The Stabilization of Lithiated Organic Compounds by Water as a Ligand – Synthesis of a New Lithium–Imidazole Complex and Regioselective Reactions with Selected Electrophiles☆

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Received June 8, 1998

Keywords: 4*H*-Imidazoles / Lithium–Imidazole complex / Regioselective acylation / Quantum-mechanical calculation / Acyl rearrangements

The deprotonation of the 4*H*-imidazoles **1** by lithium hydride yields the lithiated derivatives **2** which contain a stable delocalized anion. Surprisingly, the X-ray crystal structure analysis of **2a** reveals one molecule of water in the first complexation sphere of the lithium cation. This result is in good agreement with semiempirical calculations (PM3) which predict an increase in stability on substitution of ether ligands by water molecules. The deprotonation of **1** is accompanied by a change of colour from orange to purple because of the polymethinic character of the resulting anion. Alkylation, as well as acylation, of **2** leads to the exocyclic substituted derivatives **3** and **5**. The NMR spectra of **3** and **5** and the semiempirical calculations suggest the existence of two rotamers due to the low rotation barrier of the exocyclic C–N bond. Another type of acylation is observed when phenylacetyl chloride is used as an acylating agent. The X-ray crystal structure analysis of **6c** reveals that a rearrangement forming an unsaturated acid amide substructure takes place.

Recently, we reported the synthesis of the new deeply coloured derivatives of 4*H*-imidazoles **1**[1], by a simple cycloacylation reaction of bis-imidoyl chlorides[2][3][4] with substituted benzamidines. The special structural and spectral properties of these 5-ring cycloamidines have received particular attention. These properties arise from the cyclic meropolymethine-type chromophore which includes a weak combined C−C bond[5]. The cleavage of the exocyclic NH proton should be accompanied by a bathochromic shift of the long wavelength absorption, as a consequence of the clearly defined delocalization of bonds in the resulting anion **2**.

The formation of **2** by addition of a strong base, such as NaHMDS or LiH, to a THF solution of **1** under nitrogen is characterized by a distinct colour change from orange to purple. In the ^{1}H-NMR spectrum of **2a** the chemical shifts of the aromatic protons are not significantly different from those of the starting material **1a**. However, the triplets of the *meta*- and *para*-substituted aryl protons are not completely separated. While the ^{13}C-NMR spectra of **1a** are characterized by broad lines, all carbon atoms of **2a** show strong signals at lower field. Compared to the UV/Vis spectrum of **1a** (λ_{max} = 481 nm), the anion **2a** absorbs with λ_{max} = 561 nm at longer wavelength. This fact may be traced back to the transition of a merocyanine (partial bond alternation) into the polymethinic bond system of **2**.

Surprisingly, **2** showed an unusually high stability. For example, the colour of the THF solution of **2** remained unchanged on exposure to air. Even by heating this solution under reflux no decomposition was observed. Only the addition of a protic solvent reproduced **1**. By using commercial diethyl ether as solvent and LiH, **2a** was obtained as air-stable red crystals. The ^{1}H-NMR spectrum shows in addition to the characteristic coupling pattern of diethyl ether, a broad singlet at δ = 3.12, indicating the presence of water. The X-ray structure determination of **2a** was carried out and the result is shown in Figure 1.

In the neutral complex **2a**, the metal is coordinated in a twisted tetrahedral environment between both exocyclic nitrogen atoms of the anionic imidazole system and two oxygen atoms from water and diethyl ether, respectively. The presence of a water molecule in the first complexation sphere of the lithium seems to be startling because of the well-known moisture sensitivity of organolithium species. However, in the presence of organic compounds having pK_a values comparable to water and which are able to form hydrogen bridges to water, a small number of complexes have been described as being stable[6]. In contrast to the formation of three-dimensional polymeric structures in most of the lithium−aqua complexes described previously, the strong intermolecular hydrogen bonding (O1A−N2B 2.801

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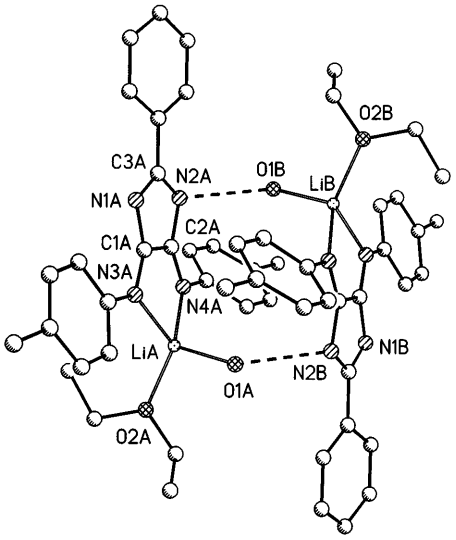
Figure 1. X-ray structure of **2a**; the numbering corresponds to that used for the X-ray analysis[a]



[a] Selected distances [Å] and angles [°]: O1A−N2B 2.801, C1A−C2A 1.508(4), C1A−N1A 1.374(3), C2A−N2A 1.377(3), C3A−N1A 1.347(3), C3A−N2A 1.363(3), C1A−N3A 1.293(3), LiA−N3A 2.087(5), LiA−N4A 2.075(5) LiA−O1A 1.933(5), LiA−O2A 1.956(5), LiA−N3A−C1A 105.3(2), LiA−N4A−C2A 104.3(2), N4A−LiA−N3A 86.2(2), N4A−LiA−O2A 123.5(3),O1A−LiA−O2A 103.9(2).

Å) in **2a** leads to discrete dimeric units showing a head-to-tail arrangement of the imidazole systems.

In order to investigate the coordinative role of H_2O in this system and the nature of its stabilisation by hydrogen bonding, we carried out semiempirical PM3 calculations[7] for the complexes **2a** and the ligand-exchanged counterparts **2a′** and **2a″**. The replacement of an ether ligand by water is exothermic for the first, as well as the second step (−8.7 and −4.5 kcal/mol respectively), and therefore the complexation of water is favoured. In contrast to **2a′**, the complex **2a** is able to gain stability by formation of dimeric units. The calculations predict a dimerization energy of 14.3 kcal/mol, which is achieved by the formation of two intermolecular hydrogen bonds. The degree of oligomerization in solution will be the subject of further investigations.

