

## The Synthesis and Some Reactions of *N*-Methylnitrilium Trifluoromethanesulphonate Salts

By BRIAN L. BOOTH,\* KEHINDE O. JIBODU, and (in part) M. FERNANDA PROENÇA

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

**Summary** *N*-Methylnitrilium trifluoromethanesulphonate (triflate) salts, prepared from nitriles and methyl triflate, have been shown to be useful reagents for the synthesis of aromatic ketimines and ketones, amidinium, imidate, and thioimidate salts, benzimidazoles, benzoxazoles, benzothiazoles, quinazolinones, and 1,2,4-triazolinium salts.

DROPWISE addition of a nitrile to methyl triflate, either as a solution in dry benzene or as a neat liquid, gives the nitrilium salts listed in the Table. Where m.p. data are given the salts were isolated as white–pale yellow, crystalline solids,

TABLE. Physical and i.r. spectroscopic data for nitrilium triflate salts.

Compound	Yield /%	M.p. /°C	$\nu_{\text{C}\equiv\text{N}}$ /cm <sup>-1</sup>
[MeC≡NMe] <sup>+</sup> Ötf	94	54–60	2400
[Pr <sup>i</sup> C≡NMe] <sup>+</sup> Ötf	95	63–66	2350
[PhCH <sub>2</sub> CH <sub>2</sub> C≡NMe] <sup>+</sup> Ötf	72	Oil	2390
[PhC≡NMe] <sup>+</sup> Ötf	96	84–86	2350
[CH <sub>2</sub> =CHCH <sub>2</sub> C≡NMe] <sup>+</sup> Ötf	94	Oil	2350
[NC(CH <sub>3</sub> ) <sub>2</sub> C≡NMe] <sup>+</sup> Ötf	89	Oil	2375
[CH <sub>2</sub> =CHC≡NMe] <sup>+</sup> Ötf	78	52–54	2355

purified by repeated washing with dry benzene, and characterised by elemental analysis (C, H, N, and S), i.r., and <sup>1</sup>H and <sup>19</sup>F n.m.r. spectroscopy. In other cases crystallisation could not be induced and the salts were isolated as red oils characterised only by their spectroscopic data. At room temperature complete reaction can take several days, but at 50–60 °C reaction is usually complete in 15–20 min. Nitriles having electron-withdrawing substituents, *e.g.* ClCH<sub>2</sub>CN, CCl<sub>3</sub>CN, 4-ClC<sub>6</sub>H<sub>4</sub>CN, 2- or 4-O<sub>2</sub>NC<sub>6</sub>H<sub>4</sub>CN, 1,2-, 1,3-, or 1,4-(NC)<sub>2</sub>C<sub>6</sub>H<sub>4</sub>, CH<sub>2</sub>(CN)<sub>2</sub>, and NCCH<sub>2</sub>CH<sub>2</sub>CN do not react with methyl triflate under similar conditions; glutaronitrile reacts at only one of the nitrile groups even when a large excess of triflate ester is present. Methylation of benzo-

