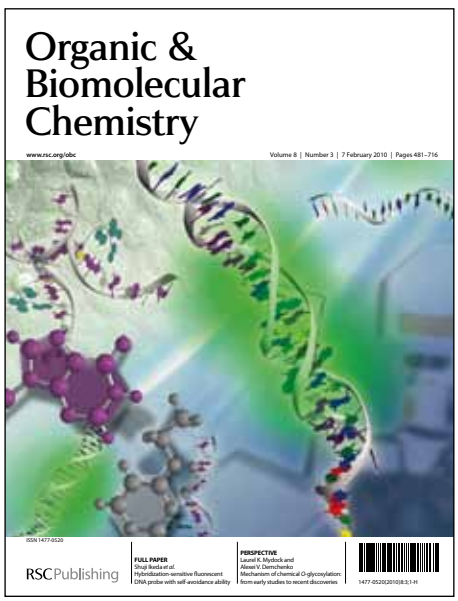
Organic & Biomolecular Chemistry

Accepted Manuscript

This article can be cited before page numbers have been issued, to do this please use: L. Dong, J. Huang, C. Qu, Q. Zhang, W. Zhang, B. Han and C. Peng, *Org. Biomol. Chem.*, 2013, DOI: 10.1039/C3OB41177J.



This is an *Accepted Manuscript*, which has been through the RSC Publishing peer review process and has been accepted for publication.

Accepted Manuscripts are published online shortly after acceptance, which is prior to technical editing, formatting and proof reading. This free service from RSC Publishing allows authors to make their results available to the community, in citable form, before publication of the edited article. This *Accepted Manuscript* will be replaced by the edited and formatted *Advance Article* as soon as this is available.

To cite this manuscript please use its permanent Digital Object Identifier (DOI®), which is identical for all formats of publication.

More information about *Accepted Manuscripts* can be found in the **Information for Authors**.

Please note that technical editing may introduce minor changes to the text and/or graphics contained in the manuscript submitted by the author(s) which may alter content, and that the standard **Terms & Conditions** and the **ethical guidelines** that apply to the journal are still applicable. In no event shall the RSC be held responsible for any errors or omissions in these *Accepted Manuscript* manuscripts or any consequences arising from the use of any information contained in them.

Cite this: DOI: 10.1039/c0xx00000x

www.rsc.org/xxxxxx

View Article Online
DOI: 10.1039/C3OB41177J

ARTICLE TYPE

Rhodium(III)-catalyzed Vinylic sp^2 C-H Bond Functionalization: Efficient Synthesis of Pyrido[1,2-α]benzimidazoles and Imidazo[1,2-α]pyridines †

Lin Dong,*[a] Ji-Rong Huang,[a] Chuan-Hua Qu,[a] Qian-Ru Zhang,[a] Wei Zhang,[a] Bo Han,[b] and Cheng Peng*[b]

Received (in XXX, XXX) Xth XXXXXXXXX 200X, Accepted Xth XXXXXXXXX 200X
DOI: 10.1039/b000000x

A simple approach for synthesis of novel aza-fused scaffolds such as pyrido[1,2-α]benzimidazoles and imidazo[1,2-α]pyridines was developed by Rh(III)-catalyzed direct oxidative coupling between alkenes and unactivated alkynes without an extra directing group. The method would render a broad substrate scope, providing fused heterocycles with potential biological preperties.

Heterocyclic frameworks are found in a large number of biologically active compounds.[1] The aza-fused scaffolds such as pyrido[1,2-α]benzimidazoles and imidazo[1,2-α]pyridines are the key structural motifs in some drug candidates,[1c–i] including Rifaximin,[1j] alpidem,[2] zolpidem,[3] zolimidine and GSK812397[4] (Figure 1). The classical synthetic approaches for preparation of those hetercycles mostly rely on the formation of the imidazole ring (eq 1).[5,6] However, these methods generally suffer from multiple preparative steps or narrow substrate scope.

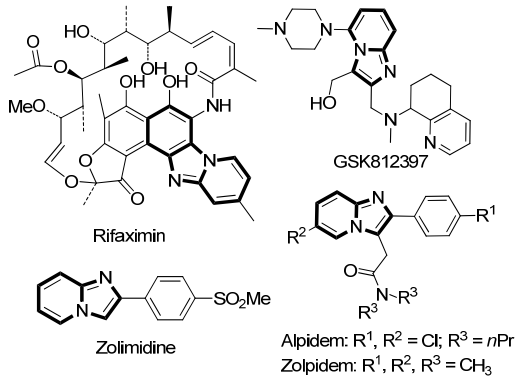
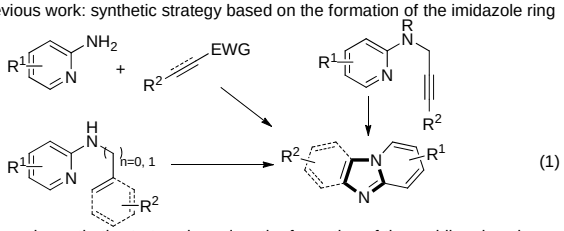


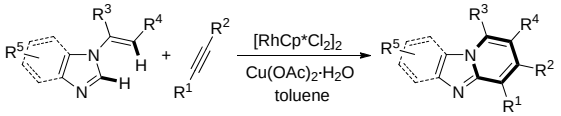
Figure 1 Selected biologically active aza-fused heterocycles

Previous work: synthetic strategy based on the formation of the imidazole ring



(1)

This work: synthetic strategy based on the formation of the pyridine ring via direct vinylic sp^2 C-H activation without extra directing group



(2)

Scheme 1 Synthetic strategy of aza-fused scaffolds

Transition-metal-catalyzed organic reactions have been significantly developed over the past decade because they can minimize waste formation and pre-functionalize steps via C–H activation.[7–11] Recently, Rh(III)-catalyzed vinylic sp^2 C–H activation followed by an annulation with a variety of internal alkynes using directing groups has been used to construct various heterocycles.[8c,8g,12] Based on recent work in our group,[13] herein, we report an efficient construction of pyridines by double C–H activations of C2-H of imidazole ring and sp^2 C-H of alkene and subsequent coupling with internal alkynes without directing groups. Both substituted pyrido[1,2-α]benzimidazoles and imidazo[1,2-α]pyridines could be prepared (eq 2).

Results and Discussion

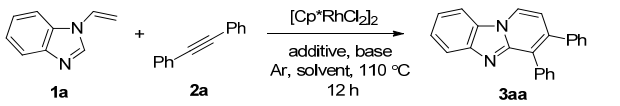
We commenced our investigation with the screening of reaction conditions between *N*-vinyl-benzimidazole **1a** and diphenylacetylene **2a**. Different oxidants have been examined first. AgOAc gave **3aa** in 72% yield (Table 1, entry 1). However, NaOAc with BQ didn't work in this reaction (entry 2). Only trace amount of product was observed when the reaction was carried out under O_2 (entry 3). A fair yield (44%) was isolated when $Cu(acac)_2$ was utilized (entry 4). Pleasingly, $Cu(OAc)_2$ provided an excellent improvement in 91% yield (entry 5). These results indicate that the oxidant plays a significant role in reaction efficiency. In addition, a series of bases were further tested, including Cs_2CO_3 and TEA, which did not improve the yield

[a]*Key Laboratory of Drug-Targeting and Drug Delivery System of the Education Ministry, Department of Medicinal Chemistry, West China School of Pharmacy, Sichuan University, Chengdu 610041, China. E-mail: dongl@scu.edu.cn.*
[b]*State Key Laboratory Breeding Base of Systematic research, Development and Utilization of Chinese Medicine Resources, School of Pharmacy, Chengdu University of Traditional Chinese Medicine, Chengdu, 610075, China*

† Electronic Supplementary Information (ESI) available: Experimental procedures, structural proofs. See http://dx.doi.org/10.1039/b000000x/

(entries 6 and 7). Furthermore, the choice of solvent was vital to the catalytic reaction, since *t*-AmOH and DMF afforded **3aa** in 70% and 14% yield, respectively (entries 8 and 9).

