US00RE35177E

United States Patent [19]

Umemoto et al.

[11] E **Patent Number: Re. 35,177**

[45] **Reissued Date of Patent: Mar. 12, 1996**

[54] **N-FLUOROPYRIDINIUM SALT AND PROCESS FOR PREPARING SAME**

[75] Inventors: **Teruo Umemoto**; **Kyoichi Tomita**, both of Sagamihara; **Kosuke Kawada**, Tokyo; **Ginjiro Tomizawa**, Wako, all of Japan

[73] Assignees: **Sagami Chemical Research Center**; **Chichibu Onoda Cement Corporation**, both of Tokyo, Japan

[21] Appl. No.: **197,711**

[22] Filed: **Feb. 17, 1994**

Related U.S. Patent Documents

Reissue of:

[64] Patent No.: **4,996,320**
Issued: **Feb. 26, 1991**
Appl. No.: **296,411**
Filed: **Jan. 9, 1989**

U.S. Applications:

[63] Continuation of Ser. No. 22,275, Mar. 5, 1987, abandoned, which is a continuation-in-part of Ser. No. 870,010, Jun. 3, 1986, abandoned.

[30] **Foreign Application Priority Data**

Jun. 3, 1985 [JP] Japan 60-118882
Mar. 7, 1986 [JP] Japan 61-48450

[51] **Int. Cl.**[6] **C07F 9/58**; C07D 491/048; C07D 213/55; C07D 219/04

[52] **U.S. Cl.** **546/9**; 546/22; 546/102; 546/116; 546/153; 546/155; 546/157; 546/168; 546/170; 546/180; 546/286; 546/287; 546/321; 546/326; 546/345; 546/346; 546/347

[58] **Field of Search** 546/9, 22, 345, 546/286, 287, 321, 326

[56] **References Cited**

FOREIGN PATENT DOCUMENTS

0204535 12/1986 European Pat. Off. 546/345

OTHER PUBLICATIONS

March, Advanced Organic Chemistry, Reactions, Mechanisms and Structure, Second Edition, pp. 460–468, McGraw–Hill Publishers (1977).

Umemoto et al, Chemical Abstracts, vol. 106(15) Abst. No. 106:119,640f Apr. 13, 1987.

"The Chemistry of Heterocyclic Compounds a Series of Monograms" Arnold Weissberger, Consulting Editor, vol. 14, Pyridine and Its Derivatives, Parts 1–4, Edited by Erwin Clingsbert, (1960–1964) Interscience Publishers Inc., New York, N.Y.

"Pyridine and Its derivatives" vol. 14, Supplement Parts 1–4 Edited by R. A. Abramovitch (1974 Parts 1–3), (1975 Part 4), John Wiley and Sons Publishers New York N.Y.

"Pyridine and Its Derivatives," vol. 14, Supplement Part 5, Edited by George R. Newkome, 1984, John Wiley and Sons, Inc Publishers.

Hasso Meinert, Habilitationsschrift, "Contributions of the Chemistry of Halogen Fluroides, Halogens in a Positive Oxidation State and Noble Gases", Dept. of Mathematics and Natural Sciences, Humbolt Univ. Berlin, Germany Dec. 11, 1968.

Primary Examiner—Alan L. Rotman
Attorney, Agent, or Firm—Oblon, Spivak, McClelland, Maier & Neustadt

[57] **ABSTRACT**

A pyridine-compound is reacted with fluorine together with a [Bronsted] *Brønsted* acid-compound or Lewis acid to form a N-fluoropyridinium salt which is very active to other compounds but is very selective for the preparation of a desired product and this product is very useful for a fluorine-introducing agent which makes it useful for the preparation of fluoro-compounds such as thyroid inhibitor.

5 Claims, No Drawings

N-FLUOROPYRIDINIUM SALT AND PROCESS FOR PREPARING SAME

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

[This application is a continuation of application Ser. No. 022,275, filed Mar. 5, 1987, now abandoned, which was a continuation-in-part application of Ser. No. 870,010, filed Jun. 3, 1986, now abandoned.]

CROSS REFERENCE

This application is a Re-issue of Ser. No. 07/296,411 filed Jan. 09, 1989, U.S. Pat. No. 4,996,320, which is a Continuation of Ser. No. 07/022,275 filed Mar. 05, 1987, (abandoned), which is a Continuation-in-part of Ser. No. 06/870, 010 filed Jun. 03, 1986 (abandoned).

BACKGROUND OF THE INVENTION

The present invention relates to a N-fluoropyridinium salt and a process for preparing same. The N-fluoropyridinium salts according to the present invention are very useful as a fluorine atom introducing agent as seen from the examples 66–133 hereinafter illustrated. The salts according to the invention have a widespread use because of their high reactivity with a wide variety of compounds and selectivity for any desired products. For example, said salt can be used for the preparation of 3-fluoro-4-hydroxyphenlacetic acid which is useful as a thyroid inhibitor by reacting the former with p-hydroxyphenylacetate followed by a common hydrolysis reaction as illustrated in examples 79 to 82 referred to hereinafter.

Heretofore, it has been well known in the art that fluorine compounds are significantly distinguished from chlorine compounds, bromine compounds, and iodine compounds in their physical properties and reactivities, because fluorine atom have characteristics such as very high electronegativity, high ionization energy, extremely high bonding ability with other atoms, small Van der Waals diameter, lack of a d-electron orbit and the like (N. Ishikawa & Y. Kobayashi; FLUORINE COMPOUNDS; THEIR CHEMISTRY AND APPLICATIONS; KodanshaSchientific, pp. 69–70. 1979). Therefore, fluorination reactions naturally have significantly different aspects from other halogenation reactions such as chlorinations, brominations and iodinations.

In reactions with organic compounds, fluorine, contrary to chlorine, bromine and iodine, reacts very violently, readily giving rise to the fission of the C—C bond of organic compounds and in cases where the reaction is excessively violent, fire or explosion in turn can break out. The abnormality of fluorination reactions relative to other halogenation reactions may be readily understood from the comparison of heat of formation in halogenation reactions (see the description on pages 69–75 of the above article) as follows:

	ΔH (Kcal/mol)			
type of reaction	X = F	Cl	Br	I
C=C + X_2—CX—CX	−111	−36	−23	−16
C—H + X_2—C—X + HX	−105	−25	−9	+6

As seen from the above Table, since the heat of reaction in the fluorination reactions amount to ever 100Kcal/-mol,

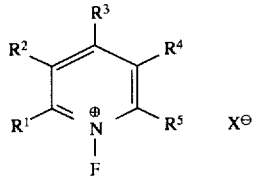
while the bonding energy between carbon-carbon atoms is approximately only 60Kcal/mol, the control of fluorination reactions is very difficult, contrary to other halogenation reactions. Accordingly, the development of fluorination reactions having better selectivity has been an important subject matter in fluorination industries.

For the purpose resolving the above problem, a wide variety of compoounds for introducing fluorine atoms have heretofore been studied and developed. As such compounds, for example, trifluoromethyl-hypofluorite (CF_3OF), trifluoroacetyl-hypofluorite (CF_3COOF), acetyihypofluorite (CH_3COOF), xenon difluoride XeF_2), $FClO_3$, sulfur tetrafluoride (SF_4), die-thylaminosulfur trifluoride (ET_2NSF_3), $CClHFCF_2NEt_2$,$CF_3CFHCF_2NEt_2$, heavy metal fluorides such as AgF, HgF, CoF_3,AgF_2 and the like were known in the art (see pages 79–94 of the above-mentioned article). However, these compounds have drawbacks such as poor selectivity for the desired reaction, are highly hazardous to handle, have high cost, unstableness, a limited scope of application, and the like which make them commercially unsatisfactory. On the other hand, hydrogen fluoride, hydrofluoric acid, potassium fluoride, cesium fluoride, and the like which are known as inexpensive agents for introducing fluorine atoms are inferior in electrophilic reactivity, which imposes such limitations that they cannot perform electrophilic substitutions for aromatic nuclei or negatively charged carbon ions. These compounds also present serious problems in handling because hydrogen fluoride or hydrofluoric acid, for example, are highly toxic. It has been suggested that a pyridine. F_2 complex can be used as a fluorine atom-introducing agent, but it can only offer low total yield of fluorination reactions [see, Z. Chem., 12, 292 (1972)] and moreover, said complex is highly hygroscopic and thermally unstable so that explosions may break out at above −2°C. [Z. Chem., 5, 64 (1965)]. From the above, it can hardly be said that the complex is a useful fluorinating agent. Recently, N-fluoro-N-alkylarenesulfoneamide have been reported as fluorine atom-introducing agents, but these compounds are low in reactivity and only effective for particular reaction species (negatively charged carbon ions) [J. Amer. Chem. Soc. 106, 452 (1984)]. Therefore, a strong need exists for the development of highly satisfactory fluorine atom-introducing agents.

As a result of a series of earnest investigations by the present inventors towards the development of a novel fluorine-introducing agent, they have succeeded in developing a novel fluorine-introducing agent which is active but stable allowing the easy handling of the agent which still retains high selectivity of a desired reaction, thus completing the present invention. The compounds according to the present invention have high reactivity with a variety of compounds and high selectivity for any desired compounds, which allows the compounds to be very useful for the synthesis of a variety of fluorine-containing compounds in a shortened process. For example, a thyroid inhibitor, 3-fluoro4-hydroxy-phenylacetic acid could easily be prepared from p-hydorxyphenylacetate available industrially (see, Examples 79–82 hereinafter described).

SUMMARY OF THE INVENTION

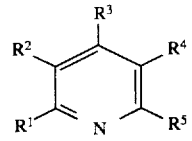
The present invention relates to a N-fluoropyridiuium salt represented by the formula:



(I)

wherein R^1, R^2, R^3, R^4 and R^5 represent a hydrogen atom, a halogen atom, an alkyl, aryl, acyl, alkoxycarbonyl, aryloxycarbonyl, carbamoyl, nitro, cyano, alkylsulfonyl arylsulfonyl, hydroxy, alkoxy, aryloxy, acyloxy, acylthio, amido, alkanesulfonyloxy, or arenesulfonyloxy group; $X_\ominus$ represents a conjugate base of Bronsted acid except for $F_\ominus$, $Cl_\ominus$, $Br_\ominus$ and $I_\ominus$ which are conjugate bases of hydrogen halides; and R^1, R^2, R^3, R^4 and R^5 may be combined together directly or through a hetero atom or atoms in a variety of combinations to form a cyclic structure, while $X_\ominus$ may be combined directly or through a hertro-atom or atoms with R^1, R^2, R^3, R^4 and R^5 in various combinations.

The present invention further relates to a process for producing the above N-fluoropyridinium salt by reacting a pyridine-compound having the general formula:



(II)

wherein R^1 to R^5 represent the same meaning as defined above, with fluorine (F_2) and a Bronsted acid compound having the general formula:

XM (III)

wherein M represents a hydrogen atom, a metal atom, an ammonium residue, a pyridinium residue or a group $SiR^6R^7R^8$ in which R^6,R^7 and R^8 are an aklyl, aryl, alkoxy, aryloxy, acyloxy group, or a halogen atom; and X represents the same meaning as above.

