Highly regioselective nucleophilic/cycloaddition reactions of *N*-arylamino 1,3-diazabuta-1,3-dienes with α-nitrosostyrenes: synthesis of functionalised imidazoles and imidazole oxides

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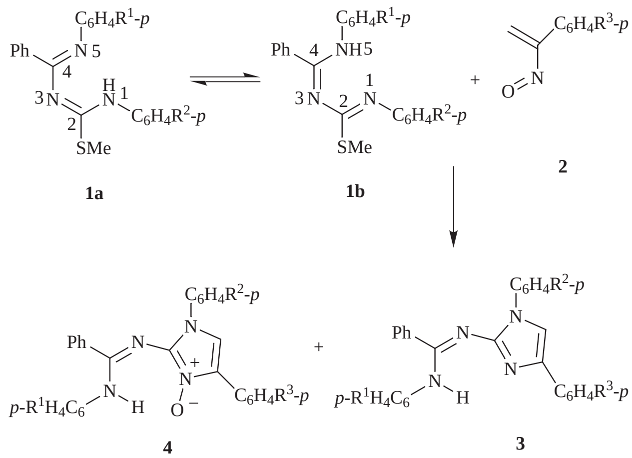
The α-nitrosostyrenes **2**, generated *in situ* from α-halogeno oximes, underwent regioselective cycloadditon/nucleophilic reactions with *N*-arylamino 1,3-diazabuta-1,3-dienes **1** leading to a mixture of imidazoles and cyclic nitrones shown to have structures **3** and **4**, respectively, by X-ray crystallographic analysis. The structure **4** for cyclic nitrones was also supported by their 1,3-dipolar cycloaddition with dimethyl acetylenedicarboxylate (DMAD). The thermolysis of nitrones **4** gives imidazoles **3** *via* oxadiazine intermediates **6**.

The *C*-nitroso group of arylnitroso, α-chloronitroso, cyanonitroso, *C*-nitroso sugar derivatives and acylnitroso compounds is known to effectively participate as a 2π component in hetero Diels–Alder reactions.[1] Of these, the acylnitroso species has been exploited much more extensively than any other dienophile.[2] On the other hand, α-nitrosostyrenes have been known to participate as 4π components in Diels–Alder reactions with various polarised and unpolarised alkenes,[3] allenes[4] and all carbon dienes.[5] Recently an unusual [3+2] cycloaddition reaction mode was observed in the cycloadditions of α-nitrosostyrenes with a carbon–carbon double bond attached to a pyrimidinone ring.[6] In contrast to cycloadditions of α-nitrosostyrenes with carbon–carbon double bonds, such reports with carbon–nitrogen double bonds are very rare.[7,8] Mackay *et al.*[7] reported an unusual [3+2] cycloaddition of α-nitrosoalkenes with carbon–nitrogen double bonds of oxazines and failed to observe any reaction of α-nitrosoalkenes with various other cyclic or acyclic compounds bearing a carbon–nitrogen double bond. A recent disclosure from our laboratories has shown a generalised and unusual [3+2] cycloaddition mode with carbon–nitrogen double bonds of various polarised 1,3-diazabuta-1,3-dienes and imines[8] resulting in an easy access to various heterocyclic *N*-oxides. It was thought worthwhile to extend such studies to *N*-arylamino 1,3-diazabuta-1,3-dienes where additional regioisomeric cycloaddition modes are possible because of the likely existence of tautomeric forms **1a** and **1b**. These 1,3-diazabuta-1,3-dienes were found to follow [4+2] cycloaddition/nucleophilic reactions with various ketenes leading to a variety of substituted pyrimidinones.[9]

Thus, the reactions of 1-aryl-2-methylthio-4-(*N*-arylamino)-4-phenyl-1,3-diazabuta-1,3-dienes **1** with α-chloro oximes, in the presence of sodium carbonate in methylene chloride resulted in the formation of a mixture of products (Scheme 1), which were easily separated by column chromatography, and characterised as 1,4-diaryl-2-[*N*-arylamino(phenyl)methyleneamino]imidazoles **3** and 1,4-diaryl-2-[*N*-arylamino(phenyl)-methyleneamino]imidazole 3-oxides **4** on the basis of their analytical and spectral data. It is possible to discern a number of alternate structures for these products on the strength of their analytical and spectral data. The detailed spectral features are discussed in the Experimental section, however, only the salient features are mentioned here. ^{1}H NMR of **3** and **4** indicated the absence of methylthio and methylene protons and the presence of vinylic and NH protons. The mass spectrum of **4** exhibited M^+ and $M^+ - 16$ peaks diagnostic of nitrones. However, the structures of imidazole **3f** and imidazole *N*-oxide **4c** were determined unambiguously by X-ray crystallography (Fig. 1 and Fig. 2).