Table 1 Conditions screening[a]



Entry	Additive	Base	Solvent	Yield[b] (%)
1	AgOAc	/	toluene	72
2	NaOAc/BQ	/	toluene	n.r.
3	O_2	/	toluene	trace
4	$Cu(acac)_2$	/	toluene	44
5	$Cu(OAc)_2·H_2O$	/	toluene	99(91[c])
6	$Cu(OAc)_2·H_2O$	$CsCO_3$	toluene	14
7	$Cu(OAc)_2·H_2O$	TEA	toluene	81
8	$Cu(OAc)_2·H_2O$	/	*t*-AmOH	70
9	$Cu(OAc)_2·H_2O$	/	DMF	14

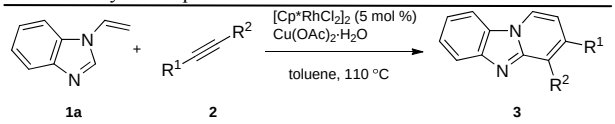
[a] Reaction conditions: **1a** (0.1 mmol), **2a** (0.2 mmol), $[Cp^*RhCl_2]_2$ (5 mol %), additive (0.12 mmol), base (0.12 mmol), solvent (1.0 mL), under Ar or O_2 (balloon pressure) atmosphere, 110 °C. [b] Yields of **3aa** were determined by ^{1}H NMR spectroscopy. [c] Isolated yield is given.

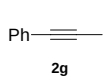
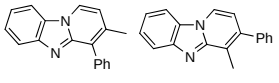
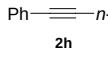
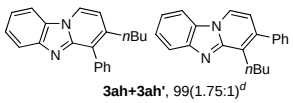
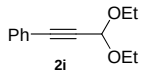
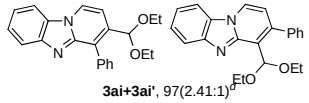
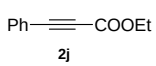
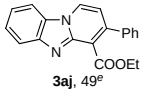
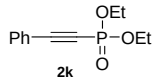
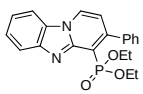
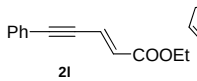
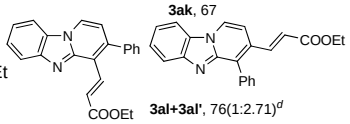
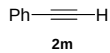
Having established the optimized reaction conditions, the substrate scope was examined with respect to various alkynes (Table 2). The present process showed wide substrate tolerance with internal alkynes. Diarylalkynes bearing either electron-donating or -withdrawing groups reacted without incident to give good yields (entries 1–4). Furthermore, the alkynes are not limited to aryl groups, heteroaryl and alkyl-substituted alkynes also proceeded smoothly (entries 5 and 6). Unsymmetrical alkynes occurred in high reactivity albeit with moderate regioselectivity (entries 7–9). Fortunately, when electron-deficient alkynes **2j** and **2k** were applied, pyrido[1,2-α]benzimidazoles **3aj** and **3ak** could be produced as the sole isomer due to the strong electronic effect (entries 10 and 11). Surprisingly, the regioselectivity could be reversed by employing the enyne ester **2l**, presumably as a result of the interaction between the catalyst and the olefin (entry 12). Previous studies on vinylic sp^2 C–H activation revealed that the reaction is controlled by electronic effects while little influence is resulted from steric effects in the alkyne insertion event. However, terminal alkyne failed to work in this reaction (entry 13).

Next, various substituted imidazoles and other azoles with diverse *N*-vinly groups were tested under the optimized conditions (Table 3). Both alkyl and aryl substituents exhibited good reactivity. α-methyl and α-phenyl substituted vinyl substituents could react well with **2a** to afford the tri-substituted pyrido[1,2-α]benzimidazole **3ba** and **3ca** in moderate yield. Moreover, β-substituted vinyl substrates were also tolerated in this system (**3da**–**3ga**). Disubstituted vinyl substrate could proceed smoothly under the optimized conditions, and qua-substituted pyrido[1,2-α]benzimidazoles **3ha** and **3ia** were obtained with moderate yields. 5,6-dimethyl substituted benzimidazole **1j** with **2a** gave the corresponding pyrido[1,2-α]benzimidazole **3ja** in 80% yield. Importantly, purine derivatives **1k** also lead to the fused heterocycles **3ka** in 67% yield. Substituted-imidazoles exhibited the similar high reactivity, reacted smoothly to produce the complex imidazo[1,2-α]pyridines in moderate to good yields (**3la**–**3na**).

View Article Online
DOI: 10.1039/C3OB41177J

Table 2 Alkynes scope[a]



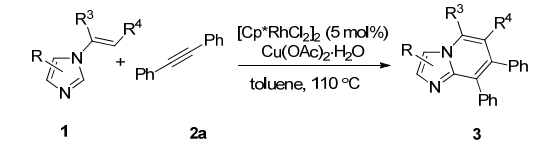
Entry	Alkynes **2**	Yield (%)[b]
1	**2a** (R^1 = R^2 = Ph)	**3aa**, 91
2	**2b** (R^1 = R^2 = *p*-MePh)	**3ab**, 99
3	**2c** (R^1 = R^2 = *p*-MeOPh)	**3ac**, 69[c]
4	**2d** (R^1 = R^2 = *p*-ClPh)	**3ad**, 75
5	**2e** (R^1 = R^2 = 3-Py)	**3ae**, 99
6	**2f** (R^1 = R^2 = *n*Bu)	**3af**, 86
7	 **2g**	 **3ag+3ag'**, 91(1.85:1)[d]
8	 **2h**	 **3ah+3ah'**, 99(1.75:1)[d]
9	 **2i**	 **3ai+3ai'**, 97(2.41:1)[d]
10	 **2j**	 **3aj**, 49[e]
11	 **2k**	 **3ak**, 67
12	 **2l**	 **3al+3al'**, 76(1:2.71)[d]
13	 **2m**	N.R.

[a] Unless otherwise specified, reactions were carried out by treatment of a mixture of *N*-vinyl benzimidazole **1a** (0.1 mmol) and alkyne **2** (0.2 mmol) with $[Cp^*RhCl_2]_2$ (5 mol %) and $Cu(OAc)_2·H_2O$ (0.12 mmol) in toluene (1 mL) at 110 °C under Ar atmosphere for 7–17 h. [b] Isolated yield. [c] *N*-vinyl benzimidazole **1a** (0.2 mmol) and alkyne **2c** (0.1 mmol) were used. [d] Regioselectivity determined by ^{1}H NMR analysis. [e] **2j** (4 equiv) was added to the reaction partially.

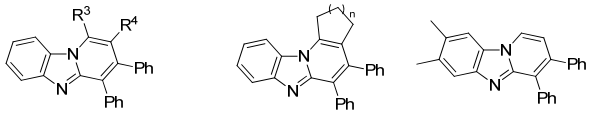
Subsequently, we conducted intermolecular competition experiments with different substituted azoles. Aryl sp^2 C–H exhibited higher reactivity than vinylic sp^2 C–H, and the ratio of **3aa**/**3a'a** was detected to be 1/1.4 by ^{1}H NMR analysis (eq 3). This result was contrary to the early observation on the C(5)-H oxidative annulations of 2−substituted imidazoles and alkynes, in which the vinylic sp^2 C–H prevailed over the aryl C–H (eq 3').[13b, 14] Those experiments suggested that there were two major rate-limiting steps had been involved in the reaction: one could be the formation of the Rh-NHC complex, in which step alkenyl had an advantage over aryl to assist the transition metal center, furthermore the Rh-NHC was more stable at C2 position with double vicinal heteroatom than C5 position with single vicinal heteroatom; another could be activation of the sp^2 C–H, in which step the vinylic sp^2 C–H presented more challenge than aryl sp^2

C–H. In addition, the oxidative annulations were favored for benzimidazole derivatives more than imidazoles for easier formation of Rh-NHC complex on the former structure (eq 4). Competition experiments with different alkynes revealed that the diarylalkynes had the similar reactivity as the alkyl-substituted alkynes while electron-donating substituents on the aryl moiety were beneficial for this reaction (eqs 5, 6).

