

Synthesis of imidazole 1-oxides from 1,2-diimines

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Various 3-substituted imidazole 1-oxides have been prepared by reaction of a 1,2-dicarbonyl compound mono- or di-imine with an oxime. The structure of the oxime determines the imidazole C-2 substituent whilst the structure of the mono- or di-imine determines the substitution patterns at N-3, C-4 and C-5.

Introduction

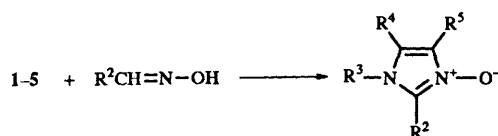
Activation of heterocyclic ring systems can be achieved by quaternization, *N*-oxidation or *N*-oxidation followed by *O*-alkylation or *O*-acylation.¹ Therefore, 3-substituted imidazole 1-oxides are potentially useful intermediates for the regioselective introduction of substituents at the ring atoms by reaction with electrophiles or nucleophiles. Subsequent removal of the *N*-oxide function provides a selective route to important *C*-substituted imidazoles. Imidazole 1-oxides are not easily accessible by *N*-oxidation, the most widely used approach to *N*-oxides, only moderate yields of product being obtained.² Similarly, alkylation of 1-hydroxyimidazoles affords the *N*-oxides in only low yield, the main reaction being *O*-alkylation.³ Substituted *N*-oxides have been prepared by cyclization of 1,2-dicarbonyl monooximes with aldimines or aldoximes,³⁻⁶ although these reactions are limited to the synthesis of poly- or per-substituted *N*-oxides.

Results and discussion

We have found that imidazole 1-oxides can be synthesized by reaction of 1,2-diimines with aldoximes. The substituent at position 3 of the imidazole 1-oxides is determined by the *N*-substituent of the diimine and can be either aliphatic or aromatic as shown by the reaction of dicyclohexylimines and di(*p*-tolyl)imines. The substituents at positions 4 or 5 of the imidazole 1-oxides are given by the substituents of the 1,2-dicarbonyl compound used for the preparation of the diimines. Thus, glyoxal gave imidazole 1-oxides devoid of substituents at C-4 and C-5. Methylglyoxal provided 4- and 5-methyl substituted compounds while butane-2,3-dione gave rise to 4,5-dimethyl substituted *N*-oxides. Finally, substitution at position 2 is controlled by selection of the aldehyde part of the aldoxime as demonstrated by the successful synthesis using oximes derived from formaldehyde, acetaldehyde, phenylacetaldehyde or benzaldehyde.

1,2-Diimines were prepared by literature procedures by reaction of 1,2-dicarbonyl compounds with 2 equivalents of an amine.⁷⁻¹⁰ In order to study the factors that influence the cyclization, the reaction of 2,3-dimethyl-1,4-di(*p*-tolyl)-1,4-diazabutadiene **1** with formaldehyde oxime was studied. Selected results are collected in Table 1.

Since formaldehyde oxime was used without isolation, the solvent used in its preparation was also present during the subsequent cyclization (solvent A). The cyclization was very sensitive to the nature of the solvent. The best results were obtained using a mixture of protic solvents (methanol-isopropyl alcohol, 1:2) for the preparation of formaldehyde oxime followed by addition of an aprotic solvent (toluene) for



8 R² = H, R³ = *p*-MeC₆H₄, R⁴ = R⁵ = Me

9 R² = R⁴ = R⁵ = H, R³ = *p*-MeC₆H₄

10 R² = PhCH₂, R³ = *p*-MeC₆H₄, R⁴ = R⁵ = Me

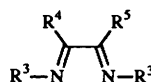
11 R² = R⁴ = R⁵ = Me, R³ = *p*-MeC₆H₄

12 R² = R⁴ = H, R³ = *p*-MeC₆H₄, R⁵ = Me

13 R² = R⁵ = H, R³ = *p*-MeC₆H₄, R⁴ = Me

14 R² = R⁴ = R⁵ = H, R³ = C₆H₁₁

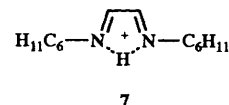
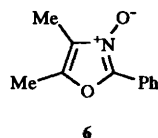
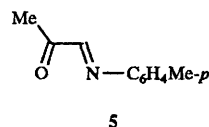
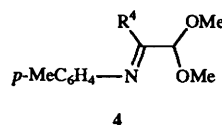
15 R² = Ph, R³ = *p*-MeC₆H₄, R⁴ = R⁵ = Me



