491. *Heterocyclic Polyfluoro-compounds. Part VIII.*[1] *Perfluoro-(2-, 3-, and 4-methylpyridine) and Tetrafluoroisonicotinic Acid*

By R. E. Banks, J. E. Burgess, and R. N. Haszeldine

Perfluoro-(2-, 3-, and 4-methylpyridine) have been prepared by defluorination of the corresponding perfluoro-(*N*-fluoro-methylpiperidine). Hydrolysis of perfluoro-(4-methylpyridine) with fuming sulphuric acid gave 2,3,5,6-tetrafluoropyridine-4-carboxylic acid.

INTERPRETATION[2] of the ^{19}F nuclear magnetic resonance spectra of monosubstituted tetrafluoropyridines obtained by nucleophilic substitution in pentafluoropyridine, under conditions used so far,[3] has enabled us to establish that at least 95% of the initial attack by the nucleophiles H^-, OH^-, MeO^-, $MeCH{:}CH^-$, NH_3, Me_2NH, or N_2H_4 occurs at the 4-position. The structures of the tetrafluoropyridine (I) and the tetrafluoropropenylpyridine (II) obtained by reaction of pentafluoropyridine with lithium aluminium hydride and propenyl-lithium, respectively, have now been proved chemically by converting 4-methylpyridine into 2,3,5,6-tetrafluoropyridine-4-carboxylic acid (III) to which both (I) and (II) are directly related.

The structures of perfluoro-(*N*-fluoro-4-methylpiperidine) (IV) and perfluoro-(4-methylpyridine), and of 2,3,5,6-tetrafluoropyridine-4-carboxylic acid (III) obtained by hydrolysis of the latter, follow from the synthesis used, and were confirmed by ^{19}F n.m.r. spectroscopy;[2,4] the infrared and ^{19}F n.m.r. spectra of the acid were identical with those of the product obtained by oxidation of the tetrafluoropropenylpyridine produced when pentafluoropyridine is treated with propenyl-lithium.[3] Thermal decarboxylation of 2,3,5,6-tetrafluoropyridine-4-carboxylic acid derived from perfluoro-(4-methylpyridine)

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[1] Part VII, R. E. Banks, and G. E. Williamson, *J.*, 1965, 815.

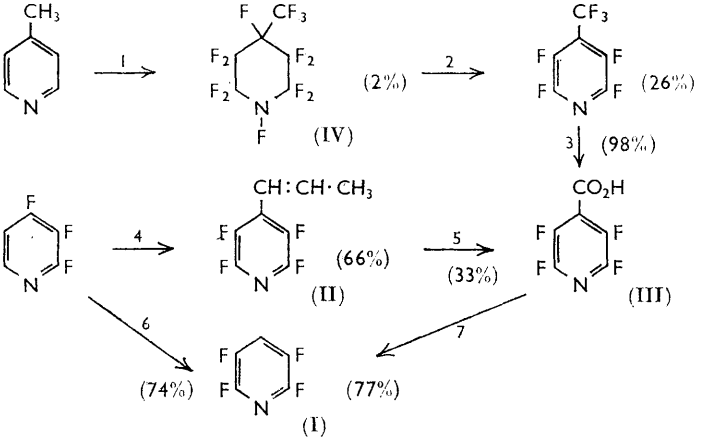
[2] J. Lee and K. G. Orrell, *J.*, 1965, 582.

[3] R. E. Banks, J. E. Burgess, W. M. Cheng, and R. N. Haszeldine, *J.*, 1965, 575.

[4] J. Lee and K. G. Orrell, in preparation.

gave 2,3,5,6-tetrafluoropyridine, the infrared spectrum of which was identical with that of the compound prepared by reaction of pentafluoropyridine with lithium aluminium hydride.[3]

Perfluoro-(2-methylpyridine) and perfluoro-(3-methylpyridine) were prepared in 57 and 83% yield, respectively, by defluorination of the corresponding perfluoro-(*N*-fluoromethylpiperidines) with iron at 580°/2 mm.; the piperidines were obtained in low yields (2—4%) by electrochemical fluorination of the corresponding methylpyridines, and their identities, like those of the derived perfluoro(methylpyridines), were confirmed by ^{19}F n.m.r. spectroscopy.[2,4]



