

The Preparation of Primary Alkyl and Benzyl Fluorides from the Corresponding Primary Amines^{1,2}

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N-Substituted 2,4,6-triphenylpyridinium fluorides (in contrast to these and other tetrafluoroborates) thermolyse to the corresponding primary alkyl and benzyl fluorides. The pyridinium fluorides are made from 2,4,6-triphenylpyridium fluoride and the relevant amine.

THE usual methods for the preparation of monofunctional alkyl and benzyl fluorides include the transformation of other halides with metallic fluorides,³ of alcohols with selenium tetrafluoride,⁴ addition of HF to olefins⁵ or to diazotoluenes⁶ and direct fluorination (replacement of H).⁷ In contrast to the aromatic series where the most usual synthetic precursor is the aromatic primary amine and the Balz-Schiemann reaction,⁸ there appears to be no previous report of the conversion of aliphatic amines into fluorides.

We now report an extension of our synthetic conversion of aliphatic amines *via* pyridinium salts, already successfully used for the preparation of iodides,⁹ chlorides,^{10,11} and bromides,^{10,12} to the preparation of fluorides.

The Pyrolysis of Tetrafluoroborates.—Early attempts at the pyrolysis of 1-substituted-2,4,6-triphenylpyridinium tetrafluoroborate (1a) failed.¹³ Later, use of rigorously dried salts (*cf.* Table 1), with potassium fluoride and triphenylpyridine as flux, at 200 °C gave benzyl fluorides, identified by their n.m.r. spectra; however, the yields were low (*ca.* 20%) and as shown by g.l.c. the products were contaminated by considerable amounts of the corresponding toluenes. Evidently radical decomposition had occurred simultaneously and the benzyl radicals had then abstracted hydrogen atoms.

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The 5,6-dihydro-2,4-diphenylbenzo[*h*]quinoline moiety of cations (2) is a far better leaving group than triphenylpyridine,¹⁴ and we therefore prepared a series of such tetrafluoroborates (2a; X = BF₄). Reaction of

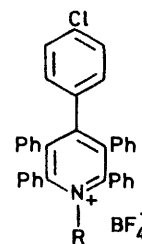


(1)

a; X = BF₄

b; X = F

(2)

a; X = BF₄

(3)

5,6-dihydro-2,4-diphenylnaphtho[1,2-*b*]pyridium tetrafluoroborate (the latter obtained from α -tetralone and chalcone¹⁴) with benzylamines in ethanol at room temperature gave crystalline quinolinium salts (2a) in yields

TABLE 1

Synthesis and pyrolysis of *N*-substituted pyridinium tetrafluoroborates (1a), (2a), and (3)

Cation	<i>N</i> -Substituent (R)	Yield (%)	Crystal form	M.p. ^a (°C)	Lit. m.p. (°C)	Found			Required			Pyrolysis temp. (°C)/ pressure (mmHg)	Yield	
						C	H	N	C	H	N		RF ^b %	RH %
2,4,6-Triphenylpyridinium (1a)	PhCH ₂	77	Plates	195—197	196—197 ^c						180/2	27 ^d	<i>ca.</i> 10	
	ClC ₆ H ₄ CH ₂ (<i>o</i>)	87	Needles	202—203	200 ^e						200/2	15	<i>ca.</i> 5	
	Cl ₂ C ₆ H ₃ CH ₂ (<i>o,p</i>)	85	Needles	235—236	239 ^e						200/2	20	<i>ca.</i> 5	
5,6-Dihydro-2,4-diphenylbenzo[<i>h</i>]quinolinium (2a)	MeOC ₆ H ₄ CH ₂ (<i>p</i>)	80	Needles	145—147	148 ^e						200/2			
	PhCH ₂	84	Needles	188—190	193 ^f						180/0.5	65	<i>ca.</i> 30	
	ClC ₆ H ₄ CH ₂ (<i>o</i>)	73	Needles	180—182	189 ^f						180/0.5	65	<i>ca.</i> 30	
4-(4-Chlorophenyl)-2,3,5,6-tetra-phenylpyridinium (3)	Cl ₂ C ₆ H ₃ CH ₂ (<i>o,p</i>)	73	Needles	153—155		66.1	4.2	2.2	66.2	4.1	2.4	180/0.5	45	<i>ca.</i> 20
	MeC ₆ H ₄ CH ₂ (<i>p</i>)	87	Needles	160—162		75.7	5.0	2.7	75.4	5.3	2.7	180/0.5	30	<i>ca.</i> 15
	ClC ₆ H ₄ CH ₂ (<i>p</i>)	88	Plates	285—286 >330		75.4	4.5	1.9	75.1	4.6	2.1	300/0.5		
						71.2	4.1	1.8	71.4	4.3	2.0	>300/0.2	20 ^d	5