1 R³ = *p*-MeC₆H₄, R⁴ = R⁵ = Me

2 R³ = *p*-MeC₆H₄, R⁴ = R⁵ = H

3 R³ = C₆H₁₁, R⁴ = R⁵ = Me



the cyclization process (entry 5). In both processes water or methanol gave rise to hydrolysis or methanolysis of the diimine (entries 1, 2) while aprotic solvents led to strongly reduced yields (entry 3). Yields were very sensitive to the composition of the alcoholic mixture but followed a clear trend. Yields were low when only methanol or isopropyl alcohol was present (entries 4, 7). Improved yields were obtained when both alcohols were present (entries 5, 6) and reached a maximum when their ratio was *ca.* 1:2 (entry 5). Ethanol having a similar polarity to this mixture gave rise to similar yields (entry 8).

The use of acid in excess (toluene-*p*-sulfonic acid or sulfuric

Table 1 Synthesis of imidazole 1-oxide **8** by reaction of 2,3-dimethyl-1,4-di(*p*-tolyl)-1,4-diazabuta-1,3-diene **1** with formaldehyde oxime

Entry	Solvent A ^a	Solvent B ^b	Acid	Time (t/h), temp.	Molar ratio ^c	Yield (%)
1	Water	AcOH	AcOH	24, RT	1:1	Traces
2	MeOH	MeOH	H ₂ SO ₄	6, reflux	1:1:3.6	13
3	MeCN	Ph	<i>p</i> -TsOH	6, reflux	1:1:4	25
4	MeOH	PhMe	<i>p</i> -TsOH	6, reflux	1:1:4	20
5	MeOH-Pr ⁱ OH ^d	PhMe	<i>p</i> -TsOH	6, reflux	1:1:4	40
6	MeOH-Pr ⁱ OH ^e	PhMe	<i>p</i> -TsOH	6, reflux	1:1:4	23
7	Pr ⁱ OH	PhMe	<i>p</i> -TsOH	6, reflux	1:1:4	17
8	EtOH	PhMe	<i>p</i> -TsOH	6, reflux	1:1:4	35
9	MeOH-Pr ⁱ OH ^d	PhMe	CF ₃ CO ₂ H	6, reflux	1:1:4	24
10	MeOH-Pr ⁱ OH ^d	PhMe	<i>p</i> -TsOH	6, reflux	1:1:2	29
11	Pr ⁱ OH	PhMe		6, reflux	1:1	5
12	MeOH	MeOH		6, reflux	1:1	7

^a Solvent used in the preparation of formaldehyde oxime. ^b Solvent added in the cyclization reaction. ^c Diimine-formaldehyde oxime-acid. ^d 1:2 v/v ratio. ^e 1:5 v/v ratio.

Table 2 Cyclization of 2,3-dimethyl-1,4-bis(*p*-tolyl)-1,4-diazabuta-1,3-diene **1** with oximes

Entry ^a	Oxime	Acid	Time (t/h), temp.	Yield (%)	<i>N</i> -oxide
1	Phenylacetaldehyde oxime	<i>p</i> -TsOH	6, reflux	17	10
2	Phenylacetaldehyde oxime	CF ₃ CO ₂ H	8, reflux	31	10
3	Acetaldehyde oxime	<i>p</i> -TsOH	7, reflux	22	11
4	Acetaldehyde oxime	CF ₃ CO ₂ H	6, reflux	15	11
5	Benzaldehyde oxime	<i>p</i> -TsOH	10, reflux	Traces	15

^a Diimine-oxime-acid, 1:1:4 molar ratio; solvent, ethanol-toluene.

Table 3 Cyclization of mono- and di-imines with formaldehyde oxime

Entry ^a	Mono or diimine	Solvent B ^b	Acid	Time (t/h), temp.	Yield (%)	<i>N</i> -Oxide
1	2	PhMe	<i>p</i> -TsOH	6, reflux	37	9
2	4	PhMe	CF ₃ CO ₂ H	6, reflux	29	12
3	5	Et ₂ O	CF ₃ CO ₂ H	24, RT	4	13
					7	12
4	3	CH ₂ Cl ₂	none	24, RT	32	14

^a Diimine-oxime-acid (1:1:4, molar ratio). ^b Solvent A, methanol-isopropyl alcohol (1:2 v/v).

acid) was necessary to effect cyclization, by mediating the elimination of *p*-toluidine; 4 equivalents of acid gave the best results (entry 5 *vs.* 10). The reaction of different aldoximes in the cyclization process is shown in Table 2. Aliphatic oximes produced the highest yields of 2-alkyl substituted imidazole 1-oxides when toluene-*p*-sulfonic acid or trifluoroacetic acid were used for the cyclization (Table 2, entries 1-4).