1, Electrochemical fluorination; 2, Fe, 590°/2 mm.; 3, Fuming H_2SO_4, 150°; 4, $CH_3{\cdot}CH{:}CHLi$, ether, —20°; 5, HNO_3, 110°; 6, $LiAlH_4$, ether; 7, 250°

Perfluoro-(2-, 3-, and 4-methylpyridine) are colourless, almost odourless, mobile liquids that boil at the same temperature as perfluorotoluene (b. p.[5] 102—103°). Their aromatic character is revealed by the presence of characteristic ring vibrations near 1500 cm.$^{-1}$ in the infrared spectra of their vapours, close to those in pentafluoropyridine (1497 cm.$^{-1}$) and hexafluorobenzene (1536 cm.$^{-1}$), and by the occurrence of *B*-bands near 260 mμ in the ultraviolet spectra of their solutions in hexane (cf.[3] pentafluoropyridine, $\lambda_{max.}$ 256 mμ).

EXPERIMENTAL

Products were identified by molecular-weight determination (Regnault's method), elemental analysis, infrared spectroscopy (Perkin-Elmer spectrophotometer model 21 with sodium chloride optics), ^{19}F nuclear magnetic resonance spectroscopy (A.E.I. RS2 spectrometer operating at 60 Mc./sec.), and gas–liquid chromatography (Perkin-Elmer " Vapor Fraktometer," model 116).

Preparation of Perfluoro-(N*-fluoro-methylpiperidines*).—Perfluoro-(*N*-fluoro-2-methylpiperidine), -(*N*-fluoro-3-methylpiperidine), and -(*N*-fluoro-4-methylpiperidine) were prepared by electrochemical fluorination of 2-, 3-, and 4-methylpyridine, respectively, essentially as described previously for pyridine[6] (5 mole % solutions in anhydrous HF were electrolysed at 25 A and 5·5 V). Pure products were isolated by a combination of precise distillation (adiabatic 45 cm. × 1·2 cm. i.d. column packed with 1/16 × 1/16 in. nickel Dixon rings) and large-scale gas–liquid chromatography (3 m. × 2·2 cm. i.d. column packed with 30% w/w of " dinonyl " phthalate–Celite at 60°), and had the following properties: *perfluoro-*(N*-fluoro-2-methylpiperidine* (yield: 4%) (Found: C, 21·7; N, 4·3%; *M*, 331. $C_6F_{13}N$ requires C, 21·6; N, 4·2%; *M*, 333); b. p. 71·7° (isoteniscope); n_D^{20} 1·3167; vapour absorbs strongly in the infrared at 876, 958, 978, and 1006 cm.$^{-1}$: *perfluoro-*(N*-fluoro-3-methylpiperidine*) (yield: 2%) (Found: C, 22·1; N, 4·6%; *M*, 337. $C_6F_{13}N$ requires C, 21·6; N, 4·2%; *M*, 333); b. p. 73°; vapour

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[5] B. Gething, C. R. Patrick, M. Stacey, and J. C. Tatlow, *Nature*, 1959, **183**, 588.

[6] R. E. Banks, A. E. Ginsberg, and R. N. Haszeldine, *J.*, 1961, 1740.

absorbs strongly in the infrared at 875, 958, and 1025 cm.$^{-1}$: and *perfluoro-(*N*-fluoro-4-methylpiperidine)* (yield: 2%) (Found: C, 22·4; N, 4·5%; *M*, 328. $C_6F_{13}N$ requires C, 21·6; N, 4·2%; *M*, 333), b. p. 72·4° (isoteniscope); vapour absorbs strongly in the infrared at 875, 958, and 975 cm.$^{-1}$.

Like perfluoro-*N*-fluoropiperidine,[7] all three perfluoro-(*N*-fluoro-methylpiperidines) liberated iodine from aqueous potassium iodide (diagnostic for the N–F bond).

The main product from the electrochemical fluorination of each methylpyridine was a perfluorohexane; no attempt was made to isolate pure and investigate any product other than the required perfluoro-(*N*-fluoro-methylpiperidine), although an analysis was performed on a perfluorohexane fraction (Found: C, 21·2%; *M*, 336. Calc. for C_6F_{14}: C, 21·4%; *M*, 338), b. p. 58—60° (lit.[8] quotes a range of b. p. values between 57 and 60° for n-C_6F_{14}), isolated by distillation from the product of electrochemical fluorination of 3-methylpyridine.

