trans-3-p-Nitrothiophenoxypropenal (V)

A mixture of 3-thiocyanopropenal (0.50 g, 4.4 mmoles) (either the *cis* or *trans* isomer) and *p*-nitrothiophenol (0.80 g, 5.1 mmoles) in 25 ml of ethyl acetate was left at room temperature for 1 h. The solution was next washed with a 5% aqueous sodium carbonate solution and dried. Removal of the solvent yielded 0.80 g (87%) of a yellow-colored solid, m.p. 109–115°. An analytical sample of fine yellow needles melting at 118–119° was obtained after two recrystallizations from ethyl acetate.

Anal. Calcd. for $C_9H_7NO_3S$: C, 51.67; H, 3.37; S, 15.33. Found: C, 51.80; H, 3.64; S, 15.39.

The nuclear magnetic resonance spectral parameters which require the *trans* configuration are reported in Table I. The infrared spectrum (in $CHCl_3$) had strong bands at 1 672, 1 562, 1 520, 1 345, 1 120, 945, and 853 cm^{-1}.

Sodium cis-Propenal-3-thiosulfate

A solution of sodium thiosulfate pentahydrate (505 g, 2.0 moles) in 600 ml of water was added dropwise in 1 h to a stirred mixture of propynal (97 g, 1.8 moles), acetic acid (111 g, 1.8 moles), water (370 ml), and acetone (185 ml). During the addition the temperature of the reaction mixture was kept at −5 to 0°. A white solid precipitated readily. After the addition was completed, the mixture was kept for an additional 30 min at 0°; then 400 ml of cold acetone was added and the white solid was filtered off and dried. The product amounted to 228 g (65%). The nuclear magnetic resonance spectral parameters are given in Table I.

Isothiazole (I)

(*a*) 3-Thiocyanopropenal (100 g, 0.89 mole; consisting of approximately 85% *cis* and 15% *trans* isomer) was added in portions, with stirring, to 500 ml of liquid ammonia at approximately −60°. The reaction mixture was left at this temperature for a few hours and was then allowed to come to room temperature. The dark-colored residue was steam-distilled until approximately 350 ml of distillate had been collected. The isothiazole layer was separated and the aqueous solution extracted with five 40 ml portions of ether. The combined organic layers were dried and fractionally distilled to give 14.0 g (22%, based on *cis*-3-thiocyanopropenal) of isothiazole, b.p. 111–112° at 700 mm (lit. (6) b.p. 113° at 770 mm).

(*b*) Sodium *cis*-propenal-3-thiosulfate (486 g, 2.56 moles) was added to liquid ammonia (approximately 1 l). The resulting mixture was stirred for a few hours at −60°, and then the ammonia was allowed to evaporate. Enough water was added to the residue to dissolve all the white solid material. The mixture was then extracted with four 150 ml portions of ether. The combined ether extracts were dried and fractionally distilled to give 133 g (61%) of isothiazole, b.p. 111–112° at 700 mm.

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R & L Molecular Research Ltd.,
Edmonton, Alberta.

SOME NEW ROUTES FOR THE SYNTHESIS OF AROMATIC FLUORINE COMPOUNDS

H. L. Sharma, V. N. Sharma, and R. L. Mital

One of the important methods for the synthesis of aromatic fluorine compounds involves the exchange of fluorine for some other halogen atom (1–3), for some other univalent functional group like the hydroxyl, or for oxygen in the carbonyl and carboxyl groups (4).

A survey of the literature reveals that only a few references (5–7) deal with the methods for the synthesis of fluoronitrobenzenes via exchange of fluorine for some other halogen atom, and that practically no work has been done on their synthesis via exchange of fluorine for the *p*-toluenesulfonic ester group, though the latter method has been worked out for the synthesis of alkyl fluorides (8, 9).

The present note describes some new routes for the synthesis of fluoronitrobenzenes via exchange of fluorine for another halogen atom or for a *p*-toluenesulfonic ester group.

Several workers have shown that picryl and 2,4-dinitrophenyl carbonium ions are stabilized by heterocyclic bases (10, 11). Thus, when polynitrohalogenobenzenes are treated with pyridine or α-, β-, or γ-picoline, polynitrophenylpyridinium or polynitrophenyl-α-, -β-, or -γ-picolinium halides are obtained. It has been observed by us that these yield fluoronitrobenzenes when treated with anhydrous potassium fluoride in dry dimethylformamide or nitrobenzene.

Polynitrophenylpyridinium or polynitrophenyl-α-, -β-, or -γ-picolinium *p*-toluenesulfonates were obtained by treating polynitrophenyl *p*-toluenesulfonates with pyridine or α-, β-, or γ-picoline, and it has been found that these, under the conditions mentioned above, yield fluoronitrobenzenes. Even polynitrophenyl *p*-toluenesulfonates were successfully converted into fluoronitrobenzenes under these conditions. Thus this method provides a new route for the synthesis of fluoronitrobenzenes from polynitrophenols.