^a Recrystallised from absolute EtOH. ^b Relative ratios from ¹H n.m.r.; CDCl₃ as solvent. ^c U. Gruntz, A. R. Katritzky, D. H. Kenny, M. C. Rezende, and H. Sheikh, *J.C.S. Chem. Comm.*, 1977, 701. ^d Obtained from g.l.c. (SE 30 at 100 °C). ^e Ref. 10. ^f A. R. Katritzky and S. Thind, recent results.

TABLE 2

Synthesis of 1-substituted-2,4,6-triphenylpyridinium fluorides^a (1b)

N-Substituent (R)	Yield (%)	Crystal form	M.p. (°C)	Found (%)			Required (%)		
				C	H	N	C	H	N
PhCH ₂	78	Needles	103—105	86.7	5.7	3.7	86.3	5.8	3.4
C ₆ H ₄ CH ₂ (<i>p</i>)	82	Prisms	118—120	79.5	4.8	2.8	79.7	5.1	3.1
Cl ₂ C ₆ H ₃ CH ₂ (<i>o,p</i>)	86	Prisms	81—82	74.4	4.1	2.9	74.1	4.5	2.9
Cl ₂ C ₆ H ₃ CH ₂ (<i>o</i>)	72	Prisms	128—130	79.5	4.9	3.4	79.7	5.1	3.1
MeC ₆ H ₄ CH ₂ (<i>p</i>)	73	Needles	117—118	86.0	5.7	2.9	86.3	6.0	3.3
HO(CH ₂) ₃	75	Prisms	43	81.5	6.3	3.5	81.0	6.2	3.6
<i>n</i> -C ₇ H ₁₅	82	Needles	103—105	84.3	7.7	3.4	84.7	7.5	3.3
-[CH ₂] ₄ -	83	Needles	195—197	84.4	5.7	3.8	84.8	5.9	4.0
-[CH ₂] ₅ -	85	Needles	92—95	84.4	6.1	3.7	84.8	6.1	3.9
-[CH ₂] ₆ -	86	Needles	110—112	84.5	6.1	3.7	84.8	6.3	3.8
<i>n</i> -C ₈ H ₁₇	78	Needles	72—74	84.3	7.8	3.0	84.7	7.7	3.2
<i>n</i> -C ₁₁ H ₂₃	85	Needles	68—70	84.6	8.1	2.8	84.8	8.3	2.9

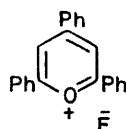
^a Recrystallised from magnesium dried ('super dry') ethanol.

>70% (Table 1). On pyrolysis with KF and triphenylpyridine they gave significantly better results:¹⁵ *e.g.* the parent benzyl derivative afforded 65% of benzyl fluoride; however, the product was contaminated with 30% of toluene.

It seemed possible that the production of hydrocarbons was due in this series to involvement of the CH₂CH₂ group in compounds (2a). Therefore representative examples of 1-benzyl-4-*p*-chlorophenyl-2,3,5,6-tetra-phenylpyridinium tetrafluoroborate (3) were prepared from the reaction of the corresponding pyrylium (obtained from the dehydrogenative cyclisation of 3-*p*-chlorophenyl-1,2,4,5-tetraphenylpentane-1,5-dione and triphenylmethane tetrafluoroborate) and benzylamines in ethanol (Table 1). However, the results of the pyrolysis in this series were less good than those for the triphenyl analogues (1)¹⁵ due in part to the high melting points of the salts (>300 °C).



(4)



(5)

The Preparation and Pyrolysis of 1-Substituted 2,4,6-Triphenylpyridinium Fluorides.—1,3,5-Triphenylpent-2-ene-1,5-dione (4) (readily available¹⁶ from 2,4,6-triphenylpyrylium tetrafluoroborate and base) reacted smoothly with HF in toluene solvent to give 2,4,6-triphenylpyrylium fluoride (5) (88%). This fluoride reacts readily with a variety of amines to yield the corresponding pyridinium fluorides (1b; X = F) (Table 2): these compounds are highly hygroscopic and could be obtained crystalline only by removing water by azeotropic distillation (see Experimental section).