Perfluoro-(2-methylpyridine).—In the low-pressure pyrolysis apparatus described previously,[3,6] perfluoro-(*N*-fluoro-2-methylpiperidine) (78·0 g.) was passed over mild-steel wool at 580°/2 mm. (contact time 38 sec.). The product, trapped at −196°, was distilled through a 20 cm. × 1 cm. i.d. adiabatic column packed with 1/16 × 1/16 in. Dixon rings, to yield *perfluoro-(2-methylpyridine)* (29·2 g., 57%) (Found: C, 33·1; N, 6·1%; *M*, 217. C_6F_7N requires C, 32·9; N, 6·4%; *M*, 219), b. p. 102—103°/767 mm., $\lambda_{max.}$ 256 mμ (ε 2320) in hexane and 256 mμ (ε 2230) in ethanol, $\nu_{max.}$ (vapour) 1480 cm.$^{-1}$ (fluorinated pyridine nucleus).

Perfluoro-(3-methylpyridine).—Perfluoro-(*N*-fluoro-3-methylpiperidine) (41·0 g.) was similarly defluorinated at 580°/2 mm. (contact time 40 sec.), to yield perfluoro-(3-methylpyridine) (22·4 g.; 83%) (Found: C, 33·0; N, 6·5%; *M*, 221. C_6F_7N requires C, 32·9; N, 6·4%; *M*, 219), b. p. 102°, $\lambda_{max.}$ 255 mμ (ε 2700) in hexane and in ethanol, $\nu_{max.}$ (vapour) 1511 cm.$^{-1}$ (fluorinated pyridine nculeus).

Perfluoro-(4-methylpyridine).—Similarly, perfluoro-(*N*-fluoro-4-methylpyridine) (25·5 g.) was defluorinated at 590°/2 mm. (contact time 38 sec.), to yield perfluoro-(4-methylpyridine) (4·4 g.; 26%) (Found: C, 33·0; N, 6·6%; *M*, 220. C_6F_7N requires C, 32·9; N, 6·4%; *M*, 219), b. p. 102—103°, $\lambda_{max.}$ 280 mμ (ε 3500) in hexane and 278 mμ (ε 3960) in ethanol, $\nu_{max.}$ (vapour) 1486 cm.$^{-1}$ (fluorinated pyridine nucleus).

Hydrolysis of Perfluoro-(4-methylpyridine).—Perfluoro-(4-methylpyridine) (0·40 g.) was heated with fuming sulphuric acid (20% SO_3; 0·4 g.) in a 5-ml. Pyrex ampoule at 150° for 3·5 days. A white solid (0·29 g.) precipitated when the reaction product was poured into water (3 ml.); a further quantity (0·08 g.) of this solid was recovered from the aqueous layer by ether extraction. Sublimation of this white solid at 80° (bath temp.)/10^{-2} mm. afforded tetrafluoropyridine-4-carboxylic acid (0·35 g.; 98%) (Found: C, 36·7; H, 0·7; N, 7·2. Calc. for $C_6HF_4NO_2$: C, 36·9; H, 0·5; N, 7·2%), m. p. (sealed tube) 98—100°, mixed m. p. (with oxidation product of tetrafluoro-4-propenylpyridine [3]) 97—99°.

2,3,5,6-Tetrafluoropyridine-4-carboxylic acid (0·07 g.) obtained as above was decarboxylated by heating it in a 1-ml. Pyrex ampoule at 240—250° for 1·5 hr. The product was separated by trap-to-trap fractional condensation, *in vacuo*, into a mixture of carbon dioxide and silicon tetrafluoride, and 2,3,5,6-tetrafluoropyridine (Found: C, 39·8; H, 0·9%; *M*, 154. Calc. for C_5HF_4N: C, 39·9; H, 0·7%, *M*, 151) that had the same infrared spectrum as the tetrafluoropyridine obtained by treatment of pentafluoropyridine with lithium aluminium hydride.[3]

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[7] R. E. Banks, W. M. Cheng, and R. N. Haszeldine, *J.*, 1962, 3407.

[8] A. M. Lovelace, D. A. Rausch, and W. Postelnek, "Aliphatic Fluorine Compounds," Reinhold, New York, 1958, p. 74.