Journal of Fluorine Chemistry, 51 (1991) 283–289

Received: August 23, 1990; accepted: December 10, 1990

3,5-BIS(TRIFLUOROMETHYL)PYRAZOLE AND SOME N-SUBSTITUTED DERIVATIVES

PREET P.K. CLAIRE, PAUL L. COE, CHRISTOPHER J. JONES AND
JON A. McCLEVERTY[a]*

School of Chemistry, University of Birmingham, PO Box 363,
Birmingham B15 2TT (U.K.)

SUMMARY

The pyrazoles $(CF_3)_2C_3HN_2R$ [R = H, COPh, C_6F_5, $C_6H_4NO_2$-4 and $C_6H_3(NO_2)_2$-2,4] have been prepared in yields ranging from 27% (R = C_6F_5) to 78% [R = $C_6H_3(NO_2)_2$-2,4] by the reaction between 1,1,1,5,5,5-hexafluoropentane-2,4-dione and the appropriately substituted hydrazine, NH_2NHR.

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[a] Present address: School of Chemistry, University of Bristol, Cantock's Close, Bristol BS8 1TS, U.K.

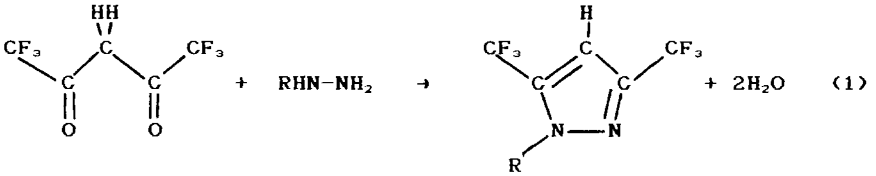
0022-1139/91/$3.50

INTRODUCTION

Despite the ready availability of its expected [1] precursors, hydrazine and 1,1,1,5,5,5-hexafluoropentane-2,4-dione, a full report of the synthesis and characterisation of 3,5-bis(trifluoromethyl)pyrazole has not appeared. There are two previous references to the use of this compound in the preparation of pyrazolyl bridged transition metal complexes such as $\{Ir(\eta^4-C_8H_8)\}_2(\mu-C_3H_3N_2)\{\mu-(CF_3)_2C_3HN_2\}$ [2] and $Ru_3(CO)_{10}(\mu-H)\}\{\mu-(CF_3)_2C_3HN_2\}$ [3]. However, the synthesis and characterisation of the fluorinated pyrazole derivative is not described in either of these reports. We have also been interested in synthesising transition metal complexes containing $3,5-(CF_3)_2C_3HN_2$ [4] and describe here the synthesis and characterisation of this compound along with some N-substituted derivatives.

DISCUSSION

The reactions between 1,1,1,5,5,5-hexafluoropentane-2,4-dione and the hydrazines H_2NNHR [R = H, COPh, C_6F_5, $C_6H_4NO_2$-4 and $C_6H_3(NO_2)_2$-2,4] proceed [1] according to eqn (1):



The yields obtained varied with R and were in excess of 75% when R = H or $C_6H_3(NO_2)_2$-2,4. Lower yields were obtained when R = COPh or $C_6H_4NO_2$-4 and in the case where R = C_6F_5 only a 26% yield was obtained. All products except when R = H were hydrates.

SPECTRA

All of the compounds exhibited ν_{CF} in the region 1100 to 1200 cm^{-1} of their IR spectra. In addition bands attributable to $\nu_{C=N}$, $\nu_{C=C}$ and, in the cases of the nitro-aryl containing compounds, ν_{NO} were evident in the region 1350 to 1620 cm^{-1}. The presence of water in the products other than 3,5-bis(trifluoromethyl)pyrazole gave rise to a broad band attributable to ν_{OH} at 3400 cm^{-1}. In the case of 3,5-bis(trifluoromethyl)pyrazole ν_{NH} was observed at 3160 cm^{-1} and in this compound and N-pentafluorophenyl-3,5-bis(trifluoromethyl)-pyrazole ν_{CH} for the pyrazolyl CH group could be found at 2900 and 2950 cm^{-1} respectively. In N-benzoyl-3,5-bis(trifluoromethyl)-pyrazole, $(CF_3)_2C_3HN_2COPh$, the carbonyl ν_{CO} band appeared at 1675 cm^{-1}.