Benzaldehyde oxime, however, afforded only traces of the expected imidazole 1-oxide. In addition, 4,5-dimethyl-2-phenyl-oxazole 3-oxide **6** was isolated as a by-product. The presence of this product is explained by hydrolysis of the diimine followed by reaction with the oxime (entry 5). Apparently this competing reaction becomes more significant when aldehyde oximes of low reactivity such as benzaldehyde oxime were used.

Imidazole 1-oxides devoid of substituents at C-4 and C-5 are easily available as demonstrated by the reaction of 1,4-di(*p*-tolyl)-1,4-diazabutadiene **2**⁹ with formaldehyde oxime under standard conditions to give 3-(*p*-tolyl)imidazole 1-oxide **9** in 37% yield (Table 3, entry 1).

A series of 1,2-dicarbonyl compounds were employed in the reaction. The results are shown in Table 3. Reaction of 1,1-dimethoxypropan-2-one with *p*-toluidine did not afford the expected 1,2-diimine. However, the two monoimines **4** and **5** were used for the preparation of 5-methyl- and 4-methyl-3-(*p*-

tolyl)imidazole 1-oxides **12** and **13**. Reaction of 2-oxopropanal 1-(*p*-tolyl)imine **11** **5** with formaldehyde oxime in diethyl ether afforded a 1.8:1 mixture of **12** and **13**.

The presence of the unexpected *N*-oxide **13** can be explained by initial formation of the diimine which then reacts with formaldehyde oxime, yielding both isomers **12** and **13** or by reaction of **5** with formaldehyde oxime yielding methylglyoxal aldoxime followed by reaction with *p*-toluidine and formaldehyde, similarly to the reported procedure.⁶ Reaction of **4** with formaldehyde oxime afforded unexpectedly 5-methyl-3-(*p*-tolyl)imidazole 1-oxide **12** as the sole *N*-oxide in 29% yield. This result confirms the second mechanism because, in this case, formation of a diimine is unlikely. 3-Alkyl substituted *N*-oxides were synthesized from aliphatic amines. Reaction between benzylamine and glyoxal afforded a complex trimer.¹² However, reaction of cyclohexylamine and glyoxal afforded 1,4-dicyclohexyl-1,4-diazabutadiene **3**.⁸ Subsequent reaction with formaldehyde oxime afforded 3-cyclohexylimidazole 1-oxide **14** (Table 4).

The best results were obtained at room temperature under neutral conditions using dichloromethane as solvent (entry 5). Higher temperatures effected decomposition of the aliphatic diimine which were less stable than the aromatic ones. The higher basicity of the diimine favours the formation of a stable

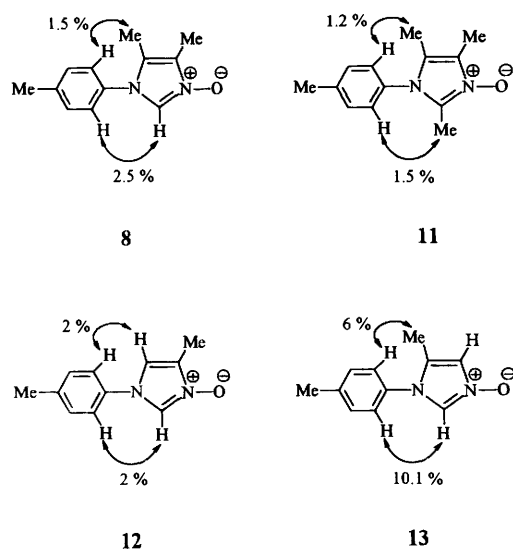
Table 4 Synthesis of imidazole 1-oxide **14** by reaction of 1,4-dicyclohexyl-1,4-diazabuta-1,3-diene **3** with formaldehyde oxime

Entry	Solvent B ^a	Acid or base	Time (t/h)	Molar ratio ^b	Yield (%)
1	PhMe	<i>p</i> -TsOH	16, reflux	1:1:4	2
2	PhMe	CF ₃ CO ₂ H	24, RT	1:1:4	3
3	PhMe		24, reflux	1:1	20
4	PhMe	AcONa	6, reflux	1:1:1	21
5	CH ₂ Cl ₂		24, RT	1:1	32

^a Solvent A, MeOH-PrⁱOH (1:2 v/v). ^b Diimine-oxime-acid or base.

immonium salt **7** under acidic conditions. Formation of this salt reduces the propensity for the cyclization to the imidazole 1-oxide (entries 1, 2).