Table 3 Scope of azoles[a]



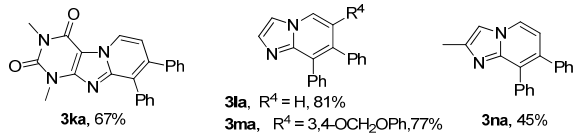
1 2a 3



3ba, R^3 = Me, R^4 = H, 66%
3ca, R^3 = Ph, R^4 = H, 74%
3da, R^3 = H, R^4 = Me, 90%
3ea, R^3 = H, R^4 = Ph, 99%
3fa, R^3 = H, R^4 = *m*-ClPh, 89%
3ga, R^3 = H, R^4 = 3,4-OCH_2OPh, 77%

3ha, n = 1, 53%
3ia, n = 2, 60%

3ja, 80%



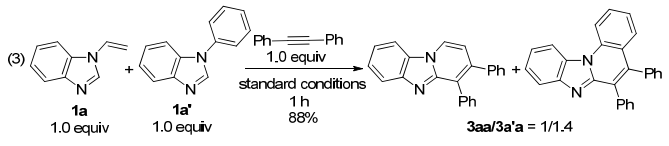
3ka, 67%

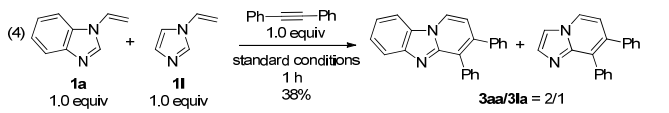
3la, R^4 = H, 81%
3ma, R^4 = 3,4-OCH_2OPh,77%

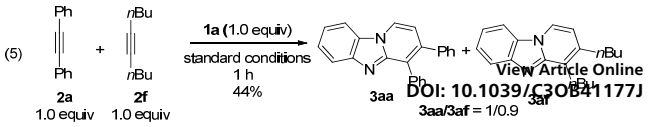
3na, 45%

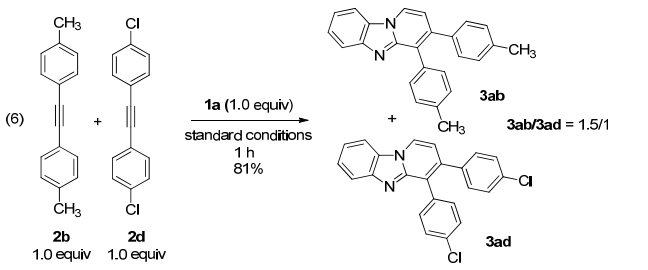
[a] Unless otherwise specified, all reactions were carried out by treatment of a mixture of azole **1** (0.1mmol) and alkyne **2a** (0.2 mmol) with $[Cp^*RhCl_2]_2$ (5 mol %) and $Cu(OAc)_2·H_2O$ (0.12 mmol) in toluene (1 mL) at 110 °C under Ar atmosphere for a certain time.

On the basis of the chemistry of known metal catalyzed C–H bond activation/annulation reactions, a plausible mechanism was proposed (Scheme 2). The C(2)–H bond of benzimidazole is initially cleaved by $Cu(OAc)_2$ as Lewis acid, then transmetallation between copper acetate intermediate **I** and the rhodium catalyst takes place to afford the *N*-heterocyclic carbene (NHC) complex **II**, which could be facilitated by the assistance of adjacent π system. Then five-membered rhodacycle **III** is generated via C–H activation of *ortho* vinylic sp^2 C–H. Insertion of alkyne **2a** into the Rh-C bond of intermediate **IV** gives seven-membered rhodacycle **V**, which would subsequent reductive elimination to afford the product **3aa** and an Rh(I) species, and the latter can be oxidized by Cu(II) to complete the catalytic cycle.



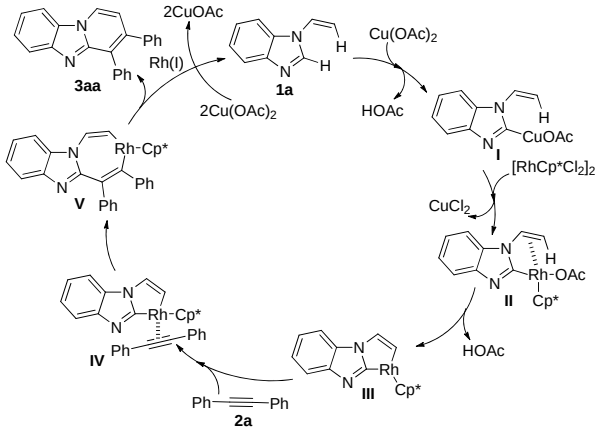






Conclusion

In summary, we have successfully developed a Rh(III)-catalyzed oxidative coupling between vinylic sp^2 C–H activation and unactivated alkynes without an extra directing group, providing complex pyrido[1,2-α]benzimidazoles and imidazo[1,2-α]pyridines. Our approach exhibits broad substrate scope and high efficacy to access aza-fused scaffolds. Further studies on the catalytic mechanism and the application of this method to built biologically active compounds are being conducted in our laboratory.



Scheme 2 Plausible mechanism

Acknowledgements

We are grateful for the financial support from the NSFC (21202106), Sichuan University Scientific Research Foundation, Sichuan University "985 project-Science and technology innovation platform for novel drug development" and the Open Research Fund from State Key Laboratory of Breeding Base of Systematic Research, Development and Utilization of Chinese Medicine Resources.

Experimental

General remarks

All NMR data were obtained for ^1H at 400 MHz, and for ^{13}C at 100 MHz. Chemical shifts were reported in ppm from tetramethylsilane with the solvent resonance as the internal standard in $CDCl_3$ or DMSO-d_6 solution. ESI HRMS was recorded on a Bruker Apex-2. Infrared spectra were recorded on a

VECTOR 22. UV detection was monitored at 220 nm. TLC was performed on glass-backed silica plates. Column chromatography was performed on silica gel (200-300 mesh), eluting with methanol, ethyl acetate, methylene dichloride and petroleum ether (EtOAc/PE or MeOH/DCM). All chemicals were used without purification as commercially available unless otherwise noted.

General Procedure for Synthesis of pyrido[1,2-α]benzimidazole and imidazo[1,2-α]pyridines

N-vinyl benzimidazole **1a** (14.4 mg, 0.1 mmol, 1.0 equiv), diphenyl acetylene **2a** (35.6 mg, 0.2 mmol, 2.0 equiv), $[Cp^*RhCl_2]_2$ (3.1 mg, 5 mol %, 0.05 equiv) and $Cu(OAc)_2{\cdot}H_2O$ (24 mg, 0.12 mmol, 1.2 equiv) were stirred in toluene (1.0 mL) under Ar at 110 °C for 12 h. TLC analyses of the mixture confirmed formation of **3aa**. The reaction mixture was neutralized with K_2CO_3, and flash chromatography on silica gel (EtOAc/PE = 1/10) to give the product **3aa** as a yellow solid (29.1 mg, 91%).

3,4-diphenylbenzo[4,5]imidazo[1,2-α]pyridine (**3aa**). 12 h, 91% yield; ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.48 (d, *J* = 7.2 Hz, 1H), 7.99 (d, *J* = 8.0 Hz, 1H), 7.92 (d, *J* = 8.0 Hz, 1H), 7.52 (t, *J* = 7.6 Hz, 1H), 7.44-7.20 (m, 11H), 7.00 (d, *J* = 7.2 Hz, 1H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ 148.8, 145.1, 139.3, 135.1, 131.0, 129.6, 128.9, 128.1, 128.0, 127.7, 127.4, 125.4, 123.5, 121.0, 120.4, 113.7, 110.2 ppm. IR (KBr): ν 3052, 1497, 1482, 1228, 760, 737, 699 cm^{-1}. ESI HRMS: calcd. for $C_{23}H_{16}N_2$+H 321.1392, found 321.1395.

3,4-di-*p*-tolylbenzo[4,5]imidazo[1,2-α]pyridine (**3ab**). 7 h, 99% yield; ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.43 (d, *J* = 6.8 Hz, 1H), 7.98 (d, *J* = 8.4 Hz, 1H), 7.89 (d, *J* = 8.4 Hz, 1H), 7.49 (t, *J* = 8.0 Hz, 1H), 7.36 (d, *J* = 7.6 Hz, 1H), 7.32 (d, *J* = 8.0 Hz, 2H), 7.16-7.06 (m, 6H), 6.97 (d, *J* = 6.8 Hz, 1H), 2.36 (s, 3H), 2.33 (s, 3H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ 149.1, 145.1, 139.9, 137.2, 137.1, 136.5, 132.3, 130.8, 129.5, 128.9, 128.8, 128.0, 125.2, 123.2, 120.8, 120.4, 113.8, 110.1, 21.4, 21.2 ppm. IR (KBr): ν 3052, 3021, 2919, 1481, 1440, 820, 780, 736 cm^{-1}. ESI HRMS: calcd. for $C_{25}H_{20}N_2$+H 349.1705, found 349.1706.