In contrast to **1a**, in **2a** the slight alternation of bond length of the C−N bonds is completely removed and at the same time the C−C bond of the imidazole ring is elongated. Fabian predicted this bond lengthening by means of DFT calculations of a symmetric anion of **1**[5]. While the bond lengths C1A−N3A and C2A−N4A reflect a partial double-bond character, the bonds C2A−N2A and C1A−N1A are significantly longer with bond lengths of 1.377 and 1.374 Å, respectively. Hence, the negative charge is especially delocalized inside the 5-ring system, resulting in the unusual stability of **2**.

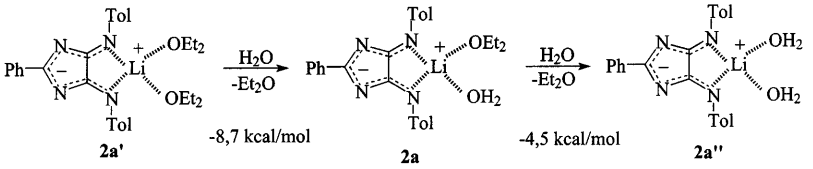
Accordingly, **2** shows a low reactivity towards electrophilic agents. Thus, the reactions between **2a** and methyl- or ethyliodide were only completed by refluxing for several days. In general, no reaction takes place with long-chain alkylhalides.

Examining these alkylation reactions, the regioselectivity of the electrophilic attack at **2** was of special interest. The TLC analysis of the reaction mixture displayed in most cases the selective formation of only one of both regioisomers. Only by using **2c** and methyliodide could a by-product be detected. The signals in the ^{1}H-NMR spectra of alkylation products **3** at room temperature were mostly very broad and no interpretation was possible. A complete separation of the signal set could be reached by cooling the samples to −50°C. The low temperature ^{1}H-NMR spectra of **3d** and **3e** were not in agreement with those of the proposed structure because of the double signal set. This fact suggested the existence of two isomers, due to the low rotation barrier of the exocyclic C−N single bond. A migration of the alkyl groups in **3a−e** or **4a** can be excluded because all known reactions of alkyl or aralkyl groups are realized under severe conditions with mostly low yields[8].

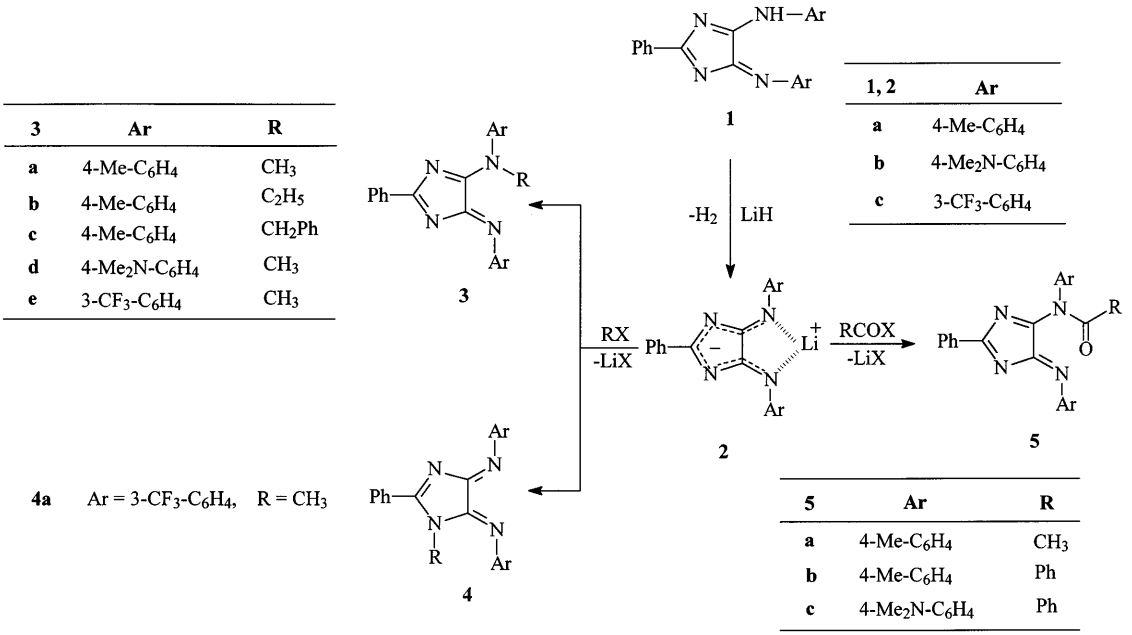
The regioselectivity of the reaction was demonstrated in NOESY experiments for the derivative **3e** by cross peaks from the methyl groups to the aromatic protons of the exocyclic aryl moieties. According to the drastic alteration of the chromophoric system, the regioisomeric derivative **4a** constitutes a yellowish compound, absorbing at λ_{max} = 398 nm. ^{1}H-, ^{13}C-NMR, and mass spectral data confirmed the structural assignments and the substitution at the ring nitrogen could be proved by NOESY investigations.

Apart from alkylation, the reactions of **2** with acylhalides were also studied. Heating the solution of **2** with acetyl chloride as well as benzoyl chloride led, after 2−4 hours, to a change of colour from purple to orange-red. The pure acylated derivatives of type **5** were obtained as air-stable crystalline compounds after recrystallization from acetone. Due to the rapid transfer processes in solution, the NMR spectra of **5** exhibit only a single signal set for the aryl moieties in positions 4 and 5 of the heterocycle. Even at −70°C, this dynamic behaviour could not be completely suppressed. The chemical difference of the tolyl residues was shown in the ^{1}H- as well as the ^{13}C-NMR spectra. The X-ray structure determination of the red tetragonal crystals of **5a** was carried out (Figure 2).

In agreement with the NMR spectroscopic studies on **5a,** the acyl group was introduced at the exocyclic nitrogen atom. Both tolyl rings are slightly twisted relative to each