DETAILED DESCRIPTION OF THE INVENTION

The pyridine-copmpounds set forth in formula (II) employable in the present invention are those which are easily available or which may be prepared readily and are exemplified by pyridine; straight or branched alkylated or cyclic alkylated pyridine such as methyipyridine, dimethylpyridine, trimethylpyridine, tetramethylpyridine, pentamethylpyridine, ethylpyridine, diethylpyridine, butylpyridine, dibutylpyridine, tributylpyridine, pentylpyridine, hexylpyridine, decylpyridine, (trifluoromethyl)-pyridine, bis(trifluoromethyl)pyridine tris(trifluoromethyl)-pyridine, (trichloromethyl)pyridine, (pentafluoroethyl)-pyridine, (perfluorooctyl)pyridine, (methoxymethyl)pyridine, ethyl pyridylacetate, pyridylacetonitrile, pyridylacetone, and the like; halopyridines such as chloropyridine, bromopyridine, fluoropyridine, dichloropyridine, difluoropyridine, trichloropyridine, tetrachloropyridine, pentachloropyridine, trifluoropyridine, pentafluoropyridine, chlorofluoropyridine, dichlorofluoropyridine, and so on; (trifluoromethyl)chloropyridine, (trifluoromethyl)dichloropyridine, (trifluoromethyl)trichloropyridine, (trifluoromethyl)fluoropyridine, methylchloropyridine, phenylpyridine, diphenylpyridine, triphenylpyridine,-dipyridyl, acetylpyridine, bisacetylpyridine, benzoylpyridine;(alkoxycarbonyl)pyridine or (aryloxycarbonyl)pyridine such as (methoxycarbonyl)-pyridine, (exthoxycarbonyl)pyridine,(butoxycarbonyl)pyridine, bis(ethoyxcarbonyl)pyridine,bis(trifluoroethoxycarbonyl)-pyridine, tris(methoxycarbonyl)pyridine,(-phenoxycarbonyl)-pryidine; 2,3-pryidinedicarboxylic anhydride,nitropyridine, cyanopyridine, dicyanopyridine, tricyanopyridine, benzenesulfonylpyridine, methylsulfonylpyridine, chlorocyanopyridine, formylpyridine, (haloformyl)pyridine, nicotinamide,picolinamide, (dimethylaminocarbonyl)pyridine, methoxypyridine, dimethoxypyridine, propoxypyridine, butoxypyridine, menthoxypyridine, trifluoromethoxypyridine, acetoxypridine, trifluoroacetoxypyridine, phenoxypyridine, acetylthipoyridine, methanesulfonyloxypyridine, benzenesulfonyloxypyridine, acetylaminopyridine,3-hydroxypyridine, and 1,2,3,4,5,6,7,8-octahydroacridine.

As the [Brøsted] *Brønsted* acid-compounds represented by the formula (III), there may be mentioned the following compounds: sulfonic acids or sulfuric acids such as methanesulfonic acid, butanesulfonic acid, benzensulfonic acid, toluenesulfonic acid, nitrobenzensulfonic acid, dinitrobenzensulfonic acid, trinitrobenzensulfonic acid, trifluoromethanesulfonic acid, perfluorobutanesulfonic acid, perfluorooctanesulfonic acid, trichloromethanesulfonic acid, diflurormethanesulfonic acid, trifluoroethanesulfonic acid, fluorosulfonic acid, chlorosulfonic acid, monomethylsulfric acid, sulfuric acid, camphorsulfonic acid, bromocamphorsulfonic acid, Δ^4-cholestene-3-on-6-sulfonic acid, 1-hydroxy- p-methane- 2-sulfonic acid, p-styrenesulfonic acid, β-styrenesulfonic acid, poly(p-styrenesulfonic acid), vinylsulfonic poly(vinylsulfonic acid), poly(2-acrylamide-2-methyl-1-propanesulfonic acid), and a copolymer of said propanesulfonic acid with styrene, perfluoro- 3,5-dioxa-4-methyl-7-octenesulfonic acid, poly(-perfluoro- 3,6-dioxa-4-methyl-7-octensulfonic acid) and a copolymer of said octnesulfonic acid with tetrafluoroethylene, and the like; phosphoric acid; nitric acid; halogen acids such as perchloric acid, perbromic acid, periodic acid, chloric acid, bromic acid, and the like; carboxylic acids such as acetic acid, formic acid, trichloro-acetic acid, trifluoroacetic acid, pentafluoropropionic acid, dichloroacetic acid, acrylic acid, poly(acrylic acid), poly-(perfluoro-3,6-dioxa-4-methyl-7-octenoic acid) and a copolymer of said octenoic acid with tetrafluoroethylene and so on; compounds resulting from hydrogen halide and Lewis acids such as HBF_4, HPF_6, $HSbF_4$, $HSbF_6$, $HAsF_6$, $HBCl_3F$, $HSiF_5$ and the like; metal salts of the above mentioned [Brøsted] *Brønsted* acids; a variety of ammonium salts or pryidinium salts of the above mentioned [Brøsted] *Brønsted* acids; silyl compounds resulting from the substitution of hydrogen atom or atoms of the above mentioned [Brøsted] *Brønsted* acids with a group $SiR^6R^7R^8$ wherein R^6, R^7 and R^8 are the same as defined above, or metal bifluoride such as sodium bifluoride, for example. As the group $SiR^6R^7R^8$, there may be listed, for example, trimethylsilyl, triethylsilyl, dimethylbutylsilyl, dimethylphenylsilyl, triphenylsilyl, trihalosilyl, triacetylsilyl, triacetoxysilyl, trimethoxysilyl, triphenoxysilyl. As the metals for the metal salts of Brøsted acids reference is preferably made to alkali metals or alkaline earth metals from the aspect of economy and reaction efficiency. Further, as the variety of ammonium salts or pyridinium salts, there may be mentioned ammonium salts, trimethylammonium salts, triethylammonium salts, tetraethylammonium salts, benzyltrimethylammonium salts, phenylammonium salts, dimethylphenylammonium salts, naphthaylammonium salts, pryidinium salts, dimethylpyridinium salts, trimethylpyridinium salts, quinolinium salts and the like.

Of the N-fluoropyridinium salts represented by formula (I), in the case where $X_\ominus$and R^1, R^2, R^3, R^4 and R^5 are

combined together in a variety combinations, the pyridinium compounds represented by formula (II) as the raw material include, for example, sodium pyridinesulfonate, pyridinesulfonic acid, ammonium pyridinesulfonate, potassium pyridylethylsulfonate, sodium pyridinecarboxylate and the like.

The pyridine.F_2 complex where $X_\ominus$ represents $F_\ominus$ which is the conjugatge base of hydrogen halide in the N-fluoropyridinium salts has a serious drawback in that it is unstable and explodes at a temperature above −2° C. and when the conjugate base is $Cl_\ominus$, $Br_\ominus$ or $I_\ominus$ the corresponding N-fluoropyridinium salts are difficult in synthesis.

The Brøsted acid-compounds for achieving better reaction efficiencies should be equal to or in excess molar amount to that of the host material, but preferably should be an equi-molar amount from an economic viewpoint. Fluorine employed in the present invention should preferably be diluted with 50 to 99.9% by volume of an inert gas in order to suppress any violent reactions. The diluting gas includes, by way of example, nitrogen, helium, argon, tetrafluoromelthane, sulfur hexafluoride and the like.

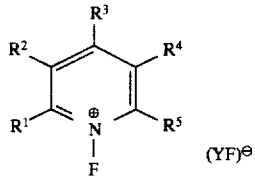
The fluorine gas for achieving better reaction efficiencies should be used in an equi-molar or in excess molar amount to be the host material. However since the amount may vary depending upon the manner of introduction, reaction temperature, reaction solvent, reaction apparatus and so on, it may preferably be selected in amounts required for eliminating the last traces of the host material.

The reaction is preferably carried out by the sue of a solvent. As the solvent, acetonitrile, methylene chloride, chloroform, carbon tetrachloride, trichlorofluoromethane, trichlorotrifluoroethane, ethyl acetate, diethyl ether, tetrahydrofuran, and the like or a mixture thereof may be used.

A reaction temperature of −100° to +40° C. may be selected, but the range of temperature of from −90° C. to room temperature is being preferred for better reaction yields.

In carrying out the process of the present invention it is occasionally preferable for improving the reaction efficiency to employ a trapping agent such as sodium fluoride to capture hydrogen fluoride produced as a by-product.

Of the N-fluoropyridinium salts having the formula (I), N-fluoropryidinium salt having the formula



(I')

(wherein R^1 to F^5 have the same meaning as above and Y represents a Lewis acid), can be prepared by reacting the pyridine-compound represented by formula (II) with fluorine (F_2) and a Lewis acid having the formula

Y (IV)

The Lewis acid, the starting material set forth in formula (IV), may include, for example, boron trifluoride, boron trichloride, triacetoxyboron, tri(tgrifluoroacetoxy)boron, aluminum trifluoride, aluminum trichloride, aluminum tribromide, phosphorous trifluoride, phosphorous pentafluoride, phosphorus pentachloride, arsenic trifluoride, arsenic trichloride, arsenic pentafluoride antimony trifluoride, antimony pentafluoride, antimony dichlorotrifluoride, silicon tetrafluoride, trimethylfluorosilane, dimethylphenylfluorosilane, sulfur trioxide, titanium tetrachloride, stannic chloride, ferric chloride, and iodine pentafluoride. Ethereal complexes of these Lewis acids may also employed without any problems. These Lewis acids may be employed in an equi-molar or in excess molar amount to he host material (II) for achieving a better reaction efficiency, but from the standpoint of economy the equi-molar amount be preferable. The manner in which fluroine is used and the amount of fluorine to be used are similar to the above embodiment.

A reaction of the present invention is preferably carried out by using a reaction solvent. The reaction solvent may include, for example, acetonitrile, methylenechloride, chloroform, trichlorofluoromethane, trichlorofluoroethane, ethylacetate, diethylether, tetrahydrofuran or a mixture thereof.

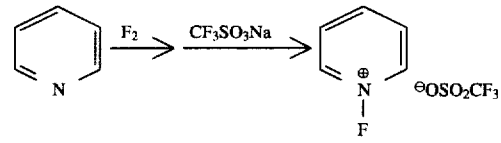
A reaction temperature may generally be in the range of [−100+'° C.,] *−100° to +40° C.* and preferably a range of [−90+° C.] *−90° to +20°* C. may be selected for a better yield.

The compounds (I) according to the present invention can be readily prepared and are in most cases stable in air at room temperature. These compounds enable the simple and selective introduction of a fluorine atom to a comtemplated compound with good efficiency and therefore serve as a superior fluorine-introducing agent. Further, the compounds according to the present invention, after they have once been reacted, reproduce the pyridine-compounds or form protonic salts of silyl salts of pyridine-compounds which can readily generate the starting pyridine-compounds by neutralization or treatment with water.

The following examples will illustrate the present invention in more detail.

EXAMPLE 1

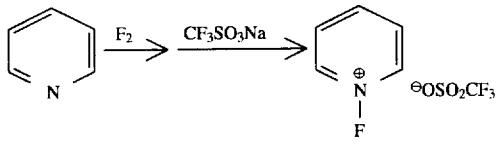
Preparation of
N-fluoropyridiniumtrifluoromethanesulfonate



To a 50 ml trichlorofluoromethane solution containing 1.0 g (12.6 m moles) of pyridine a mixed gas of fluorine and nitrogen in a volumetric ratio of 1:9 was introduced at a rate of 30 ml/min. at −78° C. under vigorous stirring. The amount of the fluorine gas introduced amounted to 34.8 mmoles. Subsequent to the fluorine introduction, 20 ml of anhydrous acetonitrile and 2.2 g (12.8 mmoles) of sodium trifluoro-methanesulfonate as a XM reactant were added to the reaction solution after which the temperature of the solution was raised to −40° C., while removing the solvent with the aid of an aspirator. The solvent, after filtering sodium fluoride formed as a byproduct, was distilled off and the resultant residue was recrystallized from THF to give 1.75 g (yield: 67%) of N-fluoropyridinium trifluoromethanesulfonate, the physical properties of which are shown in Table 6.

