- and the *trans*-modification of the *cyclo*propane acid by a different method. We agreed to leave the resolution of the two acids into their optical antipodes in his hands and the results are described in the succeeding communication.

194—195°, unaltered by further crystallisation (Found : C, 55·8; H, 6·9; *M*, 172. $C_8H_{12}O_4$ requires C, 55·8; H, 7·0%; *M*, 172). The *trans*-acid is somewhat sparingly soluble in cold water, less so in benzene and chloroform, and readily soluble in acetone and ethyl acetate. It was stable to potassium permanganate in alkaline solution and it did not give a sparingly soluble copper salt with copper acetate solution. The p-*phenylphenacyl* ester crystallised from ethyl acetate or acetone in prismatic needles, m. p. 175—176° (Found : C, 76·9; H, 5·8. $C_{36}H_{32}O_6$ requires C, 77·1; H, 5·7%).

The solvent was removed from the benzene solution, from which the *trans*-acid had been separated, and the residue was digested for 1 hour with an excess of acetyl chloride. After removal of the excess of acid chloride, the oil was dissolved in ether and the ethereal solution was washed with ice-cold sodium bicarbonate solution, which removed some *trans*-acid (0·3 g.), dried, and evaporated. Distillation of the residue gave an oil (15 g.), b. p. 138—140°/20 mm., which on digestion with water furnished dl-cis-1-iso*propyl*cyclo*propane*-1 : 2-*dicarboxylic acid monohydrate* crystallising in stout prisms, m. p. 97—98°, unaltered by further crystallisation (Found : C, 50·4; H, 7·5; loss at 100°, 10·0; *M*, 189. $C_8H_{12}O_4,H_2O$ requires C, 50·5; H, 7·4; H_2O, 9·5%; *M*, 190). The hydrated acid was readily soluble in all the ordinary organic solvents except ligroin. The *anhydrous acid* crystallised slowly from benzene–ligroin in stellate clusters of needles, m. p. 117—118° (Found : C, 55·4; H, 7·3. $C_8H_{12}O_4$ requires C, 55·8; H, 7·0%). This was apparently a labile form, since after four months the m. p. was 126—127°. The p-*phenylphenacyl* ester crystallised from acetic acid in rosettes of prismatic needles, m. p. 116—117° (Found : C, 76·9; H, 5·7. $C_{36}H_{32}O_6$ requires C, 77·1; H, 5·7%).

The *cis*-acid was prepared also by heating the *trans*-acid (3 g.) with acetic anhydride (9 g.) at 220° for 6 hours; fractionation of the product gave the *cis*-anhydride (2·3 g.), b. p. 138—140°/20 mm., from which the hydrated *cis*-acid (2·8 g.), m. p. 97—98°, was obtained on digestion with water.

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