CLXXXI.—*Reactions Involving the Addition of Hydrogen Cyanide to Carbon Compounds. Part VI. The Action of Potassium Cyanide on Pulegone.*

By REGINALD W. L. CLARKE and ARTHUR LAPWORTH.

THE action of hydrogen cyanide in presence of bases or of potassium cyanide on $\alpha\beta$ -unsaturated ketones leads in all instances hitherto examined to the formation of a β -cyanoketone:

In the case of pulegone, reaction occurs somewhat slowly at the ordinary temperature, but if the ketone is heated on the water-bath with alcoholic potassium cyanide, a product is obtained which has the composition of the expected addition compound, the change being represented by the equation:

The substance, which was first referred to in a note by Hann and Lapworth (Proc., 1904, 20, 54), behaves in some respects as would the normal addition product, namely, cyanodihydropulegone (cyano-menthone), and was for a long time supposed to be that compound. In accordance with this supposition, it could be hydrolysed by acids

or alkalis, being converted into a saturated ketonic acid, namely, menthonedicarboxylic acid,

Nevertheless, the supposed cyanoketone exhibited many characters mainly negative in type, which distinguished it from the others previously examined. Thus it did not react with hydrazines, semicarbazide, or hydroxylamine, and could not be made to yield a cyanohydrin. When boiled with alkalis, even in presence of ferrous hydroxide, no decomposition into pulegone and hydrogen cyanide could be detected, although β -cyanoketones as a rule are easily decomposed in this manner. The inactivity of the compound was suspected to be due to a manifestation of steric hindrance, although later a difficulty arose in applying this assumption, for the ketonic acid, to which it gave rise, reacted readily enough with the hydrazines and with hydrogen cyanide.

The clue to the character of the substance was finally obtained in the following manner.

Menthonedicarboxylic acid is converted with great readiness into an unsaturated lactone,

when warmed with mineral acids or when treated with acetyl chloride. This compound is precisely analogous in type to the anhydride obtained by Vorländer (*Annalen*, 1906, **345**, 188) from "pulegoneacetic acid," of which the present substance is the next lower homologue.

When the anhydro-derivative of menthonedicarboxylic acid is shaken with ammonia, it yields a mixture of substances from which, by fractional crystallisation, a compound having the formula $\text{C}_{11}\text{H}_{17}\text{ON}$, and identical in all respects with the nitrogenous compound obtained by the action of potassium cyanide on pulegone, is obtained. To this substance, therefore, must be assigned the constitution

and is referred to in the paper as an "anhydramide," as it may be regarded as formed by the dehydration of menthonedicarboxylic amide.

The foregoing formula is adopted instead of the alternative one,

for several reasons. In the first place, the substance behaves as if it contains an ethylenic linking, being capable of decolorising a dilute solution of bromine in acetic acid even when excess of sodium acetate is present, and also of reducing an ice-cold solution of potassium permanganate. Secondly, the exceptional tendency of these menthone compounds, as well as those described by Vorländer (*loc. cit.*), to form anhydro-derivatives, is shared by the menthonecarboxylic acid, and therefore is probably to be attributed to the disposition of the carbon ring to assume the *cyclohexene* form. The corresponding configuration is used by Vorländer for the anhydramide of "pulegoneacetic acid."

Menthonecarboxylic anhydramide is not the only product obtained by the action of potassium cyanide on pulegone. Menthonecarboxylic acid is also produced in considerable quantity when the reaction is carried out at the water-bath temperature, and results from the action of potassium hydroxide on the anhydramide. A third substance formed has the composition $\text{C}_{12}\text{H}_{10}\text{O}_3\text{N}$, and is a monobasic acid which must be analogous in constitution to mesitylic acid. It is therefore to

be formulated as $\text{CHMe} \begin{array}{l} \diagup \text{CH}_2 - \text{CH}_2 \\ \diagdown \text{CH}_2 \cdot \text{C}(\text{CO}_2\text{H}) \end{array} \begin{array}{l} \diagdown \text{CH} \cdot \text{CMe}_2 \\ \diagup \text{NH} \cdot \text{CO} \end{array}$, and is a

hydrolytic product of the intermediate cyanomenthonecyanohydrin,

The latter compound was at last isolated from the products obtained by leaving pulegone in contact with a solution of potassium cyanide containing free hydrogen cyanide at the ordinary temperature for a considerable period. Since the cyanohydrin can only have been formed from cyanomenthone itself in the first instance, its production indicates that the ketonitrile must have at least a transient existence, and many attempts were made to isolate the latter, but without success. On leaving pulegone with potassium cyanide solution in the cold, the only product was the cyanohydrin, in spite of the fact that much free alkali was present.