Before pyrolysis, the fluorides were dried for 1 week *in vacuo* at 40 °C. They then decomposed smoothly at *ca.* 120 °C to give the corresponding alkyl and benzyl fluorides (Table 3). The alkyl fluorides produced usually contained small quantities (<10%) of olefins (as determined by g.l.c.): however, the cyclohexyl derivative gave only cyclohexene (65%), in this case the fluoride ion is acting as a base to effect the Hoffmann elimination.

EXPERIMENTAL

Melting points are uncorrected and were measured on a Reichert microscope hot stage. I.r. and 60 MHz proton magnetic resonance spectra were recorded respectively on a Perkin-Elmer 257 grating infrared and a R12 Perkin-Elmer n.m.r. spectrometer. G.l.c. analyses were performed with a Perkin-Elmer F11 gas chromatograph (Flame ionisation, stationary phase SE30; oven temperatures 100 °C).

TABLE 3

Pyrolysis of 1-substituted-2,4,6-triphenylpyridinium fluorides

N-Substituent (R)	Pyrolysis temp. (°C)/ pressure (mmHg)	RF (%)	¹ H N.m.r. ^a
PhCH ₂	120/0.5	62 ^b	δ 5.30 (2 H, d, ² J _{HF} 49 Hz), 7.32 (5 H, s)
Cl ₂ C ₆ H ₄ CH ₂ (<i>p</i>)	120/1	65 ^b	δ 5.58 (2 H, d, ² J _{HF} 48 Hz), 7.42 (4 H, m)
Cl ₂ C ₆ H ₃ CH ₂ (<i>o,p</i>)	100/0.5	61 ^b	δ 5.40 (2 H, d, ² J _{HF} 47 Hz), 7.33 (3 H, m)
Cl ₂ C ₆ H ₃ CH ₂ (<i>o</i>)	130/0.5	67 ^b	δ 5.55 (2 H, d, ² J _{HF} 48 Hz), 7.38 (4 H, s)
MeC ₆ H ₄ CH ₂ (<i>p</i>)	120/0.5	Trace ^b	δ 2.40 (s, sharp), 2.43 (s, sharp), 5.53 (d, ² J _{HF} 48 Hz), 7.60 (m, broad)
HO(CH ₂) ₃	60/760	37 ^c	δ 4.59 (2 H, dt, ² J _{HF} 48 Hz; ³ J _{HH} 6 Hz), 3.70 (2 H, m), 1.22 (2 H, t)
<i>n</i> -C ₇ H ₁₅	120/760	65 ^c	δ 4.33 (2 H, dt, ² J _{HF} 47 Hz; ³ J _{HH} 6 Hz), 1.20 (10 H, m), 0.78 (3 H, s)
-[CH ₂] ₄ -	200/760	48 ^c	δ 4.52 (4 H, dt, ² J _{HF} 47 Hz; ³ J _{HH} 6 Hz), 2.0 (4 H, m)
-[CH ₂] ₅ -	120/760	49 ^c	δ 4.40 (4 H, dt, ² J _{HF} 48 Hz; ³ J _{HH} 6 Hz), 1.55 (6 H, m)
-[CH ₂] ₆ -	120/760	52 ^c	δ 4.45 (4 H, dt, ² J _{HF} 49 Hz; ³ J _{HH} 6 Hz), 1.50 (8 H, m)
<i>n</i> -C ₈ H ₁₇	100/760	42 ^c	δ 4.39 (2 H, dt, ² J _{HF} 48 Hz; ³ J _{HH} 6 Hz), 1.25 (12 H, m), 0.86 (3 H, s)
<i>n</i> -C ₁₁ H ₂₃	100/760	55 ^c	δ 4.43 (2 H, dt, ² J _{HF} 47 Hz; ³ J _{HH} 6 Hz), 1.30 (18 H, m), 0.90 (3 H, s)

^a 60 MHz, solvent: CDCl₃. ^b Distillate collected in a trap cooled by liquid nitrogen. ^c Distillate collected in the receiver of a micro-Hickman apparatus.