The exchange of fluorine in all these compounds has been found to be much easier in dimethylformamide than in nitrobenzene. This could be explained on the basis of the findings of Miller and Parker (12), who observed that there is a lower degree of solvation of F^- ions in dipolar aprotic solvents.

EXPERIMENTAL

Nitrophenyl p-Toluenesulfonates

4,6-Dinitro-3-methylphenyl, 2,6-dinitrophenyl, and 2,4-dinitrophenyl *p*-toluenesulfonates were prepared by the methods reported earlier (13–15).

Nitrophenylpyridinium and Nitrophenyl-α-, -β-, or -γ-picolinium Halides or p-Toluenesulfonates

A mixture of halogenonitrobenzene (0.01 mole) or nitrophenyl *p*-toluenesulfonate (0.01 mole) and one of the heterocyclic bases such as pyridine or α-, β-, or γ-picoline (0.012 mole) was heated at 90–95° in dry toluene (ca. 15 ml) under reflux for 4 h. The mixture was cooled, and the resulting solid was filtered off, washed successively with benzene and ether, and dried. The compounds are listed in Table I.

Only 2,6-dinitrochlorobenzene did not react with α-picoline, probably because the nitro groups hindered the approach of the attacking reagent.

Preparation of Fluoronitrobenzenes

(i) From Nitrophenylpyridinium or Nitrophenyl-α-, -β-, or -γ-picolinium Halides or p-Toluenesulfonates

(a) Reaction in dimethylformamide.—A mixture of nitrophenylpyridinium or nitrophenyl-α-, -β-, or -γ-picolinium halide or *p*-toluenesulfonate (0.01 mole) (as the case may be) and anhydrous potassium fluoride (0.012 mole) in dry dimethylformamide (ca. 20 ml) was heated at 110–115° for 1½ h. Dimethylformamide was removed under reduced pressure, and the residue was refluxed with 25 ml of ethanolic hydrochloric acid (1:1 v/v) for ½ h. The solution was then diluted with water (ca. 100 ml) and extracted with benzene. Removal of benzene by distillation yielded the fluoronitrobenzene.

(b) Reaction in nitrobenzene.—The same procedure was followed as described above, except that the reaction mixture was refluxed at 210° for 3 h.

(ii) From Nitrophenyl p-Toluenesulfonates

(a) Reaction in dimethylformamide.—A mixture of anhydrous potassium fluoride (0.015 mole) and nitrophenyl *p*-toluenesulfonate (0.01 mole) in dry dimethylformamide (ca. 25 ml) was heated at 150° for 2½ h. After dilution with water, the isolated product was extracted with benzene. Removal of benzene by distillation yielded the fluoronitrobenzene.

(b) Reaction in nitrobenzene.—A mixture of anhydrous potassium fluoride (0.015 mole) and the nitrophenyl *p*-toluenesulfonate (0.01 mole) in nitrobenzene (ca. 20 ml) was refluxed for 3½ h. The mixture was cooled and filtered, and the residue was washed well with hot toluene. The combined filtrate and washings were dried and vacuum-distilled to yield the fluoronitrobenzenes.

These compounds are listed in Table II.

TABLE I

Characteristics of nitrophenylpyridinium and nitrophenyl-α-, -β-, and -γ-picolinium halides and *p*-toluenesulfonates

Halogenonitrobenzene or nitrophenyl *p*-toluenesulfonate used	Heterocyclic base used	Product formed	% yield	Molecular formula	Melting point (°C)	% Cl	
						Found	Calcd.
1-Chloro-2,4-D	Pyridine	2,4-Dp (I)	95	$C_{11}H_8ClN_3O_4$	184*	12.59	12.61
	α-Picoline	2,4-Dα (II)	90	$C_{12}H_{10}ClN_3O_4$	183*	12.04	12.01
	β-Picoline	2,4-Dβ (III)	92	$C_{12}H_{10}ClN_3O_4$	195*	12.04	12.01
	γ-Picoline	2,4-Dγ (IV)	92	$C_{12}H_{10}ClN_3O_4$	163*	12.02	12.01
1-Chloro-2,6-D	Pyridine	2,6-Dp (V)	90	$C_{12}H_8ClN_3O_4$	183	12.58	12.61
	α-Picoline	—	—	—	—	—	—
	β-Picoline	2,6-Dβ (VI)	86	$C_{12}H_{10}ClN_3O_4$	176	12.03	12.01
	γ-Picoline	2,6-Dγ (VII)	86	$C_{12}H_{10}ClN_3O_4$	172	12.03	12.01
1-Chloro-2,4,6-T	Pyridine	2,4,6-Tp (VIII)	95	$C_{11}H_7ClN_4O_6$	121*	10.86	10.87
	α-Picoline	2,4,6-Tα (IX)	86	$C_{12}H_9ClN_4O_6$	118*	10.41	10.42
	β-Picoline	2,4,6-Tβ (X)	92	$C_{12}H_9ClN_4O_6$	118*	10.43	10.42
	γ-Picoline	2,4,6-Tγ (XI)	92	$C_{12}H_9ClN_4O_6$	115*	10.41	10.42
1-Chloro-3-methyl-2,4,6-T	Pyridine	3-Methyl-2,4,6-Tp (XII)	89	$C_{12}H_9ClN_4O_6$	177	10.41	10.42
	α-Picoline	3-Methyl-2,4,6-Tα (XIII)	80	$C_{13}H_{11}ClN_4O_6$	172	10.02	10.01
	β-Picoline	3-Methyl-2,4,6-Tβ (XIV)	86	$C_{13}H_{11}ClN_4O_6$	174	10.02	10.01
	γ-Picoline	3-Methyl-2,4,6-Tγ (XV)	90	$C_{13}H_{11}ClN_4O_6$	162	10.03	10.01
1-*p*-Toluenesulfonyl-2,4-D	Pyridine	2,4-DpT (XVI)	90	$C_{18}H_{15}N_3O_7S$	249	7.65†	7.67†
	α-Picoline	2,4-DαT (XVII)	90	$C_{19}H_{17}N_3O_7S$	208	7.39†	7.42†
	β-Picoline	2,4-DβT (XVIII)	92	$C_{19}H_{17}N_3O_7S$	243	7.39†	7.42†
	γ-Picoline	2,4-DγT (XIX)	92	$C_{19}H_{17}N_3O_7S$	223	7.41†	7.42†