Attempts to remove a molecule of the hydrogen cyanide from the molecule of the cyanohydrin were therefore made. At the ordinary temperature, alkali, even in the presence of ferrous

hydroxide, was without action; at higher temperatures hydrogen cyanide could be removed, but the product was always the anhydramide. By heating the cyanohydrin alone at its melting point, hydrogen cyanide is eliminated, but, again, the cyanomenthone at first produced at once undergoes isomeric change, and the anhydramide is the only substance which can be isolated. In the latter instance, it seems clear that the change must be represented as the result of the conversion of the cyanomenthone into its enolic form, in which the new ring formation then takes place,

Although menthonecarboxylic acid could not be reduced by zinc and acetic acid, sodium amalgam, or sodium and ethyl or amyl alcohol, it exhibits most of the usual characters of a γ -ketonic acid, and reacts readily with phenylhydrazine, yielding the ring compound

which is the most characteristic derivative of the acid yet obtained; the oxime and semicarbazide are difficult to obtain in a pure state.

In presence of potassium cyanide, it is converted into a mixture of isomeric cyanolactones:

EXPERIMENTAL.

When pulegone is left in a cold solution of potassium cyanide in dilute alcohol it slowly absorbs hydrogen cyanide, and at the end of a week at the summer temperature is partially converted into cyanomenthonecyanohydrin. At 80—100° a mixture of this compound

with menthonicarboxylic acid, the anhydride of menthonicarboxylic amide, and the lactame of aminomenthenedicarboxylic acid is formed.

The relative proportion of the products obtained varies very greatly with the conditions used, and directions are given in the following pages for the preparation of each of the four compounds directly from pulegone.

—A solution of pulegone (45 grams) in 96 per cent. alcohol (75 c.c.) is mixed with a solution of potassium cyanide (25 grams) in water (30 c.c.) and the whole heated on the water-bath under a reflux condenser; at the end of about half an hour one molecular proportion of acetic acid, or, better, ethyl acetate, is slowly introduced beneath the surface of the liquid. The liquid, which at first forms two layers, gradually becomes homogeneous, and at the end of a further half hour is cooled and poured into a large bulk of water, when an oil is deposited which slowly becomes semi-solid. The average yield of the dried solid obtained from the above quantities was 45 grams. The product may be purified by fusing it in a round bottomed flask for ten minutes, a process which serves to convert any cyanomenthocyanohydrin present into anhydramide, after which crystallisation from alcohol yields the pure anhydramide without difficulty. With large quantities of crude material, it is probably simpler to decompose the cyanohydrin present by boiling the material with a little alcoholic potash instead of fusing it.

0.2052 gave 0.5521 CO_2 and 0.1726 H_2O . $\text{C} = 73.4$; $\text{H} = 9.3$.

0.1703 „ 11.8 c.c. of moist nitrogen at 19° and 757 mm. $\text{N} = 7.9$.

$\text{C}_{11}\text{H}_{17}\text{ON}$ requires $\text{C} = 73.7$; $\text{H} = 9.5$; $\text{N} = 7.8$ per cent.

Menthonicarboxylic anhydramide is readily soluble in cold ethyl acetate, ethyl or methyl alcohols, chloroform, benzene, or acetic acid, and also in hot carbon disulphide, acetone, or ether, but is only sparingly dissolved by hot light petroleum or water.

The crystals are translucent needles which have straight extinction in polarised light, their directions of greatest length and elasticity being at right angles. The fused substance sets on cooling somewhat rapidly in long needles separated by air spaces, and when these are examined in convergent polarised light the acute bisectrix of a biaxial figure of narrow axial angle is sometimes seen to emerge nearly perpendicularly to the field. The dispersion is weak and the double refraction strong and negative in sign.

For the determination of its optical activity, 0.2515 gram dissolved

and made up to 25 c.c. with absolute alcohol was examined in a 2-dcm. tube at 17°; the observed rotation was +1.34°, whence $[\alpha]_D + 66.6$.