EXAMPLE 2

Preparation of
N-fluoropyridiniumtrifluoromethanesulfonate



To a 100 ml anhydrous acetonitrile solution containing 10 g (0.126 mole) of pyridine a mixed gas of fluorine and nitrogen was introduced at a rate of 90 ml/min. at –4020 C. under virorous stirring. The amount of the flourine gas introduced amounted to 0.18 mole. Subsequent to the fluorine introduction, 22 g (0.128 mole) of sodium trifluoromethanesulfonate as a XM reactant was added to the reaction solution after which the resultant reaction solution was maintained at –40° C. for 5 hours under stirring. Subsequently, the solvent, after filtering sodium fluoride, was distilled off and the resultant residue was recrystallized from methylene chloride to give 17.5 g (yield: 71%) of N-fluoropyridinium trifluoromethanesulfonate. The product thus obtained was repurified with methylene chloride/acetonitrile to recover 13.8 g (yield: 56%).

EXAMPLES 3–15

Example 3 was carried out as in Example 1 and Examples 4–15 were carried out as in Example 2. The reactants used and the results obtained are shown in Table 1 and the physical properties of the products are shown in Table 6.

Further, Example 12 employed sodium D-camphorsulfonate as the XM reactant and the angle of specific rotatory power of the product was $[\alpha]_D^{22}$=+29.51 (c=0.664, CH_3CN).

TABLE 1

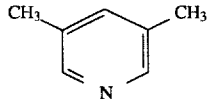
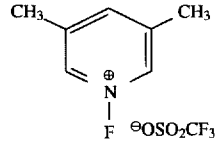
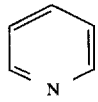
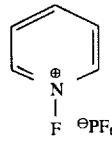
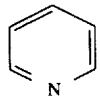
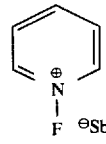
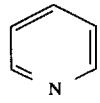
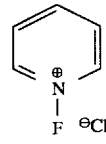
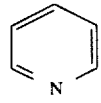
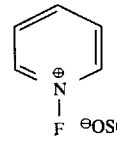
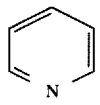
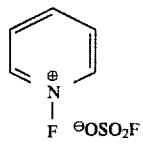
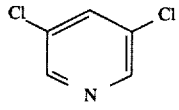
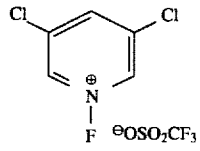
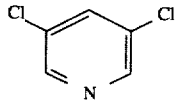
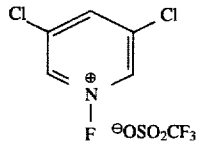
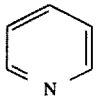
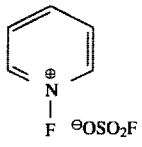
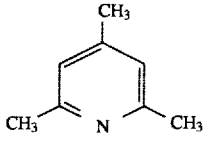
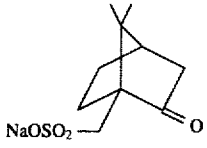
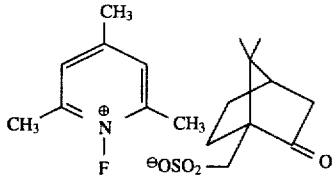
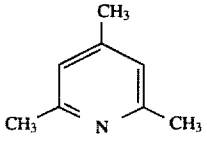
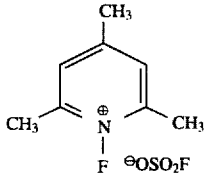
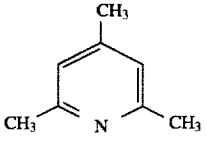
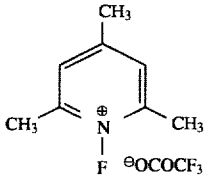
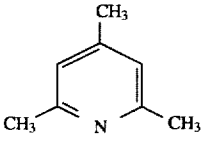
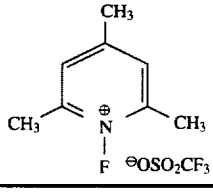
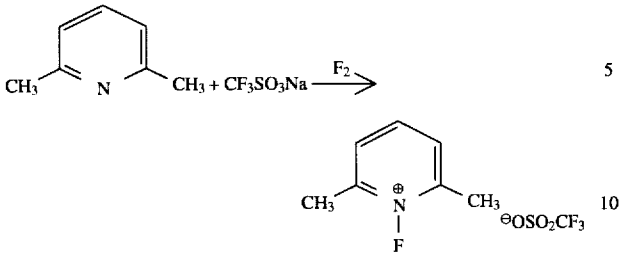
Example	pyridine-compound	XM	product	yield (%)
3		CF_3SO_3Na		60
4		$NaPF_6$		34
5		$NaSbF_6$		51
6		$NaClO_4$		72
7		CF_3SO_3H		44

TABLE 1-continued

Example	pyridine-compound	XM	product	yield (%)
8		$CF_3SO_3SiMe_3$		45
9		CF_3SO_3H		41
10		$CF_3SO_3SiMe_3$		62
11		FSO_3H		49
12				50
13		FSO_3H		56
14		$CF_3COOSiMe_3$		77
15		CF_3SO_3H		60

EXAMPLE 16



In 20 ml of anhydrous acetonitrile 0.50 g (4.67 mmoles) of 2.6- dimethylpyridine and 0.803 g (4.67 mmoles) of sodium trifluoromethanesulfonate as the XM reactant were dissolved, and to the resultant solution a mixed gas of fluorine and nitrogen (1:9) was added at a rate of 30 ml/min. at −40° C. under vigorous stirring. The amount of the fluorine gas introduced amounted to 8.93 mmoles. After the completion of the reaction, sodium fluoride was filtered and the solvent was distilled off. The resultant residue was recrystallized from THF to give 0.88 g (yield: 73%) of N-fluoro- 2,6-diemthyl-pyridinium trifluoromethanesulfonate. The resultant product was further recrystallized with THF/acetonitrile to obtain 0.82 g (yield: 69%), the physical properties of which are shown in Table 6.

EXAMPLES 17–26

Examples 17–26 were carried out as in Example 16 and the results are shown in Table 2 with the physical properties in Table 6. In Example 22, 2 -1-menthoxypyridine [[α]D^{20}= −110.7 (c=0.994, $CHCl_3$)] was used as the pyridine compound for the starting material and the specific rotary power of the resultant N-fluoro-2-1-menthoxypyridinium trifluoromethanesulfonate was [α]D^{25} =−77.73 (c=4.16, $CHCl_3$).

TABLE 2

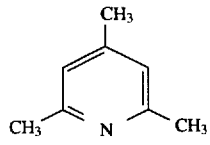
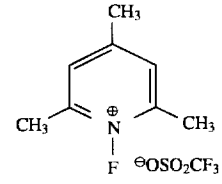
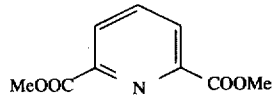
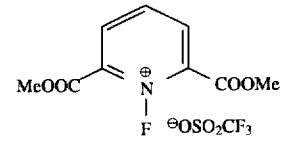
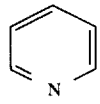
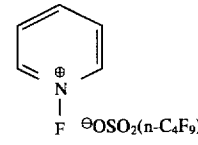
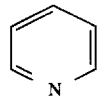
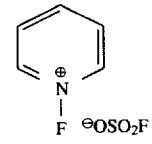
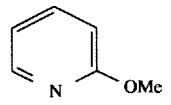
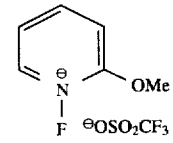
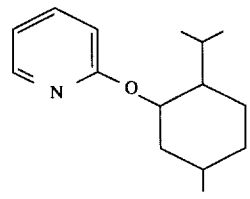
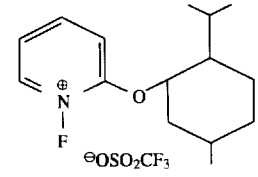
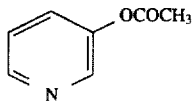
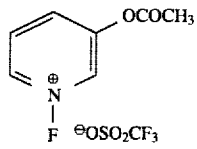
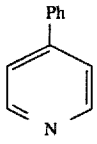
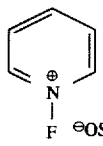
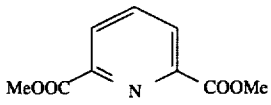
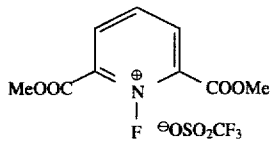
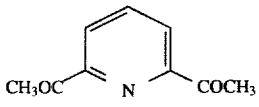
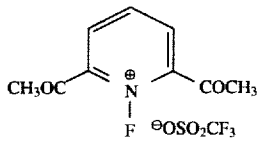
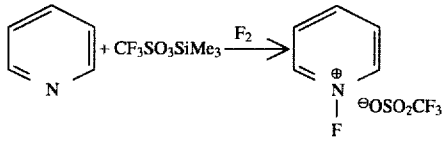
Example	Pyridine-Compound	XM	Product	Yield (%)
17		CF_3SO_3Na		82
18		CF_3SO_3Na		72
19		$n\text{-}C_4F_9SO_3Na$		87
20		CF_3SO_3Na		60
21		CF_3SO_3Na		73
22		CF_3SO_3Na		57

TABLE 2-continued

Example	Pyridine-Compound	XM	Product	Yield (%)
23		CF_3SO_3Na		90
24		CF_3SO_3Na		19
25		CF_3SO_3H		75
26		CF_3SO_3Na		60

Example 27



40

EXAMPLE 27

To a 5 ml anhydrous acetonitrile solution containing 0.408 g (5.17 mmoles) of pyridine, 1.0 ml (5.17 mmoles) of trimethylsilyl trifluoromethanesulfonate as the XM reactant was added at –40° C. under stirring. To the resultant solution a mixed gas of fluorine and nitrogen (1:9), 10 minutes after the addition, was introduced at a rate of 15 ml/min. The amount of fluorine gas introduced was 15.5 mmoles. After the completion of the reaction, an amount of ether cooled to –60° C. was added to the solution to precipitate crystals which were filtered to give 0.99 g (yield: 78%) of N-fluoropyridinium trifluoromethanesulfonate.

60

EXAMPLES 28–38

Examples 28–38 were carried out as in Example 27 except that in Examples 34 the gas ratio of fluorine:nitrogen was 2.5:97.5. The results are summarized in Table 3 with the physical properties in Table 6.