Scheme 1

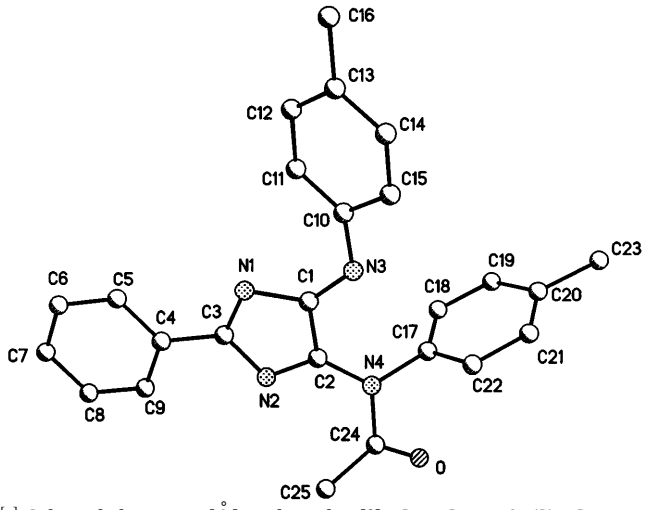


3	Ar	R
a	4-Me-C_6H_4	CH_3
b	4-Me-C_6H_4	C_2H_5
c	4-Me-C_6H_4	CH_2Ph
d	4-Me_2N-C_6H_4	CH_3
e	3-CF_3-C_6H_4	CH_3

1, 2	Ar
a	4-Me-C_6H_4
b	4-Me_2N-C_6H_4
c	3-CF_3-C_6H_4

5	Ar	R
a	4-Me-C_6H_4	CH_3
b	4-Me-C_6H_4	Ph
c	4-Me_2N-C_6H_4	Ph

Figure 2. Perspective drawing of **5a**; the numbering corresponds to that used for the X-ray analysis[a]



[a] Selected distances [Å] and angles [°]: C1−C2 1.495(3), C1−N1 1. 398(3), C2−N2 1.294(3), C3−N1 1.300(3), C3−N2 1.409(3), C1−N3 1.276(3), C2−N4 1.377(3), N3−C1−N1 130.1(2), N1−C3−N2 117.2(2), N2−C2−N4 123.6(2), C1−N3−C10 122.7(2), N4−C24−O 118.6(2).

other. In contrast to **2a,** the marked alternation of bond length of **5a** may be traced to the substitution of exocyclic hydrogen by acyl residues.

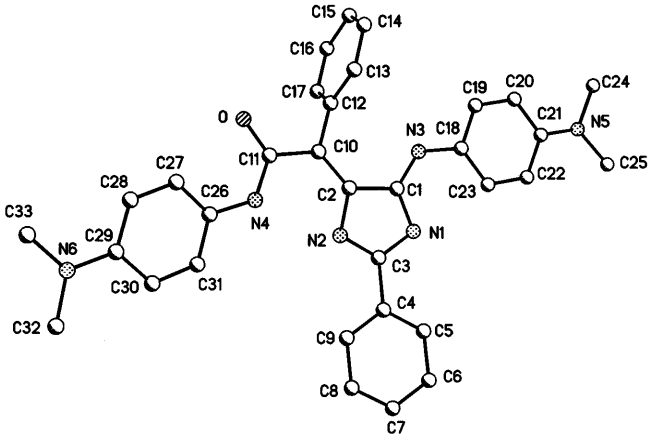
All NMR spectra of **3** and **5** suggest the existence of two isomers which arise from the low rotation barrier of the exocyclic C−N bond. In order to prove the existence of such a rotameric equilibrium, semiempirical calculations were performed. A simulated rotation around the C−N single bond of the substituted exocyclic compound revealed for both derivatives the existence of two stable rotamers which are almost isoenergetic.

Another type of acylation was observed when phenylacetyl chloride was used as an acylating agent. The mass spectral data of both products obtained were in agreement with those of the acylated structures of type **5** but the NMR spectra revealed some significant differences. In addition to the pattern of 4 aromatic systems, the ^{1}H-NMR spectrum of the mainly formed (*E*)-**6a** showed two singlets at δ = 6.75 and 13.08 which could not be assigned to a carbon atom by HMQC experiments. The methylene group of the phenacetyl residue could generally not be detected. The spectrum of the by-product (*Z*)-**6a** revealed the same phenomenon and differed only in the value of the chemical shifts, especially of the singlets (δ = 7.45 and 13.82). The ^{13}C-NMR spectroscopic studies of **6** suggested the quarternization of the methylene group during a intramolecular rearrangement. Nevertheless, the structural assignment succeeded by X-ray structure determination of the blue crystals of (*E*)-**6c**, obtained by recrystallization from acetonitrile. The results of this studies are summarized in Figure 3.

As shown, the phenacetyl residue is inserted into the exocyclic C−N single bond. Therefore, the protons of the methylene group migrated to the nitrogen atoms N3 and N4, resulting in the α,β-unsaturated carboxylic acid amide substructure. In this case the (*E*)-isomer was yielded in preference. The whole molecule is planar, with only the phenyl ring at carbon C10 in a nearly orthogonal position to the molecular plane. The most reasonable mechanistic pathway of this remarkable acylation reaction might be illustrated by Scheme 2.

The electrophilic attack of the phenacetyl chloride on the exocyclic nitrogen should lead in the first step to the formation of an acylation product comparable to **5a** or **5c**. Influenced by the more acidic methylene protons, the acylation product might predominantly exists in the enol form **5d**

Figure 3. Perspective drawing of (*E*)-**6c**; the numbering corresponds to that used for the X-ray analysis[a]



[a] Selected distances [Å] and angles [°]: C1−C2 1.494(5), C1−N1 1.312(4), C2−N2 1.398(4), C3−N1 1.381(4), C3−N2 1.317(4), C1−N3 1.333(4), C2−C10 1.347(5), C11−N4 1.343(4), N3−C1−N1 125.1(3), N1−C3−N2 117.8(3), N2−C2−C10 124.8(3), C1−N3−C18 130.0(4), C11−N4−C26 128.0(3).

which allows a cyclization resulting in the formation of an unstable β-lactam. The derivative **6** is finally formed by cleaving the primary C−N bond and subsequent prototropic rearrangement. On the other hand, the intermediary β-lactam may also be formed directly by a cycloaddition of preformed phenylketene with the exocyclic imine substructure in **2a**[9]. Our argument against this pathway is the fact that no rearranged product could be isolated by the use of other ketene precursors such as acetyl chloride.