3,4-bis(4-methoxyphenyl)benzo[4,5]imidazo[1,2-α]pyridine (**3ac**). 7 h, 69% yield; ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.42 (d, *J* = 7.2 Hz, 1H), 7.96 (d, *J* = 8.4 Hz, 1H), 7.89 (d, *J* = 8.0Hz, 1H), 7.51-7.47 (m, 1H), 7.37-7.34 (m, 3H), 7.14 (d, *J* = 8.8 Hz, 2H), 6.97 (d, *J* = 7.2 Hz, 1H), 6.89 (d, *J* = 8.8 Hz, 2H), 6.79 (d, *J* = 8.4 Hz, 2H), 3.82 (s, 3H), 3.79 (s, 3H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ 158.9, 158.8, 149.2, 145.1, 139.5, 132.3, 131.8, 130.9, 129.0, 127.6, 127.4, 125.3, 123.1, 120.8, 120.3, 113.9, 113.8, 113.6, 110.2, 55.2 ppm. IR (KBr): ν 3003, 2961, 2935, 2838, 1607, 1248, 1030, 835, 788, 742 cm^{-1}. ESI HRMS: calcd. for $C_{25}H_{20}N_2O_2$+H 381.1603, found 381.1605.

3,4-bis(4-chlorophenyl)benzo[4,5]imidazo[1,2-α]pyridine(**3ad**). 7 h, 75% yield; ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.48 (d, *J* = 6.8 Hz, 1H), 7.97 (d, *J* = 8.4 Hz, 1H), 7.92 (d, *J* = 8.0 Hz, 1H), 7.52 (t, *J* = 8.0 Hz, 1H), 7.41-7.31 (m, 5H), 7.26 (d, *J* = 8.4 Hz, 2H), 7.12 (d, *J* = 8.4 Hz, 2H), 6.94 (d, *J* = 6.8 Hz, 1H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ 148.3, 145.0, 138.9, 137.4, 133.9, 133.8, 133.3, 132.4, 130.9, 128.9, 128.6, 127.1, 125.7, 123.0, 121.4, 120.4, 113.2, 110.3 ppm. IR (KBr): ν 3060, 2924, 1499, 1090, 832, 778, 745 cm^{-1}. ESI HRMS: calcd. for $C_{23}H_{14}Cl_2N_2$+H 389.0612, found 389.0612.

3,4-di(pyridin-3-yl)benzo[4,5]imidazo[1,2-α]pyridine (**3ae**). 7 h, 99% yield; ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.59-8.53 (m, 5H), 7.98-7.92 (m, 3H), 7.55 (t, *J* = 8.0 Hz, 1H), 7.48 (d, *J* = 8.0 Hz, 1H), 7.43 (t, *J* = 7.6 Hz, 1H), 7.37-7.34 (m, 1H), 7.24-7.21 (m, 1H), 7.00 (d, *J* = 7.2 Hz, 1H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ 151.5, 150.1, 149.0, 148.9, 147.9, 145.0, 138.6, 137.2, 136.9, 128.8, 126.0, 125.4, 124.7, 123.3, 123.1, 121.8, 120.4, 112.8, 110.4 ppm. IR (KBr): ν 3054, 3036, 2923, 1493, 1406, 800, 743, 712 cm^{-1}. ESI HRMS: calcd. for $C_{21}H_{14}N_4Na$ 345.1116, found 345.1116.

3,4-dibutylbenzo[4,5]imidazo[1,2-α]pyridine (**3af**). 7 h, 86% yield; ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.20 (d, *J* = 6.8 Hz, 1H), 7.96 (d, *J* = 8.4 Hz, 1H), 7.80 (d, *J* = 8.0 Hz, 1H), 7.47 (td, *J* = 8.4, 1.2 Hz, 1H), 7.29 (t, *J* = 8.0 Hz, 1H), 6.66 (d, *J* = 7.2 Hz, 1H), 3.11 (t, *J* = 8.0 Hz, 2H), 2.71 (t, *J* = 8.0 Hz, 2H), 1.78-1.70 (m, 2H), 1.67-1.59 (m, 2H), 1.55-1.42 (m, 4H), 1.00-0.95(m, 6H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ 149.5, 144.5, 140.6, 129.2, 128.3, 125.0, 121.8, 120.2, 119.6, 113.2, 110.1, 32.8, 32.0, 31.7, 27.4, 23.1, 22.7, 14.1, 14.0 ppm. IR (KBr): ν 2958, 2866, 1638, 1609, 1493, 1466, 764, 739 cm^{-1}. ESI HRMS: calcd. for $C_{19}H_{24}N_2$+H 281.2018, found 281.2019.

3-methyl-4-phenylbenzo[4,5]imidazo[1,2-α]pyridine (**3ag**). 9 h, 59.1% yield; ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.32 (d, *J* = 6.8 Hz, 1H), 7.93 (d, *J* = 8.4 Hz, 1H), 7.85 (d, *J* = 8.0, 1H), 7.56-7.45 (m, 6H), 7.33 (t, *J* = 7.6 Hz, 1H), 6.78 (d, *J* = 7.2 Hz, 1H), 2.30 (s, 3H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ 149.0, 144.8, 136.9, 135.5, 129.9, 129.0, 128.8, 128.5, 127.9, 125.1, 123.0, 120.5, 120.1, 114.0, 110.0, 20.0 ppm. IR (KBr): ν 3054, 2946, 2916, 1630, 1605, 1488, 1433, 777, 736 cm^{-1}. ESI HRMS: calcd. for $C_{18}H_{14}N_2$+H 259.1235, found 259.1237.

4-methyl-3-phenylbenzo[4,5]imidazo[1,2-α]pyridine (**3ag'**). 9 h, 31.9% yield; ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.33 (d, *J* = 6.8 Hz, 1H), 7.99 (d, *J* = 8.0 Hz, 1H), 7.87 (d, *J* = 8.4 Hz, 1H), 7.54-7.47 (m, 4H), 7.43-7.40 (m, 2H), 7.36 (t, *J* = 7.6 Hz, 1H), 6.83 (d, *J* = 7.2 Hz, 1H), 2.67 (s, 3H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ 149.5, 144.7, 140.4, 139.4, 129.1, 128.4, 127.8, 125.4, 124.0, 121.8, 120.9, 119.8, 113.4, 110.4, 15.0 ppm. IR (KBr): ν 3056, 2925, 1631, 1602, 1501, 1483, 765, 742, 704 cm^{-1}. ESI HRMS: calcd. for $C_{18}H_{14}N_2$+H 259.1235, found 259.1236.

3-butyl-4-phenylbenzo[4,5]imidazo[1,2-α]pyridine (**3ah**). 7 h, 63% yield; ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.37 (d, *J* = 7.2 Hz, 1H), 7.90 (d, *J* = 8.4 Hz, 1H), 7.86 (d, *J* = 8.0 Hz, 1H), 7.54-7.50 (m, 2H), 7.47-7.42 (m, 4H), 7.34-7.30 (m, 1H), 6.83 (d, *J* = 6.8 Hz, 1H), 2.56 (t, *J* = 8.0 Hz, 2H), 1.59-1.51 (m, 2H), 1.31-1.21 (m, 2H), 0.82 (t, *J* = 7.6 Hz, 3H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ 149.2, 144.8, 141.8, 135.5, 130.0, 129.0, 128.8, 128.5, 127.9, 125.1, 123.4, 120.6, 120.2, 112.8, 110.0, 32.8, 32.5, 22.4, 13.8 ppm. IR (KBr): ν 2953, 2919, 2863, 1631, 1605, 1489, 733, 701 cm^{-1}. ESI HRMS: calcd. for $C_{21}H_{20}N_2$+H 301.1705, found 301.1705.