This compound, which was for a long time thought to be cyanomenthone itself, is quite different in character from all the other β -cyanoketones. Thus, when it is heated with alcoholic potassium or sodium hydroxide containing ferrous hydroxide, it does not yield a trace of ferrocyanide, and pulegone is not obtained from it by this process. Further, it does not evince any tendency to react with hydrazines, with semicarbazide, or hydroxylamine; it does not yield a cyanohydrin with hydrogen and potassium cyanides, and is hardly affected by amyl nitrite or ethyl oxalate and cold sodium ethoxide.

The anhydramide behaves as an unsaturated compound, and when shaken with a cold solution of potassium permanganate, decolorises the liquid at once; its solution in acetic acid readily absorbs bromine even in presence of excess of sodium acetate (compare Trans., 1904, 85, 38).

By the action of phosphorus pentachloride at 100° it is slowly converted with evolution of hydrogen chloride into a dark red substance. This gave a small quantity of oil when distilled, but it was not chlorocyanomenthene as was anticipated, for it was found to contain much phosphorus. The anhydramide dissolves in cold, strong sulphuric acid without change, is slowly hydrolysed by hot, strong hydrochloric or hydrobromic acid, and somewhat rapidly by alcoholic potassium hydroxide, in each case menthonicarboxylic acid being the main organic product.

Menthonicarboxylic acid, $\text{CHMe} \begin{smallmatrix} \text{CH}_2 \cdot \text{CH}_2 \\ \text{CH}_2 - \text{CO} \end{smallmatrix} \text{CH} \cdot \text{CMe}_2 \cdot \text{CO}_2\text{H}$, may be obtained from the anhydramide by the methods already mentioned, but it is more convenient to prepare it directly from pulegone by the same method as was recommended for preparing the anhydramide, but no acetic acid or ethyl acetate is added, and the heating is continued for four to five hours, after which the bulk of the alcohol is removed by distillation. The residue is diluted with water and poured into excess of dilute hydrochloric acid.

After standing for twenty-four hours, the insoluble matter which has separated is collected, washed with water, then extracted with benzene, which leaves undissolved the nitrogenous acid (p. 1879) formed at the same time, and the filtered benzene solution is extracted with dilute caustic soda solution, from which the ketonic acid is subsequently recovered by acidification. The compound is crystallised, first from dilute acetic acid, and, finally, from ethyl acetate. On analysis:

0.2002 gave 0.4864 CO_2 and 0.1636 H_2O . $\text{C} = 66.5$; $\text{H} = 9.0$.

$\text{C}_{11}\text{H}_{18}\text{O}_3$ requires $\text{C} = 66.7$; $\text{H} = 9.1$ per cent.

On titration with sodium hydroxide, 0.1962 of the acid required 10.0 c.c. of *N*/10 alkali for neutralisation, whence the equivalent of the compound was 196.2, whilst the number calculated for a monobasic acid, $C_{11}H_{18}O_3$, is 198.

Menthonecarboxylic acid dissolves readily in methyl or ethyl alcohols, acetone, benzene, chloroform, ether, acetic acid, or ethyl acetate, and sparingly in water and light petroleum. It separates from ethyl acetate in rosettes of small needles, which melt at 120–121°. Under the microscope, the needles are seen to be flattened, and in polarised light show straight extinction, and the relative directions of greatest length and elasticity vary according to the orientation of the crystal examined. After fusion, it solidifies slowly to opaque masses of very small quadrangular plates or elongated needles.

For the determination of its optical activity, 0.2500 gram dissolved and made up to 25 c.c. with absolute alcohol was examined in a 2-dcm. tube. The rotation observed was -0.46° , whence $[\alpha]_D - 23.0$.

The compound behaves as a saturated ketonic acid, and when dissolved in sodium carbonate solution does not at once decolorise a cold solution of potassium permanganate; its solution in acetic acid does not decolorise bromine if sodium acetate is present.

It is very stable towards reducing agents, and all attempts to convert it into the corresponding hydroxy-acid were unsuccessful. It did not appear to be affected by sodium amalgam, zinc dust, and acetic acid, stannous chloride in hot alkalis or cold acids, and even after attempted reduction with sodium and boiling ethyl or amyl alcohols was recovered almost unchanged. Attempts to reduce it by any agent in the presence of mineral acid resulted in the production of the anhydride mentioned later.

The *semicarbazone*, $C_{10}H_{18}O_2 \cdot N_2H \cdot CO \cdot NH_2$, was prepared by the usual method and purified by crystallisation from hot methyl alcohol, employing a Soxhlet extractor.

