L-Proline triflate as an efficient and reusable catalyst for the one-pot synthesis of 2,4,5-trisubstituted imidazoles and 1,2,4,5-tetrasubstituted imidazoles

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L-Proline triflate has been used as an efficient catalyst for an improved and rapid one-pot synthesis of 2,4,5-trisubstituted and 1,2,4,5-tetrasubstituted imidazoles in good yields. The benefit of this approach is its operational simplicity and the catalyst can be easily recovered and reused without any loss of activity.

Keywords: L-proline triflate, multicomponent reaction, 2,4,5-trisubstituted imidazoles, 1,2,4,5-tetrasubstituted imidazoles

Imidazole derivatives are of considerable interest in the pharmaceutical industry as well as in academia due to their promising biological activities such as inhibitors of p38 MAP kinase,[1] B-Raf kinase,[2] orally bioavailable HIV-1 protease inhibitors,[3] antitumour,[4] therapeutic agents,[5] plant growth regulators,[6] glucagon receptors[7] and antibacterial agents.[8] Thus, the synthesis of this heterocyclic nucleus is of great interest.

Multicomponent reactions (MCRs) are one-pot processes bringing together three or more components and show high atom economy and operational simplicity. In recent years, the synthesis of substituted imidazoles by the application of MCRs has attracted wide attention, for its great contribution to the convergent synthesis of complex and important organic molecules from simple and readily available starting materials.

Many methods have been developed for the synthesis of 2,4,5-trisubstituted imidazoles **1** by three-component cyclocondensation of a 1,2-diketone, α-hydroxyketone or α-ketomonoxime with an aldehyde and ammonium acetate, under $InCl_3 \cdot 3H_2O$,[9] or tetrabutylammonium bromide (TBAB)[10] catalysis. Similarly, the synthesis of 1,2,4,5-tetrasubstituted imidazoles **2** has been carried out by a component condensation of a 1,2-diketone, α-hydroxyketone or α-ketomonoxime with an aldehyde, primary amine and ammonium acetate using microwaves,[11] heteropoly acid,[12] BF_3/SiO_2,[13] silica gel/$NaHSO_4$[14] or $K_5CoW_{12}O_{40} \cdot 3H_2O$[15] and ionic liquids.[16] Although a variety of catalytic systems have been introduced for this cyclocondensation, many of these methodologies are associated with one or more disadvantages such as relatively long reaction times, environmentally unfriendly catalysts, or the requirement for excess reagents or catalysts and harsh reaction conditions.

Recently, ammonium triflates,[17–20] which are efficient, cost-effective catalysts can be easily prepared and have been used as readily available catalysts in a variety of organic reactions. In continuation of our previous work on triflates, we report here an efficient method for the synthesis of highly substituted imidazoles in the presence of novel types of ammonium triflates.

Initially, we chose benzil, benzaldehyde and ammonium acetate (1:1:2) as the substrates in a model reaction to screen the reaction conditions.

As indicated in Table 1, the reaction proceeded sluggishly and led to a poor yield in the absence of catalyst (Table 1, entry 1). Higher yields were obtained when L-proline triflate was used as the catalyst in comparison to other triflates. Then, the amount of L-proline triflate was decreased from 10 to 1 mol%, but the yields of the product plateaued around 84% (Table 1, entry 8). Hence, a larger amount of catalyst for the reaction is unnecessary and 5 mol% is the optimal amount (Table 1 entry 7).

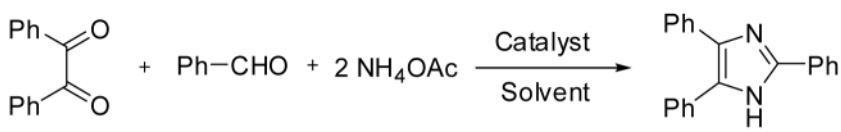
The choice of solvent is a very crucial factor for this condensation. As both protic and aprotic solvents were tested, it was found that methanol was significantly superior to other alcoholic solvents (Table 1, entries 10 and 11) and protic solvents were better than aprotic ones. It should be pointed out that no product was obtained when water was used in this reaction (Table 1, entry 15).

Next, a variety of aldehydes were examined to widen the scope of this condensation under the optimised conditions. The results showed that aromatic aldehydes (Table 2) produced high yields, whereas aliphatic aldehydes gave lower yields. In these MCRs, using benzoin instead of benzil also provided the corresponding substituted imidazoles, but in 5–10% lower yields.

