## 623. *The Reaction of Cyanogen Chloride with Sodium Salts of Carboxylic Acids.*

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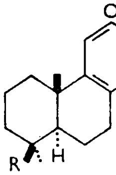
With cyanogen chloride at 250°, the sodium salts of an axial and an equatorial carboxylic acid give nitriles, with retention of configuration.

It has been shown [1] that nitriles can be obtained in good yield by the reaction between cyanogen chloride and alkali-metal salts of numerous carboxylic acids at 200—300°. For the corresponding reactions of cyanogen bromide, tracer studies [2,3] have given results in accordance with the scheme:

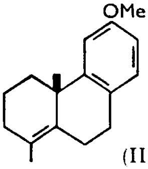
$$\text{R}\cdot{}^{*}\text{CO}_2\text{Na} + \text{Br}\cdot\text{CN} \xrightarrow{250\text{—}300^\circ} \text{R}\cdot{}^{*}\text{CN} + \text{CO}_2 + \text{NaBr} \quad (\text{R} = \text{Et, Ph})$$

*i.e.*, the carbon atom liberated as carbon dioxide is derived from the cyanogen halide, and the bond between alkyl radical R and the carboxyl carbon atom is not broken. A minor product is an α-keto-isocyanate (R·CO·NCO), and a mechanism involving this compound as intermediate has been suggested.[3] We present here stereochemical evidence as to the course of the reaction.

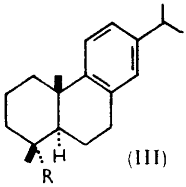
Sodium *O*-methylpodocarpate (I; R = $CO_2Na$), when heated in a sealed tube at 250° with cyanogen chloride, gave a 26% yield of the corresponding nitrile (I; R = CN), identical with a sample which we prepared by an unambiguous method (cf. ref. 4). Although searched for meticulously, the nitrile with inverted stereochemistry at position 1 (phenanthrene numbering) was not detected. A second product, $C_{17}H_{22}O$, b. p. 115°/0·1 mm., was probably the $\Delta^{1(11)}$-olefin (II), since the ethylenic bond was not revealed in the infrared spectrum. A very small quantity of carbonyl-containing material, ν 1742 and 1721 cm.$^{-1}$, could not be obtained free from nitrile, and so remains uncharacterized.



(I)



(II)



(III)

Under the same conditions, sodium dehydroabietate (III; R = $CO_2Na$) gave the known dehydroabietonitrile (III; R = CN) (32%) and none of its $C_{(1)}$-epimer. The by-products of this reaction appeared to be similar to those obtained from sodium *O*-methylpodocarpate.

The retention of configuration in both the equatorial (III; R = $CO_2Na$) and the axial (I; R = $CO_2Na$) carboxylate is consistent with the suggested mechanism,[3] and not with any simple mechanism involving replacement at the α-carbon atom.

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[1] Zappi and Bouso, *Anales Asoc. quím. Argentina*, 1947, **35**, 137 (*Chem. Abs.*, 1948, **42**, 7704); cf. Cahours, *Annalen*, 1858, **108**, 319; Cloëz, *ibid.*, 1860, **115**, 23.

[2] Douglas, Eccles, and Almond, *Canad. J. Chem.*, 1953, **31**, 1127.

[3] Douglas and Burditt, *Canad. J. Chem.*, 1958, **36**, 1256.

[4] Wenkert and Jackson, *J. Amer. Chem. Soc.*, 1958, **80**, 211.

## EXPERIMENTAL

M. p.s were determined on a Kofler block. Infrared spectra were determined for liquid films unless otherwise stated. Optical rotations are for chloroform solutions. For chromatography, Peter Spence's "Grade H" alumina was used; deactivated alumina contained 5% of 10% aqueous acetic acid. Unless otherwise stated, light petroleum refers to the fraction of b. p. 60—80°.

O-*Methylpodocarponitrile* (I; R = CN).—*O*-Methylpodocarpoyl chloride (I; R = COCl)[5] (1·01 g.) in dry tetrahydrofuran (35 ml.) was stirred with a suspension of sodamide (from 3·5 g. of sodium) in liquid ammonia (250 ml.) until most of the ammonia had evaporated (*ca.* 8 hr.). The oily product (0·96 g.) was isolated with chloroform and chromatographed on alumina (50 g.). Elution with 1 : 1 light petroleum–benzene (600 ml.) followed by recrystallization from light petroleum gave O-*methylpodocarponitrile* (I; R = CN) (107 mg.) as needles, m. p. 106—108·5°. Recrystallized again, it had m. p. 108—109°, $[\alpha]_D^{16}$ +58·1° (*c* 1·09) (Found: C, 80·3; H, 8·8; N, 5·2. $C_{18}H_{23}NO$ requires C, 80·3; H, 8·6; N, 5·2%). Elution with methanol (200 ml.) and crystallization from ether gave a solid (250 mg.) from which O-*methylpodocarpamide* (I; R = CO·NH$_2$) (160 mg.), m. p. 157—159°, was obtained on recrystallization from methanol. The analytical sample, recrystallized once more from methanol, had m. p. 160°, $[\alpha]_D^{16}$ +149° (*c* 1·33) (Found: C, 75·3; H, 9·1; N, 4·7. $C_{18}H_{25}NO_2$ requires C, 75·3; H, 8·7; N, 4·9%).

