

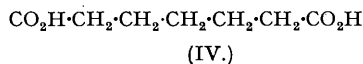
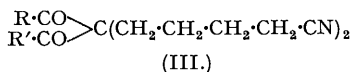
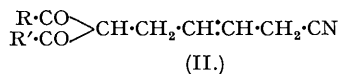
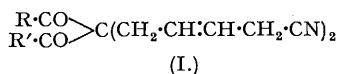
58. *Reactions of α -Cyanoprene (1-Cyanobuta-1:3-diene). Part II.*
Addition of Reactive Methylene Compounds.

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Ethyl malonate, ethyl acetoacetate, ethyl cyanoacetate, and acetylacetone add to α -cyanoprene (1-cyanobuta-1:3-diene) to give products of the type $CXY(CH_2 \cdot CH \cdot CH \cdot CH_2 \cdot CN)_2$. On being heated, these lose one mol. of α -cyanoprene yielding $CHXY \cdot CH_2 \cdot CH \cdot CH \cdot CH_2 \cdot CN$. Both types of compound are hydrogenated to saturated cyanides over 5% palladium on calcium carbonate. Certain other active methylene compounds do not add to α -cyanoprene.

In Part I (previous paper), the addition of nitro-paraffins to α -cyanoprene (1-cyanobuta-1:3-diene) was described. Extending this work, ethyl malonate, ethyl acetoacetate, ethyl cyanoacetate, and acetylacetone have now been added to α -cyanoprene in the presence of methyltriethylammonium hydroxide as catalyst. In each case, the main product was the adduct of two mols. of α -cyanoprene to one mol. of active methylene compound. The adducts were thermally unstable and lost a mol. of α -cyanoprene on being heated. Hydrogenation of the bis-adducts over Raney nickel caused partial reduction of the cyano-groups, but by using 5% palladium on calcium carbonate as catalyst the double bonds were reduced smoothly, without attack on the ketonic or cyano-groups.

In the reaction with ethyl malonate, the bis-addition product, *ethyl 1:9-dicyanonona-2:7-diene-5:5-dicarboxylate* (I; $R = R' = OEt$), was isolated in only poor yield (13%) owing to its high solubility in common solvents and its thermal instability. When heated to 200°, the adduct split off α -cyanoprene to give *ethyl 1-cyanopent-2-ene-5:5-dicarboxylate* (II; $R = R' = OEt$) which after hydrogenation, hydrolysis, and decarboxylation gave pimelic acid (IV) thus establishing that addition to α -cyanoprene had been 1:4 and not 1:2, as 1:2-addition followed by this series of reactions would have yielded β -ethylglutaric acid.



In the reaction with acetylacetone, the bis-adduct, *1:9-dicyano-5:5-diacetylnona-2:7-diene* (I; $R = R' = Me$), was isolated in two forms which gave on reduction the same tetrahydro-derivative (III; $R = R' = Me$). It is thought that the two forms are probably *cis-trans* isomers. By heating the adduct, α -cyanoprene was eliminated; the resulting *5:5-diacetyl-pent-2-enyl cyanide* (I; $R = R' = Me$), which could not be purified, was reduced and hydrolysed

to give 5-acetylhexoic acid, m. p. 27—29° (lit. m. p. 29—30°); semicarbazone, m. p. 113—114° (lit. m. p. 113°). This confirms that acetylacetone also adds to α -cyanoprene in the 1 : 4-position.

Ethyl acetoacetate added to α -cyanoprene in a similar fashion to give a bis-adduct, *ethyl 1 : 9-dicyano-5-acetylmona-2 : 7-diene-5-carboxylate* (I; R = Me, R' = OEt), which was hydrogenated over palladium on calcium carbonate to *ethyl 1 : 9-dicyano-5-acetylmonane-5-carboxylate* (II; R' = Me, R = OEt).

The adduct from ethyl cyanoacetate could not be purified, but after hydrogenation over palladium on calcium carbonate, the tetrahydro-derivative *ethyl 1 : 5 : 9-tricyanononane-5-carboxylate* was obtained.

It would appear that, for addition to α -cyanoprene to occur, it is necessary to have a fairly highly activated methylene group. Attempts to carry out addition with benzyl cyanide, deoxybenzoin, and acetophenone were unsuccessful or gave very small yields; with cyclopentadiene, only tars were formed.

EXPERIMENTAL.

The "catalyst" used in these experiments was a 38% aqueous solution of triethylmethylammonium hydroxide.

