Journal of Fluorine Chemistry, 12 (1978) 79–84

Received: April 21, 1978

SHORT COMMUNICATION

SOME 1,3-DIPOLAR CYCLOADDITION REACTIONS OF PERFLUORO-(2-AZIDO-4-ISOPROPYLPYRIDINE) AND 2-AZIDO-3,5,6-TRIFLUORO-4-METHOXYPYRIDINE

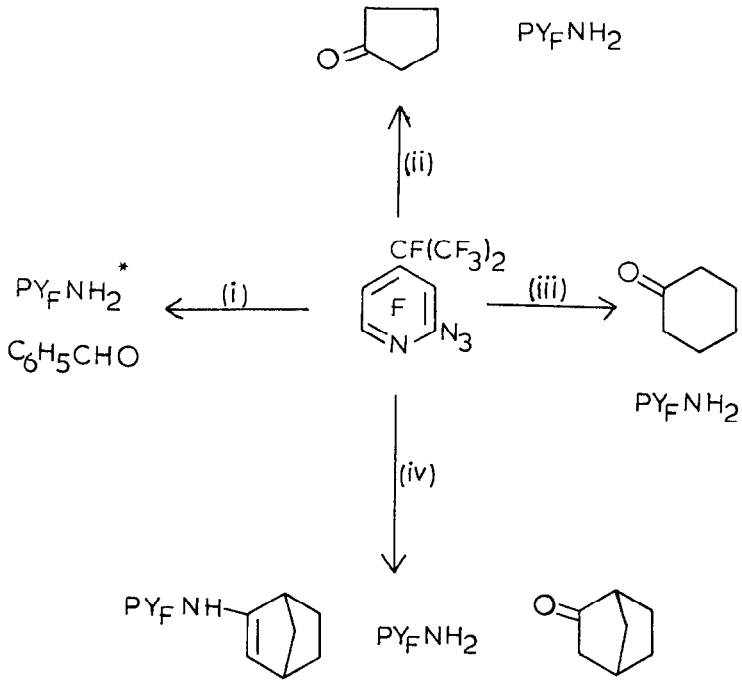
AJAI PRAKASH*

Chemistry Department, The University of Manchester Institute of Science and Technology, Manchester M60 1QD (Great Britain)

In continuation with studies on perfluorinated aryl [1] and hetaryl [2] azides some 1,3-dipolar cycloaddition reactions of perfluoro-(2-azido-4-isopropylpyridine) are summarised in Scheme 1. The azide reacts with styrene under forcing thermal conditions to give a mixture of perfluoro-(2-amino-4-isopropylpyridine) and benzaldehyde involving a more unusal type of cleavage of the triazoline formed initially [2] . Perfluoro-(2-azido-4-isopropyl-pyridine) does not react with cyclopentene or cyclohexene upto 110 °C but when the reaction is carried out at the decomposition temperature of the azide i.e. 160 °C, a mixture of the amino compound and the corresponding cyclic ketone is obtained. It is believed that at 160 °C the reaction still proceeds via 1,3-cycloaddition because no evidence of nitrene formation was found when the azide was decomposed thermally or photochemically in the presence of conventional nitrene traps e.g. dimethyl sulphoxide, cyclohexane etc. [2] and only polymeric material was obtained. Perfluoro-(2-azido-4-isopropylpyridine) reacts smoothly with norbornene at room temperature with evolution of nitrogen and only the products of decomposition of initially formed triazoline are obtained.

