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Selective Synthesis of a Novel Family of Oligopyridine Based Imino-Nitroxide Biradicals Catalysed by Selenium Dioxide

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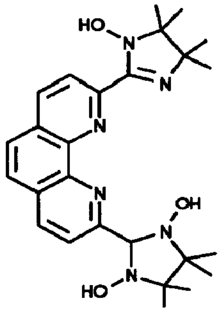
Abstract: Selective synthesis of bis-*N*-hydroxyimidazolidines based on pyridines, 2,2'-bipyridines, 1,10-phenanthroline, pyridazine and 1,8-naphthyridine from the corresponding dialdehydes and *N,N'*-dihydroxy-2,3-diamino-2,3-dimethylbutane in the presence of catalytic amounts of SeO_2. Mild oxidation afforded the corresponding stable imino-nitroxide biradicals **4** to **11**.

In the preceding communication[1] we presented the synthesis and characterization of a novel family of oligopyridine based nitronyl-nitroxide biradicals. These biradicals were prepared by condensation of *N,N'*-dihydroxy-2,3-diamino-2,3-dimethylbutane with the corresponding diformyl compounds, followed by mild oxidation under phase transfer conditions. When 2,9-diformyl-1,10-phenanthroline was allowed to react under the same experimental conditions a yellow precipitate, identified as **1**, was formed within 2 weeks. Prolonged reaction time resulted in the dissolution of **1** and formation of the bright orange compound **2**. Mild oxidation of both species resulted in the selective formation of the mixed biradical **3** and the imino-nitroxide biradical **4**, respectively. The presence of traces of selenium dioxide from the preparation of the bis-aldehyde[2] were expected to catalyse the deshydration of the *N,N'*-dihydroxyimidazolidine. Analogous results were obtained with 1,7-diformyl-2,8-naphthyridine also prepared by SeO_2 oxidation.[3]



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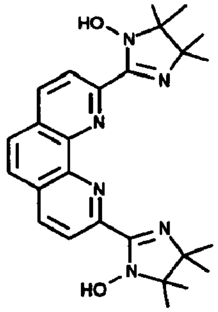

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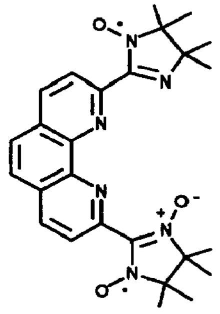

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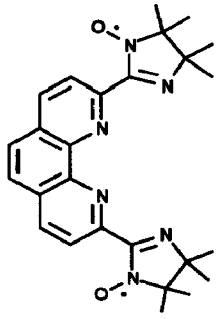

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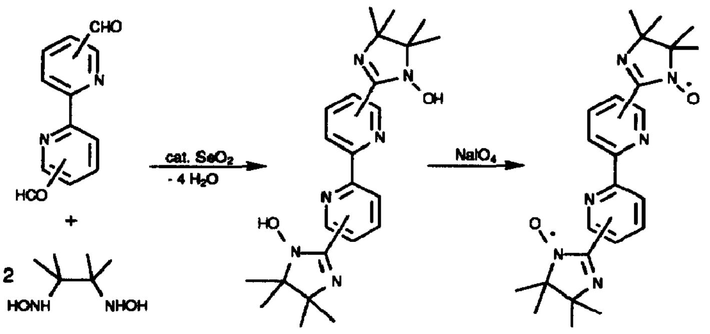
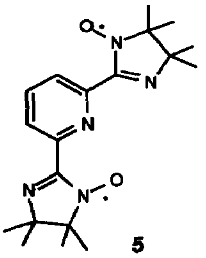
We reported in this letter a mild and versatile method for the selective preparation of a novel family of imino-nitroxide based oligopyridine biradicals. The bis-*N*-hydroxyimidazolidines were prepared in good yield (40 to 90%) by multiple condensation of *N,N'*-dihydroxy-2,3-diamino-2,3-dimethylbutane[4] with the formyl compounds[5] in methanol, using selenium dioxide as catalyst (5 mole %).



