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Regioselective synthesis of pyrrolo[1,2-*a*]imidazoles and imidazo[1,2-*a*]-pyridines†

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A concise and efficient synthesis of pyrrolo[1,2-*a*]imidazoles and imidazo[1,2-*a*]-pyridines was developed by regioselective aza-ene additions and regioselective cyclic-condensation reactions of heterocyclic ketene aminals with ethyl 3-benzoylacrylate or methyl acetylacrylate derivatives under catalyst-free conditions. This method has some advantages including highly regioselective, good yields and simple work-up procedures.

Introduction

Pyrrolo[1,2-*a*]imidazole derivatives are a class of important organic compounds that serve as key structural building blocks in numerous natural products and synthetic biological medicinal agents,[1] owing to their wide spectrum of biological activities. Pyrrolo[1,2-*a*]imidazole derivatives have been used as antimycobacterial agents (Fig. 1, Thiolutin),[2] human NK_1 antagonists (Fig. 1),[3] antitumor agents (Fig. 1, UCS1025A), [4] and so on.[5] As a result, more and more pyrrolo[1,2-*a*]imidazole derivatives have been synthesised using various methods, including furan-2, 5-dione or 1*H*-pyrrole-2, 5-diones or ethyl 2-bromoacetate addition and cyclisation with enamine derivatives,[6a-6d] cyclisations of unsaturated amides,[6e] direct reaction of imines with cyclic anhydrides,[7] Au-catalysed cyclisations,[8] carbenoid C–H insertions cyclisations[9] and ring expansions.[10]

Similarly, imidazo[1,2-*a*]-pyridines derivatives represent a class of important organic molecules that make up the core structures in drugs, including analgesics,[11] cardiotonic agents,[12] microtubule inhibitors,[13] hypnotic drugs,[14] and so on.[15] Therefore, various synthetic methods have been developed to prepare imidazo[1,2-*a*]-pyridine, including a one-pot multicomponent reaction based on the catalyst,[16] Scholtz or Tschitschibabin reactions,[17] metal-catalysed intramolecular cyclisations,[18] and 1,3-dipolar or 1,5-dipolar cyclisations.[19] However, many of these methods involve the use of expensive or toxic transition metals as catalysts, extended reaction times, and high temperatures, in addition to requiring tedious work-up procedures.

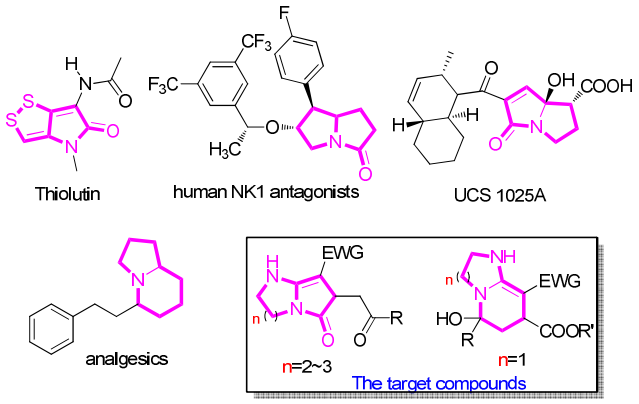

Fig. 1 Pyrrolo[1,2-*a*]imidazoles, imidazo[1,2-*a*]-pyridines and the target compounds.

Heterocyclic ketene aminals (HKAs),[20] as important building blocks, have been used for the synthesis of a variety of biologically active heterocyclic compounds.[21]

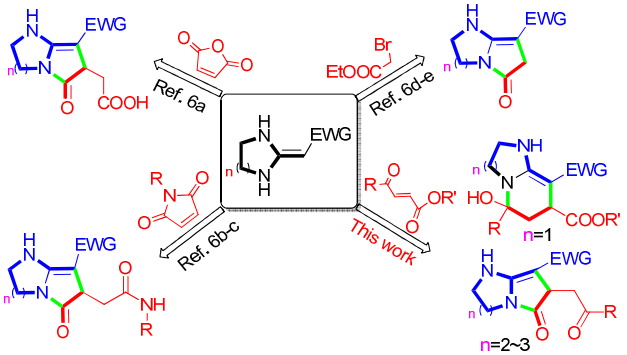

Fig. 2 Regioselective synthesis of pyrrolo[1,2-*a*]imidazoles and imidazo [1,2-*a*]-pyridines.