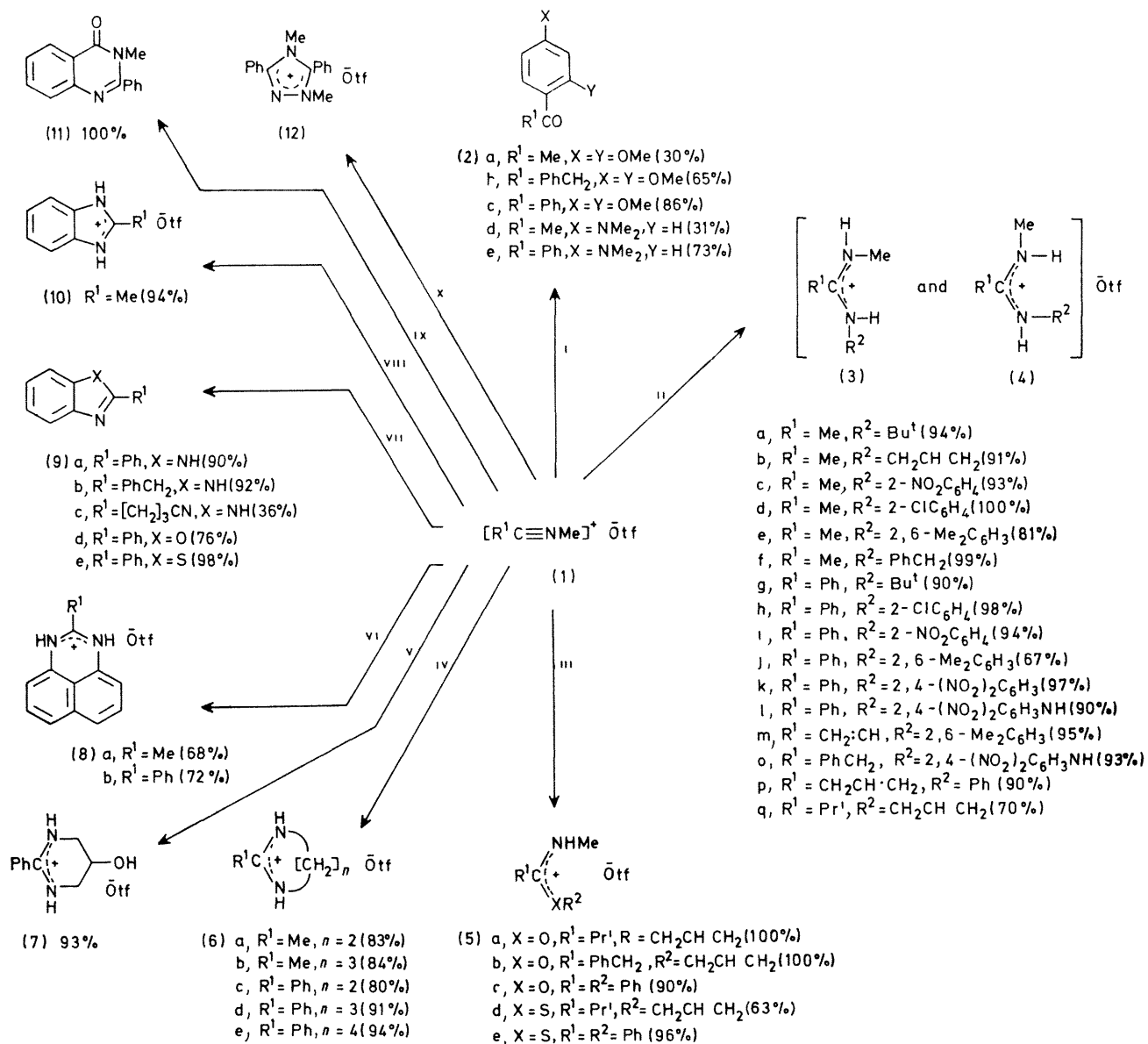
nitrile and  $\alpha\beta$ -unsaturated nitriles is slow, and is usually accompanied by *s*-triazine formation. This nitrile cyclotrimerisation reaction is probably catalysed by a trace of triflic acid which is difficult to remove completely from the methyl triflate, prepared from triflic acid and dimethyl sulphate.<sup>1,2</sup> Triazine formation with benzonitrile and acrylonitrile can be reduced to insignificant levels by repeated distillation of the methyl triflate under dry nitrogen in flame-dried apparatus, but trimerisation of cinnamonitrile is so rapid that an approximate 1:1 mixture of the nitrilium salt and the triazine is obtained, as evidenced by the isolation of (*E*)-PhCH=CHCONHMe (43%) and the corresponding triazine (45%) after alkaline hydrolysis.