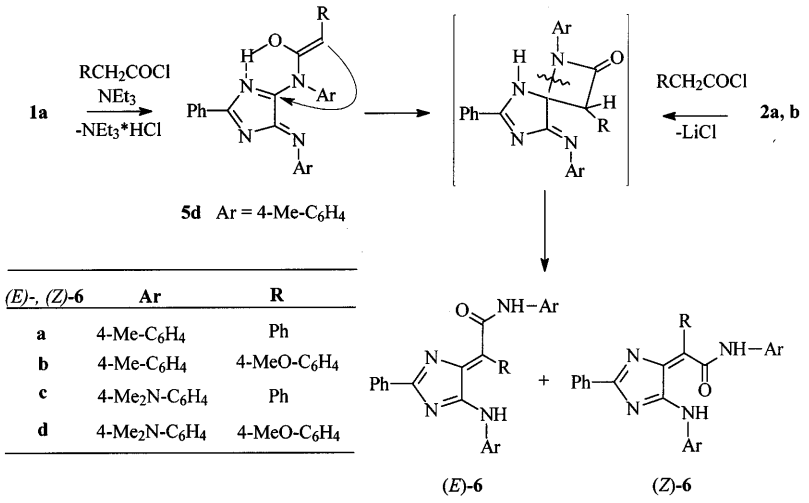
Therefore, the use of weak bases should reduce the interconversion and, hence, the isolation of **5d** should be possible. For the experimental verification of this hypothesis, **1a** was treated with phenacetyl chloride in the presence of triethylamine. As a result of this reaction the yellow-coloured derivative **5d** was isolated. The mass spectrum of **5d** includes, in addition to the expected molecular peak at $m/z = 471$, fragments which suggest the exocyclic arrangement of the phenacetyl residue. The ^{1}H- and ^{13}C-NMR spectral data confirmed the structural assignment. In addition to the signal of OH protons, the singlet of a methine carbon at $\delta = 5.88$ indicates the enolization of the methylene group in solution. The possibility of arrangement of an intramolecular hydrogen bond including a tension-free six-membered ring system seems to be the driving force for the occurrence of this tautomeric form[10]. By refluxing a solution of **5d** in THF for several hours, the formation of **6** can also be achieved without the addition of a base. From all this it follows that the intramolecular rearrangement under refluxing conditions is feasible only by displacement of protons.

The supports of the *Fonds der Chemischen Industrie, Thüringer Ministerium für Wissenschaft, Forschung und Kultur* and *Deutsche Forschungsgemeinschaft (SFB 436)* are gratefully acknowledged.

Experimental Section

General: All reagents were of commercial quality (Aldrich, Fluka, Merck) and were used as received. Solvents were dried and purified using standard techniques. − Reactions were monitored by thin-layer chromatography (TLC), on plastic plates coated with neutral alumina with fluorescence indicator (Polygram ALOX N/UV$_{254}$ from Macherey-Nagel). Separations by flash chromatography were carried out on neutral alumina (Merck, aluminium oxide 90 active neutral, activity V, particle size 0.063−0.200 mm, 70−230 mesh ASTM). − Melting points were measured with a Galen III (Boetius system) from Cambridge Instruments, and are uncorrected. − UV/Vis-spectra were obtained using a Perkin-Elmer Lambda 19 spectrophotometer. − The ^{1}H- and ^{13}C-NMR spectra were obtained with Bruker DRX 400 (400 MHz) and Bruker AC 250 (250 MHz) spectrometers (^{1}H-NMR shifts: relative to ^{1}H signals of the solvent). − Mass spectra were taken from measurements with a Finnigan MAT SAQ 710 mass spectrometer chemical ionization (CI) with H_2O]. − Elemental analyses were carried out in-house with an automatic analyzer LECO CHNS 932.

Crystal Structure Determination. − Data Collection: The intensity data for the compounds were collected on an Enraf-Nonius CAD4 diffractometer, using graphite-monochromated Mo-K_α radiation and a $\omega-2\theta$ scan technique. Data were corrected for Lorentz and polarization effects, but not for absorption[11] − *Structure Solution and Refinement*: The structures were solved by direct methods (SHELXS[12]) and refined by full-matrix least-squares



(*E*)-, (*Z*)-**6**	Ar	R
a	4-Me-C_6H_4	Ph
b	4-Me-C_6H_4	4-MeO-C_6H_4
c	4-Me_2N-C_6H_4	Ph
d	4-Me_2N-C_6H_4	4-MeO-C_6H_4

techniques against F^2 (SHELXL-93[13]). The hydrogen atoms were included at calculated positions with fixed thermal parameters. Important hydrogen atoms were located by Fourier syntheses and refined isotropically. For **2a** these were the hydrogen atoms of the water atom O1, for **5a** all except the methyl hydrogen atoms and for (*E*)-**6c** only the amine hydrogen atoms of N3 and N4. All non-hydrogen atoms were refined anisotropically. XP was used for structure representations[14].

Crystal Data for **2a**[15]: $C_{27}H_{31}LiN_4O_2$, M_r = 450.50 g mol^{-1}, red prism, size 0.40 × 0.38 × 0.36 mm^3, triclinic, space group *P*1bar a = 10.370(2), b = 11.455(3), c = 11.801(3) Å, α = 111.37(1), β = 104.34(1), γ = 94.34(1)°, V = 1243.2(5) Å^3, Z = 2, T = −90°C, $\rho_{calcd.}$ = 1.203 g cm^{-3}, μ(Mo-K_α) = 0.77 cm^{-1}, F(000) = 480, 5036 reflections in $+h$, $-k$, $-l$, measured in the range 2.38° ≤ Θ ≤ 26.29°, 5036 independent reflections, R_{int} = 0.0515, 2395 reflections with $F_o > 4\sigma(F_o)$, 315 parameters, $R1_{obs}$ = 0.0502, wR^2_{obs} = 0.1114, *GOOF* = 1.089, largest difference peak and hole: 0.265/−0.241 e Å^{-3}.

Crystal Data for **5a**[15]: $C_{25}H_{22}N_4O$, M_r = 394.47 g mol^{-1}, red prism, size 0.40 × 0.38 × 0.36 mm^3, triclinic, space group $P\bar{1}$, a = 10.477(1), b = 10.478(2), c = 11.457(1) Å, α = 93.32(1), β = 116.27(1), γ = 102.96(1)°, V = 1081.2(3) Å^3, Z = 2, T = −90°C, $\rho_{calcd.}$ = 1.212 g cm^{-3}, μ(Mo-K_α) = 0.76 cm^{-1}, F(000) = 416, 4380 reflections in $+h$, $-k$, $-l$, measured in the range 2.58° ≤ Θ ≤ 26.29°, 4380 independent reflections, R_{int} = 0.0229, 2256 reflections with $F_o > 4\sigma(F_o)$, 323 parameters, $R1_{obs}$ = 0.0487, wR^2_{obs} = 0.1254, *GOOF* = 1.172, largest difference peak and hole: 0.209/−0.159 e Å^{-3}.