Ethyl Malonate Reactions.—(a) *Ethyl 1 : 9-dicyanonona-2 : 7-diene-5 : 5-dicarboxylate* (I; R = R' = OEt). α -Cyanoprene (53.4 c.c., 0.6 mol.) was run slowly into a stirred solution of ethyl malonate (45 c.c., 0.3 mol.) and catalyst (2.0 c.c.) in dioxan (60 c.c.) at 40° \pm 2°. The mixture was maintained at 40° for 2 hours, poured into water, and extracted with ether. The ethereal solution was dried, and low-boiling material (below b. p. 49°/0.07 mm.) removed. The residual oil (37 g.) was dissolved in ether (50 c.c.), filtered, and cooled to -60° to give the white crystalline *dicyano-compound* (m. p. 44—48°; 9.1 g.) which after further crystallisation from alcohol had m. p. 49—50° (Found: C, 64.1; H, 6.5; N, 9.4. C₁₇H₂₂O₄N₂ requires C, 64.2; H, 6.9; N, 8.8%).

(b) *Ethyl 1-cyanopent-2-ene-5 : 5-dicarboxylate* (II; R = R' = OEt). The solvent was removed from the ethereal mother liquors of the dicyano-compound (previous section), and the residue, after 2 hours' heating at 200°/15 mm., was distilled to give a colourless oil, b. p. 194—198°/14 mm., refractionated to b. p. 196—198°/14 mm. (16.5 g.) (Found: C, 60.1; H, 7.0. C₁₂H₁₇O₄N requires C, 60.3; H, 7.1%).

(c) *Ethyl 1 : 9-dicyanononane-5 : 5-dicarboxylate* (III; R = R' = OEt). The unsaturated dicyano-derivative (I; R = R' = OEt) (2 g.) in alcohol (80 c.c.) was hydrogenated at ordinary temperature and pressure over 5% palladium on calcium carbonate (0.1 g.). After filtration, the solvent was removed and the residual solid crystallised from ether with ice-cooling to give *ethyl 1 : 9-dicyanononane-5 : 5-dicarboxylate*, m. p. 50—51° (mixed m. p. with starting material, 33—38°) (Found: C, 63.7; H, 8.0; N, 8.9. C₁₇H₂₂O₄N₂ requires C, 63.4; H, 8.1; N, 8.7%).

(d) *Pimelic acid* (IV). *Ethyl 1-cyanopent-2-ene-5 : 5-dicarboxylate* (12 g.) in alcohol (60 c.c.) was hydrogenated at ordinary temperature and pressure over 5% palladium on calcium carbonate (0.5 g.). The product was filtered and the solvent removed. As attempted distillation at 0.06 mm. caused decomposition, the crude oil (12 g.) was refluxed for 8 hours with 20% aqueous sodium hydroxide (40 c.c.), cooled, acidified with hydrochloric acid, treated with carbon, filtered, and the filtrate evaporated to dryness. The residual tricarboxylic acid was extracted from the sodium chloride with ether, the solvent removed, and the crude tri-acid (9.0 g.) heated at 135—140° for 1 hour and then at 165° for 15 minutes. The product (6.6 g.) solidified on cooling and was crystallised successively from benzene and water to m. p. 103—104°, not depressed by admixture with an authentic specimen of pimelic acid, m. p. 103° (Found: C, 52.8; H, 7.1; equiv., 81.5. Calc. for C₇H₁₂O₄: C, 52.5; H, 7.5%; equiv., 80.0).

Acetylacetone Reactions.—(a) *1 : 9-Dicyano-5 : 5-diacetylmona-2 : 7-diene* (I; R = R' = Me). α -Cyanoprene (71.2 c.c., 0.8 mol.) was run into a stirred solution of acetylacetone (39 c.c., 0.4 mol.) and catalyst (6 c.c.) in dioxan (80 c.c.) at 35—40°. The temperature was maintained at 40° for 1 hour, then raised to 70° and kept there for 1 hour. After cooling, the mixture was diluted with ether (100 c.c.) and cooled in ice to give a crystalline *product*, m. p. 86—89° (46 g.), which after recrystallisation from alcohol had m. p. 88—89° (Found: C, 69.4; H, 6.9; N, 11.1. C₁₅H₁₈O₂N₂ requires C, 69.8; H, 7.0; N, 10.85%). The ethereal filtrate was washed well with water, dried, and the solvent removed. The residual oil was dissolved in alcohol (30 c.c.) and cooled in ice to give a solid *product*, m. p. 82—84°, which after repeated crystallisation from alcohol had m. p. 83—84° and gave no mixed m. p. depression with the previously isolated product, m. p. 88—89°, with which it was isomeric (Found: C, 70.1; H, 7.1; N, 10.7%).

In another experiment, the total reaction mixture was poured into water and treated with ether to give a crystalline precipitate, m. p. 79—83°, from which only the isomer, m. p. 83—84°, was isolated.