The nitrilium triflate salts are converted rapidly into the corresponding amides in moist air and must be handled in a dry box. They are insoluble in CCl<sub>4</sub>, hydrocarbons, and diethyl ether, slightly soluble in CHCl<sub>3</sub>, and soluble in nitromethane; they appear to react with acetone and dimethyl sulphate forming deep red solutions over several hours. The i.r. spectra (see Table) show the characteristic<sup>3,4</sup> C≡N stretching vibration in the region of 2350–2400 cm<sup>-1</sup> in addition to bands at 1220–1300, 1160, 1030, and 630 cm<sup>-1</sup> for the triflate anion, and are very different from that of the compound believed to be *N*-phenylbenzimidoyl triflate, isolated as hygroscopic, yellow crystals [m.p. 132–134 °C,  $\nu_{\text{max}}$  1610 (C=N), 1140–1260, 1160, 1030, and 630 (CF<sub>3</sub>SO<sub>3</sub> group) cm<sup>-1</sup>] from the reaction between *N*-phenylbenzimidoyl chloride and silver triflate in dry benzene. Addition of benzoyl triflate (from benzoyl chloride and silver triflate) to a solution of benzonitrile in benzene and warming at 80–90 °C for 5 min gave a deep red solution from which yellow crystals of [PhC≡NCOPh]<sup>+</sup> Ötf (tf = O<sub>2</sub>SCF<sub>3</sub>) (31% yield, m.p. 114–118 °C) precipitated. The i.r. spectrum of this compound had no band in the region 2350–2400 cm<sup>-1</sup>, but instead had a strong band in the  $\nu_{\text{C}=\text{N}}$  region at 1590 cm<sup>-1</sup>, in addition to a strong carbonyl absorption at 1620 cm<sup>-1</sup>. On hydrolysis it gave dibenzamide

(84%) as the only product, and reaction with *o*-phenylenediamine at room temperature gave a mixture of 2-phenylbenzimidazolium triflate (80%) and 2-phenylbenzimidazole (7%) with elimination of benzamide

*N*-Methylnitrilium triflate salts (1) react at room temperature with electron-rich aromatic compounds to give the ketones (2a-e) after acid or base hydrolysis of the intermediate ketimium salts. Controlled hydrolysis of the reaction mixture from 1,3-dimethoxybenzene and (1, R<sup>1</sup> = Ph) gave an 86% yield of the ketimine, which could be hydrolysed quantitatively (dilute HCl in MeOH) to (2c). Addition of amines, hydrazines, alcohols and

thiols to suspensions of nitrilium salts in benzene gives the corresponding amidinium (3 and 4a-q), imidate (5a-c), and thionimide (5d and e) salts (see Scheme). Shaking with aqueous KOH solution converts these salts quantitatively into the free bases in overall yields frequently superior to those reported for other routes<sup>5,6</sup>. The <sup>1</sup>H n m r spectra of the amidinium salts indicate that in all cases there is restricted rotation about the C-N bonds giving rise to the two conformers (3) and (4). Aliphatic and aromatic diamines react with (1) to eliminate methylamine and give the heterocycles (6a-e) (7) (8a and b), (9a-c), and (10). Aliphatic diamines and 1,8-diaminonaphthalene invariably



SCHEME 1. Reagents: i, 1,3-C<sub>6</sub>H<sub>4</sub>XY, dry PhH, 20 °C, 24 h; ii, R<sup>2</sup>NH<sub>2</sub>, dry PhH, 20 °C, 30 min; iii, R<sup>2</sup>XH, dry PhH, 20 °C, 10 min; iv, H<sub>2</sub>N[CH<sub>2</sub>]<sub>n</sub>NH<sub>2</sub>, MeNO<sub>2</sub> or PhH, reflux, 30 min; v, H<sub>2</sub>NCH<sub>2</sub>CH(OH)CH<sub>2</sub>NH<sub>2</sub>, CHCl<sub>3</sub>, 20 °C, 24 h; vi, 1,8-diaminonaphthalene, CHCl<sub>3</sub>, 0 °C, 5 min; vii, 1-NH<sub>2</sub>-2-XH-C<sub>6</sub>H<sub>4</sub>, MeNO<sub>2</sub>, 20 °C, 10 min; viii, 1,2-(H<sub>2</sub>N)<sub>2</sub>C<sub>6</sub>H<sub>4</sub>, MeNO<sub>2</sub>, 20 °C, 10 min; ix, 1-NH<sub>2</sub>-2-CONH<sub>2</sub>-C<sub>6</sub>H<sub>4</sub>, MeNO<sub>2</sub>, 20 °C, 24 h; x, NaN<sub>3</sub>, MeNO<sub>2</sub>, 20 °C, 24 h