On the basis of the above results, the reactions were extended to the synthesis of *N*-substituted imidazoles *via* the one-pot, four component condensation of benzil, aldehyde, primary amine and ammonium acetate, as depicted in Table 3. A variety of structurally diverse primary amines were evaluated for this one-pot synthesis. Both aromatic and aliphatic primary amines afforded the corresponding imidazoles in satisfactory yields.

Because of its excellent solubility and stability in water, L-proline triflate can be easily recovered and separated from the crude reaction product. In order to examine the activity of recovered catalyst, L-proline triflate was reused more than 4 times (10 mmol scale) for the model reaction (Scheme 1). No loss in activity was observed.

Finally, a possible mechanism is proposed and shown in Scheme 4. There are two plausible pathways to generate the product. In pathway I, the reaction proceeds through the diamine intermediate [**A**]. It is proposed that the ammonium triflate moiety[19] of the catalyst facilitates the formation of [**A**] by increasing the electrophilicity of the carbonyl group of the



Scheme 1

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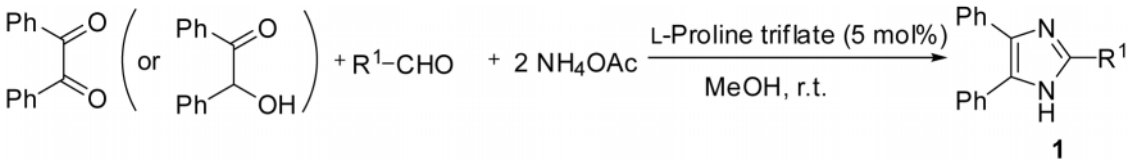
Table 1 The synthesis of 2, 4, 5-triphenylimidazole under different reaction conditions[a]

Entry	Catalyst	Loading/mol%	Solvent	Temp./°C	Time/h	Yield[b]/%
1	No catalyst	0	MeOH	RT	24	25
2	Diphenylammonium triflate	5	MeOH	RT	12	72
3	Dicyclohexylammonium triflate	5	MeOH	RT	12	46
4	Tributylamine triflate	5	MeOH	RT	12	73
5	L-Proline	5	MeOH	RT	12	55
6	L-Proline triflate	10	MeOH	RT	12	88
7	L-Proline triflate	5	MeOH	RT	12	89
8	L-Proline triflate	1	MeOH	RT	12	84
9	L-Proline triflate	5	MeOH	Reflux	12	85
10	L-Proline triflate	5	EtOH	RT	12	70
11	L-Proline triflate	5	*i*-PrOH	RT	12	54
12	L-Proline triflate	5	$CHCl_3$	RT	12	40
13	L-Proline triflate	5	Toluene	RT	12	32
14	L-Proline triflate	5	CH_3NO_2	RT	24	trace
15	L-Proline triflate	5	H_2O	RT	24	trace

[a]All reactions were run with 1.0 mmol benzil under different reaction conditions, the ratio of benzil: benzaldehyde: ammonium acetate was 1: 1: 2.
[b]Isolated yield based on benzil.



Scheme 2

Table 2 The synthesis of 2, 4, 5-trisubstituted imidazoles with a wide variety of aldehydes[a]

Entry	R^1	Products	Time/h	Yield[b]/%
1[c]	Ph	**1a**	12	89,87,89,90,88
2	4-$NO_2C_6H_4$	**1b**	12	87
3	4-$MeOC_6H_4$	**1c**	13	82
4	3,4-$(CH_3O)_2C_6H_3$	**1d**	13	84
5	3,4-$(CH_3)_2C_6H_3$	**1e**	12	77
6	3-FC_6H_4	**1f**	15	43
7	$(CH_3)_3C$	**1g**	13	65
8	2-Thiophene	**1h**	12	69
9	Cyclohexyl	**1i**	13	67

[a]Reaction conditions: benzil: aldehyde: ammonium acetate = 1:1:2.
[b]Isolated yield based on benzil.
[c]The catalyst was reused 4 times.