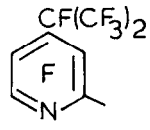
The instability of the triazoline in the reactions shown in Scheme 1 may be attributed to the powerful -I nature of the perfluoro-(4-isopropylpyrid-2-yl) group. By changing the strong

*Present address: Malti-Chem Research Centre, Nandesari, Baroda 391340, India



SCHEME 1

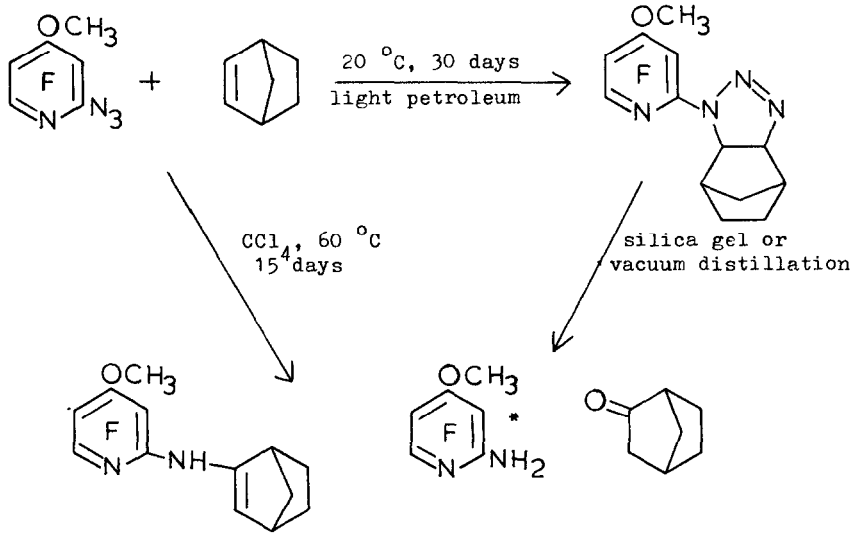
Reagents: (i) styrene, CCl_4, 77 °C.
(ii) cyclopentene, 160 °C.
(iii) cyclohexene, 160 °C.
(iv) norbornene, light petroleum, 20 °C.

$PY_F \equiv$ 

* An authentic sample was prepared from aq. ammonia and perfluoro-(4-isopropylpyridine) in hot ethanol [2] .

electron-withdrawing perfluoroisopropyl group in the 4-position with a methoxy group and 2-azido-3,5,6-trifluoro-4-methoxypyridine thus formed, on reaction with norbornene at room temperature gives an isolable triazoline. No collection of nitrogen in the nitrometer connected to the reaction vessel and disappearance of the $-N_3$ absorption (4.6 μm) in the i.r. spectrum of the reactants mixture

after 30 days were indicative of the formation of a triazoline. Attempts to obtain an analytically pure sample of the triazoline resulted in its decomposition. A rare silica gel initiated decomposition was observed when a crude sample of the triazoline was adsorbed on a column of silica gel for further purification; a spontaneous reaction occured with a visible evolution of a gas, presumably nitrogen. Vacuum distillation of the crude triazoline also resulted in the isolation of the decomposition products. Reaction of the azide with norbornene at 60 °C directly gave the decomposition products of the triazoline (Scheme 2).



SCHEME 2

* An authentic sample was prepared from aq. ammonia and 2,3,5,6-tetrafluoro-4-methoxypyridine.

EXPERIMENTAL

I.r. and n.m.r. (shifts to high field designated positive) spectra were obtained with a Perkin - Elmer spectrophotometer model 257 and a Perkin - Elmer R10 instrument (^{19}F at 54.46, ^{1}H at 60 Hz), respectively. Perfluoro-(2-azido-4-isopropylpyridine) was prepared by the reaction of sodium azide with perfluoro-(4-isopropylpyridine) and 2-azido-3,5,6-trifluoro-4-methoxypyridine was prepared *via* nitrosation of 3,5,6-trifluoro-2-hydrazino-4-methoxypyridine [2] .

Reactions of perfluoro-(2-azido-4-isopropylpyridine)—

(i) With styrene. Perfluoro-(2-azido-4-isopropylpyridine) (1.5 g, 4.4 mmol), styrene (0.45 g, 4.4 mmol) and carbon tetrachloride (25 ml) were heated under reflux for 3 weeks. Removal of the solvent by distillation left an oil which was subjected to column chromatography (silica gel). Elution with chloroform-light petroleum (b.p. 60 - 80 °C) (1:1 v/v) gave a mixture of perfluoro-(2-amino-4-isopropylpyridine) and benzaldehyde (0.3 g) (identified by direct comparision of i.r. spectrum with that of the authentic mixture); subsequent elution with chloroform gave a black unidentified gum.