Crystal Data for (*E*)-**6c**[15]: $C_{33}H_{32}N_6O$, M_r = 528.65 g mol^{-1}, blue prism, size 0.40 × 0.38 × 0.36 mm^3, monoclinic, space group $P2_1/c$, a = 12.410(2), b = 7.196(1), c = 31.615(3) Å, β = 96.35(1)°, V = 2806.0(7) Å^3, Z = 4, T = 20°C, $\rho_{calcd.}$ = 1.251 g cm^{-3}, μ(Mo-K_α) = 0.78 cm^{-1}, F(000) = 1120, 4770 reflections in $+h$, $-k$, $-l$, measured in the range 2.59° ≤ Θ ≤ 24.67°, 4770 independent reflections, R_{int} = 0.0559, 1686 reflections with $F_o > 4\sigma(F_o)$, 370 parameters, $R1_{obs}$ = 0.0560, wR^2_{obs} = 0.1218, *GOOF* = 1.155, largest difference peak and hole: 0.149/−0.142 e Å^{-3}.

General Procedure for the Alkylation and Acylation of **1**: A solution of **1** (0.35 g, 1.0 mmol) and LiH (8 mg, 1.1 mmol) in THF (30 ml) was heated at reflux for 1 h. The colour of solution turned from orange-red to deep purple. After cooling to room temperature, an excess (1.5 mmol) of the electrophilic reagent was added and the solution was refluxed again. The progress of the reaction was monitored by TLC. Usually, reaction times were chosen between 6 h and 24 h. After filtration the solvent was removed in vacuo and the residue was purified by column chromatography (aluminia, ethyl acetate/heptane, 1:5) or recrystallization from acetone/heptane, to yield the products **3** to **6**.

Li Complex **2a**: Using diethyl ether as solvent in the general procedure **2a** can be isolated by crystallisation from a concentrated solution (ca. 15 ml) at 0°C. From **1a** in 80% yield, m.p. 186°C. − UV/Vis (THF): λ_{max} (lg ε) = 288 nm (4.42), 518 (4.25), 561 (4.19). − ^{1}H NMR (400 MHz, [D$_8$]THF): δ = 8.52 (d, 2 H, *o*-Ph), 7.98 (d, 4 H, Tol), 7.42 (m, 3 H, *m*-, *p*-Ph), 7.11 (d, 4 H, Tol), 3.39 [q, ^3J = 7.5 Hz, 4 H, O(CH_2CH$_3$)$_2$], 3.12 (s, br, 2 H, H_2O), 2.32 (s, 6 H, CH_3−Tol), 1.12 [t, 6 H, ^3J = 7.5 Hz, O(CH$_2$CH_3)$_2$]. − ^{13}C NMR (100 MHz, [D$_8$]THF): δ = 191.63, 172.95, 147.02, 136.07, 133.80, 132.05, 130.32, 129.46, 128.29, 126.79, 66.19, 21.09, 15.55. − MS *m/z* (%): 352 (100) [M$^+$ − H_2O, − O(C$_2$H$_5$)$_2$, − Li$^+$], 337 (92), 234 (27), 132 (26), 117 (44). − $C_{27}H_{31}N_4O_2Li$ (450.5): calcd. C 71.93, H 6.94, N 12.45; found C 71.42, H 6.84, N 12.78.

5-(Methyl-4-tolylamino)-2-phenyl-4-(4-tolylimino)-4H-imidazole (**3a**): Yield 0.28 g (76%), m.p. 113−116°C. − UV/Vis (CHCl$_3$): λ_{max} (lg ε) = 264 nm (4.47), 325 (4.21), 472 (4.04). − ^{1}H NMR (400 MHz, CDCl$_3$): δ = 8.38 (d, br, 2 H), 7.49−7.22 (m, br, 9 H), 2.41 (s, 3 H), 2.34 (s, br, 3 H), 1.57 (s, 3 H). − ^{13}C NMR (100 MHz, CDCl$_3$): δ = 137.60, 132.79, 132.41, 129.94, 129.73, 129.26, 128.25, 126.97, 21.30, 21.16. − MS *m/z* (%): 367 (100) [M$^+$], 351 (8), 292 (10). − $C_{24}H_{22}N_4$ (366.5): calcd. C 78.66, H 6.05, N 15.29; found C 78.32, H 5.91, N 15.45.

5-(Ethyl-4-tolylamino)-2-phenyl-4-(4-tolylimino)-4H-imidazole (**3b**): Yield 0.25 g (66%), m.p. 141°C. − UV/Vis (CHCl$_3$): λ_{max} (lg ε) = 264 nm (4.42), 407 (4.07).− ^{1}H NMR (250 MHz, CDCl$_3$): δ = 7.77 (d, 2 H), 7.55 (m, 3 H), 7.34 (d, 2 H), 7.14−7.03 (m, 6 H), 3.90 (q, ^3J = 7.1 Hz, 2 H, CH_2CH$_3$), 2.35 (s, 3 H, CH_3−Tol), 2.27 (s, 3 H, CH$_3$−Tol), 1.33 (t, ^3J = 7.1 Hz, 3 H, CH$_2$CH_3). − ^{13}C NMR (62 MHz, CDCl$_3$): δ = 171.38, 151.04, 150.12, 145.19, 144.75, 136.24, 133.25, 129.79, 129.42, 129.03, 128.83, 128.69, 128.46, 126.06, 120.94, 38.12, 21.18, 21.04, 14.25. − MS *m/z* (%): 381 (100) [M$^+$], 365 (14), 176 (4), 132 (5), 105 (8). − $C_{25}H_{24}N_4$ (380.5): calcd. C 78.92, H 6.36, N 14.73; found C 78.85, H 6.39, N 14.72.

5-(Benzyl-4-tolylamino)-2-phenyl-4-(4-tolylimino)-4H-imidazole (**3c**): Yield 0.34 g (78%), m.p. 173°C. − UV/Vis (CHCl$_3$): λ_{max} (lg ε) = 243 nm (3.93), 365 (3.88), 471 (3.42). − ^{1}H NMR (400 MHz, CD$_2$Cl$_2$): δ = 7.67 (d, 2 H), 7.58 (t, 1 H), 7.47 (t, 2 H), 7.35 (t, 2 H), 7.31−7.22 (m, 5 H), 7.14 (d, 2 H), 7.10 (d, 2 H), 7.05 (d, 2 H), 5.10 (s, 2 H, CH_2), 2.36 (s, 3 H), 2.31 (s, 3 H). − ^{13}C NMR (100 MHz, CD$_2$Cl$_2$): δ = 151.87, 150.64, 145.32, 145.25, 137.38, 136.62, 133.94, 132.52, 130.01, 129.36, 129.19, 129.12, 129.05, 127.75, 127.66, 121.19, 46.48, 21.22, 21.11. − MS *m/z* (%): 443 (100) [M$^+$], 427 (11), 351 (3), 91 (6). − $C_{30}H_{26}N_4$ (442.3): calcd. C 81.41, H 5.93, N 12.67; found C 80.87, H 6.24, N 12.29.