(b) *5-Acetylhexoic acid*. *1 : 9-Dicyano-5 : 5-diacetylmona-2 : 7-diene* (40 g.) was slowly distilled to give a low boiling fraction, b. p. <130°/17 mm. (5.2 g.), consisting mainly of α -cyanoprene, a fraction, b. p. 130—196°/17 mm. (29.5 g.), and a black residue (9.0 g.). Refractionation of the main product gave a yellow mobile oil, b. p. 180—200°/17.5 mm. (18.6 g.), which was obviously a mixture. This was hydrogenated in methyl alcohol (100 c.c.) over 5% palladium on calcium carbonate (0.5 g.), filtered, and the solvent removed. As this oil (mainly 5 : 5-diacetylhexoic acid) appeared to decompose on distillation, it was hydrolysed by refluxing it for 6 hours with 10% sodium hydroxide (70 c.c.). The acid was isolated by acidification, extraction with ether, and distillation to give an oil, b. p. 105—115°/0.1 mm. (3.7 g.). Refractionation gave a small amount of 5-acetylhexoic acid, b. p. 180—181°/17 mm., m. p. 27—29°. [Léser (*Compt. rend.*, 1905, **141**, 1032) gives b. p. 184—185°/20 mm., m. p. 30°; Kipping and Perkin (*J.*, 1889, **55**, 338) report that 5-acetylhexoic acid when very impure is almost entirely decomposed when distilled under reduced pressure.] The keto-acid gave a *semicarbazone* containing acetic acid of crystallisation, m. p. 113—114.5° (from aqueous acetic acid) [Wallach (*Annalen*, 1906, **345**, 141) gives

m. p. 113—114° but does not record an analysis] (Found : C, 47·8; H, 7·8; N, 15·4. $C_9H_{17}O_3N_3, C_2H_4O_3$ requires C, 48·0; H, 7·6; N, 15·3%), and a 2 : 4-dinitrophenylhydrazone, m. p. 120—121° (Found : N, 16·6. $C_{14}H_{19}O_6N_4$ requires N, 16·6%).

(c) 1 : 9-Dicyano-5-diacetylnonane (III; R = R' = Me). 1 : 9-Dicyano-5 : 5-diacetylnona-2 : 7-diene (2 g.) in methyl alcohol (150 c.c.) was hydrogenated in the same way as the dicarbethoxy-derivative (c, p. 233) to give 1 : 9-dicyano-5 : 5-diacetylnonane, m. p. 90—91° (from alcohol) (Found : C, 68·5; H, 8·1; N, 10·8. $C_{16}H_{22}O_2N_2$ requires C, 68·7; H, 8·4; N, 10·7%). The two forms of the unsaturated dicyanide gave the same saturated product on hydrogenation.

Ethyl Acetoacetate Reactions.—(a) Ethyl 1 : 9-dicyano-5-acetylnona-2 : 7-diene-5-carboxylate (I; R = Me, R' = OEt). α -Cyanoprene (35·6 c.c., 0·4 mol.) was run into a stirred solution of ethyl acetoacetate (25·4 c.c., 0·2 mol.) and catalyst (2 c.c.) in dioxan (40 c.c.) at 35—40°. After being maintained at 40° for 2 hours the mixture was poured into water, and the oil was separated and dissolved in alcohol (40 c.c.). On cooling to 0° the dicyano-derivative separated (m. p. 73—75°; 32·2 g.) and was recrystallised from alcohol; m. p. 75—76° (Found : C, 66·7; H, 6·9; N, 10·3. $C_{16}H_{20}O_3N_2$ requires C, 66·7; H, 6·9; N, 9·95%).

(b) Ethyl 1 : 9-dicyano-5-acetylnonane-5-carboxylate (III; R = Me, R' = OEt). The unsaturated dicyano-compound (2 g.) was hydrogenated in the same way as the dicarbethoxy-derivative (c, p. 233) to give ethyl 1 : 9-dicyano-5-acetylnonane-5-carboxylate, m. p. 85—86° (from alcohol) (mixed m. p. with unsaturated dicyano-compound, 69—73°) (Found : C, 65·5; H, 7·95; N, 9·8. $C_{16}H_{24}O_3N_2$ requires C, 65·75; H, 8·2; N, 9·6%).

Ethyl Cyanoacetate Reactions.—Ethyl 1 : 5 : 9-tricyanononane-5-carboxylate. α -Cyanoprene (26·7 c.c.) was run into a stirred solution of ethyl cyanoacetate (16 c.c.) and catalyst (1 c.c.) in dioxan (30 c.c.) at 40°. The temperature was raised to 65° and kept there for 1 hour. The product was poured into water, extracted with ether, and the extract washed with dilute sulphuric acid. The resulting orange oil could not be obtained solid and decomposed on attempted distillation at 0·1 mm. The crude product in dioxan (100 c.c.) was hydrogenated over 6% palladium on calcium carbonate (1 g.), filtered, the solvent removed, and the residual oil (31·6 g.) repeatedly crystallised from alcohol at 0° to give the saturated tricyano-compound (25 g., 60%), m. p. 45—47° (Found : C, 65·1; H, 7·5; N, 15·0. $C_{15}H_{21}O_2N_3$ requires C, 65·45; H, 7·6; N, 15·3%).

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