HKAs belong to the enamine derivatives, which have served as substrates only when reacting with furan-2,5-dione, 1*H*-pyrrole-2,5-diones or ethyl 2-bromoacetate additions and cyclisations with enamine derivatives,[6] and syntheses of pyrrolo[1,2-*a*]imidazoles. However, the cheap and easily available raw material ethyl 3-benzoylacrylate or methyl acetylacrylate derivatives were not involved these protocols. Moreover, in

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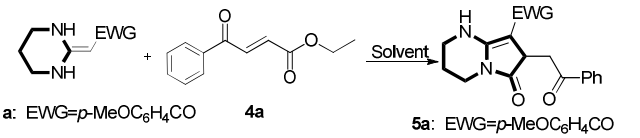
continuation of our research interests regarding the development of the synthesis and applications of HKAs for new drug discovery. Herein, we report a regioselective synthesis of pyrrolo[1,2-*a*]imidazole derivatives and imidazo[1,2-*a*]-pyridine derivatives from HKAs.

Results and discussion

Initially, HKAs **1a** and Ethyl 3-benzoylacrylate **4a** were chosen as the model substrates for optimising the reaction conditions (solvent, catalyst and temperature). The results are listed in Table 1. First, the model reaction was performed separately in various solvents, including toluene, CH_2Cl_2, THF, 1,4-dioxane, CH_3CN, EtOH, DMF, and H_2O (Table 1, entries 1–8), and it was found that CH_3CN was the best solvent, and the yield of **5a** could reach 98% (Table 1, entry 5). Next, we screened the catalyst (acids and bases) of the reaction and found that neither acids (Table 1, entries 9, 10) nor bases (Table 1, entries 11, 12) used as the catalyst obviously promoted the reactions. Finally, the model reaction was performed at different temperatures, such as ambient temperature, 45°C and 60°C. The results suggest that the **5a** yields decreased at all of these temperatures (Table 1, entries 13–15). Therefore, we propose that the optimum reaction conditions are **1a** (1.0 mmol) and **4a** (1.1 mmol), refluxed in the solution of CH_3CN without any catalyst.

Table 1 Optimisation of reaction conditions[a]



1a: EWG=*p*-MeOC$_6$H$_4$CO **4a** **5a**: EWG=*p*-MeOC$_6$H$_4$CO

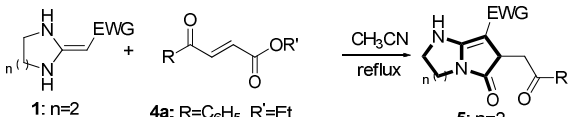
Entry	Solvent	Catalyst[b]	t(^{0}C)	Time/min	Yield[c] (%)
1	Toluene	–	reflux	30	75
2	CH_2Cl_2	–	reflux	120	90
3	THF	–	reflux	120	87
4	1,4-dioxane	–	reflux	60	82
5	CH_3CN	–	reflux	50	98
6	EtOH	–	reflux	60	53
7	DMF	–	reflux	30	81
8	H_2O	–	reflux	30	88
9	CH_3CN	HOAc	reflux	50	97
10	CH_3CN	*p*-TSA	reflux	50	95
11	CH_3CN	Et_3N	reflux	50	89
12	CH_3CN	K_2CO_3	reflux	50	90
13[d]	CH_3CN	–	r.t.	280	93
14	CH_3CN	–	45	300	95
15	CH_3CN	–	60	120	95

[a] Reagents and conditions: HKA **1a** (1.0 mmol), **4a** (1.1 mmol), solvent (10.0 mL). [b]Catalyst 10%. [c] Isolated yield based on HKA **1a**. [d] r.t. = room temperature.

Based on the optimisation conditions, the scope and limitations of this protocol have been examined, and a number of six-membered ring HKAs **1b–1g** were used as substrates to react with ethyl 3-benzoylacrylate **4a**. As can be seen, the substituent on the aromatic HKAs had some influence on the yields and reactivities. The substituted aromatic HKAs with electron-donating groups, such as methoxyl and methyl groups (Table 2, entries 1, 2), reacted faster and gave higher yields than did those with electron-withdrawing groups, such as chloro and fluoro groups (Table 2, entries 4–7). After that, seven-membered HKAs **2a–2d** were also employed as substrates, reacting with **4a** (Table 2, entries 11–14). The reactions proceeded smoothly under the same conditions and we got the final products **6a–6d** with good yields (85–95%). The size of heterocyclic ketene aminal heterocycles also has a slight influence on the reactivity and product yield of the reaction. Generally, six-membered HKAs could react faster and give higher yields than seven-membered ones.

In an endeavour to expand the scope of substrates **4** (Table 2, entries 8–10 and 15–17), methyl acetylacrylate **4b** was reacted with six-membered (Table 2, entries 8–10) and seven-membered (Table 2, entries 15–17) HKAs with both electron-withdrawing and electron-donating groups giving pyrrolo[1,2-*a*]imidazoles **5h–j**. Compared to **4a**, the yields of the **4b** were almost the same and the reaction time was identical to the corresponding reaction. The electron-donating, as well as electron-withdrawing, groups on aromatic rings of HKAs were also tolerated, although the former gave slightly higher yields.