In the ^1H NMR spectra of these compounds the pyrazolyl proton appears at *ca.* 3.5 ppm compared to the value of 5.8 ppm in $3,5\text{-}Me_2C_3HN_2H$. In the N-substituted derivatives two signals of relative area 1 were observed which might be attributed to the molecule of water associated with the product. One of these appeared as a sharp singlet while the other was broadened. This latter signal may be attributed to a proton hydrogen bonded to nitrogen. In the ^{19}F NMR spectra the trifluoromethyl groups give rise to resonances in the region of 62 to 82 ppm. In the case of $(CF_3)_2C_3HN_2H$ only one signal was observed due to rapid site exchange of the NH proton. However, in the N-substituted compounds two signals are observed. N-(2',4'-dinitrophenyl)-3,5-bis(trifluoromethyl)pyrazole was insufficiently soluble for NMR studies.

The E.I. mass spectrum of 3,5-bis(trifluoromethyl)-pyrazole exhibited a molecular ion at m/z 204 as the base peak. N-benzoyl-3,5-bis(trifluoromethyl)pyrazole exhibited a molecular ion at m/z 307 $[(M-H)^+]$ and an ion at m/z 326 (RI 20% of M^+) attributable to $(M+H_2O)^+$. N-(4'-nitrophenyl)-3,5-bis(trifluoromethyl)pyrazole exhibited a molecular ion at m/z 325 in addition to an ion of similar intensity at 343 attributed to {$(M+H_2O)^+$. Strong ions were also present at m/z 274 and 228 which may be attributed to successive losses of CF_3 and NO_2 from {$M+H_2O)^+$. N-(2',4'-dinitrophenyl)-3,5-bis(trifluoromethyl)pyrazole also exhibits a molecular ion at m/z 370 with RI 25% of that of an ion at m/z at 388 attributable to {$M+H_2O)^+$. Again an ion at m/z 319 of similar intensity to that at 388 may be attributed to the loss of CF_3 from {$M+H_2O)^+$.

EXPERIMENTAL

Materials

All reagents were obtained from commercial sources and were used as supplied.

Physical Measurements

IR spectra: Perkin Elmer 297 600 - 4 000 cm^{-1}, KBr dics.

NMR spectra: ^1H, 90 MHz, $SiMe_4$; ^{19}F, 84.7 MHz, $CFCl_3$; Jeol FX90Q

Mass spectra: Kratos MS80RF E.I. mode.

Syntheses

3,5-bis(trifluoromethyl)pyrazole

Hydrazine hydrate (1cm^3, 31 mmol) was slowly added to a solution of 1,1,1,5,5,5-hexafluoropentane-2,4-dione (4.4 cm^3, 31 mmol) in ethanol (60 cm^3). The mixture was heated under reflux for 5h, allowed to cool and filtered. Removal of the solvent produced a yellow oil which, after repeated washing with aliquots of petroleum ether (40–60°C boiling range) and cooling to 0°C, afforded white crystals of 3,5-bis(trifluoromethyl)pyrazole (nc) (4.95g, 77%). [Found: C, 29.1; H, 0.9; N, 13.9%; M(mass spec.), 204 (base peak, M^+). $C_5H_2F_6N_2$ requires C, 29.4; H, 1.0; N, 13.7%; M, 204], m.p. 71–72°C, ν_{max} (KBr) 3160 (N–H str.), 2900 (C–H str.), 1510, 1595 (C=N str.), (C=C str.), 1150br cm^{-1} (C–F str.), δ_F ($CDCl_3$) −62.48 (s; 3-,5-CF_3) ppm, δ_H (same soln.) 6.85 (s; 4-H), 1.5 (br.s; NH) ppm.

N-benzoyl-3,5-bis(trifluoromethyl)pyrazole

1,1,1,5,5,5-Hexafluoropentane-2,4-dione (0.2 cm^3, 1.44 mmol) was added dropwise to a stirred solution of benzoylhydrazine (0.2g, 1.47 mmol) in ethanol (50 cm^3). The mixture was heated under reflux for 5h, allowed to cool and filtered. Removal of the solvent produced a colourless oil which, after repeated washing with aliquots of petroleum ether (40–60°C boiling range) and cooling to 0°C, afforded white crystals of N-benzoyl-3,5-bis(trifluoromethyl)pyrazole hydrate (nc) (0.19g, 40%). [Found: C, 44.6; H, 2.0; N, 8.8%; M(mass spec.), 307 (M^+). $C_{12}H_6F_6N_2O.H_2O$ requires C, 44.2; H, 2.5; N, 8.6%; M, 326], m.p. 83–84°C, ν_{max} (KBr) 3390 (O–H str.), 1675 (C=O str.), 1640, 1600 (C=N str.), (C=C str.), 1100–1200 cm^{-1} (C–F str.), δ_F ($CDCl_3$) −68.01, −81.37 (s; s; 3-,5-CF_3) ppm, δ_H (same soln.) 3.51(s; 4-H), 3.26 (s; OH), 6.2 (br.s; OH), 7.40, 7.80, (m; m; $-C_6H_5$) ppm.