(ii) With cyclopentene. Perfluoro-(2-azido-4-isopropylpyridine) (1.5 g, 4.4 mmol) and cyclopentene (25 ml) were heated together at 160 °C for 15 h in a stainless steel rocking autoclave (100 ml). Unreacted cyclopentene was distilled from the product and the residual oil was subjected to column chromatography. Elution with carbon tetrachloride provided a mixture of perfluoro-(2-amino-4-isopropylpyridine) and cyclopentanone (1.0 g) (identified by direct comparision of i.r. spectrum with that of the authentic mixture); subsequent elution with chloroform gave a black unidentified gum.

(iii) With cyclohexene. Perfluoro-(2-azido-4-isopropylpyridine) (1.7 g, 5 mmol) and cyclohexene (20 ml) were heated together at 160 °C for 15 h in a stainless steel rocking autoclave. Removal of unreacted cyclohexene by distillation left an oil which was subjected to column chromatography; elution with carbon tetrachloride - benzene (3:1 v/v) gave a mixture of perfluoro-(2-amino-4-isopropylpyridine) and cyclohexanone (1.0 g) (identified by comparision of i.r. spectrum with that of the authentic mixture); further elution with chloroform provided a black unidentified gum.

(iv) With norbornene. A solution of perfluoro-(2-azido-4-isopropylpyridine) (3.0 g, 8.8 mmol) and norbornene (0.85 g, 9 mmol) in light petroleum (20 ml) was stirred in a flask attached to a nitrometer. Steady evolution of a gas (presumably nitrogen) occured and the quantitative volume was collected after the mixture had been stirred at 20 °C for 120 h and at 70 °C for 8 h. Evaporation of the solvent left an oil which was distilled in vacuo (b.p. 84-86 °C at 0.3 mmHg; 3.2 g, 8 mmol; 90%) and shown to be a mixture of two components (by t.l.c.). A sample (1.0 g) of the distillate was subjected to column chromatography (alumina type H) and elution with light petroleum gave 2-(3,5,6-trifluoro-4-heptafluoroisopropyl-2-pyridylamino)bicyclo(2,2,1)hept-2-ene (0.6 g, 1.5 mmol; 60%) (Found: C, 44.0; H, 2.5; F, 46.6; N, 6.9%. $C_{15}H_{10}F_{10}N_2$ requires: C, 44.1; H, 2.5; F, 46.6; N, 6.9%), colourless oil, δ_F(neat liquid, ext. CF_3COOH) -2.0 [m, $CF(CF_3)_2$], +12.0(m, 6-F), +51.0(br, m, 3-F), +67.5(br, m, 5-F) and +102.0[m, $CF(CF_3)_2$] (rel. int. 6:1:1:1:1), δ_H(neat liquid) +3.3 to +5.0(br, complex), λ_{max}(film) 2.9 μm(N-H str.). Subsequent elution with benzene provided a mixture of perfluoro-(2-amino-4-isopropyl-pyridine) and nor-camphor (0.3 g) (identified by comparision of i.r. spectrum with that of the authentic mixture).