4-[4-(Dimethylamino)phenylimino]-5-[4-(dimethylamino)-phenyl(methyl)amino]-2-phenyl-4H-imidazole (**3d**): Yield 0.31 g (73%), m.p. 168°C. − UV/Vis (THF): λ_{max} (lg ε) = 293 nm (4.32), 544 (4.36). − ^{1}H NMR (400 MHz, [D$_8$]THF, 335 K): δ = 8.40 (d, 2 H), 7.92 (d, br, 2 H), 7.46 (t, 1 H), 7.40 (t, 2 H), 7.29 (d, br, 2 H), 6.81 (d, 2 H), 6.71 (d, br, 2 H), 3.12 (s, br, 3 H, CH_3), 2.99 [s, 6 H, N(CH_3)$_3$], 2.97 [s, 6 H, N(CH_3)$_3$]. − ^{1}H NMR (400 MHz, [D$_8$]THF, 243 K): δ = 8.48, 8.34 (2d, 2 H), 8.25, 7.70 (2d, 2 H), 7.56−7.45 (m, 3 H), 7.41, 7.19 (2d, 2 H), 6.82 (d, br, 2 H), 6.80, 6.62 (2d, 2 H), 4.16, 3.79 (2s, 3 H, CH_3), 3.11, 3.04 [2s, 6 H, N(CH_3)$_3$], 3.04, 2.71 [2s, 6 H, N(CH_3)$_3$]. − ^{13}C NMR (100 MHz, [D$_8$]THF, 243 K): δ = 181.35, 180.6, 170.4, 170.21, 159.6, 150.63, 150.29, 149.44, 149.0, 137.74, 136.3, 136.09, 134.51, 134.06, 133.87, 132.08, 131.35, 131.17, 129.71, 129.54, 128.47, 128.34, 127.66, 127.1, 126.3, 112.71, 112.25, 112.12, 111.80, 111.44, 43.22, 40.62, 40.79, 40.22, 39.85, 39.78. − MS *m/z* (%): 425 (49) [M$^+$], 411 (13), 151 (100), 137 (18), 89 (23). − $C_{26}H_{28}N_6$ (424.5): calcd. C 73.56, H 6.59, N 19.79; found 73.61, H 6.63, N 19.70.

2-Phenyl-4-[3-(trifluormethyl)phenylimino]-5-[3-(trifluormethyl)phenyl(methyl)amino]-4H-imidazole (**3e**): Yield 0.23 g (48%), m.p. 128°C. − UV/Vis (CH$_2$Cl$_2$): λ_{max} (lg ε) = 249 nm (4.47), 328 (4.35), 466 (3.97). − ^{1}H NMR (400 MHz, CDCl$_3$, 223 K): δ = 8.43, 8.26 (2d, 2 H), 7.94 (m, 1 H), 7.81, 7.70 (2d, 1 H), 7.67−7.37 (m, 18 H), 4.19, 3.85 (s, 3 H). − MS *m/z* (%): 474 (100) [M$^+$], 455 (13), 405 (18), 356 (8), 300 (9), 145 (18), 103 (43). − $C_{24}H_{16}N_4F_6$ (474.4): calcd. 60.76, H 3.40, N 11.81; found C 61.07, H 3.47, N 11.56.

4,5-Dihydro-1-methyl-2-phenyl-4,5-bis[3-(trifluoromethyl)-phenylimino]-1H-imidazole (**4a**): Yield 0.1 g (22%), m.p. 140−142°C. − UV/Vis (CH$_2$Cl$_2$): λ_{max} (lg ε) = 269 nm (4.43), 398

(4.17). – ^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.87 (d, 2 H), 7.67 (t, 1 H), 7.62 (s, 1 H), 7.60 (t, 2 H), 7.51 (d, 1 H), 7.50–7.45 (m, 2 H), 7.42–7.37 (m, 3 H), 7.28 (d, br, 1 H), 3.55 (s, 3 H, C*H*$_3$). – ^{13}C NMR (100 MHz, $CDCl_3$): δ = 172.94, 152.43, 151.78, 148.15, 147.12, 132.80, 130.80 [q, ^2J(C,F) = 32 Hz, *ipso*-CF_3], 130.75 [q, ^2J(C,F) = 31.9 Hz, *ipso*-CF_3], 129.26, 129.00, 128.88, 128.73, 128.24, 125.62 [q, ^1J(C,F) = 268.5 Hz, *C*F_3], 125.34 [q, ^1J(C,F) = 270.1 Hz, *C*F_3], 123.9, 122.82 [q, ^3J(C,F) = 3.6 Hz, *o*-CF_3], 122.51 [q, ^3J(C,F) = 3.8 Hz, *o*-CF_3], 120.50 [q, ^3J(C,F) = 3.8 Hz, *o*-CF_3], 117.83 [q, ^3J(C,F) = 3.7 Hz, *o*-CF_3]. – MS *m/z* (%): 474 (100) [M^+], 455 (24), 405 (56), 227 (13), 200 (13), 145 (20), 118 (53), 103 (21). – $C_{24}H_{16}N_4F_6$ (474.4): calcd. 60.76, H 3.40, N 11.81; found C 60.58, H 3.45, N 11.88.

5-[Acetyl(4-tolyl)amino]-2-phenyl-4-(4-tolylimino)-4H-imidazole (**5a**): Yield 0.19 g (48%), m.p. 141°C. – UV/Vis ($CHCl_3$): λ_{max} (lg ε) = 336 nm (4.06), 437 (3.86). – ^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.44 (d, 2 H), 7.61 (t, 1 H), 7.52 (t, 2 H), 7,34 (s, br, 4 H), 7.19 (d, 4 H), 2.74 (s, 3 H, COC*H*$_3$), 2.38 (s, 6 H, C*H*$_3$). – ^{1}H NMR (400 MHz, CD_2Cl_2, 223 K): δ = 8.41 (d, 2 H), 7.66 (t, 1 H), 7.55 (t, 2 H), 7.45 (d, 2 H), 7.25 (d, 2 H), 7.16 (d, 2 H), 7.12 (d, 2 H), 2.77 (s, 3 H, COC*H*$_3$), 2.41 (s, 3 H, C*H*$_3$), 2.33 (s, 3 H, C*H*$_3$). – ^{13}C NMR (100 MHz, CD_2Cl_2, 223 K): δ = 180.70, 173.65, 171.12, 159.91, 143.30, 140.68, 138.19, 137.10, 133.96, 130.66, 129.87, 129.54, 129.44, 128.82, 128.14, 127.84, 26.59, 21.31, 21.03. – MS *m/z* (%): 395 (32) [M^+], 353 (61), 150 (100), 121 (70), 107 (31), 91 (74). – $C_{25}H_{22}N_4O$ (394.5): calcd. C 76.12, H 5.62, N 14.20; found C 75.84, H 5.66, N 14.12.