4-butyl-3-phenylbenzo[4,5]imidazo[1,2-α]pyridine (**3ah'**). 7 h, 36% yield; ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.33 (d, *J* = 7.2 Hz, 1H), 8.01 (d, *J* = 8.4 Hz, 1H), 7.89 (d, *J* = 8.0 Hz, 1H), 7.55-7.34 (m, 7H), 6.79 (d, *J* = 6.8 Hz, 1H), 3.07(t, *J* = 8.0 Hz, 2H), 1.78-1.70 (m, 2H), 1.34-1.28 (m, 2H), 0.80 (t, *J* = 7.6 Hz, 3H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ 140.4, 139.8, 129.1, 128.8, 128.4, 127.7, 125.3, 121.8, 120.8, 119.9, 113.7, 110.3, 31.5, 28.3, 22.7, 13.8 ppm. IR (KBr): ν 3051, 2959, 2927, 2852, 1632, 1602, 1499,

801, 765, 703 cm^{-1}. ESI HRMS: calcd. for $C_{21}H_{20}N_2$+H 301.1705, found 301.1706.

3-(diethoxymethyl)-4-phenylbenzo[4,5]imidazo[1,2-α]pyridine (**3ai**). 7 h, 68.6% yield; ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.49 (d, *J* = 7.2 Hz, 1H), 7.94 (d, *J* = 8.0 Hz, 1H), 7.91 (d, *J* = 7.6 Hz, 1H), 7.58-7.47 (m, 6H), 7.39-7.35 (m, 1H), 7.27 (d, *J* = 7.6 Hz, 1H), 5.22 (s, 1H), 3.64-3.57 (m, 2H), 3.44-3.37 (m, 2H), 1.19 (t, *J* = 7.2 Hz, 6H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ 148.1, 144.7, 137.7, 133.9, 130.2, 129.4, 128.9, 128.4, 125.4, 124.2, 121.3, 120.4, 110.3, 108.9, 99.6, 62.9, 15.1 ppm. IR (KBr): ν 3056, 2973, 2925, 2872, 1489, 1104, 1059, 739, 700 cm^{-1}. ESI HRMS: calcd. for $C_{22}H_{22}N_2O_2$+H 347.1760, found347.1760.

4-(diethoxymethyl)-3-phenylbenzo[4,5]imidazo[1,2-α]pyridine (**3ai'**). 7 h, 28.4% yield; ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.40 (d, *J* = 7.2 Hz, 1H), 8.06 (d, *J* = 8.0 Hz, 1H), 7.86 (d, *J* = 8.4 Hz, 1H), 7.53-7.42 (m, 6H), 7.35 (t, *J* = 7.6 Hz, 1H), 6.77 (d, *J* = 7.2 Hz, 1H), 5.92 (s, 1H), 3.76-3.70 (m, 2H), 3.50-3.42 (m, 2H), 1.12 (t, *J* = 7.2 Hz, 6H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ 147.0, 145.1, 141.6, 139.3, 129.1, 128.5, 127.9, 127.9, 125.4, 124.4, 124.0, 120.9, 120.5, 113.6, 110.0, 100.6, 63.6, 15.1 ppm. IR (KBr): ν 2973, 2925, 2872, 1635, 1603, 1108, 1062, 739, 699 cm^{-1}. ESI HRMS: calcd. for $C_{22}H_{22}N_2O_2$+Na 369.1579, found 369.1579.

ethyl 3-phenylbenzo[4,5]imidazo[1,2-α]pyridine-4-carboxylate (**3aj**). 7 h, 49% yield; ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.50 (d, *J* = 7.2 Hz, 1H), 7.99 (d, *J* = 8.0 Hz, 1H), 7.94 (d, *J* = 8.4 Hz, 1H), 7.56-7.41 (m, 7H), 7.28 (d, *J* = 7.2 Hz, 1H), 4.09 (q, *J* = 7.2 Hz, 2H), 0.97 (t, *J* = 7.6 Hz, 3H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ 167.1, 147.7, 145.2, 135.3, 132.6, 130.1, 129.3, 128.9, 128.5, 128.3, 126.0, 123.9, 122.2, 120.9, 110.6, 110.3, 61.5, 13.5 ppm. IR (KBr): ν 3058, 2977, 1712, 1476, 1327, 1230, 1137, 1027, 743, 698 cm^{-1}. ESI HRMS: calcd. for $C_{20}H_{16}N_2O_2$+Na 339.1109, found 339.1109.

diethyl (3-phenylbenzo[4,5]imidazo[1,2-α]pyridin-4-yl)phosphonate (**3ak**). 7 h, 67% yield; ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.52 (dd, *J* = 7.2 , 3.6 Hz, 1H), 7.97 (d, *J* = 8.0 Hz, 1H), 7.94 (d, *J* = 8.4 Hz, 1H), 7.60-7.58 (m, 2H), 7.54-7.40 (m, 6H), 4.00-3.92 (m, 2H), 3.89-3.83 (m, 2H), 1.17 (t, *J* = 7.2 Hz, 6H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ 145.1, 137.0, 135.0, 135.0, 130.0, 128.8, 127.9, 126.1, 123.5, 123.4, 122.2, 121.1, 112.6, 112.5, 110.7, 62.3, 62.3, 16.1, 16.1 ppm. IR (KBr): ν 2986, 1481, 1323, 1229, 1048, 1019, 771, 739 cm^{-1}. ESI HRMS: calcd. for $C_{21}H_{21}N_2O_3P$+Na 403.1187, found 403.1189.

(*E*)-ethyl 3-(3-phenylbenzo[4,5]imidazo[1,2-α]pyridin-4-yl)acrylate (**3al**). 12 h, 20.5% yield; ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.44 (d, *J* = 6.8 Hz, 1H), 8.21 (d, *J* = 16.0 Hz, 1H), 8.03 (d, *J* = 8.0 Hz, 1H), 7.90 (d, *J* = 8.0 Hz, 1H), 7.86 (d, *J* = 16.0 Hz, 1H), 7.58-7.39 (m, 7H), 6.90 (d, *J* = 6.8 Hz, 1H), 4.24 (q, *J* = 7.2 Hz, 2H) , 1.32 (t, *J* = 7.2 Hz, 3H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ 168.0, 146.8, 145.3, 144.8, 138.2, 137.7, 129.7, 128.7, 128.6, 128.3, 125.9, 125.2, 124.6, 121.7, 120.5, 120.3, 113.4, 110.2, 60.3, 14.3 ppm. IR (KBr): ν 3058, 2980, 1706, 1601, 1283, 1182, 741, 703 cm^{-1}. ESI HRMS: calcd. for $C_{22}H_{18}N_2O_2$+H 343.1447, found 343.1449

(*E*)-ethyl 3-(4-phenylbenzo[4,5]imidazo[1,2-α]pyridin-3-yl)acrylate (**3al'**). 12 h, 55.5% yield; ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.42 (d, *J* = 7.2 Hz, 1H), 7.96 (d, *J* = 8.4 Hz, 1H), 7.89 (d, *J* = 8.0 Hz, 1H), 7.69 (d, *J* = 16.0 Hz, 1H), 7.57-7.48 (m, 6H), 7.40 (t, *J* = 7.6 Hz, 1H), 7.13 (d, *J* = 7.2 Hz, 1H), 6.49 (d, *J* = 16.0 Hz, 1H), 4.22 (q, *J* = 7.2 Hz, 2H), 1.29 (t, *J* = 7.2 Hz, 3H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ 166.3, 148.1, 145.2, 140.3, 133.5, 132.5, 131.8, 130.8, 129.2, 128.9, 128.5, 125.7, 123.8, 122.0, 121.3, 120.7, 110.3, 107.9, 60.7, 14.2 ppm. IR (KBr): ν 3060, 2988, 1705, 1627, 1285, 1183, 786, 740 cm^{-1}. ESI HRMS: calcd. for $C_{22}H_{18}N_2O_2$+H 343.1447, found 343.1449.