TABLE 3

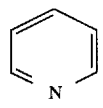
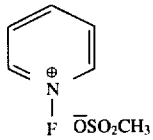
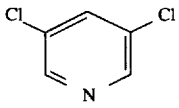
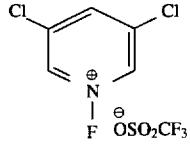
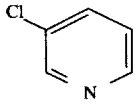
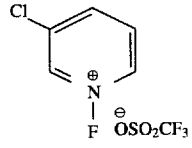
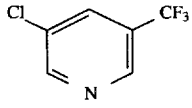
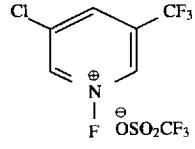
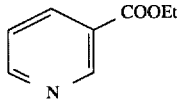
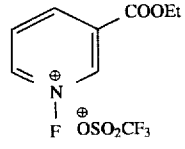
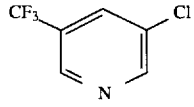
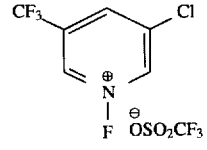
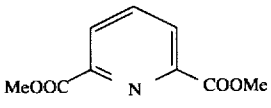
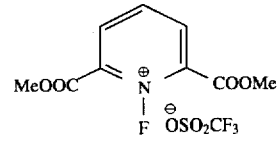
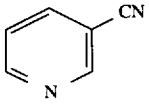
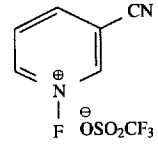
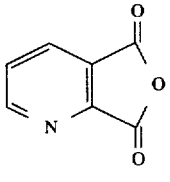
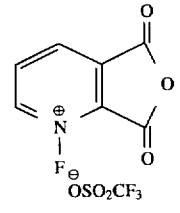
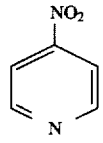
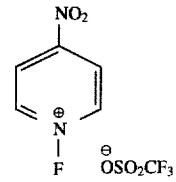
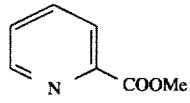
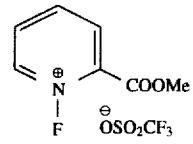
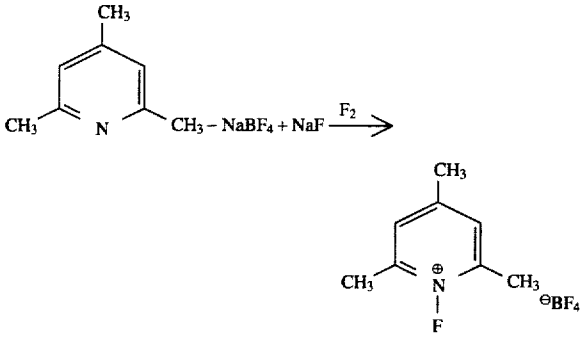
Example	Pyridine-Compound	XM	Product	Yield (%)
28		$CH_3SO_3SiMe_3$		42
29		$CF_3SO_3SiMe_3$		55
30		$CF_3SO_3SiMe_3$		79
31		$CF_3SO_3SiMe_3$		71
32		$CF_3SO_3SiMe_3$		69
33		$CF_3SO_3SiMe_2Ph$		71
34		$CF_3SO_3SiMe_3$		68
35		$CF_3SO_3SiMe_3$		30
36		$CF_3SO_3SiMe_3$		28

TABLE 3-continued

Example	Pyridine-Compound	XM	Product	Yield (%)
37		$CF_3SO_3SiMe_3$		52
38		$CF_3SO_3SiMe_3$		86

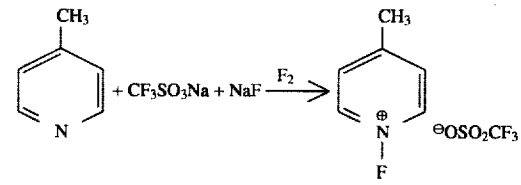
EXAMPLE 39



In a 25 ml pear-shaped flask, 2,4,6-trimethylpyridine (1.21 g, 10 mmoles), sodium borofluoride (1.23 g 10 mmoles) as the XM reactant and anhydrous sodium fluoride (2.1 g, 50 mmoles) were dissolved in 15 ml of anhydrous acetonitrile and to the resulting solution a mixed gas of nitrogen/fluorine (9:1) was introduced at a rate of 50 ml/min. at –40 ° C. under vigorous stirring.

The amount of fluorine introduced was 20 mmoles. After the completion of the reaction, precipitates were filtered and then the solvent was distilled off. The resultant residue was recrystallized from acetonitrile/diethylether to obtain 1.59 g (yield: 70%)of N-fluoro-2,4,6-trimethylpyridinium tetrafluoroborate the physical properties of which are shown in Table 6.

EXAMPLE 40



This example was effected as in example 39 to give N-fluoro-4-methylpyridinium trifluoromethanesulfonate in 90% yield, the physical properties of which are indicated in Table 6.

EXAMPLE 41–60

Further examples were carried out by using various pyridine compounds and XM. The experimental methods, the reaction products and the yeilds are shown in Table 4. The physical properties of the products are indicated in Table 6.

TABLE 4

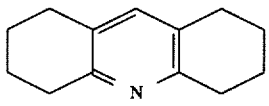
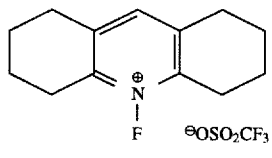
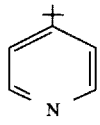
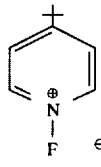
Example	Pyridine Compound	XM	Trapping Agent	Experimental Method	Product	Yield (%)
41		CF_3SO_3Na	—	Ex. 16		76
42		CF_3SO_3Na	NaF	Ex. 39		86

TABLE 4-continued

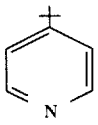
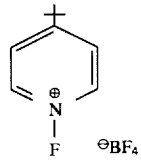
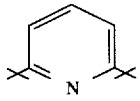
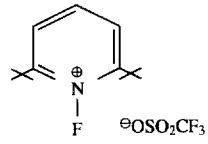
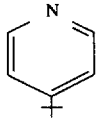
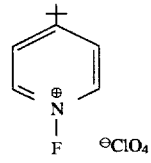
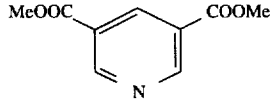
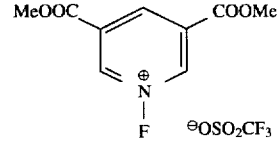
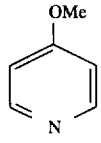
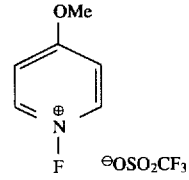
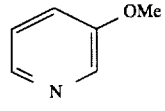
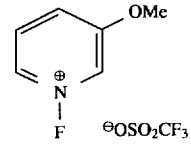
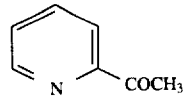
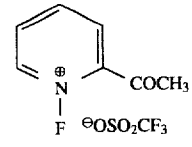
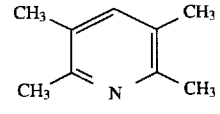
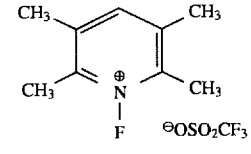
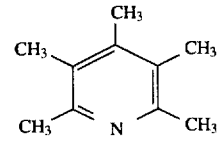
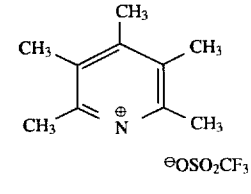
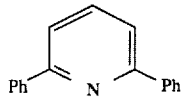
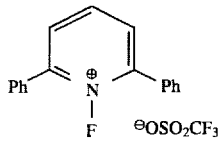
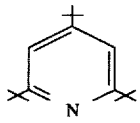
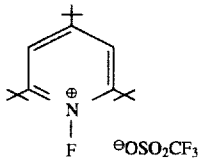
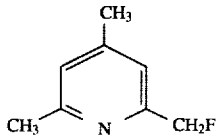
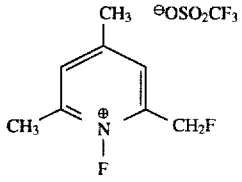
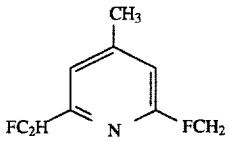
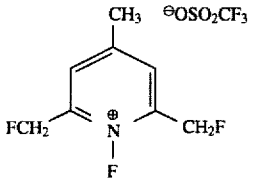
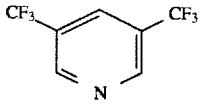
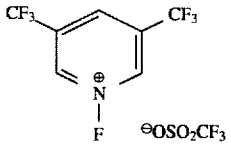
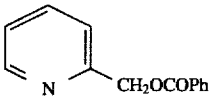
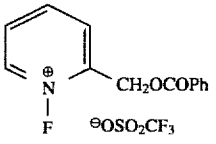
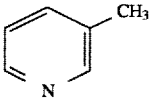
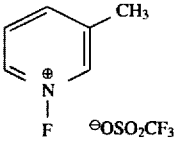
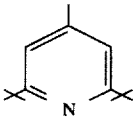
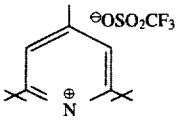
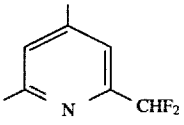
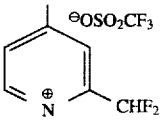
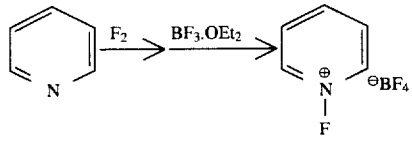
Example	Pyridine Compound	XM	Trapping Agent	Experimental Method	Product	Yield (%)
43		$NaBF_4$	NaF	Ex. 39		65
44		CF_3SO_3Na	NaF	Ex. 39		26
45		$NaClO_4$	—	Ex. 39		81
46		$CF_3SO_3SiMe_3$	—	Ex. 27		60
47		CF_3SO_3Na	NaF	Ex. 39		87
48		CF_3SO_3Na	NaF	Ex. 39		62
49		CF_3SO_3Na	—	Ex. 16		72
50		CF_3SO_3Na	NaF	Ex. 39		33
51		$CF_3SO_3SiMe_3$	NaF	Ex. 39		18

TABLE 4-continued

Example	Pyridine Compound	XM	Trapping Agent	Experimental Method	Product	Yield (%)
52		$CF_3SO_3SiMe_3$	—	Ex. 2		15
53		CF_3SO_3Na	NaF	Ex. 39		1.3
54		$CF_3SO_3SiMe_3$	—	Ex. 1		little
55		$CF_3SO_3SiMe_3$	—	Ex. 1		little
56		$CF_3SO_3SiMe_3$	—	Ex. 27		68
57		CF_3SO_3Na	NaF	Ex. 39		84
58		CF_3SO_3Na	NaF	Ex. 39		56
59*		CF_3SO_3Na	Na_2CO_3	Ex. 39		10
60		$CF_3SO_3SiMe_3$	—	Ex. 1		little

*Acetonitrile-water (1:1) is used as a reaction medium.

EXAMPLE 61

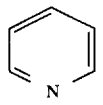
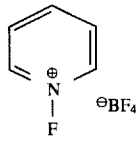
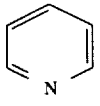
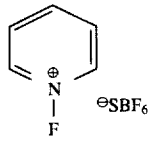
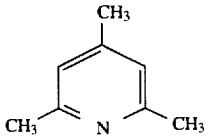
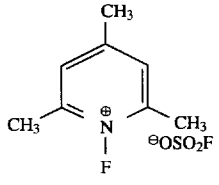


To a 30 ml anhydrous acetonitrile solution containing 0.71 g (8.98 mmole) of pyridine a mixed gas of fluorine and nitrogen (1:9) was introduced at a rate of 20 ml/min. at −40° C. under vigorous stirring, the amount of fluorine gas introduced being 26 mmoles. Subsequently, at the same temperature, 1 ml (8.13 mmole) of an ethereal complex of boron trifluoride as the Lewis acid was added and the resulting solution was stirred for 5 hours. The post treatment was effected as in example 13 to give 0.91 g (yield: 69%) of N-fluoropyridinium tetrafluoroborate, the physical properties of which are reproduced in Table 6.