5-[Benzoyl(4-tolyl)amino]-2-phenyl-4-(4-tolylimino)-4H-imidazole (**5b**): Yield 0.24 g (53%), m.p. 123°C. – UV/Vis (CH_2Cl_2): λ_{max} (lg ε) = 245 nm (4.25), 342 (4.04), 466 (4.05). – ^{1}H NMR (400 MHz, [D_8]THF, 198 K): δ = 8.36 (d, 2 H), 7.91 (d, 2 H), 7.80 (d, 2 H), 7.66 (t, 1 H), 7.53 (t, 2 H), 7.44 (t, 1 H), 7.39–7.35 (m, 4 H), 7.29 (d, 2 H), 7.20 (d, 2 H), 2.39 (s, 3 H, C*H*$_3$), 2.34 (s, C*H*$_3$). – ^{13}C NMR (100 MHz, [D_8]THF, 198 K): δ = 183.81, 175.72, 172.83, 160.29, 144.12, 141.27, 140.45, 138.02, 137.88, 134.85, 133.23, 132.08, 130.9 (br), 130.67, 130.36, 129.80, 129.58, 129.38, 127.67, 21.53, 21.21. – MS *m/z* (%): 457 (100) [M^+], 441 (7), 351 (15), 248 (6), 212 (7), 105 (19). – $C_{30}H_{24}N_4O$ (456.5): calcd. C 78.92, H 5.29, N 12.27; found C 78.75, H 5.38, N 12.36.

5-{Benzoyl[4-(dimethylamino)phenyl]amino}-4-[4-(dimethylamino)phenylimino]-2-phenyl-4H-imidazole (**5c**): Yield 0.3 g (58%), m.p. 222–223°C – UV/Vis ($CHCl_3$): λ_{max} (lg ε) = 259 nm (4.46), 303 (4.46), 593 (4.64). – ^{1}H NMR (250 MHz, CD_2Cl_2): δ = 8.30 (d, 2 H), 7.80 (d, 2 H), 7.56–7.42 (m, 6 H), 7.33–7.25 (m, 4 H), 6.72 (d, br, 4 H), 3.05 [s, br, 12 H, N(C*H*$_3$)$_3$]. – ^{13}C NMR (62 MHz, CD_2Cl_2): δ = 178.19, 172.99, 138.25, 132.84, 132.62, 131.59, 129.58, 129.48, 128.89, 128.55, 40.58. – MS *m/z* (%): 515 (100) [M^+], 241 (28), 135 (6), 105 (9). – $C_{32}H_{30}N_6O$ (514.6): calcd. C 74.68, H 5.88, N 16.33; found C 74.60, H 5.83, N 16.21.

5-[Phenacetyl(4-tolyl)amino]-2-phenyl-4-(4-tolylimino)-4H-imidazole (**5d**): Yield 0.35 g (74%), m.p. 185–187°C – UV/Vis ($CHCl_3$): λ_{max} (lg ε) = 286 nm (4.28), 307 (4.24), 367 (4.08). – ^{1}H NMR (250 MHz, [D_6]DMSO): δ = 11.75 (s, br, 1 H, N*H*), 8.40 (d, 2 H), 7.83 (t, 2 H), 7.70 (t, 2 H), 7.43 (d, 2 H), 7.33–7.12 (m, 12 H), 5.88 (s, br, 1 H), 2.27 (s, 6 H). – ^{13}C NMR (62 MHz, [D_6]DMSO): δ = 158.45, 135.10, 133.8, 133.65, 130.00, 129.25, 129.21, 129.10, 128.85, 128.16, 125.4, 121.72, 120.34, 116.47, 45.33, 20.49. – MS *m/z* (%): 471 (49) [M^+], 353 (41) [M^+–$COCH_2Ph$], 338 (15), 305 (11), 269 (65), 226 (25), 137 (16), 119 (100), 91 (64). – $C_{31}H_{26}N_4O$ (470.6): calcd. C 79.12, H 5.57, N 11.91; found C 79.57, H 5.63, N 11.43.

(E)-2-Phenyl-2-[2-phenyl-4-(4-tolylamino)imidazol-5-ylidene]-N-(4-tolyl)acetamide [(*E*)-**6a**]: Yield 0.2 g (42%), m.p. 206–208°C. – UV/Vis ($CHCl_3$): λ_{max} (lg ε) = 255 nm (4.41), 353 (4.33), 484 (4.23). – ^{1}H NMR (400 MHz, $CDCl_3$): δ = 13.01 (s, 1 H, N*H*), 8.47 (d, 2 H), 7.71 (d, 2 H), 7.66 (m, 3 H), 7.58 (m, 3 H), 7.48 (m, 2 H), 7.23 (d, 2 H), 7.21 (d, 2 H), 7.08 (d, 2 H), 6.75 (s, 1 H, N*H*), 2.34 (s, 3 H), 2.29 (s, 3 H) – ^{13}C NMR (100 MHz, $CDCl_3$): δ = 177.85, 167.41, 163.03, 150.14, 136.40, 135.07, 134.88, 133.71, 133.65, 132.91, 131.95, 131.45, 130.12, 130.07, 129.84, 129.78, 129.72, 129.56, 128.75, 119.73, 119.67, 20.99, 29.96. – MS *m/z* (%): 471 (100) [M^+], 364 (4), 336 (7), 89 (4). – $C_{31}H_{26}N_4O$ (470.6): calcd. C 79.12, H 5.57, N 11.91; found C 78.93, H 5.33, N 11.80.