Mild oxidation of the bis-*N*-hydroxyimidazolidines under phase transfer conditions, using $NaIO_4$ gave the corresponding pure orange imino-nitroxide biradicals **4** to **11**, after alumina chromatography and recrystallisation from dichloromethane/hexane.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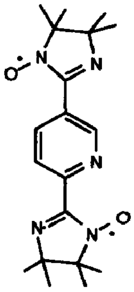
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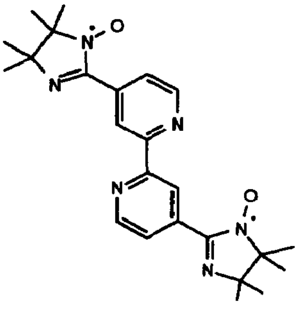
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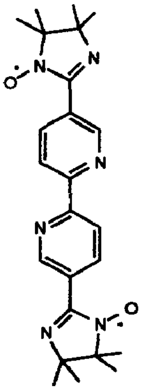
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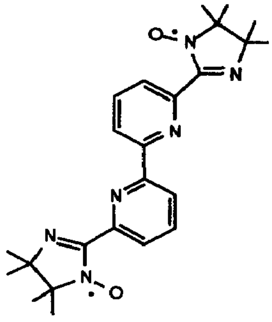
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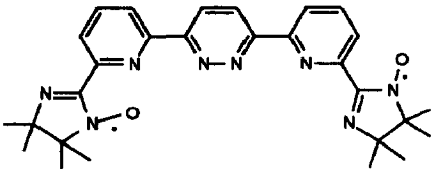
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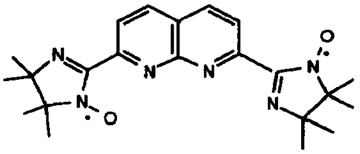
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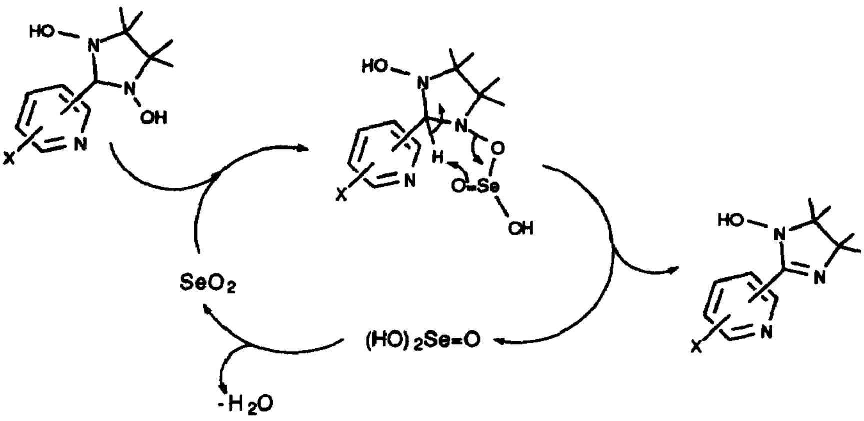
These free imino-nitroxide radicals also appear to be very stable and show, as expected, the characteristic orange colour of imino-nitroxides.[6] The imino-nitroxide biradicals are easily reduced during the mass analysis and thus exhibit in the FAB$^+$ mass spectra intense molecular ion peaks ([M+2e+3H]$^+$) plus characteristic major fragments due to the successive loss of oxygen atoms. All compounds were obtained as solids and were characterized by IR, UV-Vis and mass (FAB$^+$). All data are consistent with the proposed structures (see Table for selected data).

Table: Selected data for compounds depicted in Schemes

Product	Isolated yield (%) a)	Mp (°C)	IR ν (cm^{-1}) b)	R_f c)	UV-Vis. d) λ_{max} (nm) ε (M^{-1}cm^{-1})	Mass e)
1	25	295 dec.	3213/1656	-	-	479
2	39	230-231	3210/1667	0.11	425(12500)	461
3	20	224 dec.	1623/1357 1370	0.36	537(630) 500(580)	475
4	24*	218-219	1623/1376	0.60	429(570)	460
5	73	165-166	1539/1372	0.75	420(680)	359
6	20	215-216	1605/1371	0.77	410(800)	359
7	50	265 dec.	1597/1360	0.82	427(650)	436
8	65	232-233	1594/1368	0.82	461(1180)	436
9	50	230 dec.	1576/1371	0.80	418(800)	436
10	45	259-260	1565/1385	0.77	445(770)	514
11	23*	216-217	1602/1371	0.77	449(1000)	410

a) Oxidation reaction, except for (*) which correspond to a global yield (condensation + oxidation); b) $\nu_{N\text{-}O}$ (1350-1380 cm^{-1}), $\nu_{N=C}$ (1623-1539 cm^{-1}) and $\nu_{N\text{-}OH}$ (3210 cm^{-1}), measured in KBr pellets; c) determined on alumina sheets in ethyl acetate/methanol 95/5; d) measured in dichloromethane; e) obtained by FAB$^+$ using (m-NBA) as matrix and correspond to [M+2e+3H]$^+$, [M+e+2H]$^+$ or [M+H]$^+$.

The bis-*N*-hydroxyimidazolidines (characterized by ^{1}H, ^{13}C and IR) are either prepared at room-temperature in a one-flask procedure involving the addition of SeO_2 to an in-situ generated bis-*N,N'*-dihydroxyimidazolidine, or by deshydration of the isolated bis-*N,N'*-dihydroxyimidazolidine species in the presence of catalytic amounts of SeO_2. An optimum catalytic activity was obtained using 5 to 10 mole% of SeO_2. Stoechiometric amounts of SeO_2 have previously been used to convert aldoximes to nitriles[7] or aldehydes to nitriles in the presence of hydroxylamine hydrochloride. In this latter case a catalytic reaction could only be obtained using a continuous and efficient removal of water.[8] In our system the presence of water appears not to alter the course of the reaction. The most probable reaction pathway involves the nucleophilic attack of *N,N'*-dihydroxyimidazolidine on SeO_2, followed by proton transfer with formation of *N*-hydroxyimidazolidine and selenic acid. Water elimination restores SeO_2 which perpetuates the catalytic cycle.



Although we have not investigated the full scope of the catalytic reaction describe here, we feel that its high selectivity and mildness will make it a very useful reagent for the synthesis of mixed nitronyl-nitroxide/ imino-nitroxide ligands. Future studies of this novel series of polydentate ligands will include complexation with paramagnetic metals as well as the determination of the coordination mode (imino versus nitroxide).

Acknowledgments

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