The assignment of the structure of the regioisomers **13** and **12** was achieved through NOE difference spectroscopy.¹³ On irradiation at the frequency of the *ortho*-phenyl proton in **13** a positive NOE was observed for the signals at 8.01 (2-H) and 2.14 ppm (4-Me). Similarly, irradiation on the *ortho*-phenyl proton in **12** gave rise to a positive NOE at 8.24 (2-H) and 6.88 ppm (4-H). Selected NOEs are shown in Fig. 1.

**Fig. 1**

Assignment of the ¹H NMR spectra of *N*-oxides devoid of substituents at positions 2, 4 and 5 was performed by one-bond heteronuclear correlation spectroscopy, while two- or three-bond heteronuclear correlation was applied in the case of persubstituted *N*-oxides.

In conclusion, imidazole 1-oxides are obtained in one step by cyclization of 1,2-diimines with oximes. Although yields are modest the present method offers the advantage that imidazole 1-oxides can be obtained in one step from simple acyclic precursors which are more stable than those used in previous cyclizations.³⁻⁶ The precursors allow extensive control of the nature of the other substituents in the imidazole nucleus making the method quite general.

The present approach also offers advantages to reported methods based upon oxidation of preformed imidazoles since these may be difficult to prepare and since the oxidation gives poor yields.^{2,3}

Experimental

NMR spectra were recorded in a Varian Unity 300 working at 299.903 MHz in ¹H NMR and 75.423 MHz in ¹³C NMR and

using Me₄Si as internal standard; *J* values are given in Hz. NOE difference spectra were recorded using a decoupler power of 10 dB. HETCOR experiments were recorded using the standard Varian parameters. High resolution mass spectra was performed on electron impact. 1,4-Di(*p*-tolyl)-1,4-diazabuta-1,3-diene **2**,⁹ 1,4-dicyclohexyl-1,4-diazabutadiene **3**⁸ and oximes¹⁴ were prepared according to literature procedures.

1,2-Diimines and monoimines

2,3-Dimethyl-1,4-di(*p*-tolyl)-1,4-diazabuta-1,3-diene 1. Butane-2,3-dione (1.76 cm³, 0.02 mol) and sulfuric acid (0.05 cm³) were added to a solution of *p*-toluidine (4.28 g, 0.04 mol) in methanol (20 cm³). The reaction mixture was stirred at room temperature for 6 h to give a yellow precipitate (3.35 g, 63%), mp 109–110 °C (from EtOH) (Found: C, 81.6; H, 7.5; N, 10.7. C₁₈H₂₀N₂ requires C, 81.8; H, 7.6; N, 10.6%); δ_H(CDCl₃) 2.1 (6 H, s, 2-Me, 3-Me), 2.3 (6 H, s, 2 × 4'-Me), 6.46 (2 H, d, *J* 8.5, 2'-H, 6'-H) and 7.41 (2 H, d, *J* 8.5, 3'-H, 5'-H).

2-Methyl-3-(*p*-tolyl)-3-azapropenal dimethyl acetal 4. Methylglyoxal dimethyl acetal (1.24 cm³, 0.01 mol) and sulfuric acid (0.05 cm³) were added to a solution of *p*-toluidine (1.07 g, 0.01 mol) in isopropyl alcohol (10 cm³) and the mixture stirred at room temperature for 24 h. After neutralization with 20% aq. ammonia, the mixture was filtered and evaporated to afford a mixture of *p*-toluidine and the title compound **4** (1:1; 1.53 g). This product decomposed during the purification; δ_H(CDCl₃) 1.8 (3 H, s, 2-Me), 2.3 (3 H, s, 4'-Me), 3.4 (6 H, s, 2 × MeO), 4.6 (1 H, s, 1-H), 6.43 (2 H, d, *J* 6.9, 2'-H, 6'-H) and 7.34 (2 H, d, *J* 6.9, 3'-H, 5'-H).