0.1049 gave 15 c.c. moist nitrogen at 18° and 759 mm. $N = 16.4$.

$C_{12}H_{21}O_3N_3$ requires $N = 16.5$ per cent.

It is sparingly soluble in methyl or ethyl alcohol, chloroform, acetone, ethyl acetate, benzene, carbon disulphide, or carbon tetrachloride. It separates from boiling methyl alcohol in small needles melting at 188° with evolution of gas, but without darkening.

is formed when the ketonic acid is heated with phenylhydrazine acetate, and usually crystallises when the product is washed with acid. It is purified by crystallisation from alcohol.

the neutral substance being extracted with ether. The dried ethereal extract is then fractionated at the ordinary pressure and the portion boiling at 245—247° cooled in a freezing mixture. The crystals which separated were drained on cold, porous earthenware and analysed :

0·2124 gave 0·5661 CO₂ and 0·1702 H₂O. C = 72·7 ; H = 8·9.

C₁₁H₁₆O₂ requires C = 73·3 ; H = 8·8 per cent.

The anhydride forms massive transparent rhombs, often approaching a centimetre in length. It is readily soluble in the usual organic solvents, but is only recrystallised from them with much difficulty ; it melts at 17·5—18°. 0·2500 gram dissolved and made up to 25·2 c.c. with absolute alcohol, was examined in a 2-dcm. tube at 18° ; the observed rotation was +1·46°, whence $[\alpha]_D + 73·6$.

When shaken with cold, dilute alkalis, even in the fused state, it does not at once dissolve, but disappears at the end of some hours or days, according to the temperature of the air. It is also reconverted into the ketonic acid by long-continued contact with water.

The substance, which is somewhat volatile in steam, has a marked odour of cocoa-nuts, and this renders it easy to detect small quantities of the ketonic acid. as it is merely necessary to boil it with 20 per cent. sulphuric acid when the odour of the anhydride soon becomes noticeable.

It has the properties of an unsaturated compound, at once absorbing bromine even in presence of sodium acetate and acetic acid. When it is shaken with a cold solution of potassium permanganate, the colour of the latter is almost instantaneously discharged.

In the expectation that the anhydro-compound would readily be converted into the amide of menthonecarboxylic acid, a portion of the former was shaken with aqueous ammonia (sp. gr. = 0·880) until it was converted into a mass of white needles. These were collected, washed, and crystallised from alcohol. Analysis of a specimen dried at 100° gave the following result :

0·2034 gave 14·25 c.c. of moist nitrogen at 19° and 762 mm. N = 8·1.

C₁₁H₁₉O₂N requires N = 7·1.

C₁₁H₁₇ON „ N = 7·8 per cent.

The compound was therefore an anhydride of the amide, and was finally identified with the substance previously regarded as cyanomenthone, obtained by the action of potassium cyanide on pulegone. It melts at 165°, alone or when mixed with the supposed cyanomenthone. When 0·2518 gram was dissolved and made up to 25·1 c.c. with absolute alcohol, and examined in a 2-dcm. tube at 22°, a rotation of +1·34° was observed, whence $[\alpha]_D + 67·0$.

Cyanomenthonecyanohydrin, $\text{CHMe} \begin{matrix} \text{CH}_2 & \text{---} & \text{CH}_2 \\ \text{CH}_2 & \cdot \text{C}(\text{OH})(\text{CN}) & \end{matrix} \text{CH} \cdot \text{CMe}_2 \cdot \text{CN}.$

—This compound was obtained on attempting to prepare cyanomenthone by the action of potassium cyanide on pulegone in the cold. The ketone, dissolved in a large bulk of alcohol, was mixed with an aqueous solution of potassium cyanide, the amount of water and alcohol being so regulated that the whole was a homogeneous liquid. The mixture was allowed to remain at the ordinary temperature for about a week, and afterwards worked up by diluting it with water, when the oil which separated gradually became semi-solid. The solid matter was freed from adherent pulegone either by spreading it on porous porcelain or removing the pulegone with a current of steam. It was found that the same product was obtained whatever proportions of potassium cyanide were used in the first instance. A certain quantity of the anhydramide already described was usually formed at the same time, but cyanomenthone itself was never detected.

The cyanohydrin was purified by crystallisation from ethyl alcohol. On analysis :

0.1438 gave 16.7 c.c. of moist nitrogen at 17° and 771 mm. $N = 13.6$.
 $C_{12}H_{18}ON_2$ requires $N = 13.6$ per cent.