Table 2 Preparation of pyrrolo[1,2-*a*]imidazole derivatives[a]



1: n=2 **2**: n=3 **4a**: R=C$_6$H$_5$, R'=Et **4b**: R=Me, R'=Me **5**: n=2 **6**: n=3

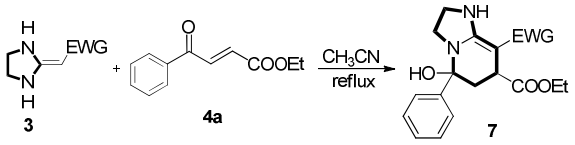
Entry	n	EWG	4	5/6	Time/min	Yield[b](%)
1	2	*p*-MeOC$_6$H$_4$CO (**1a**)	**4a**	**5a**	30	98
2	2	*p*-MeC$_6$H$_4$CO (**1b**)	**4a**	**5b**	30	98
3	2	C$_6$H$_5$CO (**1c**)	**4a**	**5c**	50	96
4	2	*p*-ClC$_6$H$_4$CO (**1d**)	**4a**	**5d**	70	93
5	2	*p*-FC$_6$H$_4$CO (**1e**)	**4a**	**5e**	90	91
6	2	NO$_2$ (**1f**)	**4a**	**5f**	120	86
7	2	*o*-ClC$_6$H$_4$CO (**1g**)	**4a**	**5g**	120	90
8	2	*p*-MeC$_6$H$_4$CO (**1b**)	**4b**	**5h**	30	97
9	2	C$_6$H$_5$CO (**1c**)	**4b**	**5i**	50	96
10	2	*p*-FC$_6$H$_4$CO (**1e**)	**4b**	**5j**	90	92
11	3	*p*-MeC$_6$H$_4$CO (**2a**)	**4a**	**6a**	40	95
12	3	C$_6$H$_5$CO (**2b**)	**4a**	**6b**	70	90
13	3	*p*-ClC$_6$H$_4$CO (**2c**)	**4a**	**6c**	90	87
14	3	*p*-FC$_6$H$_4$CO (**2d**)	**4a**	**6d**	120	85
15	3	*p*-MeC$_6$H$_4$CO (**2a**)	**4b**	**6e**	40	94
16	3	C$_6$H$_5$CO (**2b**)	**4b**	**6f**	70	91
17	3	*p*-ClC$_6$H$_4$CO (**2c**)	**4b**	**6g**	100	86

[a] Reagents and conditions: HKA (1.0 mmol), **4** (1.1 mmol) and the solvent CH_3CN (10.0 mL) at reflux. [b] Isolated yield based on HKA.

In order to further investigate the scope of HKAs, five-membered HKAs **3a–h** were also employed to react with ethyl 3-benzoylacrylate **4a**. Surprisingly, the desired pyrrolidinone derivatives were not obtained, while we found the imidazo[1,2-*a*]-pyridine derivatives **7** in good yields (Table 3, entries 1–8). As can been seen, the substituent on the aromatic HKAs **3a–h** had little influence on the yield. Obtaining different products (**5** or **6** *vs.* **7**) of different membered ring HKAs (n = 2 or 3 *vs.* n = 1) on account of the six- or seven-membered rings of HKAs **1** or **2** showed that it was easy to fuse a five-membered ring, while the five-membered ring of

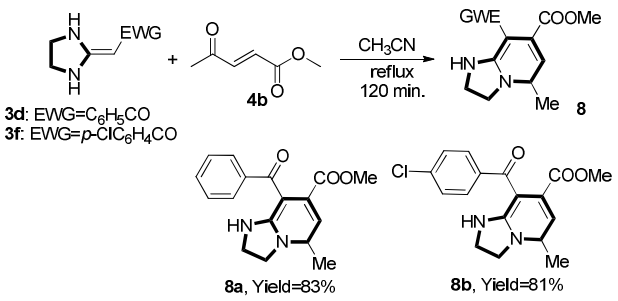
HKAs **3** could not fuse a five-membered ring, owing to the tension of the ring, which was too high to form bicyclic fused products. Then, methyl acetylacrylate **4b** was reacted with five-membered HKAs (Scheme 1, **3d** and **3f**).