Reaction of methylglyoxal with *p*-toluidine.¹¹ A mixture of methylglyoxal (40% in water; 4.06 g, 0.025 mol) and diethyl ether (20 cm³) was cooled in an ice-bath. A solution of *p*-toluidine (2.14 g, 0.02 mol) in diethyl ether (3 cm³) was added dropwise to it with efficient stirring. The stirring was continued for 10 min after which the aqueous layer was separated and the organic layer was washed with water (3 × 1 cm³). The organic solution of 4-methyl-*N*-(2-oxopropylidene)benzeneamine **5** was dried (MgSO₄) and stored at -15 °C.

Imidazole 1-oxides

General method. A solution of the mono- or diimine (5 mmol) in the appropriate solvent (10 cm³) together with the appropriate acid (20 mmol) were added to a solution of the oxime (5 mmol) in the appropriate solvent (3 cm³). Reactions were conducted under the conditions indicated in Tables 1–4. The solution was poured into aqueous potassium hydroxide (1 mol dm⁻³; 40 cm³) and the aqueous layer was separately washed with tetrachloromethane (2 × 10 cm³) and extracted with chloroform (10 × 10 cm³). The combined extracts were dried (MgSO₄) and evaporated to afford the crude product.

4,5-Dimethyl-3-(*p*-tolyl)imidazole 1-oxide 8. Table 1, entry 5. From diazabutadiene **1** (1.32 g, 5 mmol) and formaldehyde oxime (*ca.* 5 mmol). The crude product (0.5 g) was filtered through silica gel (10 g) with ethyl acetate-ethanol (1:1) as eluent to yield the title compound **8** (0.40 g, 40%); *R*_F 0.28, mp 163–164 °C (from CCl₄) (Found: C, 71.5; H, 6.6; N, 13.8. C₁₂H₁₄N₂O requires C, 71.3; H, 7.0; N, 13.85%); δ_H(CDCl₃) 2.10 (3 H, s, 4-Me), 2.25 (3 H, s, 5-Me), 2.43 (3 H, s, 4'-Me), 7.09 (2 H, d, *J* 8.3, 2'-H, 6'-H), 7.38 (2 H, d, *J* 8.3, 3'-H, 5'-H) and 8.02 (1 H, s, 2-H); δ_C(CDCl₃) 7.3 (5-Me), 9.3 (4-Me), 21.0 (4'-Me), 121.7 (C-4), 124.4 (C-2), 125.5 (C-2', C-6'), 127.0 (C-5), 130.3 (C-3', C-5'), 132.1 (C-1') and 139.4 (C-4).

3-(*p*-Tolyl)imidazole 1-oxide 9. Table 3, entry 1. From diazabutadiene **2** (1.18 g, 5 mmol) and formaldehyde oxime (*ca.* 5 mmol). The crude product (0.45 g) was filtered through silica gel (10 g) using ethyl acetate-ethanol (1:1) as eluent to yield the title compound **9** (0.35 g, 37%); *R*_F 0.23; mp 168–170 °C (from water) (Found: C, 69.1; H, 5.8; N, 15.5. C₁₀H₁₀N₂O

requires C, 68.95; H, 5.8; N, 16.1%); $\delta_{\text{H}}(\text{CDCl}_3)$ 2.39 (3 H, s, 4'-Me), 7.09 (1 H, t, *J* 1.8, 4-H), 7.18 (2 H, d, *J* 8.5, 2'-H, 6'-H), 7.24 (1 H, t, *J* 1.8, 5-H), 7.28 (2 H, d, *J* 8.4, 3'-H, 5'-H) and 8.25 (1 H, t, *J* 1.8, 2-H); $\delta_{\text{C}}(\text{CDCl}_3)$ 21.2 (4'-Me), 115.7 (C-4), 121.1 (C-2', C-6'), 123.4 (C-5), 125.8 (C-2), 130.9 (C-3', C-5'), 133.6 (C-1') and 139.2 (C-4').