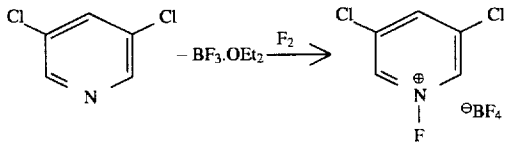
EXAMPLES 62–64

These Examples 62 to 64 were carried out as in Example 61, and the results of which are summarized in Table 5 with the physical properties in Table 6. It should be noted that the appropriate amount of boron fluoride, BF_3, was introduced in the form of a gas, because [BD] BF_3 is a gas, while SbF_5 and SO_3 are introduced in liquid form.

TABLE 5

Example No.	Pyridine-Compound	Lewis Acid	Product	Yield (%)
62		BF_3		62
63		SbF_5		37
64		SO_3		46

Example 65



This Example was carried out as in Example 16 except that boron trifluoride etherate was used in place of sodium trifluoromethanesulfonate to obtain N-fluoro- 3,5-dichloro-pyridinium tetrafluoroborate (yield: 79%), the physical properties of which are given in Table 6.

TABLE 6

Physical Properties of N-fluoropyridinium Salts

Example No.	Melting Point (°C.)	F-NMR (ppm) ($CFCl_3$ internal standard in CD_3CN)	Mass (m/e)	Elemental analysis (Calculated) C %	H %	N %
1, 2, 7, 8, 27	185–187	–48.75 (1F, bs, NF) 77.61 (3F, s, CF_3)	227(M^+-HF)	29.17 (29.16)	1.99 (2.04)	5.66 (5.67)
3	41–42	–46.89 (1F, bs, NF) 77.75 (3F, s, CF_3)	255(M^+-H)	34.72 (34.91)	3.35 (3.30)	5.07 (5.09)
4	202 (decomposition)	–48.58 (1F, bs, NF) 71.68 (6F, d, J = 715 Hz, PF_6)	174, 172 107, 97	24.84 (24.69)	2.10 (2.06)	5.65 (5.76)
5, 63	>300	–48.82 (1F, bs, NF) 69.0–175.0 (6F, m, SbF_6)	278, 276 (M^+-3F)	18.02 (17.96)	1.50 (1.50)	4.09 (4.19)
6	225–227.5 (with decompo.)	–48.75 (1F, bs, NF)	156, 155, 97, 79	30.50 (30.38)	2.23 (2.53)	7.12 (7.09)
9, 10, 29	99.5–110	–52.13 (1F, bs, NF) 77.63 (3F, s, CF_3)	299, 297 295 (M^+-HF)	22.68 (22.80)	0.94 (0.96)	4.58 (4.43)
11	120–125	–48.18 (1F, bs, NF) –38.21 (1F, s, S)	177 (M^+-HF) 149	30.56 (30.46)	2.57 (2.56)	7.03 (7.10)
12	135–136.5	–17.25 (bs, NF)	151, 139	58.00 (58.20)	7.05 (7.05)	3.74 (3.77)
13, 64	162–164 (decomposition)	–38.25 (1F, s, SO_2F) –17.25 (1F, bs, NF)	237 219(M^+-HF)	39.36 (40.16)	4.52 (4.60)	5.90 (5.89)
14	24–25.5	–17.63 (1F, bs, NF) 75.00 (3F, s, CF_3)	— —	— —	— —	— —
15, 17	168.5–170	–17.25 (1F, bs, NF) 77.62 (3F, s, CF_3)	139 121	37.15 (37.37)	3.87 (3.84)	4.66 (4.84)
16	126–128	–24.75 (1F, bs, NF) 77.75 (3F, s, CF_3)	255(M^+-HF)	34.86 (34.91)	3.26 (3.30)	5.03 (5.09)
18, 25, 34	140–143	–25.50 (1F, bs, NF) 77.61 (3F, s, CF_3)	227, 137, 69, 59	30.31 (30.32)	2.52 (2.53)	5.07 (5.05)
19	111–112	–48.37 (1F, bs, NF), 80.30 (3F, tt, J = 10.1, 3.0 Hz, CF_3) 114.2 (2F, m, CF_2), 120.9 (2F, m, CF_2), 125.2 (2F, M, CF_2S)	377(M^+-HF)	27.08 (27.22)	1.35 (1.27)	3.55 (3.53)
20	119.5–120.5	–37.13 (1F, bs, NF) 77.25 (3F, s, CF_3)	— —	— —	— —	— —
21	95–96	–0.75 (1F, bs, NF) 77.58 (3F, s, CF_3)	182, 179, 128 113, 95, 69	30.31 (30.32)	2.52 (2.53)	5.07 (5.05)
22	111–111.5 (decomposition)	–0.75 (1F, bs, NF) 77.62 (3F, s, CF_3)	— —	47.70 (47.87)	5.87 (5.77)	3.46 (3.49)
23	111.5–112.5	–51.00 (1F, bs, NF) 77.61 (3F, s, CF_3)	243, 187, 186 137, 135, 113	31.72 (31.48)	2.02 (2.30)	4.43 (4.60)
24	88–91	–39.38 (1F, bs, NF) 77.63 (3F, s, CF_3)	— —	— —	— —	— —
26	79–80	–25.05 (1F, bs, NF) 77.98 (3F, s, CF_3)	163 137	— —	— —	— —
28	55–58	–48.75 (1F, bs, NF) (*)	173 (M^+-HF)	—	—	—
30	108–109	–50.59 (1F, bs, NF) 70.70 (3F, s, CF_3)	263, 261 (M^+-HF)	26.38 (26.52)	1.53 (1.47)	5.81 (5.17)
31, 33	105–108	–54.22 (1F, bs, NF) 61.50 (3F, s, CF_3) 78.10 (3F, s, CF_3S)	341, 199 197	23.81 (24.05)	1.12 (0.86)	3.98 (4.01)
32	115–116	–50.02 (1F, bs, NF) 77.68 (3F, s, CF_3)	299 (M^+-HF)	33.74 (33.86)	2.73 (2.85)	4.28 (4.39)
35	57–65	–53.25 (1F, bs, NF) 77.61 (3F, s, CF_3)	— —	— —	— —	— —
36	110–115 (decomposition)	–36.38 (1F, bs, NF) 77.61 (3F, s, CF_3)	— —	— —	— —	— —
37	112–116	–54.75 (1F, bs, NF) 77.61 (3F, s, CF_3)	— —	— —	— —	— —
38	115–116	–38.44 (1F, bs, NF) 78.04 (3F, s, CF_3)	137, 107, 79, 78	31.49 (31.48)	2.28 (2.30)	4.59 (4.59)
39	215–217	–17.25 (1F, bs, NF) 149.6 (4F, s, BF_4)	157, 139	42.37 (42.33)	4.75 (4.88)	6.24 (6.17)
40	84–88	–40.50 (1F, bs, NF) 77.48 (3F, s, CF_3)	241 (M^+-HF)	32.12 (32.19)	2.87 (2.70)	5.25 (5.36)
41	149.5–152	–19.75 (1F, bs, NF) 78.00 (3F, s, CF_3)	— —	— —	— —	— —
42	116–118	–40.05 (1F, bs, NF) 78.02 (3F, s, CF_3)	268 (M^+-HF) 135, 120	39.29 (39.60)	4.22 (4.32)	4.50 (4.62)
43	143–145	–39.99 (1F, bs, NF) 150.6 (4F, s, BF_4)	138, 110	44.21 (44.85)	5.32 (5.44)	5.64 (5.81)
44	112–114	–23.63 (1F, bs, NF) 78.00 (3F, s, CF_3)	210, 190	46.56 (46.80)	5.89 (5.85)	3.86 (3.90)
45	146–148	–40.00 (bs, NF)	120	—	—	—

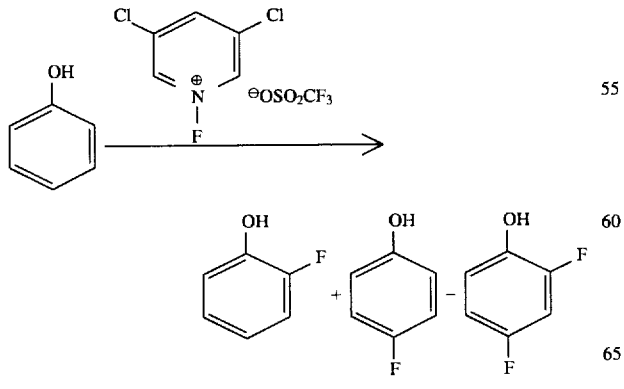
TABLE 6-continued

Physical Properties of N-fluoropyridinium Salts

Example No.	Melting Point (°C.)	F-NMR (ppm) ($CFCl_3$ internal standard in CD_3CN)	Mass (m/e)	Elemental analysis (Calculated) C %	H %	N %
46	144–147	−51.88 (1F, bs, NF) 78.00 (3F, s, CF_3)	343 (M^+-HF), 248, 182	32.84 (33.07)	2.46 (2.50)	3.84 (3.86)
47	32	−27.38 (1F, bs, NF) 77.25 (3F, s, CF_3)	258 257(M^+-HF), 69	30.35 (30.33)	2.61 (2.55)	5.02 (5.05)
48	viscous	−50.10 (1F, bs, NF) 77.20 (1F, s, CF_3)	108	—	—	—
49	151–152	−37.5 (1F, bs, NF) 77.30 (3F, s, CF_3)	—	—	—	—
50	136–138	−28.88 (1F, bs, NF) 78.00 (3F, s, CF_3)	283 (M^+-HF) 135	39.84 (39.60)	4.36 (4.29)	4.41 (4.62)
51	97–97.5	−27.00 (1F, bs, NF) 77.62 (3F, s, CF_3)	168, 167 149	51.83 (52.05)	6.95 (6.99)	3.33 (3.37)
52	131–133	−19.50 (1F, bs, NF) 77.25 (3F, s, CF_3)	249 231	53.72 (54.10)	3.19 (3.26)	3.42 (3.51)
53	238–239	−17.25 (1F, bs, NF) 77.25 (3F, s, CF_3)	266, 246 232, 205	41.20 (41.38)	4.75 (4.70)	4.33 (4.39)
54	162.5–163.5	−15.75 (1F, bs, NF) 77.72 (3F, s, CF_3) 226.5 (1F, dt, J = 45, 10.5 Hz, CH_2F)	139 121	35.07 (35.18)	3.26 (3.26)	4.43 (4.56)
55	160–163	−14.63 (1F, bs, NF) 77.62 (3F, bs, CF_3) 228.0 (2F, dt, J = 45, 10.2 Hz, CH_2F)	306, 305 157	32.65 (33.23)	2.70 (2.77)	4.14 (4.31)
56	193–195	−54.75 (1F, bs, NF) 61.50 (6F, s, β-CF_3) 78.00 (3F, s, CF_3)	375 271 69	24.9 (25.08)	0.85 (0.79)	3.64 (3.66)
57	94–96	−36.37 (1F, bs, NF) 77.40 (3F, s, CF_3)	361 (M^+-HF)	43.63 (44.10)	2.72 (2.91)	3.58 (3.67)
58	vsicous	−46.88 (1F, bs, NF) 78.00 (3F, s, CF_3)	241 (M^+-HF)	31.17 (32.18)	2.72 (2.68)	5.26 (5.36)
59	159	−15.75 (1F, bs, NF) 76.87 (3F, s, NF)	359 338 190	48.04 (47.75)	6.27 (6.14)	3.68 (3.71)
60	162–168	−15.75 (1F, bs, NF) 77.68 (3F, s, CF_3) 119.3 (2F, dd, J = 52.5, 10.6 Hz, CHF_2)	306, 305 175, 172 157, 156	33.11 (33.23)	2.68 (2.77)	4.20 (4.31)
61, 62	90–91	−48.75 (1F, bs, NF) 149.6 (4F, s, BF_4)	104	32.53 (32.43)	2.64 (2.70)	7.43 (7.57)
65	208–209	−52.67 (1F, bs, NF) 150.5 (4F, s, BF_4)	169 167(M^+-HBF_4) 165	23.62 (23.66)	1.11 (1.19)	5.44 (5.52)