\* All the compounds were characterised by elemental analysis [C, H, N, (S)], i r and n m r spectroscopy, and mass spectrometry

produce the triflate salt of the heterocyclic base, but the reactions with *o*-phenylenediamine give the free bases directly (when  $R^1 = \text{Ph}$ ) together with methylammonium triflate. The relative basicities of the benzimidazoles and methylamine are delicately balanced, however, and when  $R^1 = \text{Me}$  the products are methylamine and the benzimidazolium salt (**10**). Excellent yields of the heterocycles (**9d**) and (**9e**) are obtained from the reactions of (**1**,  $R^1 = \text{Ph}$ ) with 2-aminophenol and 2-aminobenzenethiol at room temperature, but under similar conditions reaction between 2-aminophenol and (**1**,  $R^1 = \text{Me}$ ) gives only *N*-(2-hydroxyphenyl)-*N'*-methylacetamidinium triflate in 84% yield; cyclisation of this compound to the corresponding benzoxazole did not occur even after 4 h at the reflux temperature of nitromethane. Reaction between (**1**,  $R^1 = \text{Ph}$ ) and 3-aminopropan-1-ol similarly gave only an amidinium salt at room temperature. A mixture of anthranilamide and (**1**,  $R^1 = \text{Ph}$ ) reacts at room temperature to give equimolar amounts of 3-methyl-2-phenylquinazolin-4(3*H*)-one (**11**) and ammonium triflate. Under similar conditions methyl anthranilate gives mainly *N*-(2-methoxycarbonyl)phenyl-*N'*-methylbenzamidinium triflate (60%; 2 conformers), and only a low yield (36%) of the product of ring closure, 2,3-dihydro-3-methyl-4-oxo-2-phenylquinazolinium triflate. When heated at the reflux temperature

of bromobenzene, the amidinium salt is converted quantitatively into the quinazolinium salt with elimination of methanol.

It has been reported previously<sup>7</sup> that *N*-ethylbenzotriazolium tetrafluoroborate reacts with sodium azide to give 1-ethyl-5-phenyltetrazole and 1,3-diethyl-2,4-diphenyl-1,2,4-triazolinium tetrafluoroborate in proportions which depend upon the mode of addition, the solvent, and the reaction temperature. Tetrazole formation is favoured by addition of the nitrilium salt to sodium azide at room temperature, whereas the yield of triazolinium salt is highest when sodium azide is added to the nitrilium salt in acetonitrile at 60–70 °C. Reaction between (**1**,  $R^1 = \text{Ph}$ ) and sodium azide in nitromethane at room temperature gave the triazolinium salt (**12**) as the only product under all conditions investigated, namely (i) addition of nitrilium salt (2 mol) to  $\text{NaN}_3$  (1 mol); (ii) addition of nitrilium salt (1 mol) to  $\text{NaN}_3$  (2 mol); and (iii) dropwise addition of nitrilium salt to an excess of  $\text{NaN}_3$ .

Thanks are due to Ibadan Polytechnic, Nigeria (K.O.J.) and to the University of Minho, Portugal (M.F.P.) for study leave grants.

(Received, 6th August 1980; Com. 867.)

<sup>1</sup> B. L. Booth, R. N. Haszeldine, and K. Laali, *J. Chem. Soc., Perkin Trans. 1*, 1980, 2887.

<sup>2</sup> R. Norell, U.S. Pat. 3,932,402/1976.

<sup>3</sup> D. Hall, P. K. Ummat, and K. Wade, *J. Chem. Soc. (A)*, 1967, 1612; J. E. Gordon and G. C. Turrell, *J. Org. Chem.*, 1959, **24**, 269; *J. Chem. Phys.*, 1959, **30**, 895.

<sup>4</sup> G. A. Olah and T. E. Kiovsky, *J. Am. Chem. Soc.*, 1968, **90**, 4666.

<sup>5</sup> R. L. Shriner and F. W. Newmann, *Chem. Rev.*, 1944, **35**, 351; 'The Chemistry of Amidines and Imidates,' ed. S. Patai, Wiley-Interscience, New York, 1975.

<sup>6</sup> R. Roger and D. G. Neilson, *Chem. Rev.*, 1961, **61**, 179.

<sup>7</sup> L. A. Lee, R. Evans, and J. W. Wheeler, *J. Org. Chem.*, 1972, **37**, 343.