Cyanomenthonecyanohydrin is fairly soluble in cold ethyl or methyl alcohol, acetone, ethyl acetate, chloroform, or ether, readily so in the hot solvents, sparingly so in carbon disulphide or carbon tetrachloride, and is almost insoluble in light petroleum or water.

It melts somewhat indefinitely at 195—197°, and decomposes if heated to its melting point for a short time without blackening, hydrogen cyanide being evolved.

0.2606 gram dissolved in absolute alcohol and made up to 25.1 c.c., was examined in a 2-dcm. tube at 16°; a rotation of -0.63° was observed, whence $[\alpha]_D - 30.3$. The crystals from alcohol are six-sided plates or elongated flat needles, having straight extinction in polarised light. The axial plane is identical with the plane of the larger faces of the crystals, but crushed fragments of the substance, examined in convergent polarised light, occasionally show the bisectrix of a figure of moderate axial angle. The double refraction is strong and positive in sign; the dispersion is weak.

The compound loses hydrogen cyanide readily and quantitatively at its melting point, and the residue sets to a mass of needles which, after recrystallisation, melted at 164—165°, and were identical with menthonecarboxylic anhydramide. At the ordinary temperature, however, the cyanohydrin exhibits a remarkable degree of stability, and is not decomposed by cold alcoholic potassium hydroxide even in presence of ferrous hydroxide, an agent which decomposes most cyanohydrins with great rapidity. No precipitate is formed when silver nitrate is added to the alcoholic solution, although cyanohydrins, as

a rule, are quantitatively decomposed by such treatment. When warmed with alcoholic alkalis in presence of ferrous hydroxide, the substance is decomposed and the ferrous hydroxide dissolves, but the product in all instances is the anhydramide and not cyanomenthone; the latter compound must be regarded as a very unstable one, being quickly converted into the anhydramide by heat or by the action of warm dilute alkalis.

The cyanohydrin is slowly converted by hydrochloric acid at 100° into the nitrogenous acid described below, but when heated with strong hydrobromic acid on the water-bath, it suffers more profound decomposition, and yields little but ammonium bromide and menthonicarboxylic acid after prolonged treatment.

The lactame of aminomenthane dicarboxylic acid,

is produced in considerable quantities when pulegone is heated with potassium cyanide in dilute alcohol for several hours, and was therefore obtained in considerable quantities as a by-product in the preparation of menthonicarboxylic acid from pulegone. It was freed from attendant impurities by extracting it repeatedly with warm benzene and then recrystallising it from glacial acetic acid:

0.2454 gave 0.5751 CO₂ and 0.1860 H₂O. C = 63.9; H = 8.4.

0.1346 „ 7.7 c.c. moist nitrogen at 20° and 757 mm. N = 6.5.

C₁₂H₁₉O₃N requires C = 64.0; H = 8.4; N = 6.2 per cent.

On titration with standard alkali, 0.3034 gram required 13.7 c.c. N/10 NaOH for complete neutralisation, the equivalent was therefore 222, whilst the number calculated for a monobasic acid of the above formula is 225.

This compound is very sparingly soluble in water, light petroleum, benzene, or chloroform, somewhat more readily so in alcohol, acetone, or ethyl acetate, but is freely dissolved only by glacial acetic acid. It separates from a hot solution in the latter solvent in small crystals melting at 237—239° after some preliminary sintering. Under the microscope, the substance presents the appearance of nodular aggregates of small needles, of which the optical characters could not be directly determined. The crystals obtained by fusing the substance between glass slips are transparent, well-formed needles, which slowly become opaque owing to contraction and consequent cracking; a part of the material often sublimes when heated, and the deposit consists of brilliant, well-formed, but minute plates, faceted in a complicated manner.