2-Benzyl-4,5-dimethyl-3-(*p*-tolyl)imidazole 1-oxide 10. Table 2, entry 2. From diazabutadiene **1** (1.32 g, 5 mmol) and phenylacetaldehyde oxime (0.68 g, 5 mmol). The aqueous mixture was extracted with chloroform ($5 \times 10 \text{ cm}^3$) and the crude product (1.7 g) was filtered through silica gel (20 g) with ethyl acetate-ethanol (2:1) as eluent to yield the title compound **10** (0.45 g, 31%); R_{F} 0.15; mp 113–115 °C [from light petroleum (bp 40–60 °C)-ethyl acetate] (Found: C, 77.7; H, 6.9; N, 9.4. $\text{C}_{19}\text{H}_{20}\text{N}_2\text{O}$ requires C, 78.05; H, 6.9; N, 9.6%); $\delta_{\text{H}}(\text{CDCl}_3)$ 1.92 (3 H, s, 4-Me), 2.29 (3 H, s, 5-Me), 2.42 (3 H, s, 4'-Me), 4.08 (2 H, s, CH_2), 7.06 (2 H, dd, *J* 7.5, 2.1, 2'-H, 6'-H), 7.15 (3 H, m, 3'-H, 4'-H, 5'-H), 6.7 (2 H, d, *J* 8.4, 2'-H, 6'-H), 7.39 (2 H, d, *J* 8.4, 3'-H, 5'-H); $\delta_{\text{C}}(\text{CDCl}_3)$ 7.4 (5-Me) 9.0 (4-Me), 21.1 (4'-Me), 28.6 (CH_2), 120.0 (C-4), 125.2 (C-5), 126.4 (C-4'), 127.6 (C-2', C-6'), 128.2 (C-3', C-5'), 128.4 (C-2'', C-6''), 130.0 (C-3', C-5'), 131.7 (C-1'), 134.7 (C-2), 136.4 (C-1'') and 139.6 (C-4').

2,4,5-Trimethyl-3-(*p*-tolyl)imidazole 1-oxide 11. Table 2, entry 3. From diazabutadiene **1** (1.32 g, 5 mmol) and acetaldehyde oxime (*ca.* 5 mmol). The crude product (0.33 g) was filtered through silica gel (10 g) with ethyl acetate-ethanol (2:1) as eluent to yield the title compound **11** (0.24 g, 22%); R_{F} 0.20; mp 115–117 °C (from ethyl acetate) (Found: C, 71.9; H, 7.4; N, 12.7. $\text{C}_{13}\text{H}_{16}\text{N}_2\text{O}$ requires C, 72.2; H 7.5; N, 12.95%); $\delta_{\text{H}}(\text{CDCl}_3)$ 1.96 (3 H, s, 4-Me), 2.25 (3 H, s, 5-Me), 2.29 (3 H, s, 2-Me), 2.45 (3 H, s, 4'-Me), 6.93 (2 H, d, *J* 8.1, 2'-H, 6'-H) and 7.45 (2 H, d, *J* 8.1, 3'-H, 5'-H); $\delta_{\text{C}}(\text{CDCl}_3)$ 7.1 (5-Me), 8.5 (2-Me), 8.8 (4-Me), 20.8 (4'-Me), 119.5 (C-4), 124.7 (C-5), 126.9 (C-2', C-6'), 130.1 (C-3', C-5'), 131.5 (C-1'), 132.5 (C-2) and 139.4 (C-4').

5-Methyl-3-(*p*-tolyl)imidazole 1-oxide 12. Table 3, entry 2. From 2-methyl-3-(*p*-tolyl)-3-azapropenal dimethyl acetal **4** (0.76 g)† and formaldehyde oxime (*ca.* 5 mmol). The crude product (0.32 g) was filtered on silica gel (10 g) with ethyl acetate-ethanol (1:1) as eluent to yield the title compound **12** (0.27 g, 29%); R_{F} 0.25; mp 197–199 °C (from CH_2Cl_2) (Found: C, 70.3; H, 6.5; N, 14.6. $\text{C}_{11}\text{H}_{12}\text{N}_2\text{O}$ requires C, 70.2; H, 6.4; N, 14.9%); $\delta_{\text{H}}(\text{CDCl}_3)$ 2.28 (3 H, d, *J* 1, 5-Me), 2.36 (3 H, s, 4'-Me), 6.88 (1 H, dq, *J* 1.9, 1, 4-H), 7.14 (2 H, d, *J* 8.3, 2'-H, 6'-H), 7.28 (2 H, d, *J* 8.3, 3'-H, 5'-H) and 8.24 (1 H, d, *J* 1.9, 2-H); $\delta_{\text{C}}(\text{CDCl}_3)$ 8.0 (5-Me), 20.9 (4'-Me), 112.2 (C-4), 120.4 (C-2', C-6'), 124.1 (C-2), 130.6 (C-3', C-5'), 131.5 (C-5), 133.7 (C-1') and 138.2 (C-4').