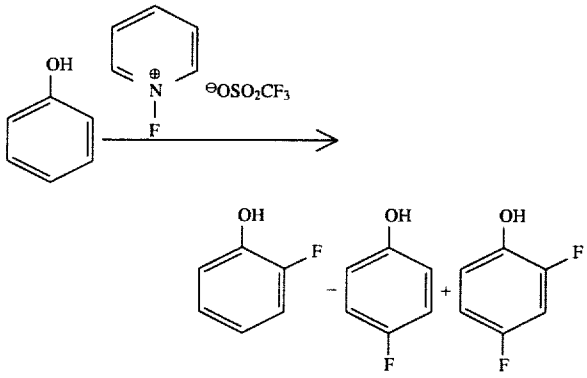
The Following Examples 66–133 are contemplated to elucidate the use of the compounds according to the present invention as the fluorine introducing agent.

EXAMPLE 66



A methylene chloride solution (1 ml) containing 1.0 mmole of phenol and 1.0 mmole of N-fluoro-3,5-dichloropyridinium trifluyoromethanesulfonate was refluxed under an argon atmosphere for 5 hours. After the reaction was completed, the reaction solution was analysed by gas chromatography to reveal that it contained o-fluorophenol (0.44 mmole), p-fluorophenol (0.13 mmole), 2,4-difluorophenol (0.06 mmole), and phenol (0.27 mmole). Thus the yields of o-fluorophenol, p-fluorophenol and 2,4-difluorophenol were 60%, 18%, and 7% respectively. The total yield was 88% corresponding to the total conversion of 73%. It is noted that no m-fluorophenol was formed.

EXAMPLE 67



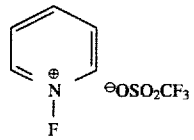
A 1,1,2-trichloroethane solution (2 ml) containing 1.0 mmole of phenol and 0.5 mmole of N-fluoropyriinium trifluoromethanesulfonate was heated at 100° C. for 24 hours under an argon atmosphere and 0.25 mmole of additional N-fluoropyridinium trifluoromethanesulfonate, was added both after 3 hours and 6 hours, thus bringing the total amount of N-fluoropyridinium trifluoromethanesulfonate to 1.0 mmole. After the reaction, the resulting reaction solution was subjected to gas chromatography to reveal that it contained 0.40 mmole of o-fluorophenol, 0.14 mmole of p-fluorophenol, 0.05 mmole of 2,4-difluorophenol and 0.21 mmole of phenol. Therefore, the yields of o-, p-fluorophenols and 2,4-difluoro-phenol were 51%, 18% and 6% respectively, corresponding to the total yields to 75%, with the total conversion of 79%.

EXAMPLES 68–133

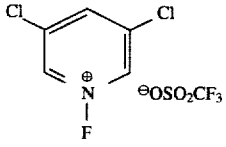
A wide variety of fluorine- containing compounds were prepared by reacting N-fluoropyridinium salts according to the present invention with an equi-molar amount of compounds contemplated to be fluorinated. These examples were carried out similar to Example 66 with the reaction conditions set forth in Tables 7–10. The results obtained are also indicated in Tables 7–10. The identification of the structures of the resulting compounds were effected by comparing those with a standard specimem or with spectroscopy.

In Tables 7–10, the N-fluoropydinium salts set foth below were expressed, for simplicity' sake, with the following No. of compounds:

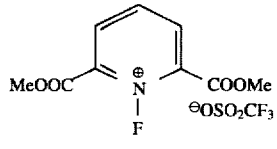
1



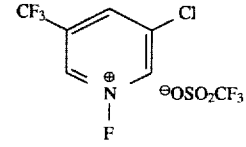
2



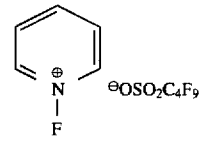
3



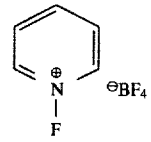
4



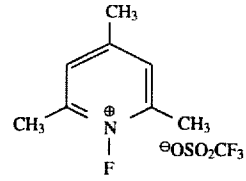
5



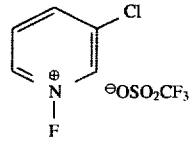
6



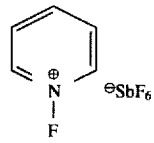
7



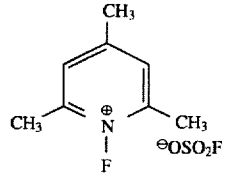
8



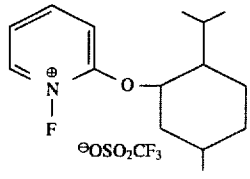
9



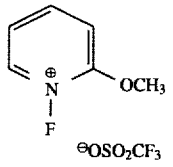
10



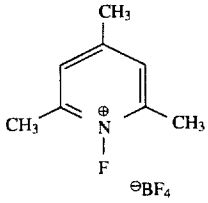
11



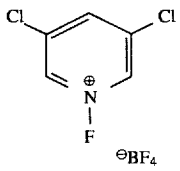
12



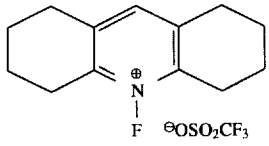
-continued



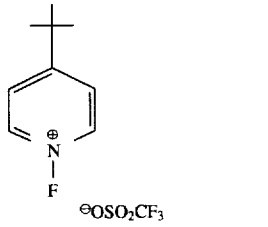
13



14



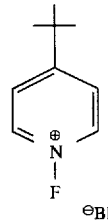
15



16

-continued

17



18

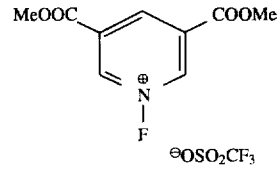


TABLE 7

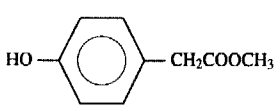
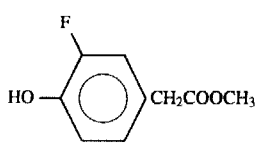
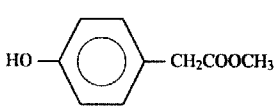
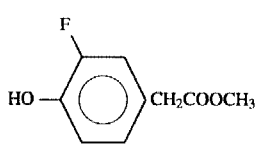
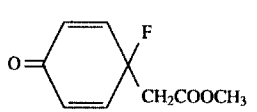
Example No.	Aromatic Compound	N-Fluoropyridinium salt (indicated by compound number)	Solvent	Temperature (°C.)	Hours (b)	Conversion (%)	Fluorine containing compound	Yield (%)	^{19}F-NMR (ppm) ($CFCl_3$ internal standard in $CDCl_3$)
68	phenol	3	CH_2CH_2	room temp	18	78	o-fluorophenol	30	—
							p-fluorophenol	24	—
							2,4-difluorophenol	3	—
69	phenol	4	CH_2CH_2	reflux temp	5		o-fluorophenol	40	—
							p-fluorophenol	11	
							2,4-difluorophenol	5	—
70	phenol	5	$CH_2ClCHCl_2$	100	16	80	o-fluorophenol	49	—
							p-fluorophenol	14	—
							2,4-difluorophenol	trace	—
71	phenol	6	$CH_2ClCHCl_2$	reflux temp	72	73	o-fluorophenol	24	—
72	phenol	7	$CH_2ClCHCl_2$	100	24	75	o-fluorophenol	47	—
							p-fluorophenol	31	—
							2,4-difluorophenol	3	—
73	phenol	14	CH_2Cl_2	reflux temp	24	61	o-fluorophenol	84	—
							p-fluorophenol	10	—
							2,4-difluorophenol	1	—
74	phenol	16	$CH_2ClCHCl_2$	120	10	70	o-fluorophenol	45	—
							p-fluorophenol	15	—
75	phenol	17	$CH_2ClCHCl_2$	120	10	70	o-fluorophenol	42	—
							p-fluorophenol	15	—
76	anisole	2	CH_2ClCH_2Cl	reflux temp	18	65	o-fluoroanisole	48	—
							p-fluoroanisole	51	—
77	anisole	1	CH_2ClCH_2Cl	reflux temp	18	58	o-fluoroanisole	40	—
							p-fluoroanisole	47	—
78	anisole	3	CH_2Cl_2	reflux temp	24	71	o-fluoroanisole	44	—
							p-fluoroanisole	48	—
79		2	CH_2Cl_2	reflux temp	5	57		71	140.3
80		3	CH_2Cl_2	reflux temp	3	79		46	140.3
								23	149.6

TABLE 7-continued

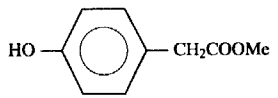
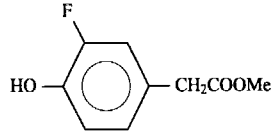
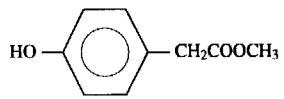
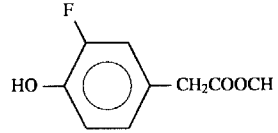
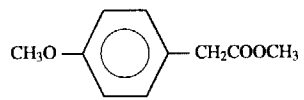
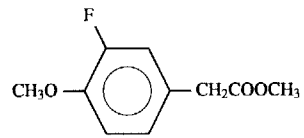
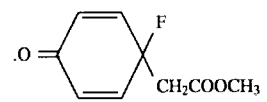
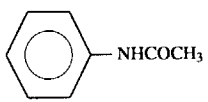
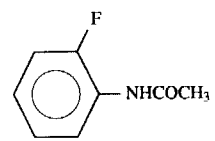
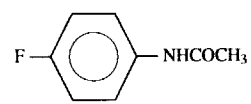
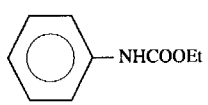
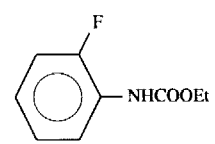
Example No.	Aromatic Compound	N-Fluoropyridinium salt (indicated by compound number)	Solvent	Temperature (°C.)	Hours (b)	Conversion (%)	Fluorine containing compound	Yield (%)	^{19}F-NMR (ppm) ($CFCl_3$ internal standard in $CDCl_3$
81		18	CH_2Cl_2	reflux temp	50	85		55	140.3
82		2	CH_2Cl_2	reflux temp	47	78		51	140.3
83		3	CH_2Cl_2	reflux temp	25	62		47	134.6
								31	149.6
84		3	CH_2Cl_2	reflux temp	48	53		28	130.5
								24	117.8
85		3	CH_2Cl_2	reflux temp	32	68		47	131.9