3, 4 **a** $R^1 = R^2 = R^3 = H$
b $R^1 = R^2 = H, R^3 = Cl$
c $R^1 = R^3 = H, R^2 = OMe$
d $R^1 = H, R^2 = OMe, R^3 = Me$
e $R^1 = R^3 = Me, R^2 = Cl$
f $R^1 = H, R^2 = R^3 = Me$

Scheme 1 *Reagents and conditions*: Na_2CO_3, CH_2Cl_2, 2–3 h.

Bond lengths and bond angles in all the four aryl rings (A, B, C, D) in both the compounds **3** and **4** are normal. The C1–N2 bond is shorter than the C2–N2 bond in both compounds showing a partial double bond character in the former bond of the imidazole ring. Similarly, the C4–N3 bond in **3** and **4** is close to partial double bond length (1.322 ± 3 Å). Also, the C1–N3 bond length is shorter than a C–N single bond (1.472 ± 5 Å) and is closer to C–N partial double bond distance, more so in compound **4**. These bond lengths indicate a delocalisation of electron density in the region N2–C1–N3–C4–N4. In both compounds, the fragment N2–C1–N3–C4–N4 is almost planar (deviation ~0.1 Å from a least square plane). All the four aryl rings and the imidazole ring are planar. The aryl ring substituted at N1 is rotated with respect to the imidazole ring to an almost equal extent [dihedral angle 54.7(2)° and 56.5(2)°] in **3** and **4**, respectively, whereas the ring (C24–C29) is rotated more in **4** than in **3** [36.5(2)° and 27.8(3)°, respectively]. The torsion

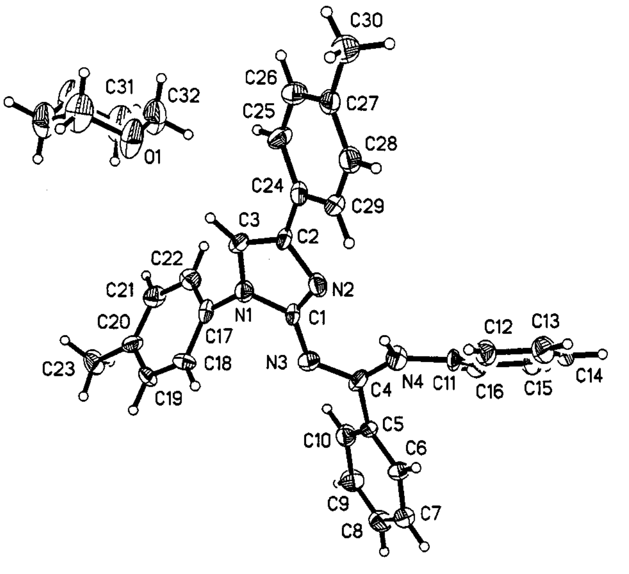


Fig. 1 An ORTEP drawing of **3f** at 30% probability (SHELXTL-PC).

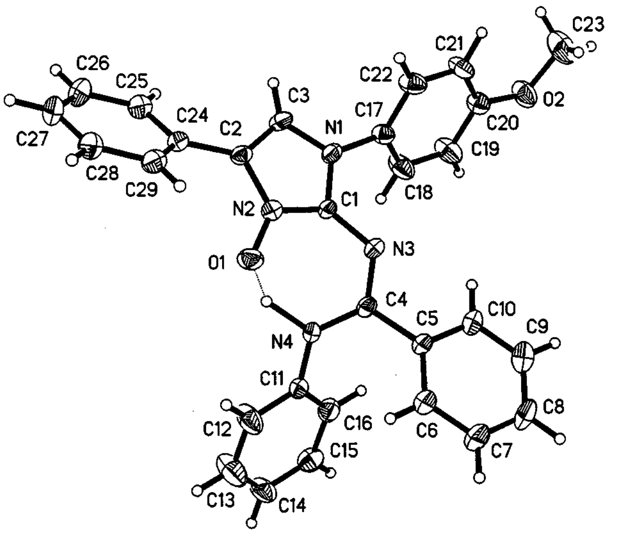


Fig. 2 An ORTEP drawing of **4c** at 30% probability (SHELXTL-PC).

angles in **3** and **4** are comparable except for the rotation about the C1–N3 bond. The C1–N1 bond is in *syn* (−10.5°) and the C1–N2 is in *anti* (170.3°) conformation with respect to C4–N3 in **3**, but in **4** the C1–N2 bond moves towards a *gauche* conformation (45.8°) and the C1–N1 bond is rotated (−144.2°) by about 26° in comparison to **3**. There is a strong intramolecular H-bonding intraction between O1 and N4 *via* the proton of the amino nitrogen in **4**. The N4 acts as a H-bond donor and O1 is an acceptor, giving rise to a H-bonding N4 · · · O1 distance of 2.62 Å and H4 · · · O1 distance of 1.86(1) Å. A solvent molecule was detected in the crystal structure of imidazole **3** and was present on the centre of symmetry. The solvent is in a chair conformation with C32 and its centrosymmetrically equivalent carbon atom occupying the apical position.