N-(4'-nitrophenyl)-3,5-bis(trifluoromethyl)pyrazole

1,1,1,5,5,5-Hexafluoropentane-2,4-dione (0.2 cm^3, 1.44 mmol) was added dropwise to a stirred solution of 4-nitrophenylhydrazine (0.2g, 1.31 mmol) in ethanol (50 cm^3). The mixture was heated under reflux for 3h, allowed to cool and filtered. Removal of the solvent produced an orange solid which, after repeated washing with aliquots of petroleum ether (40-60°C boiling range) afforded an orange powder: N-(4'-nitrophenyl-3,5-bis(trifluoromethyl)pyrazole hydrate (nc) (0.24g, 52%). [Found: C, 37.8; H, 2.2; N, 11.9%; M(mass spec.), 325 (M^+). $C_{11}H_5F_6N_3O_2.1.5H_2O$ requires C, 37.5; H, 2.3; N, 11.9%; M, 353], m.p. 105-108°C, ν_{max} (KBr) 3400 (O-H str.), 1320, 1480, 1590 (C=N str.), (N=O str.), (C=C str.), 1180br cm^{-1} (C-F str.), δ_F ($CDCl_3$) -67.23, -79.86 (s; s; 3,5-CF_3) ppm, δ_H (same soln.) 3.71 (s; 4-H), 3.30 (s; OH), 1.70 (br.s; OH), 7.55, 8.10 (d; d; $-C_6H_4-$) ppm, ($J_{2'-4'}$ 9Hz).

N-(2',4'-dinitrophenyl)-3,5-bis(trifluoromethyl)-pyrazole

1,1,1,5,5,5-Hexafluoropentane-2,4-dione (0.14 cm^3, 1.0 mmol) was added dropwise to a stirred solution of 2,4-dinitrophenylhydrazine (0.26g, 1.3 mmol) in ethanol (60 cm^3). The mixture was heated under reflux for 5h, allowed to cool and filtered. Removal of the solvent produced a yellow oil which, after repeated washing with aliquots of petroleum ether (40-60°C boiling range) afforded a yellow powder : N-(2',4'-dinitrophenyl-3,5-bis(trifluoromethyl)pyrazole hydrate (nc) (0.29g, 66%). [Found: C, 34.3; H, 2.1; N, 15.2%; M(mass spec.), 370 (M^+). $C_{11}H_4F_6N_4O_4.0.5H_2O$ requires C, 34.8; H, 1.3; N, 14.8%; M, 380], m.p. 82-83°C, ν_{max} (KBr) 3200, 3520 (O-H str.), 1330, 1510, 1600, 1620 (C=N str.), (N=O str.), (C=C str.), 1110, 1190 cm^{-1} (C-F str.).

N-pentafluorophenyl-3,5-bis(trifluoromethyl)-pyrazole

1,1,1,5,5,5-Hexafluoropentane-2,4-dione (0.14 cm^3, 1.0 mmol) was added dropwise to a stirred solution of pentafluorophenylhydrazine (0.14g, 1.0 mmol) in ethanol (60 cm^3). The mixture was heated under reflux for 2h, allowed to cool and filtered. Removal of the solvent produced an orange oil which, after repeated washing with aliquots of petroleum ether (40-60°C boiling range) afforded a brown solid. Sublimation of this material *in vacuo* afforded white crystals of N-pentafluorophenyl-3,5-bis(trifluoromethyl)pyrazole hydrate (nc) (0.1g, 26%). [Found: C, 34.1; H, 0.5; N, 7.5%. $C_{11}HF_{11}N_2.H_2O$ requires C, 34.0; H, 0.8; N, 7.2%], m.p. 60-62°C, ν_{max} (KBr) 3400 (O-H str.), 2950 (C-H str.), 1400, 1510, 1625 (C=N str.), (C=C str.), 1150, 1190 cm^{-1} (C-F str.), δ_F ($CDCl_3$) -67.33, -81.16 (s; s; 3-,5-CF_3), -142.97, -151.31, -161.74 (d; t; t; C_6F_5) ppm, (J_{FF} 21Hz), δ_H (same soln.) 3.60 (s; 4-H), 3.45 (br; OH), 1.65 (s; OH) ppm.

ACKNOWLEDGEMENT

We are grateful to the SERC for supporting this work.

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