5-Methyl-3-(*p*-tolyl)imidazole 1-oxide 12 and 4-methyl-3-(*p*-tolyl)imidazole 1-oxide 13. Table 3, entry 3. From 4-methyl-*N*-(2-oxopropylidene)aniline **5** (*ca.* 20 mmol, solution in diethyl ether) and formaldehyde oxime (12 cm^3 , *ca.* 20 mmol). The crude product (1.02 g) was filtered through silica gel (20 g) using ethyl acetate-ethanol (1:1) as eluent to yield a mixture of both

N-oxides (0.42 g). Preparative TLC on silica gel with ethyl acetate-ethanol (4:1) as eluent yielded the title compounds **12** (0.26 g, 7%), R_{F} 0.4 and **13** (0.16 g, 4%); R_{F} 0.25, mp 137–140 °C (from CCl_4); $\delta_{\text{H}}(\text{CDCl}_3)$ 2.14 (3 H, s, 4-Me), 2.44 (3 H, s, 4'-Me), 7.07 (1 H, s, 5-H), 7.12 (2 H, d, *J* 8.3, 2'-H, 6'-H), 7.4 (2 H, d, *J* 8.3, 3'-H, 5'-H) and 8.01 (1 H, d, *J* 1.8, 2-H); $\delta_{\text{C}}(\text{CDCl}_3)$ 9.8 (4-Me), 21 (4'-Me), 120.3 (C-5), 125.5 (C-2', C-6'), 125.8 (C-2), 126.1 (C-4), 130.4 (C-3', C-5'), 131.7 (C-1') and 139.8 (C-4') (Found: M^+ , 188.0943. Calc. for $\text{C}_{11}\text{H}_{12}\text{N}_2\text{O}$; *M*, 188.0950).

3-Cyclohexylimidazole 1-oxide 14. Table 4, entry 5. From diazabutadiene **3** (1.1 g, 5 mmol) and formaldehyde oxime (*ca.* 5 mmol). After the reaction mixture had been stirred for 24 h at room temperature, potassium carbonate (0.64 g, 5 mmol) and anhydrous magnesium sulfate were added to it and the stirring was continued at room temperature for 1 h. The solid was filtered off and the filtrate extracted with dichloromethane ($2 \times 10 \text{ cm}^3$). Evaporation of the extracts followed by filtration of the residue through silica gel (20 g) with ethyl acetate-ethanol (1:1) as eluent yielded 3-cyclohexylimidazole 1-oxide **14** (0.27 g, 32%); R_{F} 0.13, mp 184–186 °C (from $\text{EtOAc}-\text{CH}_2\text{Cl}_2$) (Found: C, 65.4; H, 8.3; N, 16.9. $\text{C}_9\text{H}_{14}\text{N}_2\text{O}$ requires C, 65.0; H, 8.5; N, 16.85%); $\delta_{\text{H}}(\text{CDCl}_3)$ 1.23 (1 H, qt, *J* 12.4, 3.3, 4'a-H), 1.41 (2 H, qt, *J* 13, 3.2, 3'a-H, 5'a-H), 1.6 (2 H, qd, *J* 12.2, 3.0, 2'a-H, 6'a-H), 1.73 (1 H, d, *J* 13, 4'e-H), 1.90 (2 H, d, *J* 13.2, 3'e-H, 5'e-H), 2.12 (2 H, d, *J* 10.7, 2'e-H, 6'e-H), 3.84 (1 H, tt, *J* 11.6, 3.7, 1'-H), 6.79 (1 H, t, *J* 1.7, 4-H), 7.12 (1 H, t, *J* 1.7, 5-H) and 7.97 (1 H, t, *J* 1.7, 2-H); $\delta_{\text{C}}(\text{CDCl}_3)$ 24.8 (C-4'), 25 (C-3', C-5'), 33.7 (C-2', C-6'), 58.7 (C-1'), 114.3 (C-4), 121.8 (C-5) and 124.7 (C-2).

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† 1:1 Mixture of *p*-toluidine and 2-methyl-3-(*p*-tolyl)-3-azapropenal dimethyl acetal.