Supplementary Material (ESI) for Chemical Communications
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Supporting information.

General Considerations

NMR studies were carried out on a Varian Gemini Mercury Plus spectrometer at 293 K in $CDCl_3$ unless otherwise stated. ^1H NMR spectra were recorded at 300 MHz and were referenced to the residual ^1H resonance of the solvent. ^{13}C NMR spectra were recorded at 75 MHz and referenced to the resonance of the deuterated solvent.

Isoniazid, benzhydrazide, periodic acid and TEMPO were purchased from Sigma-Aldrich and used as received. The manganese catalyst, $[Mn^{IV}\text{-}Mn^{IV}(\mu\text{-}O)_3L_2](PF_6)_2$ (L=1,4,7-trimethyl-1,4,7-triazacyclononane) was available in the group and prepared by the method of Wieghardt.[1] All competitive trapping (section 3.2.2 and 3.2.3) experiments were performed in duplicate.

Anhydrous magnesium sulphate was used for drying of solvent extracts and solvents removed under reduced pressure on a rotary evaporator.

Mass Spectrometry was performed using a Finnigan LCQ ion trap mass spectrometer fitted with an electrospray ion source. The samples were infused directly using a syringe pump at 10 μL per minute. The nitrogen nebulising gas pressure was 413 kPa, the needle voltage 4 kV, and the capillary voltage 8 V. The MS/MS scans were selected interactively using an isolation width of 3 m/z units. Molecular ions and mass fragments are referenced in intensity relative to the most intense peak (given the value 100%).

General Procedure for Trapping with TEMPO

TEMPO (**4**) (62.5 mg, 0.4 mmol) was added to a solution of benhydrazide (**6a**) (54 mg, 1.2 mmol) in aqueous acetonitrile (4:1 MeCN: H_2O, 5 mL) at 0 °C. Potassium permanganate (76 mg, 1.2 mmol) was added (in portions) and the solution stirred for 5 min before being warmed to room temperature.

The reaction (including unreacted TEMPO) was quenched by adding 1M sulphuric acid (1 mL), 0.5M potassium hydrogen sulphate (1 mL) and saturated sodium sulphite solution (1 mL). The mixture was made alkaline with sodium carbonate and extracted with dichloromethane (3x20 mL). The organic extract was dried and evaporated to give a solid which was passed through a short plug of silica using 20% ethyl acetate in hexanes to give the TEMPO adduct as a clear solid in 43%.

General Procedure for Competitive Trapping – Methanol as Solvent

To degassed ($N_{2(g)}$) methanol (5 mL) was added TEMPO (62.5 mg, 0.4 mmol), isoniazid (54.9 mg, 0.4 mmol) and Mn catalyst ($[Mn^{IV}\text{-}Mn^{IV}(\mu\text{-}O)_3L_2](PF_6)_2$ (L=1,4,7-trimethyl-1,4,7-triazacyclononane)) (5mg, 6 x 10^{-3} mmol, 1.6 mol%). Periodic acid (180 mg, 0.8 mmol) was added slowly and the reaction mixture stirred for a further 15 min. The solvent was removed and the reaction worked up as previously described. The resulting ratio of methyl ester to tempo ester was determined by ^1H NMR integration.

General Procedure for Competitive Trapping – Acetonitrile as Solvent

To a solution of Mn catalyst ($[Mn^{IV}\text{-}Mn^{IV}(\mu\text{-}O)_3L_2](PF_6)_2$ (L=1,4,7-trimethyl-1,4,7-triazacyclononane)) (5 mg, 6 x10^{-3} mmoles, 1.6 mol%) in degassed ($N_{2(g)}$) acetonitrile (4.5 mL) and pyridine (0.5 mL), was added TEMPO (62.5 mg, 0.4 mmol), methanol (52 μL, 1.2 mmol) and isoniazid (54.9 mg, 0.4 mmol). To this was added slowly periodic acid (180 mg, 0.8 mmol, in 1 mL 25% pyridine in acetonitrile) and the reaction mixture stirred for a further 15 min. The solvent was removed and the reaction worked up as previously described. The resulting ratio of methyl ester to tempo ester was found by ^{1}H NMR integration.