1-methyl-3,4-diphenylbenzo[4,5]imidazo[1,2-α]pyridine (**3ba**). 8 h, 66% yield; ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.18 (d, *J* = 8.4 Hz, 1H), 7.98 (d, *J* = 8.0Hz, 1H), 7.50(t, *J* = 7.6 Hz, 1H), 7.41-7.38 (m, 2H), 7.35-7.17 (m, 9H), 6.77 (s, 1H), 3.11 (s, 3H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ 149.9, 145.6, 140.2, 139.4, 137.2, 135.6, 131.3, 130.2, 129.6, 128.0, 128.0, 127.5, 127.3, 125.6, 124.9, 120.7, 120.3, 114.4, 114.1, 21.4 ppm. IR (KBr): ν 3049, 2919, 2850, 1632, 1602, 1501, 1440, 763, 733, 698 cm^{-1}. ESI HRMS: calcd. for $C_{24}H_{18}N_2$+H 335.1548, found 335.1548.

1,3,4-triphenylbenzo[4,5]imidazo[1,2-α]pyridine (**3ca**). 12 h, 74% yield; ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.94 (d, *J* = 8.4 Hz, 1H), 7.67-7.62 (m, 5H), 7.48 (d, *J* = 7.2 Hz, 2H), 7.40-7.31 (m, 4H), 7.26-7.23 (m, 5H), 6.97 (t, *J* = 8.0 Hz, 1H), 6.86 (s, 1H), 6.65 (d, *J* = 8.4 Hz, 1H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ 149.8, 145.6, 140.0, 139.5, 139.3, 135.5, 134.4, 131.3, 130.0, 129.7, 129.4, 129.1, 129.1, 128.1, 128.0, 127.6, 127.3, 126.9, 124.8, 120.3, 120.2, 115.3, 114.5 ppm. IR (KBr): ν 3059, 3034, 1598, 1482, 1450, 1313, 766, 743 cm^{-1}. ESI HRMS: calcd. for $C_{29}H_{20}N_2$+H 397.1705, found 397.1705.

2-methyl-3,4-diphenylbenzo[4,5]imidazo[1,2-α]pyridine (**3da**). 10 h, 90% yield; ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.34(s, 1H), 7.94 (d, *J* = 8.0 Hz, 1H), 7.91 (d, *J* = 8.0 Hz, 1H), 7.48 (t, *J* = 7.6 Hz, 1H), 7.36 (t, *J* = 7.6 Hz, 1H), 7.31-7.17 (m, 8H), 7.08 (d, *J* = 6.8 Hz, 2H), 2.16 (s, 3H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ148.2, 144.8, 142.9, 137.9, 135.4, 130.7, 129.7, 129.2, 128.8, 127.9, 127.8, 127.3, 127.1, 125.1, 121.8, 120.7, 120.3, 120.0, 110.2, 18.6 ppm. IR (KBr): ν 3051, 2958, 2918, 1636, 1600, 1487, 1443, 731, 697 cm^{-1}. ESI HRMS: calcd. for $C_{24}H_{18}N_2$+H 335.1548, found 335.1548.

2,3,4-triphenylbenzo[4,5]imidazo[1,2-α]pyridine (**3ea**). 9 h, 99% yield; ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.48 (s, 1H), 7.99 (d, *J* = 8.0, 1H), 7.91 (d, *J* = 8.4 Hz, 1H), 7.53-7.49 (m, 1H), 7.39-7.35 (m, 3H), 7.31-7.23 (m, 6H), 7.16-7.14 (m, 2H), 7.05-6.99 (m, 3H), 6.90-6.87 (m, 2H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ 148.1, 145.1, 141.0, 137.6, 137.3, 135.5, 131.0, 130.9, 130.0, 129.3, 129.0, 127.9, 127.8, 127.4, 127.3, 127.0, 126.6, 126.6, 125.4, 123.3, 121.0, 120.4, 110.3 ppm. IR (KBr): ν 3056, 3027, 1476, 1319, 1259, 754, 698 cm^{-1}. ESI HRMS: calcd. for $C_{29}H_{20}N_2$+H 397.1705, found 397.1707.

2-(4-chlorophenyl)-3,4-diphenylbenzo[4,5]imidazo[1,2-α]pyridine (**3fa**). 12 h, 89% yield; ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.47 (s, 1H), 7.97 (d, *J* = 8.4 Hz, 1H), 7.92 (d, *J* = 8.4 Hz, 1H), 7.51(t, *J* = 8.0 Hz, 1H), 7.38 (t, *J* = 7.2 Hz, 1H), 7.34-7.32 (m, 2H), 7.28-7.19 (m, 5H), 7.10 (t, *J* = 8.8 Hz, 1H), 7.06-7.02 (m, 3H), 6.93 (d, *J* = 7.6 Hz, 1H) , 6.87-6.86 (m, 2H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ 148.0, 145.2, 140.6, 139.5, 137.0, 135.3, 133.8, 130.9, 129.8, 129.6, 129.1, 129.0, 128.3, 127.9, 127.5, 127.2, 126.9, 125.6, 125.3, 123.4, 121.3, 120.6, 110.3 ppm. IR (KBr): ν 3057, 3027, 1599, 1469, 1320, 787, 744, 702 cm^{-1}. ESI HRMS: calcd. for $C_{29}H_{19}ClN_2$+H 431.1315, found 431.1315.

2-(benzo[d][1,3]dioxol-5-yl)-3,4-diphenylbenzo[4,5]imidazo

[1,2-α]pyridine (**3ga**). 8 h, 77% yield; ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.44 (s, 1H), 7.97 (d, *J* = 8.0 Hz, 1H), 7.90 (d, *J* = 8.0, 1H), 7.49 (t, *J* = 8.0 Hz, 1H), 7.36 (d, *J* = 7.6 Hz, 1H), 7.33-7.31 (m, 2H), 7.28-7.21 (m, 3H), 7.05-7.03 (m, 3H), 6.89-6.87 (m, 2H), 6.68 (d, *J* = 8.0 Hz, 1H), 6.63 (dd, *J* = 8.0, 1.2 Hz, 1H), 6.56 (d, *J* = 1.2 Hz, 1H), 5.90 (s, 2H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ 148.1, 147.2, 146.7, 145.1, 141.1, 137.4, 135.5, 131.4, 130.9, 130.9, 129.3, 129.0, 127.8, 127.4, 127.4, 126.7, 126.2, 125.4, 123.6, 123.1, 121.0, 120.5, 110.5, 110.3, 107.9, 101.0 ppm. IR (KBr): ν 3062, 3026, 2895, 2207, 1476, 1232, 1034, 927, 728, 699 cm^{-1}. ESI HRMS: calcd. for $C_{30}H_2N_2O_2$+H 441.1603, found 441.1604.

4,5-diphenyl-2,3-dihydro-1H-benzo[4,5]imidazo[1,2-α] cyclopenta [e] pyridine (**3ha**). 12 h, 53% yield; ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.04 (d, *J* = 8.0 Hz, 1H), 7.96 (d, *J* = 8.4 Hz, 1H),7.47 (t, *J* = 7.6 Hz, 1H), 7.33(t, *J* = 6.8 Hz, 2H), 7.29-7.19 (m, 7H), 7.12-7.10 (m, 2H), 3.73 (t, *J* = 7.6 Hz, 2H), 2.87 (t, *J* = 7.6 Hz, 2H), 2.41-2.34 (m, 2H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ 149.7, 145.2, 139.8, 139.0, 138.2, 135.8, 131.3, 129.6, 129.4, 127.8, 127.2, 127.0, 126.1, 124.8, 124.6, 120.5, 120.1, 112.9, 32.2, 30.7, 22.5 ppm. IR (KBr): ν 3057, 3025, 2926, 1500, 1478, 1028, 736, 695 cm^{-1}. ESI HRMS: calcd. for $C_{26}H_{20}N_2$+H 361.1705, found 361.1706.

5,6-diphenyl-1,2,3,4-tetrahydrobenzo[4,5]imidazo[1,2-α]quinoline (**3ia**). 12 h, 60% yield; ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.23 (d, *J* = 8.8 Hz, 1H), 7.96 (d, *J* = 8.0 Hz, 1H), 7.46 (t, *J* = 8.0 Hz, 1H), 7.31-7.15 (m, 9H), 7.07-7.05 (m, 2H), 3.56 (t, *J* = 6.4 Hz, 2H), 2.44 (t, *J* = 6.0 Hz, 2H), 2.11-2.05 (m, 2H), 1.84-1.78 (m, 2H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ 177.1, 145.5, 142.7, 138.1, 136.6, 136.0, 130.9, 130.4, 129.8, 127.8, 127.7, 127.0, 126.9, 124.4, 120.2, 118.5, 115.4, 28.9, 28.0, 22.3, 22.2 ppm. IR (KBr): ν 3055, 3023, 2926, 1494, 1441, 1292, 728, 697 cm^{-1}. ESI HRMS: calcd. for $C_{27}H_{22}N_2$+H 375.1861, found 375.1863.