The probable mechanistic pathways for the formation of products **3** and **4** are outlined in Scheme **2**. In this scheme it is assumed that the initial nucleophilic attack by the arylamino nitrogen (N-1 of **1a**) on the *trans* form of α-nitrosostyrene, as in reactions of morpholine,[10] leads to an interconvertible *cis* and *trans* intermediate **5**. The *cis* form of **5** presumably rearranges to intermediate **7** *via* an oxadiazine intermediate **6** and deoxygenation of **7** then finally yields imidazole **3**. The *trans* form of **5**, on the other hand, leads to intermediate **8** which rearranges, as shown, to yield nitrone **4**. It is also possible that the nitrone **4** may undergo deoxygenation under the reaction conditions to yield imidazole **3**. The intermediates **6** and **8** are probably obtained from the interconvertible *cis* and *trans* intermediate **9** formed by the initial nucleophilic attack by N-1 of 1,3-diazabuta-1,3-diene **1b** on α-nitrosostyrene. However, AM1 calculations performed on **1a** and **1b** have indicated that N-1 in structure **1a**, having greater charge density than N-1 in structure **1b**, is more nucleophilic.[9a] Also, tautomer **1a** is more stable than **1b** by about 0.81 kcal mol^{-1}, indicating the possible predominance of tautomer **1a** in solution.[9b] On the basis of these results it may be concluded that imidazole **3** and nitrone **4** are probably the result of reaction sequence **1a**→**5**→**6** + **8**→**3** + **4** (Scheme 2).

The *N*-oxide structure was further confirmed by its 1,3-dipolar cycloaddition reactions with DMAD. Thus, the treatment of **4** with DMAD in methylene chloride at room temperature resulted in the formation of adducts **10** in quantitative yields (Scheme 3). The structure **10** assigned to these products was based on their IR, mass, ^{1}H and ^{13}C NMR spectral data. The product **10a**, for example, analysed for $C_{36}H_{32}N_4O_5$ exhibited a molecular ion peak at *m*/*z* 600. Its IR spectrum showed strong peaks at 1748 and 1723 cm^{-1} due to ester carbonyls. Its ^{1}H NMR showed, in addition to aromatic protons, singlets for two methyl protons (*δ* 2.37 and 2.40), two ester methyl singlets (*δ* 3.58 and 3.85) and an olefinic proton (*δ* 5.36). It also exhibited a broad singlet at *δ* 12.63, exchangeable with D_2O, which was assigned to a NH proton. Its ^{13}C NMR spectrum was also in agreement with the assigned structure.

The thermolysis of heterocyclic nitrones has been reported to yield interestingly rearranged heterocycles.[8] In order to gain further insight into the mechanistic aspects of these transformations, it was thought worthwhile to carry out the thermolysis of nitrones **4**. Thus, the thermolysis of nitrones **4** in refluxing xylene resulted in their conversion to the corresponding imidazole derivatives **3** (Scheme 3). It is presumed that at a higher temperature the nitrone structure **4** is interconvertible with the oxadiazine intermediate **6** which as usual yields imidazole **3** *via* deoxygenation of bicyclic intermediate **7**. This is another valuable addition to the rare examples of nitrone→oxadiazine→imidazole interconversions.[11]