The following compounds were made by the literature methods indicated: 2,4,6-triphenylpyrylium tetrafluoroborate,¹⁶ m.p. 249—250 °C (lit.,¹⁶ m.p. 253—255 °C); 5,6-dihydro-2,4-diphenylnaphtho[1,2-*b*]pyrylium tetrafluoroborate,¹⁴ m.p. 270—273 °C (lit.,¹⁴ m.p. 270 °C); 3-(4-chlorophenyl)-1,2,4,5-tetraphenylpentane-1,5-dione,¹⁷ m.p. 230—232 °C (lit.,¹⁷ m.p. 234 °C); 1,3,5-triphenylpent-2-ene-1,5-dione,¹⁸ m.p. 119 °C (lit.,¹⁸ m.p. 120 °C); triphenylmethane tetrafluoroborate¹⁹ (used immediately due to its hygroscopic nature), and 2,4,6-triphenylpyridine,²⁰ m.p. 137 °C (lit.,²⁰ m.p. 139 °C).

4-(4-Chlorophenyl)-2,3,5,6-tetraphenylpyrylium Tetrafluoroborate.—3-(4-Chlorophenyl)-1,2,4,5-tetraphenylpentane-1,5-dione (1.0 g, 2.0 mmol) and freshly prepared triphenylmethane tetrafluoroborate (1 g, 3.0 mmol) in HOAc–Ac₂O (2 : 1 by volume, 10 ml) was refluxed for 12 h. The resulting dark oil was poured into Et₂O (20 ml) to give the pyrylium tetrafluoroborate (0.4 g, 35%), as yellow needles (from absolute EtOH), m.p. 263—265 °C (Found: C, 72.0; H, 3.9; Cl, 6.0. C₃₅H₂₄ClF₄O requires C, 72.1; H, 4.1; Cl, 6.1%).

Preparation of Pyridinium Tetrafluoroborates (1a), (2a), and (3).—The pyrylium tetrafluoroborate (20 mmol) and primary amine (20 mmol) were stirred in abs. EtOH (50 ml) for 6 h. The mixture was diluted with Et₂O (100 ml) to give the pyridinium tetrafluoroborates as white crystalline materials which were recrystallised from absolute EtOH.

Pyrolysis of Pyridinium Tetrafluoroborates (1a), (2a), and (3).—The pyridinium tetrafluoroborate and 2,4,6-triphenylpyridine (1 : 3 by weight) were dried in a pyrolysis apparatus (previously described²¹) to ca. 100 °C/2 mmHg. The mixture was then heated to >180 °C/2 mmHg for ca. 3 h. The products of the pyrolysis were collected in a trap cooled by liquid nitrogen.

2,4,6-Triphenylpyrylium Fluoride (5).—1,3,5-Triphenylpent-2-ene-1,5-dione (2 g) was dissolved in toluene (10 ml) in a polyethylene beaker. To this vigorously stirred solution was added excess of HF (40% aqueous solution) and the two phase system stirred for 12 h. The resulting yellow crystals of 2,4,6-triphenylpyrylium fluoride were filtered using a porcelain filter funnel and recrystallised from magnesium-dried EtOH as yellow needles (1.7 g, 88%), m.p. 112 °C (Found: C, 83.8; H, 4.8; F, 5.9. C₂₃H₁₇OF requires C, 84.2; H, 5.2; F, 5.8%).

Preparation of 1-Substituted 2,4,6-Triphenylpyridinium Fluorides (1b).—2,4,6-Triphenylpyrylium fluoride (20 mmol) and the primary amine (20 mmol) in magnesium-dried EtOH₄-sodium-dried benzene (100 ml, 1 : 1 by volume)

were heated in a Dean-Stark apparatus for 12 h. The solvents were removed *in vacuo* (25 °C/20 mmHg) and the resultant oil triturated with Et₂O to give white crystals of the pyridinium fluoride; this was recrystallised from 'super dry' ethanol, and dried *in vacuo* over P₂O₅ (40 °C/3 mmHg) for 7 days.

Pyrolysis of 1-Substituted-2,4,6-triphenylpyridinium Fluorides.—The rigorously dried pyridinium fluorides were heated in a pyrolysis apparatus (with a liquid nitrogen-cooled trap) at a pressure of 2 mmHg or alternatively for lower boiling fluoride in a micro-Hickman apparatus at 760 mmHg. The distillates were characterised by ¹H n.m.r. and the purity established by v.p.c.

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