(Z)-2-Phenyl-2-[2-phenyl-4-(4-tolylamino)imidazol-5-ylidene]-N-(4-tolyl)acetamide [(*Z*)-**6a**]: Yield 0.13 g (27%), m.p. 188°C. – UV/Vis ($CHCl_3$): λ_{max} (lg ε) = 258 nm (4.36), 362 (4.30), 518 (4.14), – ^{1}H NMR (400 MHz, $CDCl_3$): δ = 13.82 (s, 1 H, N*H*), 8.29 (d, 2 H), 8.02 (d, 2 H), 7.58 (d, 2 H), 7.55–7.46 (m, 4 H), 7.44 (s, br, 1 H, N*H*), 7.39 (t, 2 H), 7.33 (d, 2 H), 7.23 (d, 2 H), 7.14 (d, 2 H), 2.37 (s, 3 H, C*H*$_3$). – ^{13}C NMR (100 MHz, $CDCl_3$): δ = 180.22, 166.56, 165.83, 158.32, 136.63, 136.58, 135.46, 134.60, 134.31, 132.43, 132.04, 131.20, 130.90, 129.84, 129.68, 129.61, 128.90, 128.63, 128.19, 121.33, 120.77, 21.12, 20.99. – MS *m/z* (%): 471 (100) [M^+], 369 (62), 257 (16), 107 (8), 89 (40). – $C_{31}H_{26}N_4O$ (470.6): calcd. C 79.12, H 5.57, N 11.91; found C 79.03, H 5.46, N 12.05.

(E)-2-(4-Methoxyphenyl)-2-[2-phenyl-4-(4-tolylamino)-imidazol-5-ylidene]-N-(4-tolyl)acetamide [(*E*)-**6b**]: Yield 0.26 g (52%), m.p. 226°C – UV/Vis ($CHCl_3$): λ_{max} (lg ε) = 357 nm (4.28), 484 (4.20). – ^{1}H NMR (400 MHz, $CDCl_3$): δ = 13.39 (s, 1 H, N*H*), 8.48 (d, 2 H), 7.73 (d, 2 H), 7.62 (m, 3 H), 7.43 (d, 2 H), 7.29 (d, 2 H), 7.20 (m, 4 H), 7.12 (d, 2 H), 7.06 (s, 1 H, N*H*), 3.98 (s, 3 H), 2.36 (s, 3 H), 2.32 (s, 3 H). – ^{13}C NMR (100 MHz, $CDCl_3$): δ = 177.48, 167.54, 163.19, 160.92, 150.10, 136.45, 135.20, 134.82, 133.64, 132.80, 131.90, 131.76, 131.52, 129.74, 129.71, 129.55, 128.73, 125.25, 119.72, 119.64, 115.48, 55.65, 20.98, 20.96. – MS *m/z* (%): 501 (6) [M^+], 257 (6), 146 (9), 107 (6), 89 (100). – $C_{32}H_{28}N_4O_2$ (500.6): calcd. C 76.78, H 5.64, N 11.19; found C 76.75, H 5.80, N 11.12.

(E)-2-[4-(Dimethylamino)phenyl]-2-[[4-(4-(dimethylamino)-phenylamino]-2-phenylimidazol-5-ylidene]-2-phenylacetamide [(*E*)-**6c**]: Yield 0.18 g (34%), m.p. 203–206°C. – ^{1}H NMR (400 MHz, $CDCl_3$): δ = 14.18 (s, 1 H, N*H*), 8.33 (d, 2 H), 8.09 (d, 2 H), 7.61 (d, 2 H), 7.54 (t, 2 H), 7.54 (t, 2 H), 7.46 (m, 2 H), 7.41 (m, 3 H), 7.37 (d, 2 H), 6.83 (d, 2 H), 6.70 (d, 2 H), 3.02 (s, 6 H), 2.95 (s, 6 H). – ^{13}C NMR (100 MHz, $CDCl_3$): δ = 179.95, 166.41, 164.70, 158.24, 148.55, 148.09, 137.19, 132.91, 131.61, 131.30, 129.68, 129.50, 129.23, 128.51, 128.07, 126.63, 122.76, 122.34, 112.85, 112.60, 40.71, 40.62. – MS *m/z* (%): 529 (8) [M^+], 395 (7), 365 (11), 281 (6), 264 (11), 163 (100), 135 (19). – $C_{33}H_{32}N_6O$ (528.7): calcd. C 74.97, H 6.10, N 15.89; found C 74.74, H 5.93, N 16.12.

(Z)-2-[4-(Dimethylamino)phenyl]-2-[[4-(4-(dimethylamino)-phenylamino]-2-phenylimidazol-5-ylidene]-2-phenylacetamide [(*Z*)-**6c**]: Yield 0.12 (24%), m.p. 219–221°C. – UV/Vis (THF): λ_{max} (lg ε) = 274 nm (4.47), 378 (3.84), 566 (4.00). – ^{1}H NMR (400 MHz, $CDCl_3$): δ = 13.01 (s, 1 H, N*H*), 8.43 (d, 2 H), 7.75 (d, 2 H), 7.65–7.55 (m, 8 H), 7.50–7.25 (m, 4 H), 6.81 (s, 1 H, N*H*), 6.65 (d, 2 H), 2.96 (s, 6 H), 2.94 (s, 6 H). – MS *m/z* (%): 529 (7) [M^+], 393 (6), 369 (12), 269 (5), 255 (25), 163 (100), 137 (19). – $C_{33}H_{32}N_6O$ (528.7): calcd. C 74.97, H 6.10, N 15.89; found C 74.62, H 6.14, N 16.24.

(E)-2-[4-(Dimethylamino)phenyl]-2-[[4-[4-(dimethylamino)-phenylamino]-2-phenylimidazol-5-ylidene]-2-(4-methoxyphenyl)-

acetamide [(*E*)-**6d**]: Yield 0.19 g (34%), m.p. 228−231°C. − UV/Vis ($CHCl_3$): λ_{max} (lg ε) = 280 nm (4.61), 395 (4.14), 572 (4.34). − ^{1}H NMR (400 MHz, $CDCl_3$): δ = 12.99 (s, 1 H, N*H*), 8.49 (d, 2 H), 7.75 (d, 2 H), 7.59 (m, 3 H), 7.43 (d, 2 H), 7.32 (d, 2 H), 7.19 (d, 2 H), 7.05 (s, 1 H, N*H*), 6.79 (d, 2 H), 6.67 (d, 2 H), 3.92 (s, 3 H), 2.97 (s, 6 H), 2.94 (s, 6 H). − MS *m/z* (%): 559 (5) [M^+], 395 (6), 163 (100), 137 (22). − $C_{34}H_{34}N_6O_2$ (558.7): calcd. C 73.09, H 6.13, N 15.04; found C 73.37, H 6.37, N 14.87.

☆ Dedicated to Professor *A. R. Katritzky*, Gainesville, Florida on the occasion of his 70th birthday.

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