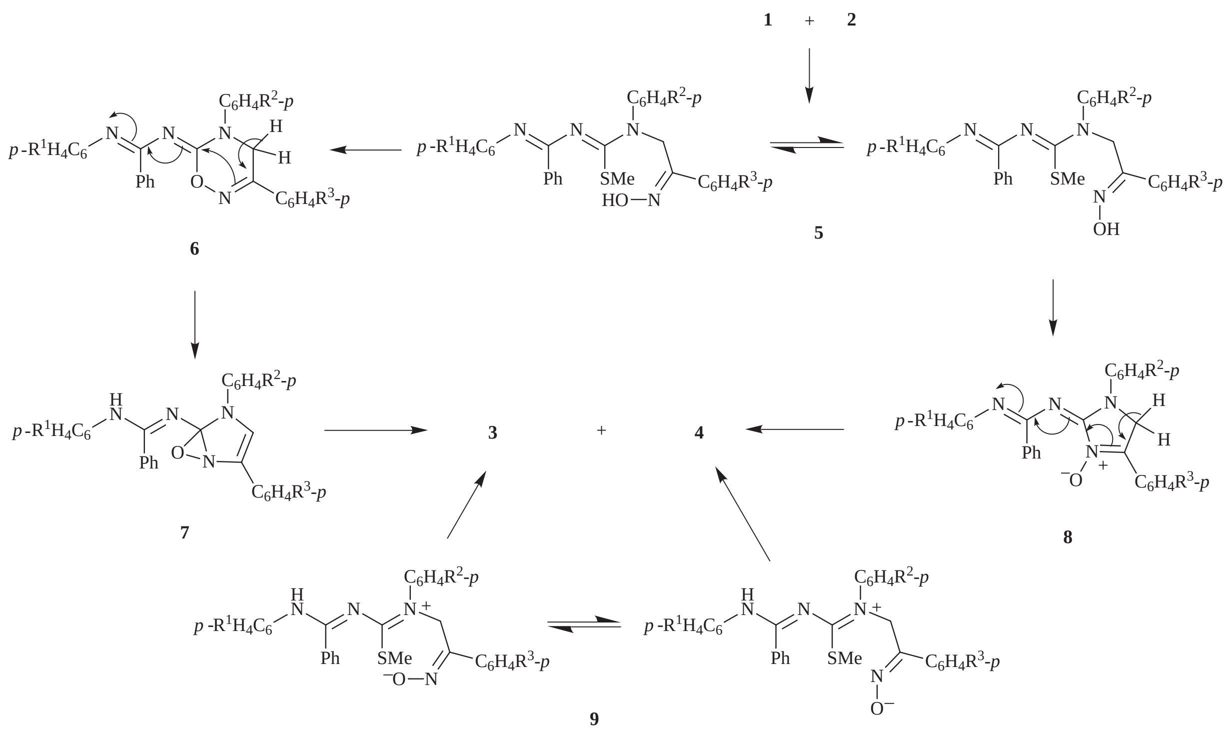
Experimental

Melting points were determined with a Toshniwal melting point apparatus and are uncorrected. IR spectra were recorded on a Perkin-Elmer 983 infrared spectrophotometer. ^{1}H NMR spectra were recorded in deuteriochloroform, with a Bruker AC-F 300 (300 MHz) and Varian 390 (90 MHz) spectrometer using TMS as internal standard. Chemical shift values are expressed as *δ* (ppm) downfield from TMS and *J* values are in Hz. Splitting patterns are indicated as: s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet and br = broad. ^{13}C NMR spectra were also recorded on a Bruker AC-F 300 spectrometer in deuteriochloroform using TMS as internal standard. Mass spectra were obtained by electron impact at 70 eV. Column chromatography was performed on silica gel 60–120 mesh.

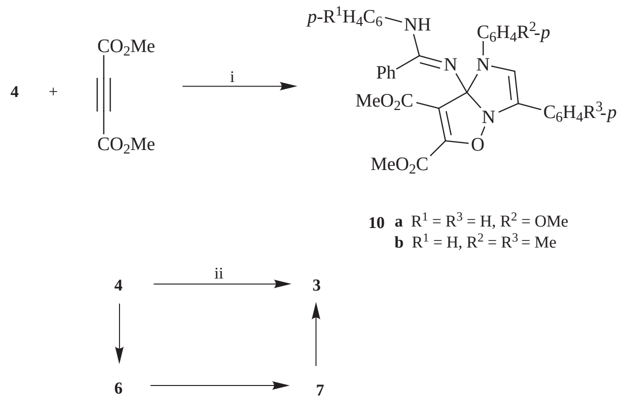
X-Ray structure determination

The crystals used for X-ray study were grown by recrystallisation in 1,4-dioxane for compounds **3** and **4**. The crystal data, parameters of data collection and refinement results are in Table 1.† The unit cell dimensions were determined by least-

† Full crystallographic details, excluding structure factor tables, have been deposited at the Cambridge Crystallographic Data Centre (CCDC). For details of the deposition scheme, see 'Instructions for Authors', *J. Chem. Soc.*, *Perkin Trans. 1*, available *via* the RSC Web page (http://www.rsc.org/authors). Any request to the CCDC for this material should quote the full literature citation and the reference number 207/295. See http://www.rsc.org/suppdata/p1/1999/615/for crystallographic files in .cif format.



Scheme 2



Scheme 3 *Reagents and conditions*: i, CH_2Cl_2, rt, 45 min; ii, xylene, reflux, 1 h.

squares using 25 centred reflections using graphite monochromated Mo-Kα radiation. The data were corrected for Lorentz and polarisation effects. No correction was made for absorption. Both the structures were solved by direct methods. The non-hydrogen atoms were refined anisotropically and hydrogen atoms were located using geometric considerations. Poor quality of the crystals restrained the data collection up to a 2θ value of 40°. Due to the limited data, the parameters/data ratio is low and probably leads to slightly high thermal parameters in the case of some atoms. All calculations and graphics were performed using SHELXTL-PC.[12]

Starting materials

All the *N*-arylamino 1,3-diazabuta-1,3-dienes **1** were prepared following the reported procedures.[9]

Reactions of *N*-arylamino 1,3-diazabuta-1,3-dienes 1 with α-nitrosostyrenes. General procedure

A solution of *N*-arylamino 1,3-diazabuta-1,3-dienes **1** (4 mmol) and α-chloro oxime (4.2 mmol) in dry CH_2Cl_2 (40 ml) was stirred at room temperature in the presence of anhydrous sodium carbonate (0.64 g, 6 mmol) for 2–3 h. The deposited salt and excess of sodium carbonate were filtered off and washed with small portions (2 × 10 ml) of CH_2Cl_2. The combined filtrate was washed with water, dried over anhydrous Na_2SO_4 and concentrated under reduced pressure. The crude reaction mixture was chromatographed over a silica gel column. Elution with EtOAc–hexane (1:20) resulted in the isolation of imidazoles **3**. Further elution with EtOAc–hexane (1:5) afforded nitrones **4**.