Table 3 The synthesis of 1,2,4,5-tetrasubstituted imidazoles with a wide variety of primary amines[a]

Entry	R^2	R^3	Products	Time/h	Yield[b]/%
1	Ph	Ph	**2a**	12	85
2	Ph	$C_6H_5CH_2$	**2b**	12	83
3	Ph	4-$CH_3C_6H_4$	**2c**	11	79
4	Ph	4-ClC_6H_4	**2d**	12	62
5	Ph	4-$MeOC_6H_4$	**2e**	12	76
6	Ph	Cyclohexyl	**2f**	13	75
7	Ph	$HOCH_2CH_2$	**2g**	11	78
8	Ph	$(CH_3)_2CH$	**2h**	13	76
9	4-$NO_2C_6H_4$	Ph	**2i**	11	71

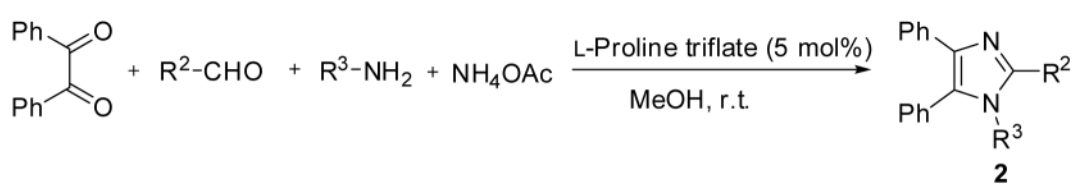
[a]Reaction conditions: 1,2-Diketone: aldehyde: primary amine: ammonium acetate = 1:1:1:1.
[b]Isolated yield based on benzil.

aldehyde. Then, intermediate [**A**], in the presence of catalyst, condenses with benzil to form [**D**], which in turn is dehydrated to the trisubstituted imidazole. On the other hand, in pathway II it is proposed that the aldehyde reacts with the amine to form an imine intermediate [**B**], which then condenses with [**C**] to form intermediate [**D**]. The latter is converted to the product by dehydration.

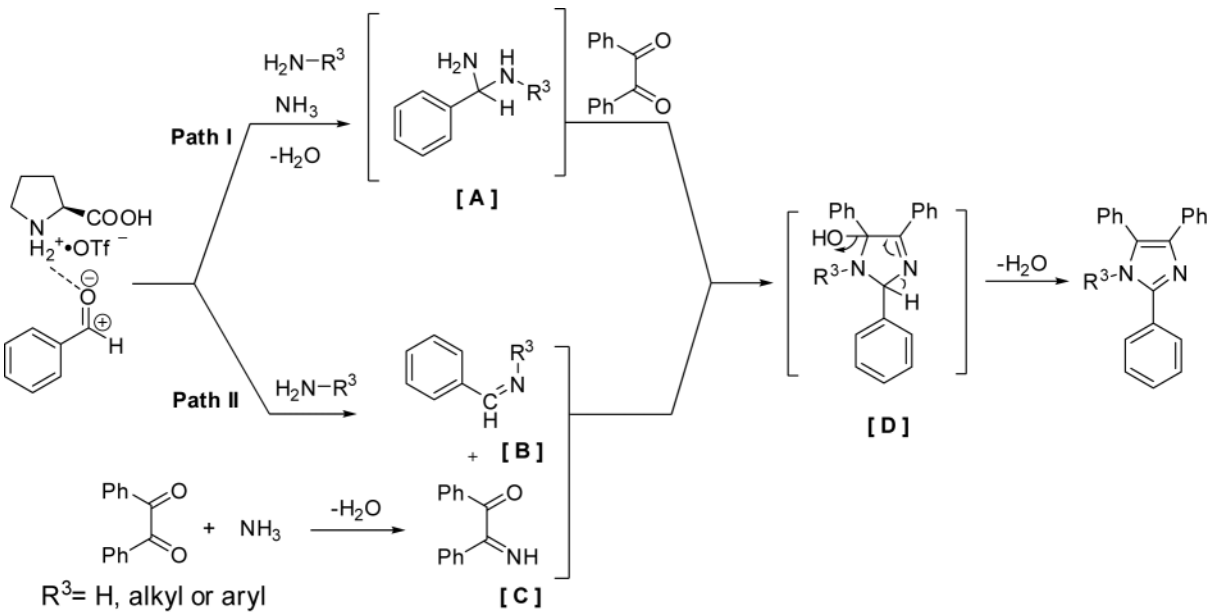
In summary, the present procedure involving catalysis by L-proline triflate (5 mol%) provides an efficient method for the synthesis of 2,4,5-trisubstituted imidazoles and 1,2,4,5-tetrasubstituted imidazoles by a one-pot, multicomponent methodology. This protocol affords good yields with low catalyst loading, cost efficiency and simplicity of operation. It is thus a practical alternative to the existing procedures for the synthesis of imidazoles.