*Literature (10) m.p. 186, 184, 197, 163, 121, 117, 119, and 114 °C, respectively.

†Percentage of sulfur.

NOTE: D = dinitrobenzene; T = trinitrobenzene; Dp, Dα, Dβ, and Dγ = dinitrophenylpyridinium and dinitrophenyl-α-, -β-, and -γ-picolinium chlorides, respectively; Tp, Tα, Tβ, and Tγ = trinitrophenylpyridinium and trinitrophenyl-α-, -β-, and -γ-picolinium chlorides, respectively; DpT, DαT, DβT, and DγT = dinitrophenylpyridinium and dinitrophenyl-α-, -β-, and -γ-picolinium *p*-toluenesulfonates, respectively.

TABLE II

Characteristics of fluoronitrobenzenes

Reactant used	Fluoronitrobenzene formed	Melting or boiling point (°C)	% yield*	Molecular formula	% N	
					Found	Calcd.
I, II, III, IV, XVI, XVII, XVIII, XIX, or 2,4-dinitrophenyl *p*-toluenesulfonate	1-Fluoro-2,4-D	135†	80	$C_6H_3FN_2O_4$	15.02	15.05
V, VI, VII, or 2,6-dinitrophenyl *p*-toluenesulfonate	1-Fluoro-2,6-D	61‡	75	$C_6H_3FN_2O_4$	15.01	15.05
VIII, IX, X, or XI	1-Fluoro-2,4,6-T	126§	80	$C_6H_2FN_3O_6$	19.02	19.04
XII, XIII, XIV, or XV	1-Fluoro-3-methyl-2,4,6-T	86‖	81	$C_7H_4FN_3O_6$	17.09	17.14
4,6-Dinitro-3-methylphenyl *p*-toluenesulfonate	1-Fluoro-3-methyl-4,6-D	78¶	70	$C_7H_5FN_2O_4$	13.88	14.00

*The average % yields obtained from various reactants are reported here.
†Literature (6) b.p. 138 °C at 2 mm.
‡Literature (16) m.p. 63 °C.
§Literature (17) m.p. 128 °C.
‖Literature (19) m.p. 88 °C.
¶Literature (18) m.p. 78–79 °C.
NOTE: D = dinitrobenzene, T = trinitrobenzene.

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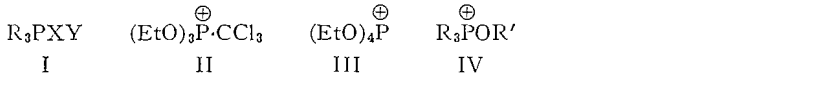
DEPARTMENT OF PHARMACOLOGY,
S.M.S. MEDICAL COLLEGE,
AND
DEPARTMENT OF CHEMISTRY,
UNIVERSITY OF RAJASTHAN,
JAIPUR, INDIA.

SUGAR ESTERS
III. NEW REAGENT FOR DEOXYHALO SUGAR PREPARATION

J. B. LEE AND T. J. NOLAN

The need to prepare deoxyhalo analogues of certain sugar-containing natural products, together with the potential synthetic applications of deoxyhalo sugars, has prompted our examination of a number of possible routes to these compounds (1), including various modifications of Rydon's reagents (2). The latter reagents, of the type I (R = aryloxy or alkoxy, X = alkyl or halide, Y = halide), in principle offer ready means for conversion of



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alcohols into halides. In practical use with natural products, we have found the original conditions used by Rydon to be unsatisfactory with respect to either yield, need for vigorous conditions, or necessitating tedious processes. These difficulties have been overcome by modification of the original conditions or reagents (3), but a need still exists for a reagent which would act rapidly in mild, essentially neutral, conditions.

Crofts and Downie (4) describe the reaction of triethyl phosphite with ethanol and carbon tetrachloride to give ethyl chloride, chloroform, and triethyl phosphate. Since