2-[Anilino(phenyl)methyleneamino]-1,4-diphenylimidazole 3a. Yield 31%; mp 174–175 °C (Found: C, 81.04; H, 5.33; N, 13.57. $C_{28}H_{22}N_4$ requires C, 81.13; H, 5.35; N, 13.52%); ν_{max}/cm^{-1} (KBr) 3446 (br), 1623, 1590, 1490, 1399; δ_H (300 MHz) 6.93 (d, *J* 7.5, with fine splitting, 2H, ArH), 6.99–7.06 (m, 1H, ArH), 7.17–7.55 (m, 14H; 13H, ArH and 1H, olefinic), 7.69 (d, *J* 7.5, with fine splitting, 2H, ArH), 7.83 (d, *J* 8.3, with fine splitting, 2H, ArH), 12.81 (br s, exchangeable with D_2O, 1H, NH); δ_C (75.5 MHz) 112.7 (C-4), 123.4, 124.0, 124.5, 125.1, 126.8, 126.9, 128.0, 128.6, 128.9, 129.6, 129.8, 133.8, 135.5, 137.2, 137.7, 140.1, 150.1 (C-2), 157.1 (C-amidino); *m/z* 414 (M^+).

2-[Anilino(phenyl)methyleneamino]-1,4-diphenylimidazole 3-oxide 4a. Yield 49%; mp 195–197 °C (Found: C, 78.23; H, 5.21; N, 13.09. $C_{28}H_{22}N_4O$ requires C, 78.12; H, 5.15; N, 13.01%); ν_{max}/cm^{-1} (KBr) 3418 (br), 1636, 1595, 1495, 1395, 1257; δ_H (300 MHz) 6.83 (d, *J* 7.7, 2H, ArH), 6.88–6.94 (m, 1H, ArH), 7.07–7.70 (m, 16H; 15H, ArH and 1H, olefinic), 8.05 (d, *J* 8.4, with fine splitting, 2H, ArH), 13.88 (br s, exchangeable with D_2O, 1H, NH); δ_C (75.5 MHz) 111.0 (C-4), 121.8, 123.0, 123.4, 123.9, 124.5, 125.1, 125.2, 126.7, 127.0, 127.8, 128.0, 128.1, 128.3, 128.6, 128.7, 128.8, 129.2, 129.5, 129.8, 129.9, 130.3, 134.9, 136.8, 140.6 (C-2), 140.7, 158.2 (C-amidino); *m/z* 430 (M^+), 414 ($M^+ - 16$).

2-[Anilino(phenyl)methyleneamino]-4-(*p*-chlorophenyl)-1-phenylimidazole 3b. Yield 32%; mp 179–180 °C (Found: C, 74.79; H, 4.75; N, 12.56. $C_{28}H_{21}N_4Cl$ requires C, 74.91; H, 4.71; N, 12.48%); ν_{max}/cm^{-1} (KBr) 3417 (br), 1625, 1592, 1569, 1493, 1434, 1390, 1197; δ_H (300 MHz) 6.93 (d, *J* 7.8, 2H, ArH), 7.03–7.07 (m, 1H, ArH), 7.18–7.38 (m, 9H; 8H, ArH and 1H olefinic), 7.46–7.54 (m, 4H, ArH), 7.68 (d, *J* 7.8, 2H, ArH), 7.75

Table 1 Crystal data collection and refinement parameters

	Imidazole, **3f**	Imidazole *N*-oxide, **4c**
Formula	$C_{32}H_{30}N_4O$	$C_{29}H_{24}N_4O_2$
Mass	486.60	460.52
Crystal system	Monoclinic	Monoclinic
Space group	$P2_1/n$	$P2_1/n$
Dimension/mm	0.2 × 0.2 × 0.1	0.3 × 0.2 × 0.2
a/Å	6.056(2)	12.295(1)
b/Å	20.437(5)	9.554(1)
c/Å	21.335(5)	20.636(2)
β/°	95.20(2)	99.7(1)
Z	4	4
V/Å^3	2629.7(1)	2389.4(4)
Density$_{(calc.)}$/mg m^{-3}	1.229	1.280
F(000)/e	1032	968
T/K	293(2)	293(2)
Diffractometer	SiemenP4	SiemenP4
Index	$h = 0$ to 4, $k = 0$ to 17, $l = \pm 17$	$h = 0$ to 7, $k = 0$ to 9, $l = \pm 19$
2θ range/°	4.00 to 40.00	3.60 to 40.00
Total data collected	1853	1948
Scan mode	θ–2θ	θ–2θ
Unique data	1600 (R_{int} = 0.0252)	1812 (R_{int} = 0.0295)
Observed data used [$I > 2\sigma(I)$]	1491	1812
No. of parameters refined	334	317
Final shift/error	0.002	0.001
Max residual density/e Å^{-3}	0.197 and −0.194	0.132 and −0.155
R = (based on F)	0.051	0.0447
Rw = (based on F^2)	0.148	0.1122

(d, J 7.3, 2H, ArH), 12.70 (br s, exchangeable with D_2O, 1H, NH); m/z 448 (M^+, 13%), 356 (15%), 207 (12%), 180 (100%), 77 (63%), 51 (13%).