Spectral Data for Novel Compounds

Isonicotinoylhydroxylamine

δ_H(acetone-d_6) 1.1-1.7 (18H, m,), 7.9 (2H, m, Py), 8.8 (2H, m, Py).
δ_C(acetone-d_6) 17.0(CH_2) 21.0(CH_3), 32.1(CH_3), 39.2(CH_2), 60.9(C), 123.7(CH), 138.1(C), 149.7(CH), 164.7(C=O).
m/z EI 262 (M^+, 1%), 247(84%), 156(32%), 139(13%), 125(65%), 123(100%), 106(50%), 97(27%), 83(76%), 77(37%), 69(60%), 55(76%), 51(31%), 41(50%)
HRMS 262.1682, $C_{15}H_{22}N_2O_2$ requires 262.1681
ν_{MAX}/cm^{-1} 1755(CO)

m-Nitro-O-benzoylhydroxylamine

δ_H($CDCl_3$) 1.1-1.8 (18H, m), 7.7 (1H, t, Ph), 8.4 (2H, m, Ph), 8.8 (1H, s, Ph).
δ_C($CDCl_3$) 16.9 (CH_2), 20.9 (CH_3), 32.0(CH_3), 39.1(CH_2), 60.7(C), 124.4(CH), 127.4(CH), 129.8(CH), 131.5(C), 135.3(CH), 148.3(C), 164.4(C=O).
m/z EI 306 (M^+, 1%), 291(100%), 167(12%), 156(37%), 150(36%), 123(20%), 104(7%), 69(24%), 55(42%), 41(50%).
HRMS 306.1578, $C_{16}H_{22}N_2O_4$ requires 306.1579
ν_{MAX}/cm^{-1} 1752(CO), 1534(NO_2), 1351(NO_2)

See attached pdf of ^{13}C and ^{1}H nmr

General Procedure for the calculation of Redox Potentials

Redox potentials were calculated using a modified version of the method by Fu *et al.*[2] as follows:
E^o (versus NHE) = IP + (1/96.48)(-TΔS + $\Delta G_{solvation,cation} - \Delta G_{solvation,radical}$) – 4.28
IP was calculated at ROB3LYP/6-311+G(2d,2p)//B3LYP/6-31G(d) and 0.28V added to correct for the systematic underestimation found by Fu *et al.*[1]
Solvation calculations were performed using the D-PCM formulation developed by Tomasi *et al.*[3-5] at the B3LYP/6-31G(d) level using the following G03 keywords cavity=pentakisdodecahedra, Icomp=4, TSNUM=60, TSARE=0.4, radii=bondi, alpha = 1.20.
Solvation calculations were performed using water as the solvent to allow comparison with values of experimental aqueous redox potentials.
The value of 4.28V was used for the absolute potential of the normal hydrogen electrode in water.[6]
All calculations were carried out using Gaussian03 software.[7]

Ionisation potentials at different levels of theory (eV)

	isoniazid	benzhydrazide	*p*-methoxybenzhydrazide	*m*-nitrobenzhydrazide
B3LYP	7.00	6.47	6.04	7.04
BHandHLYP	6.96	6.42	6.02	6.96
MPW1K	7.16	6.63	6.22	7.17
BMK	6.92	6.39	6.02	6.95
MPWB1K	6.89	6.37	5.95	6.89
QB3	6.98	6.52	6.15	7.01
HF	6.48	5.89	5.50	6.46
MP2	6.70	6.24	5.90	6.75
MP4	6.73	6.25	5.87	6.74
CCSD(T)	6.84	6.34	5.43	6.29

Values are the uncorrected ΔH (cation – radical)
All calculations performed with a 6-311+G(2d,2p) basis set on geometries optimized with B3LYP/6-31G(d)
Enthalpy corrections added from a B3LYP/6-31G(d) frequency calculation

Calculations for aqueous redox potential vs the normal hydrogen electrode (NHE)

Optimised Geometries (B3LYP/6-31G(d))

Radicals

derived from isoniazid

Atomic Coordinates (Å)

Atom	X	Y	Z
C	1.725123	-0.977972	0.000290
C	0.364262	-1.289502	-0.000015
C	-0.554620	-0.238001	-0.000382
C	-0.075523	1.079404	-0.000257
C	1.303894	1.275002	-0.000125
H	2.471159	-1.770247	0.000304
H	0.021082	-2.319404	-0.000079
H	-0.767745	1.915288	-0.000192
H	1.716487	2.282222	0.000391
C	-2.016641	-0.530034	-0.000596
O	-2.912296	0.257243	0.000625
N	2.196918	0.274401	0.000156

derived from benzhydrazide

Atomic Coordinates (Å)

Atom	X	Y	Z
C	-1.711575	-1.053979	-0.000030
C	-0.340426	-1.304642	0.000012
C	0.565111	-0.236031	-0.000022
C	0.094785	1.089041	-0.000007
C	-1.274598	1.334271	0.000029
H	-2.416551	-1.880364	0.000067
H	0.043608	-2.320761	-0.000007
H	0.813544	1.903112	-0.000014
H	-1.644537	2.356006	0.000000
C	2.019024	-0.522520	0.000038
O	2.924005	0.258171	-0.000017
C	-2.176132	0.263485	-0.000002
H	-3.245235	0.458889	-0.000031

derived from *m*-nitrobenzhydrazide

Atomic Coordinates (Å)