7,8-dimethyl-3,4-diphenylbenzo[4,5]imidazo[1,2-α]pyridine (**3ja**). 7 h, 80% yield; ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.38 (d, *J* = 7.2 Hz, 1H), 7.73 (s, 1H), 7.66 (s, 1H), 7.42-7.40 (m, 2H), 7.34-7.17(m, 8H), 6.93 (d, *J* = 7.2 Hz, 1H), 2.48 (s, 3H), 2.44 （s, 3H） ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ 148.3, 143.8, 139.6, 139.3, 135.3, 134.7, 131.1, 130.5, 129.7, 128.1, 128.0, 127.5, 127.4, 127.2, 123.3, 120.2, 113.3, 110.1, 20.7, 20.6 ppm. IR (KBr): ν 3049, 2968, 2917, 1615, 1498, 1433, 753, 701 cm^{-1}. ESI HRMS: calcd. for $C_{25}H_{20}N_2$+H 349.1705, found 349.1706.

1,3-dimethyl-8,9-diphenyl-1,10a-dihydropyrido[2,1-*f*]purine-2,4(3H,4aH)-dione (**3ka**). 9 h, 67% yield; ^{1}H NMR (400 MHz, $CDCl_3$): δ 9.07 (d, *J* = 6.8 Hz, 1H), 7.36-7.30 (m, 5H), 7.27-7.16 (m, 6H), 3.62 (s, 3H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ155.1, 152.0, 151.3, 147.5, 141.6, 138.7, 134.0, 131.2, 129.6, 128.2, 128.0, 127.9, 127.8, 127.4, 125.7, 117.0, 30.2, 27.8 ppm. IR (KBr): ν 3057, 2956, 1700, 1660, 1540, 758, 702 cm^{-1}. ESI HRMS: calcd. for $C_{23}H_{18}N_4O_2$+K 421.1067, found421.1067.

7,8-diphenylimidazo[1,2-α]pyridine (**3la**). 12 h, 81% yield; ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.16 (d, *J* = 6.8 Hz, 1H), 7.67-7.65 (m, 2H), 7.37-7.16 (m, 10H), 6.95 (d, *J* = 6.8, 1H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ 145.4, 139.4, 135.5, 135.2, 134.3, 130.9, 129.7, 128.3, 128.0, 127.4, 127.0, 124.2, 115.6, 112.4 ppm. IR (KBr): ν 3093, 3060, 1482, 1436, 1310, 1142, 756, 699 cm^{-1}. ESI HRMS: calcd. for $C_{19}H_{14}N_2$+H 271.1235, found 271.1235.

6-(benzo[d][1,3]dioxol-5-yl)-7,8-diphenylimidazo[1,2-α]pyridine (**3ma**). 13 h, 77% yield; ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.14 (s, 1H), 7.66 (d, *J* = 13.2 Hz, 2H), 7.28-7.19 (m, 5H), 7.03-7.00 (m, 3H), 6.87-6.84 (m, 2H), 6.64 (d, *J* = 8.0 Hz, 1H), 6.57 (dd, *J* = 8.0, 1.6 Hz, 1H), 6.51 (d, *J* = 1.2 Hz, 1H), 5.89 (s, 2H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ 147.1, 146.6, 144.8, 137.4, 136.3, 135.6, 134.6, 131.6, 131.2, 130.7, 129.4, 128.1, 127.7, 127.3, 127.2, 126.5, 123.9, 123.5, 112.4, 110.4, 107.8, 101.0 ppm. IR (KBr): ν 3135, 3057, 3025, 1477, 1323, 1237, 1039, 745, 702 cm^{-1}. ESI HRMS: calcd. for $C_{26}H_{18}N_2O_2$+H 391.1447, found 391.1449.

2-methyl-7,8-diphenylimidazo[1,2-α]pyridine (**3na**). 8 h, 45% yield; ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.05 (d, *J* = 6.8 Hz, 1H), 7.40 (s, 1H), 7.35-7.34 (m, 2H), 7.29-7.19 (m, 6H), 7.13-7.11 (m, 2H), 6.86 (d, *J* = 7.2 Hz, 1H), 2.45 (s, 3H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ 144.3, 139.8, 135.4, 135.2, 131.1, 129.8, 127.9, 127.9, 127.4, 126.8, 123.6, 114.9, 109.7, 14.7 ppm. IR (KBr): ν 3025, 2919, 2853, 1319, 1269, 753, 733, 698 cm^{-1}. ESI HRMS: calcd. for $C_{20}H_{16}N_2$+H 285.1392, found 285.1395.

Notes and references

1 (a) A. T. Balaban, D. C. Oniciu, A. R. Katritzky, *Chem. Rev*., 2004, **104**, 2777; (b) J. A. Joule, K. Mills, Heterocyclic Chemistry, 5th ed.; Wiley: New York, 2010; For selected recent examples of biological activity of imidazo[1,2-*α*]pyridines: (c) M. Lhassani, O. Chavignon, J. M. Chezal, J. C. Teulade, J. P. Chapat, R. Snoeck, G. Andrei, J. Balzarini, E. De Clercq, A. Gueiffier, *Eur. J. Med. Chem*., 1999, **34**, 271; (d) K. C. Rupert, J. R. Henry, J. H. Dodd, S. A. Wadsworth, D. E. Cavender, G. C. Olini, B. Fahmy, J. Siekierka, *Bioorg. Med. Chem. Lett.,* 2003, **13**, 347; (e) Y. Rival, G. Grassy, G. Michel, *Chem. Pharm. Bull.,* 1992, **40**, 1170; (f) Y. Abe, H. Kayakiri, S. Satoh, T. Inoue, Y. Sawada, K. Imai, N. Inamura, M. Asano, C. Hatori, A. Katayama, T. Oku, H. Tanaka, *J. Med. Chem.*, 1998, **41**, 564; For selected recent examples of biological activity of pyrido[1,2-*α*]benzimidazoles: (g) M. Hammad, A. Mequid, M. E. Ananni, N. Shafik, *Egypt. J. Chem*., 1987, **29**, 5401; (h) M. Hranjec, I. Piantanida, M. Kralj, L. Šuman, K. Pavelí, G. Karminski-Zamola, *J. Med. Chem.*, 2008, **51**, 4899; (i) S. K. Kotovskaya, Z. M. Baskakova, V. N. Charushin, O. N. Chupakhin, E. F. Belanov, N. I. Bormotov, S. M. Balakhnin, O. A. Serova, *Pharm. Chem. J.,* 2005, **39**, 574; (j) H. L. Koo, H. L. Dupont, *Curr. Opin. Gastroenterol*. 2010, **26**, 17.

2 (a) A. Berson, V. Descatoire, A. Sutton, D. Fau, B. Maulny, N. Vadrot, G. Feldmann, B. Berthon, T. Tordjmann, D. Pessayre, *J. Pharmacol. Exp. Ther.*, 2001, **299**, 793; (b) J. Saletu, B. unberger, L. Linzmayer, *Int. Clin. Psychopharmacol*. 1986, **1**, 145.

3 (a) A. Berson, V. Descatoire, A. Sutton, D. Fau, B. Maulny, N. Vadrot, G. Feldmann, B. Berthon, T. Tordjmann, D. J. Pessayre, *Pharmacol. Exp. Ther.* 2001, **299**, 793; (b) J. Saletu, B. Grunberger, L. Linzmayer, *Int. Clin. Psychopharmacol.* 1986, **1**, 145; (c) M. Anzini, A. Cappelli, S. Vomero, G. Giorgi, T. Langer, G. Bruni, R. Romeo, A. S. Basile, *J. Med. Chem.,* 1996, **39**, 4275.