Experimental

Melting points were measured on a Büchi B-540 capillary melting point apparatus and are uncorrected. IR spectra were recorded on a Nicolet Aviatar-370 instrument, spectrometer using samples as KBr plates. ^{1}H NMR and ^{13}C NMR spectra were recorded on a Varian 400 MHz instrument using DMSO-d_6 as the solvent, and chemical shifts are expressed in parts per million (ppm) using TMS as an internal standard. Mass spectra were measured with a Trace Finnigan DSQ.



Scheme 3



Scheme 4

High resolution mass spectra (HRMS) were measured on an Agilent 6210 TOF LC/MS using APCI (electrospray ionisation) techniques. All spectral data of the products were identical to authentic samples.

General procedure for the preparation of 2, 4, 5-trisubstituted imidazoles

In a 50 mL round-bottom flask, benzil (1 mmol), an aldehyde (1 mmol) and ammonium acetate (2 mmol) were stirred in the presence of of L-proline triflate (5 mol%) in methanol (5 mL) at room temperature for the stipulated time. The reaction was monitored by TLC. After the completion of the reaction, the mixture was diluted with water and extracted with ethyl acetate. The organic layer was washed with brine then it was dried over $MgSO_4$ and evaporated. Recrystallisation of the residue from ethyl acetate or elution from a silica gel column (ethyl acetate-petroleum ether 1:16) afforded the pure product.

General procedure for the preparation of 1,2,4,5-tetrasubstituted imidazoles

In a 50 mL round-bottom flask, benzil (1 mmol), an aldehyde (1 mmol), a primary amine (1 mmol) and ammonium acetate (1 mmol) were stirred in the presence of of L-proline triflate (5 mol%) in methanol (5 mL) at room temperature for the stipulated time. The reaction was monitored by TLC. After completion of the reaction, the mixture was diluted with water and extracted with ethyl acetate. The organic layer was washed with brine then it was dried over $MgSO_4$ and evaporated. Recrystallisation of the residue from ethyl acetate or elution from a silica gel column (ethyl acetate-petroleum ether 1:16) afforded the pure product.

General procedure for the preparation of L-proline triflate

L-Proline (20 mmol, 2.3 g) was dissolved in water (10 mL) cooled in ice-salt bath. Then trifuoromethanesulfonic acid (3.0 g, 20 mmol) in aqueous solution was added dropwise. The mixture was stirred for 2 h at 0 °C. The residue was extracted with petroleum ether three times. The combined organic layers were evaporated under reduced pressure to afford the pure L-proline triflate 5.0 g (95 % yield).

General procedure for recycling of L-proline triflate

After the completion of the reaction, the mixture was diluted with water and extracted with ethyl acetate. The organic layer was washed with water (10 mL). The combined water layers were collected and concentrated to afford the recycled catalyst.

2,4,5-Triphenyl-1H-imidazole **(1a)**: White solid, m.p. 270–272 °C (lit.[9] M.p. 269 °C). IR (KBr, cm^{-1}): 3446, 1631. ^{1}H NMR (DMSO-d_6, 400 MHz) δ: 7.21–7.56 (m, 13H), 8.09 (d, 2H, J = 8.4 Hz) 12.68 (s, 1H). ^{13}C NMR (DMSO-d_6, 100 MHz) δ: 125.4, 126.7, 127.4, 127.8, 128.2, 128.4, 128.5, 128.7, 130.4, 131.2, 135.2, 137.3, 137.3, 145.6. MS (ESI): m/z = 296 (M^+).

4,5-Diphenyl-2-(4-nitrophenyl)-1H-imidazole **(1b)**: White solid, m.p. 237–238 °C (lit.[10] M.p. 238–239 °C). IR (KBr, cm^{-1}): 3456, 1640. ^{1}H NMR (DMSO-d_6, 400 MHz) δ: 7.24–8.44 (m, 14H), 12.61 (s, 1H). ^{13}C NMR (DMSO-d_6, 100 MHz) δ: 126.3, 128.0, 128.4, 128.5, 129.1, 130, 134.8, 135.8, 141.8. MS (ESI) m/z = 341 (M^+).