TABLE 7-continued

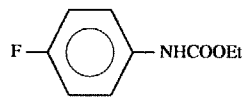
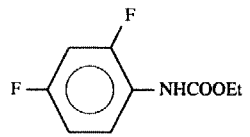
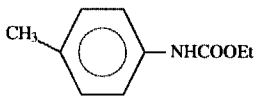
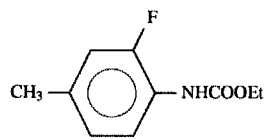
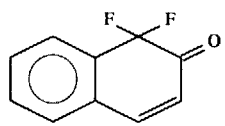
Example No.	Aromatic Compound	N-Fluoropyridinium salt (indicated by compound number)	Solvent	Temperature (°C.)	Hours (b)	Conversion (%)	Fluorine containing compound	Yield (%)	^{19}F-NMR (ppm) ($CFCl_3$ internal standard in $CDCl_3$
								32	119.1
								5	1158 126.7
86		2	CH_2Cl_2	reflux temp	18	56		71	133.1
87	p t butyphenol	2	CH_2Cl_2	reflux temp	27	83	2-fluoro-4,1-butylphenol	68	139.1
							p-fluorophenol	7	123.5
88	2 naphthol	2	CH_2Cl_2	room temp	26	80	1-fluoro-2-naphthol	84	155.2
								11	101.6
89	benzene	3	benzene	reflux temp	24	—	fluorobenzene	56	111.4 (in benzene solvent)

TABLE 8

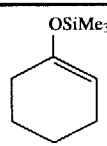
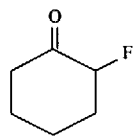
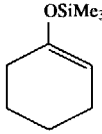
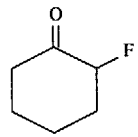
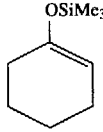
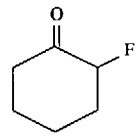
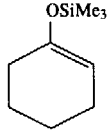
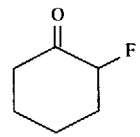
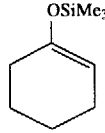
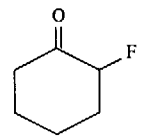
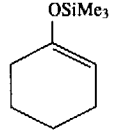
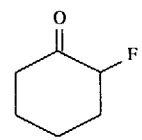
Example No.	Enol Compound	N-Fluoropyridinium salt (indicated by compound number)	Solvent	Temperature (°C.)	Hours (h)	Fluorine Containing compound	Yield (%)	^{19}F-NMR (ppm) ($CFCl_3$ internal standard in $CDCl_3$)
90		1	CH_2Cl_2	room temp	7		87	188(d, J=50Hz)
91		7	CH_2Cl_2	room temp	4		57	188(d, J=50Hz)
92		8	CH_2CH_2	room temp	3		65	188(d, J=50Hz)
93		2	CH_2Cl_2	room temp	2		62	188(d, J=50Hz)
94		6	CH_2Cl_2	reflux temp	6		41	188(d, J=50Hz)
95		9	CH_2CH_2	reflux temp	8		23	188(d, J=50Hz)

TABLE 8-continued

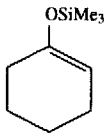
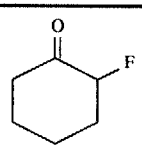
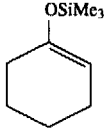
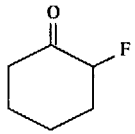
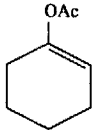
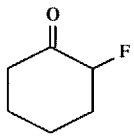
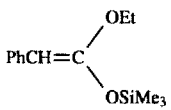
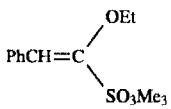
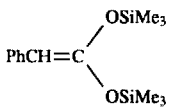
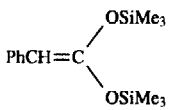
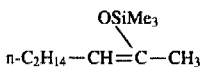
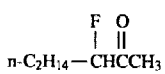
Example No.	Enol Compound	N-Fluoropyridinium salt (indicated by compound number)	Solvent	Temperature (°C.)	Hours (h)	Fluorine Containing compound	Yield (%)	^{19}F-NMR (ppm) ($CFCl_3$ internal standard in $CDCl_3$)
96		5	CH_2Cl_2	room temp	5		69	188(d, J=50Hz)
97		10	CH_2Cl_2	reflux temp	24		40	188(d, J=50Hz)
98		3	CH_2Cl_2	reflux temp	3		24	188(d, J=50Hz)
99		1	CH_2Cl_2	room temp	2	PhCHFCOOEt	65	180(d, J=48Hz)
100		7	CH_2Cl_2	room temp	2	PhCHFCOOEt	71	180(d, J=48Hz)
101		7	CH_2Cl_2	room temp	2	PhCHFCOOH	68	181(d, J=48Hz)
102		11	CH_2Cl_2	room temp	2	PhCHFCOOH	70	181(d, J=48Hz)
103		1	CH_2Cl_2	reflux temp	3		58	188(m)

TABLE 8-continued

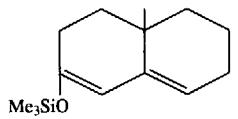
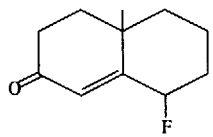
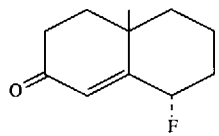
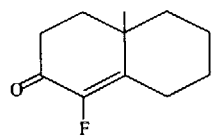
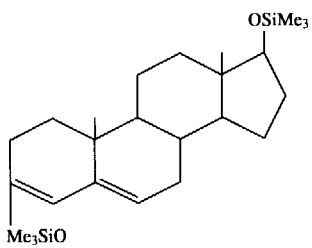
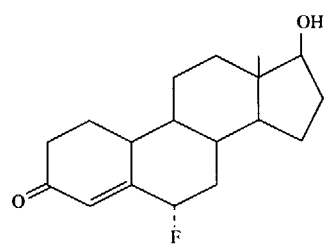
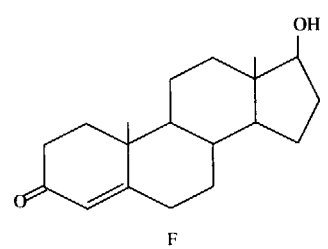
Example No.	Enol Compound	N-Fluoropyridinium salt (indicated by compound number)	Solvent	Temperature (°C.)	Hours (h)	Fluorine Containing compound	Yield (%)	^{19}F-NMR (ppm) ($CFCl_3$ internal standard in $CDCl_3$)
104		1	CH_2Cl_2	room temp	3		31	168(t, J=51Hz)
							21	184(d, J=50Hz)
							10	206(d, J=50Hz)
105		1	CH_2Cl_2	room temp	1		31	166(t, J=50Hz)
							11	183(d, J=50Hz)

TABLE 8-continued

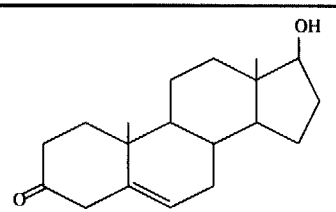
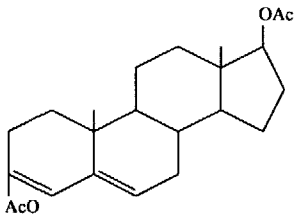
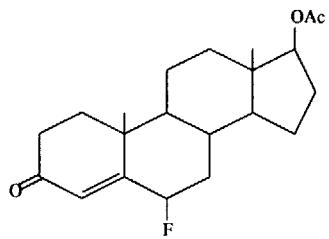
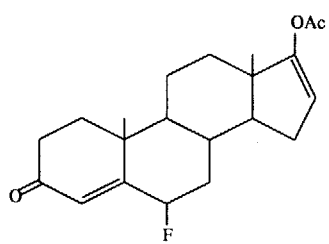
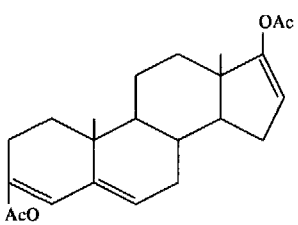
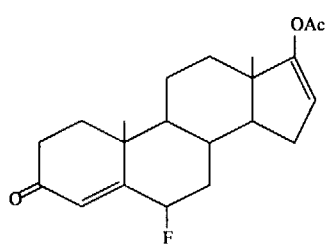
Example No.	Enol Compound	N-Fluoropyridinium salt (indicated by compound number)	Solvent	Temperature (°C.)	Hours (h)	Fluorine Containing compound	Yield (%)	^{19}F-NMR (ppm) ($CFCl_3$ internal standard in $CDCl_3$)
							18	206(d, J=50Hz)
106		1	CH_2Cl_2	reflux temp	10		48	166(t, J=48Hz)
							24	184(d, J=48Hz)
107		1	CH_2Cl_2	reflux temp	14		31	166(t, J=49.5Hz)

TABLE 8-continued

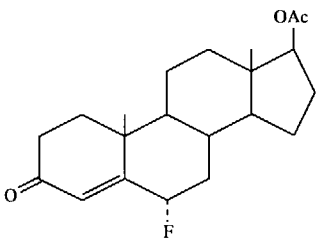
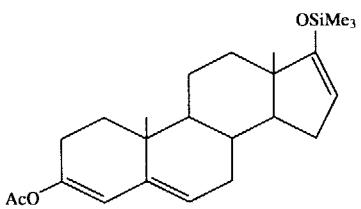
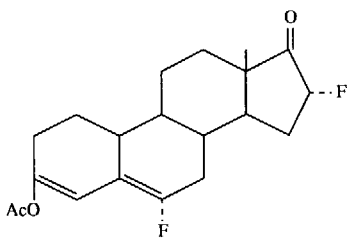
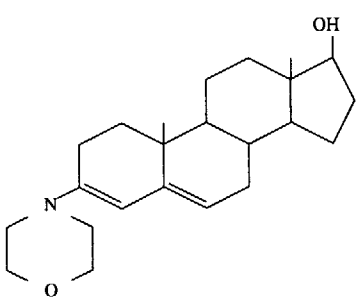
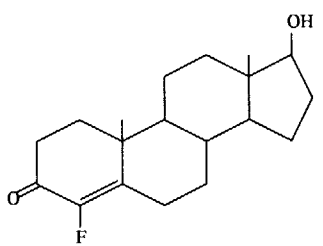
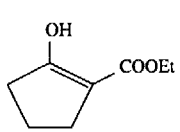
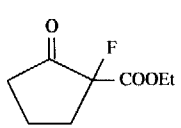
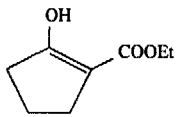
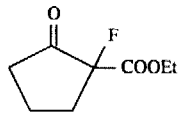
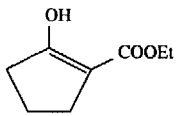
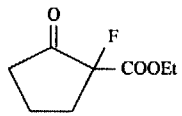
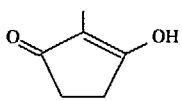
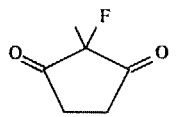
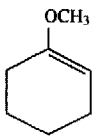
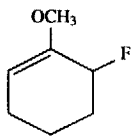
Example No.	Enol Compound	N-Fluoropyridinium salt (indicated by compound number)	Solvent	Temperature (°C.)	Hours (h)	Fluorine Containing compound	Yield (%)	^{19}F-NMR (ppm) ($CFCl_3$ internal standard in $CDCl_3$)
							20	183(d, J=50Hz)
108		1	CH_2Cl_2	reflux temp	2		59	192(m)
109		15	CH_2CH_2—CH_3CN (4/1)	15	1		63	138(s)
110		2	CH_2Cl_2	reflux temp	24		72	163(t, J=20Hz)