2-[Anilino(phenyl)methyleneamino]-4-(*p*-chlorophenyl)-1-phenylimidazole 3-oxide 4b. Yield 53%; mp 169–171 °C (Found: C, 72.41; H, 4.52; N, 12.00. $C_{28}H_{21}N_4OCl$ requires C, 72.33; H, 4.55; N, 12.05%); ν_{max}/cm^{-1} (KBr) 3430 (br), 1626, 1589, 1570, 1491, 1396, 1251; δ_H (300 MHz) 6.82 (d, J 7.7, 2H, ArH), 6.90–6.95 (m, 1H, ArH), 7.07–7.62 (m, 15H; 14H, ArH and 1H, olefinic), 8.02 (d, J 8.6, with fine splitting, 2H, ArH), 13.27 (br s, exchangeable with D_2O, 1H, NH); δ_C (75.5 MHz) 111 (C-4), 121.7, 123.0, 125.2, 126.3, 128.0, 128.1, 128.2, 128.8, 129.2, 130.2, 130.3, 134.0, 134.7, 136.6, 140.6 (C-2), 158.2 (C-amidino); m/z 464 (M^+, 15%), 448 ($M^+ - 16$, 45%), 356 (25%), 207 (22%), 180 (100%), 104 (10%), 77 (79%), 51 (17%).

2-[Anilino(phenyl)methyleneamino]-1-(*p*-methoxyphenyl)-4-phenylimidazole 3c. Yield 36%; mp 158–159 °C (Found: C, 78.28; H, 5.48; N, 12.71. $C_{29}H_{24}N_4O$ requires C, 78.36; H, 5.44; N, 12.60%); ν_{max}/cm^{-1} (KBr) 3426 (br), 1622, 1596, 1510, 1248, 1175; δ_H (300 MHz) 3.86 (s, 3H, OCH_3), 6.92 (d, J 7.7, 2H, ArH), 6.98–7.05 [m, 3H, ArH; consisting of 6.99 (d, J 8.9, 2H)], 7.17–7.34 (m, 8H; 7H, ArH and 1H, olefinic), 7.37–7.43 (m, 1H, ArH), 7.53 (d, J 7.7, with fine splitting, 2H, ArH), 7.58 (d, J 8.9, with fine splitting, 2H, ArH), 7.82 (d, J 8.3, with fine splitting, 2H, ArH), 12.79 (br s, exchangeable with D_2O, 1H, NH); δ_C (75.5 MHz) 55.6 (OCH_3), 113.0 (C-4), 114.0, 123.4, 123.9, 124.4, 126.4, 126.7, 128.0, 128.6, 128.8, 129.5, 129.7, 130.9, 133.9, 135.6, 136.9, 140.2, 150.2 (C-2), 157.0 (C-amidino), 158.4; m/z 444 (M^+).

2-[Anilino(phenyl)methyleneamino]-1-(*p*-methoxyphenyl)-4-phenylimidazole-3-oxide 4c. Yield 53%; mp 175–176 °C (Found: C, 75.74; H, 5.31; N, 12.15. $C_{29}H_{24}N_4O_2$ requires C, 75.63; H, 5.25; N, 12.17%); ν_{max}/cm^{-1} (KBr) 3421 (br), 1618, 1592, 1491, 1571, 1511, 1385, 1250; δ_H (300 MHz) 3.88 (s, 3H, OCH_3), 6.82 (d, J 8.0, 2H, ArH), 6.88–6.93 (m, 1H, ArH), 7.04–7.12 (m, 5H, ArH), 7.17–7.24 (m, 2H, ArH), 7.28–7.30 (m, 2H, ArH), 7.42–7.53 (m, 6H; 5H, ArH and 1H, olefinic), 13.42 (br s, exchangeable with D_2O, 1H, NH); δ_C (75.5 MHz) 55.6 (OCH_3), 113.3 (C-4), 114.3, 121.8, 122.9, 126.6, 127.0, 128.0, 128.2, 128.5, 128.6, 129.5, 129.8, 130.2, 130.3, 134.9, 140.6 (C-2), 140.8, 158.1 (C-amidino), 159.2; m/z 460 (M^+), 444 ($M^+ - 16$).