4,5-Diphenyl-2-(4-methoxyphenyl)-1H-imidazole **(1c)**: White solid, m.p. 229–231 °C (lit.[10] M.p. 228 °C). IR (KBr, cm^{-1}): 3432, 1630. ^{1}H NMR (DMSO-d_6, 400 MHz) δ: 3.82 (s, 3H), 7.04 (d, 2H, J = 9.2 Hz), 7.21–7.55 (m, 12H), 8.01(d, 2H, J = 8.4 Hz) 12.51 (s, 1H). ^{13}C NMR (DMSO-d_6, 100 MHz) δ: 55.2, 114.1, 123.1, 126.4, 126.7, 127.0, 127.6, 128.1, 128.3, 128.6, 131.2, 135.3, 136.8, 145.6, 159.4. MS (ESI): m/z = 326 (M^+).

2-(3,4-Dimethoxyphenyl)-4,5-diphenyl-1H-imidazole **(1d)**: White solid, m.p. 214–215 °C (lit.[9] M.p. 215 °C). IR (KBr, cm^{-1}): 3446, 1633. ^{1}H NMR (DMSO-d_6, 400 MHz) δ: 3.85 (s, 3H), 3.83 (s, 3H), 3.91 (s, 3H), 6.65–6.70 (m, 2H) 7.20–7.53 (m, 10H), 7.95(d, 1H, J = 8.8 Hz) 11.73 (s, 1H). ^{13}C NMR (DMSO-d_6, 100 MHz) δ: 55.4, 55.6, 98.4, 105.6, 112.0, 126.3, 127.1, 128.1, 128.5, 129.8, 143.4, 157.2, 168.9. MS (ESI): m/z = 356 (M^+).

2-(3,4-Dimethylphenyl)-4,5-diphenyl- 1H-imidazole **(1e)**: White solid, m.p. 234 °C. IR (KBr, cm^{-1}): 3415, 1617. ^{1}H NMR (DMSO-d_6, 400 MHz) δ: 2.27–2.51 (m, 6H), 7.20–7.56 (m, 11H), 7.80 (d, 1H, J = 7.6 Hz), 7.90 (s, 1H) 12.57 (s, 1H). ^{13}C NMR (DMSO-d_6, 100 MHz) δ: 19.2, 19.5, 122.7, 126.2, 126.4, 127.1, 127.6, 128.0, 128.1, 128.4, 128.7, 129.8, 136.5, 145.8. MS (ESI): m/z = 324 (M^+). HRMS (ESI): m/z Calcd for $C_{23}H_{20}N_2$: 324.1626. Found: 324.1610.

4,5-Diphenyl-2-(3-fluorophenyl)-1H-imidazole **(1f)**: White solid, m.p. 285 °C. IR (KBr, cm^{-1}): 3412, 1633. ^{1}H NMR (DMSO-d_6, 400 MHz) δ: 7.20–7.56 (m, 12H), 7.91(m, 2H) 12.82 (s, 1H). ^{13}C NMR (DMSO-d_6, 100 MHz) δ: 111.5, 111.7, 114.8, 115.0, 121.2, 126.6, 127.1, 128.0, 128.2, 128.4, 128.7, 130.9, 132.5, 132.6, 135.0, 137.3, 144.2, 161.3, 163.7. MS (ESI): m/z = 314 (M^+). HRMS (ESI): m/z Calcd for $C_{21}H_{15}N_2F$: 314.1219. Found: 314.1210.

2-(1,1-Dimethylethyl)-4,5-diphenyl-1H-imidazole **(1g)**: White solid, m.p. 198–200 °C. IR (KBr, cm^{-1}): 3325, 1623. ^{1}H NMR (DMSO-d_6, 400 MHz) δ: 1.37 (s, 9H), 7.17–7.45 (m, 10H), 11.82 (s, 1H). ^{13}C NMR (DMSO-d_6, 100 MHz) δ: 29.5, 32.6, 127.0, 127.3, 128.0, 128.5, 155.4. MS (ESI): m/z = 276 (M^+). HRMS (ESI): m/z Calcd for $C_{19}H_{20}N_2$: 276.1626. Found: 276.1630.

4,5-Diphenyl-2-(2-thienyl)-1H-imidazole **(1h)**: White solid, m.p. 265–267 °C. IR (KBr, cm^{-1}): 3414, 1618. ^{1}H NMR (DMSO-d_6, 400 MHz) δ: 7.15 (d, 1H, J = 3.6 Hz), 7.16-7.69 (m, 11H), 7.70 (d, 1H, J = 1.2 Hz), 12.80 (br, s, 1H). ^{13}C NMR (DMSO-d_6, 100 MHz) δ: 124.2, 126.2, 127.2, 127.9, 128.4, 133.9, 141.5. MS (ESI): m/z = 302 (M^+). HRMS (ESI): m/z Calcd for $C_{19}H_{14}N_2S$: 302.0878. Found: 302.0871.