Reaction of 2-azido-3,5,6-trifluoro-4-methoxypyridine with norbornene-

(i) At room temperature. A solution of 2-azido-3,5,6-trifluoro-4-methoxypyridine (1.4 g, 7 mmol) and norbornene (0.66 g, 7 mmol) in light petroleum (b.p. 60-80 °C) was stirred at room temperature in a flask attached to a nitrometer. The nitrogen was not collected in the nitrometer and disappearance of $-N_3$ absorption in i.r. spectrum indicated the completion of the reaction (30 days). Removal of the solvent under reduced pressure at room temperature left an oil which was subjected to column chromatography (silica gel). A spontaneous reaction was observed and a gas , presumably nitrogen, evolved. When the reaction was over (2-3 minutes) the column was eluted with light petroleum to give 2-(3,5,6-trifluoro-4-methoxy-2-pyridylamino)-bicyclo(2,2,1)hept-2-ene (1.0 g, 3.7 mmol; 53%) (Found: C, 58.1; H, 5.1; F, 20.7; N, 10.3%. $C_{13}H_{13}F_3N_2O$ requires: C, 57.8; H, 4.8; F, 21.1; N, 10.3%), colourless oil, δ_F(neat liquid) +16.0(d of d, 6-F), +87.5(m, 3-F), +98.0(m, 5-F) p.p.m. (rel. int. 1:1:1), δ_H(neat liquid) +0.6 to +5.5(m) p.p.m. $\lambda_{max.}$(film) 2.9 (N-H str.), 3.4 μm (C-H str.).

Subsequent elution with light petroleum-chloroform (1:1 v/v) provided 2-amino-3,5,6-trifluoro-4-methoxypyridine (0.04 g, 0.22 mmol; 3%), m.p. 93-5 °C, colourless crystals, identified by mass spectroscopy (m/e 178, $C_6H_5F_3N_2O^+$, 100%) and mixed m.p. determination using an authentic sample. Attempts of purification of the oily product by vacuum distillation also resulted in the isolation of a mixture of 2-amino-3,5,6-trifluoro-4-methoxypyridine and nor-camphor (b.p. 60-65 °C at 0.7 mmHg) identified by i.r. spectroscopy [$\lambda_{max.}$ (film) 2.85, 3.0, 3.1(N-H str.), 3.4(C-H str.), 5.75 μm(C=O str.)].

(ii) At 60 °C. A solution of 2-azido-3,5,6-trifluoro-4-methoxypyridine (0.7 g, 3.5 mmol) and norbornene (0.35 g, 3.6 mmol) in carbon tetrachloride was heated at 60 °C for 15 days. Removal of solvent under reduced pressure left an oil that partly solidified when cooled in ice. It was filtered and crystallization with light petroleum provided 2-amino-3,5,6-trifluoro-4-methoxypyridine (0.02 g, 0.11 mmol; 3%). The oily filtrate on column chromatography (silica gel) and elution with light petroleum gave 2-(3,5,6-trifluoro-4-methoxy-2-pyridylamino)-bicyclo(2,2,1)hept-2-ene (0.3 g, 1.1 mmol; 31%), identified by i.r. spectroscopy; subsequent elution with light petroleum-chloroform (3:2 v/v) provided a mixture of 2-amino-3,5,6-trifluoro-4-methoxypyridine and nor-camphor (0.2 g), identified by i.r. spectroscopy.

2-Amino-3,5,6-trifluoro-4-methoxypyridine. A mixture of 2,3,5,6-tetrafluoro-4-methoxypyridine (2.0 g, 11 mmol) and aq. ammonia (15 ml) was heated under reflux for 5 h. The product was poured into water and extracted with ether. The extract was dried ($MgSO_4$) and evaporated leaving an oil shown by t.l.c. to be a mixture of two components. The oil was subjected to column chromatography (silica gel) and elution with light petroleum gave unreacted 2,3,5,6-tetrafluoro-4-methoxypyridine (1.6 g, 8.8 mmol), 72% recovery; subsequent elution with chloroform provided 2-amino-3,5,6-trifluoro-4-methoxypyridine (0.03 g, 0.16 mmol; 1.4%), m.p. 94-5 °C, identified by i.r. and mass spectroscopy.

REFERENCES

1 R.E. Banks and A. Prakash, J.C.S. Perkin Trans. I, (1974) 1365.

2 R.E. Banks and A. Prakash, J.C.S. Perkin Trans. I, (1974) 2479.