2-[Anilino(phenyl)methyleneamino]-1-(*p*-methoxyphenyl)-4-(*p*-tolyl)imidazole 3d. Yield 38%; mp 165–167 °C (Found: C, 78.66; H, 5.69; N, 12.17. $C_{30}H_{26}N_4O$ requires C, 78.58; H, 5.71; N, 12.26%); ν_{max}/cm^{-1} (KBr) 3447 (br), 1623, 1594, 1510, 1440, 1242, 1179; δ_H (300 MHz) 2.37 (s, 3H, CH_3), 3.85 (s, 3H, OCH_3), 6.92 (d, J 7.7, 2H, ArH), 6.95–7.05 (m, 3H, ArH), 7.16–7.32 (m, 8H; 7H, ArH and 1H, olefinic), 7.53 (d, J 6.8, with fine splitting, 2H, ArH), 7.57 (d, J 8.9, with fine splitting, 2H, ArH), 7.71 (d, J 8.1, 2H, ArH), 12.82 (br s, exchangeable with D_2O, 1H, NH); δ_C (75.5 MHz) 21.3 (CH_3), 55.5 (OCH_3), 112.5 (C-4), 114.0, 123.3, 123.8, 124.3, 126.3, 128.0, 128.8, 129.3, 129.5, 129.7, 131.1, 135.6, 136.3, 136.9, 140.2, 150.0 (C-2), 156.8 (C-amidino), 158.3; m/z 458 (M^+, 46%), 366 (12%), 260 (17%), 229 (12%), 210 (12%), 180 (100%), 104 (11%), 77 (67%), 51 (9%).

2-[Anilino(phenyl)methyleneamino]-1-(*p*-methoxyphenyl)-4-(*p*-tolyl)imidazole 3-oxide 4d. Yield 44%; mp 170–171 °C (Found: C, 75.85; H, 5.43; N, 11.86. $C_{30}H_{26}N_4O_2$ requires C, 75.93; H, 5.52; N, 11.80%); ν_{max}/cm^{-1} (KBr) 3423 (br), 1625, 1592, 1512, 1384, 1250; δ_H (300 MHz) 2.40 (s, 3H, CH_3), 3.90 (s, 3H, OCH_3), 6.82 (d, J 8.1, 2H, ArH), 6.88–6.94 (m, 1H, ArH), 7.05–7.31 (m, 10H; 9H, ArH and 1H, olefinic), 7.46 (d, J 8.4, with fine splitting, 2H, ArH), 7.53 (d, J 8.8, 2H, ArH), 7.93 (d, J 8.1, 2H, ArH), 13.43 (br s, exchangeable with D_2O, 1H, NH); δ_C (75.5 MHz) 21.4 (CH_3), 55.6 (OCH_3), 110.9 (C-4), 114.3, 121.8, 122.8, 125.0, 126.6, 127.0, 128.0, 128.6, 129.3, 129.9, 130.2, 130.3, 134.9, 138.2, 140.8 (C-2), 158.0 (C-amidino), 159.2; m/z 474 (M^+), 458 ($M^+ - 16$).

1-(*p*-Chlorophenyl)-2-[phenyl(*p*-toluidino)methyleneamino]-4-(*p*-tolyl)imidazole 3e. Yield 37%; mp 171–172 °C (Found: C, 75.43; H, 5.31; N, 11.81. $C_{30}H_{25}N_4Cl$ requires C, 75.54; H, 5.28; N, 11.75%); ν_{max}/cm^{-1} (KBr) 3437 (br), 1623, 1588, 1511, 1395, 1239; δ_H (90 MHz) 2.24 (s, 3H, CH_3), 2.35 (s, 3H, CH_3), 6.88 (d, J 8.5, 2H, ArH), 7.07 (d, J 8.5, 2H, ArH), 7.21–7.81 (m, 14H; 13H, ArH and 1H, olefinic), 12.71 (br s, exchangeable with D_2O, 1H, NH); m/z 477 (M^+).

1-(*p*-Chlorophenyl)-2-[phenyl(*p*-toluidino)methyleneamino]-4-(*p*-tolyl)imidazole 3-oxide 4e. Yield 51%; mp 151–152 °C (Found: C, 73.17; H, 5.08; N, 11.43. $C_{30}H_{25}N_4OCl$ requires C, 73.09; H, 5.11; N, 11.36%); ν_{max}/cm^{-1} (KBr) 3427 (br), 1618, 1594, 1391, 1249; δ_H (90 MHz) 2.22 (s, 3H, CH_3), 2.40 (s, 3H, CH_3), 6.73–7.00 (m, 4H, ArH), 7.07–7.70 (m, 12H; 11H, ArH and 1H, olefinic), 7.98 (d, *J* 8.8, 2H, ArH), 12.34 (br s, exchangeable with D_2O, 1H, NH); *m*/*z* 493 (M^+), 477 ($M^+ - 16$).

2-[Anilino(phenyl)methyleneamino]-1,4-bis(*p*-tolyl)imidazole 3f. Yield 32%; mp 156–157 °C (Found: C, 81.51; H, 5.90; N, 12.59. $C_{30}H_{26}N_4$ requires C, 81.42; H, 5.92; N, 12.66%); ν_{max}/cm^{-1} (KBr) 3427 (br), 1623, 1593, 1573, 1494, 1434, 1396; δ_H (90 MHz) 2.40 (s, 3H, CH_3), 2.43 (s, 3H, CH_3), 6.77–7.73 (m, 19H; 18H ArH and 1H, olefinic), 12.75 (br s, exchangeable with D_2O, 1H, NH); *m*/*z* 442 (M^+).