2-Cyclohexyl-4,5-diphenyl-1H-imidazole **(1i)**: White solid, m.p. 240–241 °C. IR (KBr, cm^{-1}): 3414, 1633. ^{1}H NMR (DMSO-d_6, 400

MHz) δ: 1.22–1.40 (m, 3H), 1.53–1.62 (m, 2H), 1.67–1.70 (m, 1H), 1.78–1.95 (m, 2H), 1.95–1.99 (m, 2H), 2.65–2.72 (m, 1H), 7.17–7.47(m, 10H), 11.92(s, 1H). ^{13}C NMR (DMSO-d_6, 100 MHz) δ: 25.6, 25.7, 31.5, 37.2, 126.6, 127.4, 128.3, 152.4. MS (ESI): *m/z* = 302 (M^+). HRMS (ESI): *m/z* Calcd for $C_{21}H_{22}N_2$: 302.1783. Found: 302.1789.

1,2,4,5-Tetraphenylimidazole **(2a)**: White solid, m.p. 215–217 °C (lit.[9] M.p. 216–217 °C). IR (KBr, cm^{-1}) 1600, 1579. ^{1}H NMR (DMSO-d_6, 400 MHz) δ: 7.18–7.20 (m, 1H), 7.23–7.39(m, 17H), 7.40–7.51(m, 2H). ^{13}C NMR (DMSO-d_6, 100 MHz) δ: 125.2, 126.5, 127.8, 128.3, 128.5, 128.7, 130.3, 131.1, 135.2, 137.1, 145.5. MS (ESI): *m/z* = 372 (M^+).

1-Benzyl-2,4,5-triphenyl-1H-imidazole **(2b)**: White solid, m.p. 160–162 °C (lit.[9] m.p. 159–160 °C). IR (KBr, cm^{-1}): 1601, 1581. ^{1}H NMR (DMSO-d_6, 400 MHz) δ: 5.16 (s, 2H), 6.77(d, 2H, *J* = 6.8 Hz), 7.14–7.17 (m, 6H), 7.29–7.31(m, 2H), 7.40–7.47(m, 8H), 7.65–7.67 (m, 2H). ^{13}C NMR (DMSO-d_6, 100 MHz) δ: 47.6, 58.0, 125.6, 126.1, 126.2, 127.1, 128.1, 128.5, 128.9, 130.1, 130.5, 130.7, 130.8, 134.5, 136.9, 137.3, 147.1. MS (ESI): *m/z* = 386 (M^+).

1-p-Tolyl-2,4,5-triphenyl-1H-imidazole **(2c)**: White solid, m.p.177–179 °C. (lit.[22] M.p. 183–184 °C). IR (KBr, cm^{-1}): 3447, 1636. ^{1}H NMR (DMSO-d_6, 400 MHz) δ: 2.26 (s, 3H), 7.20–7.39 (m, 17H), 7.48 (d, 2H, *J* = 7.3 Hz). ^{13}C NMR (DMSO-d_6, 100 MHz) δ: 20.6, 126.3, 128.1, 128.2, 128.4, 129.6, 130.5, 131.1, 134.1, 134.4, 136.7, 138.1, 146.0. MS (ESI): *m/z* = 386 (M^+).

1-(4-Chlorophenyl)-2,4,5-triphenyl-1H-imidazole **(2d)**: White solid, m.p. 197–199 °C (lit.[21] M.p. 196–199 °C). IR (KBr, cm^{-1}): 3442, 1636. ^{1}H NMR (DMSO-d_6, 400 MHz) δ: 7.16–7.41 (m, 17H), 7.49 (d, 2H, *J* = 8.8 Hz). ^{13}C NMR (DMSO-d_6, 100 MHz) δ: 126.3, 126.6, 128.2, 128.3, 128.4, 128.6, 129.2, 130.2, 130.6, 131.2, 133.3, 134.2, 135.6, 136.9, 146.1. MS (ESI): *m/z* = 406 (M^+).