Atom	X	Y	Z
C	0.315000	2.240336	-0.000057
C	1.536617	1.566032	0.000020
C	1.569593	0.165451	0.000072
C	0.376242	-0.571627	0.000096
C	-0.824714	0.124351	0.000029
H	0.288682	3.325390	-0.000144
H	2.474878	2.112811	0.000014
H	0.390078	-1.654930	0.000122
C	2.884349	-0.528962	0.000062
O	3.088000	-1.703935	-0.000105
C	-0.877867	1.519833	-0.000039
H	-1.842565	2.012490	-0.000009
N	-2.091486	-0.634933	0.000005
O	-3.138635	0.009781	0.000006
O	-2.017613	-1.861311	-0.000042

derived from *p*-methoxybenzhydrazide

Atomic Coordinates (Å)

Atom	X	Y	Z
C	0.543884	1.468728	-0.000165
C	-0.840540	1.432115	0.000225
C	-1.522857	0.203425	-0.000107
C	0.606435	-0.967238	-0.000296
H	1.089115	2.406956	-0.000112
H	-1.415455	2.353762	0.000515
C	-2.995186	0.186123	0.000278
O	-3.729260	-0.759936	0.000177
H	1.159211	-1.899708	-0.000271
C	1.276580	0.268709	-0.000372
C	-0.783614	-0.990748	-0.000323
H	-1.315922	-1.937495	-0.000548
O	2.626002	0.408226	-0.000257
C	3.435710	-0.761476	0.000561
H	4.467522	-0.407135	0.001085
H	3.259000	-1.370090	0.896126
H	3.260116	-1.370438	-0.894960

Cations

derived from isoniazid

Atomic Coordinates (Å)

Atom	X	Y	Z
C	-1.542988	1.158332	0.000284
C	-0.151879	1.235966	0.000038
C	0.540431	0.000162	-0.000027
C	-0.151605	-1.235783	-0.000038
C	-1.542668	-1.158592	-0.000122
H	-2.140195	2.066279	0.000115
H	0.367689	2.188030	-0.000024
H	0.368428	-2.187600	-0.000045
H	-2.139698	-2.066635	0.000067
C	1.934029	0.000194	-0.000090
O	3.067651	-0.000069	-0.000141
N	-2.215622	-0.000171	0.000107

derived from benzhydrazide

Atomic Coordinates (Å)

Atom	X	Y	Z
C	1.515414	1.225236	0.000004
C	0.132136	1.248204	0.000005
C	-0.554766	0.000280	0.000000
C	0.131730	-1.247645	-0.000010
C	1.514987	-1.225749	-0.000005
H	2.067469	2.159126	0.000009
H	-0.418714	2.182866	0.000013
H	-0.419723	-2.182011	-0.000015
H	2.066539	-2.159895	-0.000008
C	-1.937095	0.000347	0.000001
O	-3.074577	-0.000236	0.000002
C	2.200080	-0.000348	0.000001
H	3.286127	-0.000147	0.000007

derived from *m*-nitrobenzhydrazide

Atomic Coordinates (Å)

Atom	X	Y	Z
C	-0.385201	2.162085	0.000046
C	-1.570448	1.444259	0.000183
C	-1.495189	0.021792	0.000006
C	-0.259414	-0.676327	-0.000330
C	0.883949	0.095424	0.000034
H	-0.412275	3.246593	0.000126
H	-2.532047	1.946935	0.000129
H	-0.191613	-1.758873	-0.000072
C	-2.670416	-0.716625	-0.000059
O	-3.631802	-1.320796	-0.000055
C	0.846753	1.492660	0.000021
H	1.784689	2.038698	-0.000016
N	2.202033	-0.599384	0.000375
O	3.191842	0.116188	-0.000288
O	2.169561	-1.822551	0.000069

derived from *p*-methoxybenzhydrazide

Atomic Coordinates (Å)

Atom	X	Y	Z
C	-0.446593	1.421470	0.000344
C	0.915026	1.296703	0.000411
C	1.490086	-0.017035	0.001102
C	-0.706211	-1.034370	0.001213
H	-0.921856	2.396280	0.000084
H	1.553101	2.173959	0.000060
C	2.851286	-0.164070	-0.000551
O	3.987440	-0.288143	-0.001931
H	-1.334102	-1.916610	0.002114
C	-1.279553	0.266463	0.000318
C	0.659357	-1.179559	0.001506
H	1.105748	-2.168587	0.002672
O	-2.572853	0.510405	0.000904
C	-3.541441	-0.564494	-0.002239
H	-4.509815	-0.067941	-0.011841
H	-3.423860	-1.176821	-0.900462
H	-3.437660	-1.169019	0.902966

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