2-[Anilino(phenyl)methyleneamino]-1,4-bis(*p*-tolyl)imidazole 3-oxide 4f. Yield 51%; mp 193–194 °C (Found: C, 78.71; H, 5.75; N, 12.14. $C_{30}H_{26}N_4O$ requires C, 78.58; H, 5.71; N, 12.21%); ν_{max}/cm^{-1} (KBr) 3433 (br), 1621, 1596, 1491, 1434, 1393, 1248; δ_H (90 MHz) 2.40 (s, 3H, CH_3), 2.47 (s, 3H, CH_3), 6.83–7.64 (m, 17H; 16H ArH and 1H, olefinic), 113.29 (br s, exchangeable with D_2O, 1H, NH); *m*/*z* 458 (M^+), 442 ($M^+ - 16$).

Dipolar cycloaddition adducts of 4 and DMAD

A solution of nitrone **4c/f** (0.30 g, 0.50 mmol) and DMAD (0.06 g, 0.50 mmol) in dry CH_2Cl_2 was stirred at room temperature for 45 min. The solvent was removed under reduced pressure and the residue chromatographed over a silica gel column (eluent: a mixture of EtOAc–hexane in 1 : 3 ratio).

7a-[Anilino(phenyl)methyleneamino]-6,7-bis(methoxycarbonyl)-1-(*p*-methoxyphenyl)-3-phenyl-1,7a-dihydroimidazo[1,2-*b*]isoxazole 10a. Yield 94%; mp 177–179 °C (Found: C, 69.87; H, 4.97; N, 9.21. $C_{35}H_{30}N_4O_6$ requires C, 69.75; H, 5.02; N, 9.30%); ν_{max}/cm^{-1} (KBr) 1745, 1717, 1641, 1613, 1588, 1511, 1487, 1355, 1253, 1167, 1107; δ_H (300 MHz) 3.60 (s, 3H, CO_2CH_3), 3.86 (s, 6H, CO_2CH_3 and OCH_3), 5.38 (s, 1H, olefinic), 6.93 (d, *J* 7.5, 2H, ArH), 7.00 (d, *J* 9.0, with fine splitting, 2H, ArH), 7.04–7.08 (m, 1H, ArH), 7.19–7.31 (m, 6H, ArH), 7.40–7.48 (m, 6H, ArH), 7.86 (d, *J* 8.5, with fine splitting, 2H, ArH), 12.61 (br s, exchangeable with D_2O, 1H, NH); δ_C (75.5 MHz) 51.9 (CO_2CH_3), 53.2 (CO_2CH_3), 55.5 (OCH_3), 100.1, 114.1, 122.0, 123.5, 124.2, 125.2, 126.0, 126.9, 128.0, 128.2, 128.7, 128.9, 129.6, 129.9, 131.7, 135.1, 139.8, 146.8, 157.9, 158.1, 159.1, 162.2 (CO_2CH_3), 165.1 (CO_2CH_3); *m*/*z* 602 (M^+).

7a-[Anilino(phenyl)methyleneamino]-6,7-bis(methoxycarbonyl)-1,3-bis(*p*-tolyl)-1,7a-dihydroimidazo[1,2-*b*]isoxazole 10b. Yield 96%; mp 196–197 °C (Found: C, 72.07; H, 5.45; N, 9.27. $C_{36}H_{32}N_4O_5$ requires C, 71.98; H, 5.37; N, 9.33%); ν_{max}/cm^{-1} (KBr) 1748, 1723, 1644, 1622, 1592, 1507, 1494, 1480, 1437, 1356, 1204, 1166, 1117; δ_H (300 MHz) 2.37 (s, 3H, CH_3), 2.40 (s, 3H, CH_3), 3.58 (s, 3H, CO_2CH_3), 3.85 (s, 3H, CO_2CH_3), 5.36 (s, 1H, olefinic), 6.93 (d, *J* 7.7, 2H, ArH), 7.02–7.07 (m, 1H, ArH), 7.18–7.32 (m, 9H, ArH), 7.39 (d, *J* 8.2, 2H, ArH), 7.47 (d, *J* 7.7, 2H, ArH), 7.55 (d, *J* 8.1, 2H, ArH), 12.63 (br s, exchangeable with D_2O, 1H, NH); δ_C (75.5 MHz) 21.2 (CH_3), 21.3 (CH_3), 51.8 (CO_2CH_3), 53.1 (CO_2CH_3), 100.1, 122.2, 123.4, 124.2, 125.2, 126.7, 127.9, 128.9, 129.4, 129.5, 129.8, 130.7, 135.2, 136.6, 137.9, 139.9, 146.6, 157.8, 158.2, 162.2 (CO_2CH_3), 165.1 (CO_2CH_3); *m*/*z* 600 (M^+).

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