TABLE 8-continued

Example No.	Enol Compound	N-Fluoropyridinium salt (indicated by compound number)	Solvent	Temperature (°C.)	Hours (h)	Fluorine Containing compound	Yield (%)	^{19}F-NMR (ppm) ($CFCl_3$ internal standard in $CDCl_3$)
111		7	CH_2Cl_2	reflux temp	48		83	163(t, J=20Hz)
112		12	CH_2Cl_2	reflux temp	48		68	163(t, J=20Hz)
113		2	CH_2Cl_2	reflux temp.	15		48	171(q, J=28Hz)
114		1	CH_2Cl_2	reflux temp	0.4		59	177(m)

*the reaction product was hydrorized in a DMF-conc. HCl aqueous soln (R1)

TABLE 9

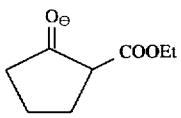
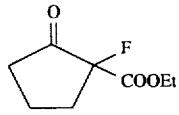
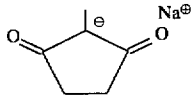
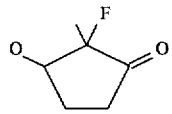
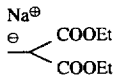
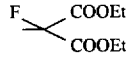
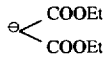
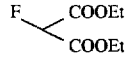
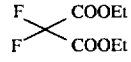
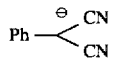
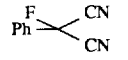
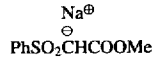
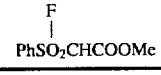
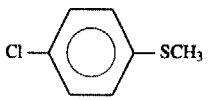
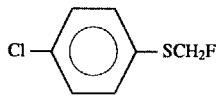
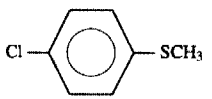
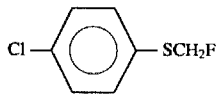
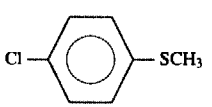
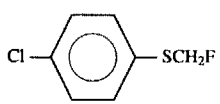
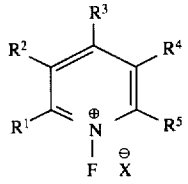
Example No.	Carbon anion	N-Fluoropyndinium salt (indicated by compound number)	Solvent	Temperature (°C.)	Hours (h)	Fluorine containing compound	Yield (%)	^{19}F-NMR(ppm) ($CFCl_3$ internal standard in $CDCl_3$)
115		7	THF	room temp.	0.17		78	162.8(t, J=20.3Hz)
116		7	THF	room temp.	1		44	172.5(q, J=22.5Hz)
117		7	THF	0	0.17		78	158.0(q, J=21.9Hz)
118		7	THF	0			42	144.6(q, J=48.6Hz)
							6	111.0(s)
119		7	THF	0-room temp.	0.17		71	118.9(s)
120	n-$C_{12}H_{25}MgCl$	7	Et_2O	0	0.5	n-$C_{12}H_{25}F$	75	210.8(tt, J=51.3, 17Hz)
121	PhMgCl	7	THF	0	0.17	PhF	58	—
122		7	THF	0	1		50	179.6(d, J=49.6Hz)

TABLE 10

Example No.	Sulfide	N-Fluoropyridinium salt (indicated by compound number)	Solvent	Temperature (°C.)	Hours (h)	α-fluorosulfide	Yield (%)	F-NMR (ppm) ($CFCl_3$ internal standard) Solvent	182.8(t, 52.5Hz)
123		7	CH_2Cl_2	room temp.	8		87	$CDCl_3$	182.8(t, 52.5Hz)
124		1	CH_2Cl_2	room temp.	75		48	$CDCl_3$	182.8(t, 52.5Hz)
125	$PhSCH_3$	7	CH_2Cl_2	room temp.	4	$PhSCH_2F$	85	$CDCl_3$	180.3(t, 54Hz)
126	$PhSCH_3$	1	CH_2Cl_2	room temp.	6	$PhSCH_2F$	56	$CDCl_3$	180.3(t, 54Hz)
127	$PhCH_2SCH_3$	7	CH_2Cl_2	room temp.	1	$PhCHFSCH_3$ 4 $PhCH_2SCH_2F$ 3	76	CH_2Cl_2 CH_2Cl_2	152.0(d, 56Hz) 187.2(t, 51Hz)
128	$PhCH_2SCH_3$	7	CH_2Cl_2	0	3	$PhCHFSCH_3$ 4 $PhCH_2SCH_2F$ 3	48	CH_2Cl_2 CH_2Cl_2	152.0(d, 56Hz) 187.2(t, 51Hz)
129	$n\text{-}C_{12}H_{25}SCH_3$	7	CH_2Cl_2	room temp.	175	$n\text{-}C_{12}H_{25}SCH_2F$	41	CH_2Cl_2	184.2(t, 52Hz)
130	CH_3SCH_2COOEt	7	CH_2Cl_2	room temp.	10	$CH_1SCHFCOOEt$	48	CH_2Cl_2	167.3(d, 54Hz)
131	$CH_3SCH_2CH_2CHCOOMe$ $NHCOCF_3$	7	CH_2Cl_2	room temp.	75	$FCH_2SCH_2CH_2CHCOOMe$ $NHCOCF_3$	40	$CDCl_2$	183.8(t, 51Hz)
132		13	CH_2Cl_2	40	4.5		75	$CDCl_3$	182.8(t, 52.5Hz)
133	$PhSC_2COOMe$	7	CH_2Cl_2	room temp.	23	PhSCHFCOOMe	45	$CDCl_3$	158.4(d, 52Hz)

What is claimed is:

1. A N-fluoropyridinium salt having the general formula:



wherein:

(a) R^1 through R^5 are each a group selected from the class consisting of hydrogen, halogen, and methyl;

(b) when at least two of each of R^1 through R^5 are hydrogen, then the remaining one through three groups of R^1 through R^5 can each be selected from the class consisting of:

phenylcarbonyloxy substituted methyl,

a mixture of at least one fluoro substituted methyl group and at least one group selected from the class consisting of methyl, trifluoromethyl and halogen, and

tertiary butyl or a mixture of methyl and t-butyl provided that, when at least two of each of R^1 through R^5 are tertiary butyl, said tertiary butyl groups are not adjacent;

(c) when at least three of each of R^1 through R^5 are hydrogen, then the remaining one or two groups of R^1 through R^5 can each be selected from the class consisting of:

phenyl,

acetyl,

alkoxycarbonyl containing a total of 2 through 5 carbon atoms wherein said aklyl substitute contains a total of 1 through 4 carbon atoms,

nitro

cyano,

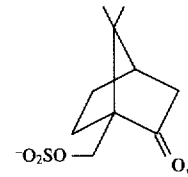
alkoxy containing 1 through 10 carbon atoms, and acyloxy wherein said acyl group contains 1 through 4 carbon atoms;

(d) when R^3 is hydrogen, then R^1 and R^2 taken together and R^4 and R^5 taken together can each form a six-membered carbocyclic ring which is inclusive of two adjacent carbon atoms of the pyridine ring; [and] *or*

(e) when R^3 and R^5 are each hydrogen, then R^1 and R^2 taken together can form a five-membered heterocyclic ring which contains one oxygen atom, which is inclusive of two carbon atoms of the pyridine ring, and which has an oxo oxygen atom substituted on each ring carbon atom adjacent said ring oxy oxygen atom; and

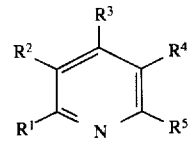
(f) X is a conjugate base of a [Brøsted] *Brønsted* acid except for halides, *provided that said N-fluoropyridinium salt is not N-fluoropyridinium hexafluoroantimonate, N-fluoropyridinium hexafluoroarsenate, or N-fluoropyridinium hexafluoroiodate.*

2. The N-fluoropyridinium salt of claim 1 wherein X is selected from the class consisiting of: $—OSO_2CF_3$, $—PF_6$, [SbF_6,] $—ClO_4$, $—OSO_2F$, $—OSO_2CH_3$,



$^-OSO_2C_4F_9$, $^-BF_4$, and $^-OCOCF_3$.

3. A process for making an N-fluoropyridinium salt comprising reacting fluorine, a Brønsted acid containing a conjugate base except for haldies, and a pyridine compound in a reaction solvent, said pyridine compound having a general formula:



wherein:

(a) R^1 through R^5 are each a group selected from the class consisting of hydrogen, halogen, and methyl;

(b) when at least two of each of R^1 through R^5 are hydrogen, then the remaining one through three groups of R^1 through R^5 can each be selected from the class consisting of:

phenylcarbonyloxy substituted methyl,

a mixture of at least one fluoro substitutedmethyl group and at least one group selected from the class consisting of methyl, trifluoromethyl and halogen, and

alkyl containing two through four carbon atoms, provided that when each of two of R^1 through R^5 are tertiary butyl, said tertiary butyl groups are not adjacent; and

(c) when at least three of R^1 through R^5 are each hydrogen, then the remaining one or two groups of R^1 through R^5 can each be selected from the class consisting of:

phenyl,

acetyl,

alkoxycarbonyl containing a total of 2 through 4 carbon atoms wherein said alkyl substitutent contains a total of 1 through 4 carbon atoms,

nitro,

cyano,

alkoxy containing 1 through 10 carbon atoms, and acyloxy wherein said acyl group contains 1 through 4 carbon atoms;

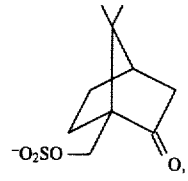
(d) when R^3 is hydrogen, then R^1 and R^2 taken together and R^4 and R^5 taken together can each form a six-membered carbocyclic ring which is inclusive of two adjacent carbon atoms of the pyridine ring; [and] *or*

(e) when R^3 through R^5 are each hydrogen, then R^1 and R^2 taken together can form a five-membered heterocyclic ring which contains one oxygen atom, which is inclusive of two carbon atoms of the pyridine ring, and which has an oxo oxygen atom substituted on each ring carbon atom adjacent said ring oxy oxygen atom, *provided that said conjugate base is not* $^-SbF_6$, $^-AsF_6$, *or* $^-IF_6$, *when* R^1, R^2, R^3, R^4, *and* R^5 *are each hydrogen.*

4. The process of claim 3 wherein said reaction solvent is selected from the class consisting of acetonitrile, methylene

chloride, chloroform, tri-chloromethane, trichlorofluoromethane, trichlorotrifluoromethane, ethyl acetate, diethyl ether, tetrahydrofuran and mixtures thereof at a temperature in the range of about −100° C. to about 40° C., while maintaining the molar ratio of said Brønsted acid to said pyridine compound at least about 1:1, and wherein the molar ratio of said fluorine to said pyridine compound is at least about 1:1.

5. The process of claim **3** wherein said [Brøsted] *Brønsted* acid conjugate base is selected from the class consisting of:



* * * * *