The substance is extremely stable and many attempts were made to convert it into hydroxymenthenedicarboxylic acid or its lactone, but without success. It was not appreciably affected by strong boiling potassium hydroxide, hydrochloric acid, or dilute sulphuric acid. When dissolved in strong sulphuric acid to which sodium nitrite or amyl nitrite had been added, a slight change occurred on warming, but the greater portion of the material was recovered unchanged. Hypobromites or hypochlorites also had little or no effect at the temperature of the water-bath. When heated in a closed tube with fuming hydrochloric acid, no change was noticed at 120°, but after being heated to 170—180° for ten hours, the liquid separated into two layers, the upper one a dark brown oil. The whole was diluted with water and extracted with ether, and the ethereal solution shaken repeatedly with sodium hydroxide solution. On evaporation of the ether, a neutral oil remained. An attempt was made to distil this, but at 280° it evolved hydrogen chloride and the distillate had an odour of paraffin and peppermint, so that the original oil was probably a mixture of hydrochlorides of unsaturated ketones or of a hydrocarbon. The alkaline extract when acidified deposited an oil, which slowly solidified. After being drained on porous porcelain and crystallised from ethyl acetate it was obtained in needles melting at 122° and having all the characters of menthonecarboxylic acid.

Addition of Hydrogen Cyanide to Menthonecarboxylic Acid. Formation of Isomeric Cyanohydrins (Cyanomentholcarboxylactones),

—Menthonecarboxylic acid (1 mol.) dissolved in the requisite quantity of dilute sodium carbonate solution, was mixed with an aqueous solution of potassium cyanide (1½ mols.) in a flask which was afterwards closed with an india-rubber stopper, through which passed a dropping-funnel containing dilute sulphuric acid (1 mol.). A few c.c. of the sulphuric acid were allowed to run very slowly into the flask, which was then closed, and the addition of the remainder of the acid allowed to occur automatically (compare *Trans.*, 1906, 89, 964). At the end of twenty-four hours, the alkaline liquid was rendered slightly acid with sulphuric acid, the dark brown oil which separated being washed first with water, then with warm hydrochloric acid and finally extracted with petroleum. The petroleum solution was shaken with dilute sodium carbonate solution to remove acids, a process which caused the

separation of needles, but these dissolved on the addition of a little benzene. On evaporating the dried benzene-petroleum solution, a substance separated, which was purified by recrystallisation from light petroleum. On analysis :

0.1952 gave 0.4969 CO_2 and 0.1952 H_2O . $\text{C} = 69.9$; $\text{H} = 8.4$.

$\text{C}_{12}\text{H}_{17}\text{O}_2\text{N}$ requires $\text{C} = 69.6$; $\text{H} = 8.2$ per cent.

α -Cyanomentholcarboxylactone is readily soluble in all the usual organic media, and crystallises from light petroleum in slender needles melting at $48-49^\circ$.

The crystals are opaque needles, of which the optical properties are difficult to determine. When fused between glass slips, the substance sets to a mass of needles, through most of which a bisectrix of a narrow angled axial figure emerges obliquely. The double refraction is weak and positive in sign.

The compound is not acted on by cold aqueous alkali, but when boiled with aqueous sodium hydroxide dissolves, being converted into menthonecarboxylic acid and hydrogen cyanide. It is somewhat stable towards mineral acids, but when warmed with fuming hydrobromic acid yields ammonium bromide and menthonecarboxylic acid.

β -Cyanomentholcarboxylactone was obtained from that portion of the original oil which did not dissolve in light petroleum. It was isolated by dissolving the residue in benzene, shaking the resulting solution with sodium carbonate, and evaporating, the crystals which separated being purified by recrystallisation from a mixture of benzene and light petroleum. On analysis :

0.1845 gave 0.4683 CO_2 and 0.1371 H_2O . $\text{C} = 69.2$; $\text{H} = 8.3$.

$\text{C}_{11}\text{H}_{17}\text{O}_2\text{N}$ requires $\text{C} = 69.6$; $\text{H} = 8.2$ per cent.

The substance is very readily dissolved by chloroform, benzene, or alcohol, somewhat readily also by ether or ethyl acetate, but is very sparingly soluble in light petroleum. It separates from a mixture of benzene and light petroleum in large, transparent crystals melting at $126-127^\circ$. The prisms are well formed, and in convergent polarised light some of these show the bisectrix of an axial figure of moderate angle. The double refraction is strong and negative in sign ; the dispersion is also fairly strong, the angle for blue light being greater than that for red. The axial plane is perpendicular to the direction of greatest length in the crystal. After fusion on a glass slide beneath a cover-slip, the lactone rapidly sets to patches of radiating or parallel needles, the optical properties of which were identical with those of the prisms just described.

In chemical properties the compound closely resembles the isomeric cyanolactone.

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CHEMICAL DEPARTMENT,
GOLDSMITHS' COLLEGE,
NEW CROSS, S.E.