*Cyanogen Chloride Reactions.*—Cyanogen chloride was prepared from chlorine and sodium cyanide,[6] and was stored in sealed ampoules each containing 0·5—1 g.

(*A*) *O*-Methylpodocarpic acid[7] (0·62 g.) in ethanol was treated with the calculated quantity of sodium ethoxide in ethanol. Removal of the solvent *in vacuo* and recrystallization from water gave the sodium salt (I; R = CO$_2$Na) (0·56 g.) as needles, which were dried at 175°/0·1 mm.

The sodium salt (430 mg.) was sealed in a Carius tube at −60° with the contents of one ampoule of cyanogen chloride. After being shaken vigorously at room temperature, the tube was heated at 250° for ¾ hr., with occasional shaking. The tube was opened at −60°, and the excess of cyanogen chloride was removed under reduced pressure. After the addition of water, the oily neutral product (290 mg.) was isolated with ether. (No acidic material was obtained on acidification of the aqueous layer combined with the alkali washings of the ethereal solution.) Chromatography on deactivated alumina (60 g.) and elution with 4 : 1 light petroleum–benzene (120 ml.) gave an oil (56 mg.) which, after distillation, had b. p. 115° (bath)/0·1 mm., ν 1212m, 1170m, 1066w, 871m, 835m, and 800 cm.$^{-1}$ (no bands due to C⋮N or C:O) (Found: C, 83·2, 83·4; H, 8·7, 8·9. $C_{17}H_{22}O$ requires C, 84·3; H, 9·2%). Further elution with the same solvent mixture (60 ml.) gave a semisolid fraction (29 mg.), ν 2227 (C⋮N), 1742, and 1721 cm.$^{-1}$ (C:O); and then (with 240 ml. of solvent) *O*-methylpodocarponitrile (I; R = CN) (89 mg.), m. p. 98—103°. Elution with benzene and finally with ether gave intractable resins (52 mg.) which were not investigated further. Rechromatography of the semisolid fraction gave a mixed fraction (16 mg.) and the nitrile (7 mg.).

After recrystallization from light petroleum (b. p. 40—60°), the nitrile was obtained as needles, m. p. 107—108° (undepressed by admixture with an authentic sample), $[\alpha]_D^{16}$ +57·4° (*c* 1·22) (Found: C, 80·4; H, 8·7; N, 5·3%). The identity of this product and the authentic nitrile was confirmed by comparison of their infrared spectra both in carbon disulphide solution and in Nujol.

(*B*) Sodium dehydroabietate was prepared by titration of aqueous ethanolic solutions of dehydroabietic acid (III; R = CO$_2$H) and sodium hydroxide to the phenolphthalein end-point. After removal of the solvents, the salt was dried thoroughly *in vacuo*.

The salt (620 mg.) was treated with cyanogen chloride under the conditions described in (*A*) above. Chromatography of the product (500 mg.) on deactivated alumina (75 g.) and elution with light petroleum (b. p. 40—60°) (150 ml.) gave an oil (79 mg.), ν 887 and 832 cm.$^{-1}$ (no bands due to C⋮N or C:O). The same solvent eluted successively: (with 200 ml.) an oil (62 mg.), ν 1724 cm.$^{-1}$; (with 100 ml.) a mixed fraction (28 mg.); and then (with 600 ml. solvent) dehydroabietonitrile (III; R = CN) (174 mg.), m. p. 78—85°. Recrystallized twice from hexane, the nitrile had m. p. 87—88° (Found: C, 85·3; H, 9·6. Calc. for $C_{20}H_{27}N$: C, 85·4;

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[5] Campbell and Todd, *J. Amer. Chem. Soc.*, 1942, **64**, 928.

[6] Coleman, Leeper, and Schulze. *Inorg. Synth.*, 1946, **2**, 90.

[7] Sherwood and Short, *J.*, 1938, 1006.

H, 9·6%), and it was shown to be identical with authentic dehydroabietonitrile (m. p. 87—88°) by the mixed m. p. test and by comparison of infrared spectra in carbon disulphide solution.

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