1-(4-Methoxyphenyl)-2,4,5-triphenyl-1H-imidazole **(2e)**: White solid, m.p. 185–186 °C. (lit.[23] M.p. 180–182 °C). IR (KBr, cm^{-1}): 3448, 1636. ^{1}H NMR (DMSO-d_6, 400 MHz) δ: 3.70 (s, 3H), 6.85 (m, 2H, *J* = 9.2 Hz), 7.17–7.32 (m, 13H), 7.49 (d, 2H, *J* = 7.2 Hz). ^{13}C NMR (DMSO-d_6, 100 MHz) δ: 55.2, 114.1, 126.3, 126.4, 128.2, 128.3, 128.4, 128.5, 129.3, 129.9, 130.5, 131.1, 131.5, 134.5, 136.7, 146.2, 158.9. MS (ESI): *m/z* = 402 (M^+).

1-Cyclohexyl-2,4,5-triphenyl-1H-imidazole **(2f)**: White solid, m.p. 168–169 °C (lit.[11] m.p. 167–169 °C). IR (KBr, cm^{-1}): 3442, 1635. ^{1}H NMR (DMSO-d_6, 400 MHz) δ: 0.57 (m, 1H), 0.91–1.01 (m, 2H), 1.40–1.55 (m, 5H), 1.87 (d, 2H, *J* = 11.2 Hz), 3.92 (m, 1H), 7.05–7.16 (m, 3H), 7.29–7.32 (d, 2H, *J* = 12 Hz), 7.48–7.62 (m, 10H). ^{13}C NMR (DMSO-d_6, 100 MHz) δ: 24.7, 25.7, 33.0, 57.9, 125.9, 127.9, 128.8, 132.0, 134.7, 146.9. MS (ESI): *m/z* = 378 (M^+).

2-(2,4,5-Triphenyl-1H-imidazol-1-yl)ethanol **(2g)**: White solid, m.p.182–183 °C. IR (KBr, cm^{-1}): 3425, 1636. ^{1}H NMR (DMSO-d_6, 400 MHz) δ: 3.17–3.37 (m, 2H), 4.00 (m, 2H), 4.90–4.93 (m, 1H), 7.10–7.21 (m, 3H), 7.41 (d, 2H, *J* = 8 Hz). ^{13}C NMR (DMSO-d_6, 100 MHz) δ: 46.5, 59.3, 126.1, 128.0, 128.5, 128.7, 129.1, 129.8, 131.0,131.1, 131.2, 134.7, 136.5, 147.1. MS (ESI): *m/z* = 340 (M^+). HRMS (ESI): *m/z* Calcd for $C_{28}H_{22}N_2O$: 340.1576. Found: 340.1654.

1-Isopropyl-2,4,5-triphenyl-1H-imidazole **(2h)**: White solid, m.p.179–180 °C (lit.[11] M.p. 159–160 °C). IR (KBr, cm^{-1}): 3445, 1634. ^{1}H NMR (DMSO-d_6, 400 MHz) δ: 1.04–1.20 (m, 6H), 4.36–4.43 (m, 1H), 7.06–7.16 (m, 2H), 7.23 (d, 2H, *J* = 7.6 Hz), 7.61–7.64 (m, 11H), 8.09 (d, 1H, *J* = 7.2 Hz). ^{13}C NMR (DMSO-d_6, 100 MHz) δ: 22.9, 49.1, 124.8, 125.0, 125.1, 125.2, 125.9, 127.8, 127.9, 128.9, 129.7, 132.1, 134.8, 136.8, 146.7. MS (ESI): *m/z* = 338 (M^+).

2-(4-Nitrophenyl)-1,4,5-triphenyl- 1H-imidazole **(2i)**: Yellow solid, m.p. 220–223 °C. (lit.[21] m.p. 223–225 °C). IR (KBr, cm^{-1}): 3445, 1634. ^{1}H NMR (DMSO-d_6, 400 MHz) δ: 7.19–7.40 (m, 13H), 7.52 (d, 2H, *J* = 8.8 Hz), 7.60–7.63 (m, 2H), 8.14–8.17 (m, 2H). ^{13}C NMR (DMSO-d_6, 100 MHz) δ: 123.5, 126.4, 126.8, 128.2, 128.5, 128.6, 128.7, 128.8, 129.2, 129.5, 129.8, 131.1, 132.8, 133.9, 135.1, 136.2, 136.3, 137.8, 143.8, 146.7. MS (ESI): *m/z* = 417 (M^+).

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