4 (a) K. Gudmundsson, S. D. Boggs, PCT Int. Appl. WO 2006026703, 2006; *CAN* 2006, **144**, 274; (b) S. Boggs, V. I. Elitzin, K. Gudmundsson, M. T. Martin, M. J. Sharp, *Org. Process Res. Dev.*, 2009, **13**, 781.

5 For selected recent examples of synthesis of imidazo[1,2-*α*]pyridines, see: (a) N. Chernyak, V. Gevorgyan, *Angew. Chem., Int. Ed.,* 2010, **49**, 2743; (b) A. L. Rousseau, P. Matlaba, C. J. Parkinson, *Tetrahedron Lett.,* 2007, **48**, 4079; (c) E. F. DiMauro, J. M. Kennedy, *J. Org. Chem.,* 2007, **72**, 1013; (d) M. Aginagalde, Y. Vara, A. Arrieta, R. Zangi, V. L. Cebolla, A. Delgado-Camon, F. P. Cossio, *J. Org. Chem.,* 2010, **75**, 2776; (e) M. Adib, A. Mohamadi, E. Sheikhi, S. Ansari, H. Bijanzadeh, *Synlett,* 2010, 1606; (e) S. Husinec, R. Markovic, M. Petkovic, V. Nasufovic, V. Savic, *Org. Lett.,* 2011, **13**, 2286; (f) D. K. Nair, S. M. Mobin, I. N. N.

View Article Online
DOI: 10.1039/C3OB41177J

Namboothiri, *Org. Lett.,* 2012, **14**, 4580; (g) S. K. Guchhait, A. L. Chandgude, G. Priyadarshani, *J. Org. Chem*., 2012, **77**, 4438; (h) S. K. Guchhait, C. Madaan, *Org. Biomol. Chem.,* 2010, **8**, 3631; (i) J. Zeng, Y.-J. Tan, M. L. Leow, X.-W. Liu, *Org. Lett.,* 2012, **14**, 4386.

6 For selected recent examples of synthesis of pyrido[1,2-α]benzimidazoles, see: (a) N. C. Fletcher, D. Abeln, A. V. Zelewsky, *J. Org. Chem.,* 2007, **62**, 8577; (b) C.-G. Yan, Q.-F. Wang, X.-K. Song, J. Sun, *J. Org. Chem.,* 2009, **74**, 710; (c) H.-G. Wang, Y. Wang, C.-L. Peng, J.-C. Zhang, Q. Zhu, *J. Am. Chem. Soc.*, 2010, **132,** 13217; (d) K.-S. Masters, T. R. M. Rauws, A. K. Yadav, W. A. Herrebout, B. Van der Veken, B. U. W. Maes, *Chem.–Eur. J.,* 2011, **17**, 6315.

7 For select recent reviews about C-H bond functionalizations, see: (a) D. A. Colby, R. G. Bergman, J. A. Ellman, *Chem. Rev*., 2010, **110**, 624; (b) T. W. Lyons, M. S. Sanford, *Chem. Rev.,* 2010, **110**, 1147; (c) M. C. Willis, *Chem. Rev.,* 2010, **110**, 725; (d) C.-L. Sun, B.-J. Li, Z.-J. Shi, *Chem. Commun.,* 2010, **46**, 677; (e) R. Jazzar, J. Hitce, A. Renaudat, J. Sofack-Kreutzer, O. Baudoin, *Chem.–Eur. J.,* 2010, **16**, 2654; (f) A. Lei, W. Liu, C. Liu, M. Chen, *Dalton Trans.* 2010, **39**, 10352; (g) L. Ackermann, *Chem. Commun*., 2010, **46**, 4866; (h) T. Satoh, M. Miura, *Synthesis.*, 2010, 3395; (i) Y. J. Park, J.-W. Park, C.-H. Jun, *Acc. Chem. Res.* 2008., **41**, 222; (j) D. Alberico, M. E. Scott, M. Lautens, *Chem. Rev.,* 2007, **107**, 174; (k) G.-Y. Song, F. Wang, X.-W. Li, *Chem. Soc. Rev*. 2012, **41**, 3651.

8 (a) T. Satoh, M. Miura, *Chem.–Eur. J.,* 2010, **16**, 11212; (b) K. Morimoto, K. Hirano, T. Satoh, M. Miura, *Org. Lett*., 2010, **12,** 2068; (c) S. Mochida, K. Hirano, T. Satoh, M. Miura, *J. Org. Chem.,* 2009, **74**, 6295; (d) S. Mochida, N. Umeda, K. Hirano, T. Satoh, M. Miura, *Chem. Lett.,* 2010, **39**, 744; (e) S. Mochida, M. Shimizu, K. Hirano, T. Satoh, M. Miura, *Chem. Asian J.* 2010, **5**, 847; (f) N. Umeda, H. Tsurugi, T. Satoh, M. Miura, *Angew. Chem., Int. Ed.,* 2008, **47**, 4019; (g) T. Fukutani, N. Umeda, K. Hirano, T. Satoh, M. Miura, *Chem. Commun*., 2009, 5141; (h) K. Ueura, T. Satoh, M. Miura, *Org. Lett*., 2007, **9**, 1407.

9 (a) N. Guimond, C. Gouliaras, K. Fagnou, *J. Am. Chem. Soc.,* 2010, **132**, 6908; (b) D. R. Stuart, M. Bertrand-Laperle, K. M. N. Burgess, K. Fagnou, *J. Am. Chem. Soc.,* 2008, **130**, 16474; (c) N. Guimond, K. Fagnou, *J. Am. Chem. Soc*., 2009, **131**, 12050.

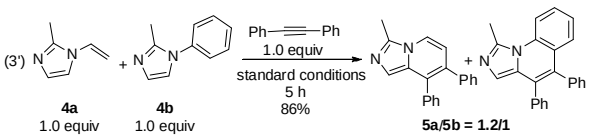
10 G. Song, D. Chen, C.-L. Pan, R. H. Crabtree, X. Li, *J. Org. Chem.,* 2010, **75**, 7487.

11 (a) P. A. Evans, P. A. Inglesby, *J. Am. Chem. Soc*., 2008, **130**, 12838; (b) T. K. Hyster, T. Rovis, *J. Am. Chem. Soc.,* 2010**, 132**, 10565; (c) L. Li, W. W. Brennessel, W. D. Jones, *J. Am. Chem. Soc.,* 2008, **130**, 12414; (d) L. Li, W. W. Brennessel, W. D. Jones, *Organometallics.* 2009, **28**, 3492.

12 (a) S. Rakshit, F. W. Patureau, F. Glorius, *J. Am. Chem. Soc.*, 2010, **132**, 9585; (b) Y. Su, M. Zhao, K. Han, G. Song, X.-W Li, *Org. Lett.*, 2010, **12**, 5462; (c) T. K. Hyster, T. Rovis, *Chem. Sci.*, 2011, **2**, 1606; (d) T. K. Hyster, T. Rovis, *Chem. Commun.*, 2011, **47**, 11846; (e) P. C. Too, T. Noji, Y. J. Lim, X. Li, S. Chiba, *Synlett*, 2011, 2789; (f) D. A. Colby, R. G. Bergman, J. A. Ellman, *J. Am. Chem. Soc*., 2008, **130**, 3645; (g) M. P. Huestis, L. Chan, D. R. Stuart, K. Fagnou, *Angew. Chem., Int. Ed.,* 2011, **50**, 1338; (h) H. G. Wang, C. Grohmann, C. Nimphius, F. Glorius, *J. Am. Chem. Soc.*, 2012, **134**, 19592; (i) D. A. Colby, R. G. Bergman, J. A. Ellman, *J. Am. Chem. Soc*., 2006, **128**, 5604; (j) Y. J. Lian, T. Huber, K. D. Hesp, R. G. Bergman, J. A. Ellman. *Angew. Chem., Int. Ed.,* 2012, **52**, 629.

13 (a) J.-R. Huang, L. Dong, B. Han, C. Peng, Y.-C. Chen. *Chem. –Eur. J.,* 2012, **18**, 8896; (b) J.-R. Huang, Q.-R. Zhang, C.-H. Qu, X.-H. Sun, L. Dong, Y.-C. Chen. *Org. Lett.*, 2013**, 15**, 1878.

14 Determination of the activation of π system in the C-H activation reaction.



4a 1.0 equiv **4b** 1.0 equiv **5a/5b = 1.2/1**