Table 3 Optimisation of reaction conditions[a]



Entry	EWG (**3**)	**7**	Time/min	Yield[c] (%)
1	*p*-MeOC$_6$H$_4$CO (**3a**)	**7a**	60	93
2	*p*-EtC$_6$H$_4$CO (**3b**)	**7b**	60	90
3	*p*-MeC$_6$H$_4$CO (**3c**)	**7c**	60	91
4	C$_6$H$_5$CO (**3d**)	**7d**	60	90
5	*p*-BrC$_6$H$_4$CO (**3e**)	**7e**	120	85
6	*p*-ClC$_6$H$_4$CO (**3f**)	**7f**	120	85
7	*p*-FC$_6$H$_4$CO (**3g**)	**7g**	120	82
8	NO$_2$ (**3h**)	**7h**	120	81

[a] Reagents and conditions: HKA **3** (1.0 mmol), **4a** (1.1 mmol), solvent (10.0 mL). [b] Isolated yield based on HKA **3**.



Scheme 1 Synthesis of imidazo[1,2-*a*]-pyridine derivatives **8**.

Two potential directions of this reaction are outlined in Scheme 2. During our investigation, we did not trace **A**, and only **5**–**8** were obtained exclusively. These results indicated that this reaction might provide a highly regioselective method for the pyrrolo[1,2-*a*]imidazoles and imidazo[1,2-*a*]-pyridines.

The ^{1}H, ^{13}C NMR spectra, IR spectra and high-resolution mass spectra data have confirmed the structure of the target compound **5**–**8**. In order to specifically test the structure, **5e** and **7e** were characterised by X-ray crystallography as a representative compound, as shown in Figure **3** and **4**.

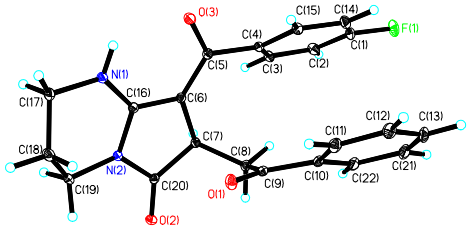


Fig. 3 ORTEP diagram of **5e**; ellipsoids are drawn at the 30% probability level.

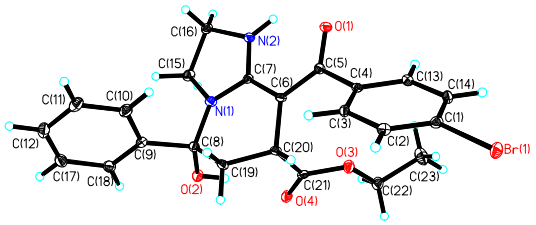
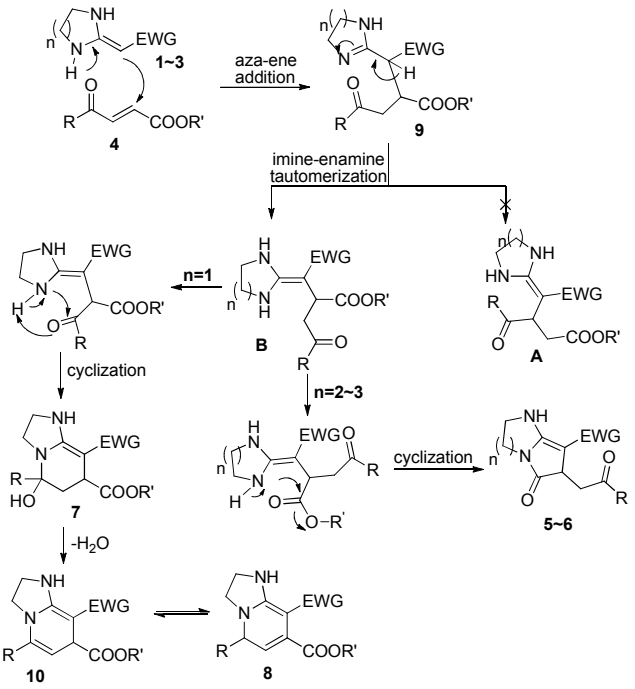


Fig. 4 ORTEP diagram of **7e**; ellipsoids are drawn at the 30% probability level.

A proposed mechanism for the synthesis of pyrrolo[1,2-*a*]imidazoles **5**–**6** and imidazo[1,2-*a*]-pyridines **7**–**8** is shown in Scheme 2. First, the *α*-*C* of HKAs **1**–**3** adds to the double bond of compound **4** and affords intermediates **9** via an aza-ene addition reaction.[22] Second, the intermediates **9** is followed by imine-enamine tautomerisation to give the key compound **B**. Next, there are two directions for the five-membered ring of HKAs (n=1). The key compound A underwent the intramolecular *N*-cyclisation of the ketonic carbonyl, leading to **7**, which loses an H_2O to form **10**. Then, compound **10** forms compound **8** via an aromatic reaction. Likewise, for the six- and seven-membered ring of HKAs (n=2, 3), the key compound **B** underwent the intramolecular *N*-cyclisation of the carbonyl group of ester to give the final products, **5** or **6**.



Scheme 2 Proposed mechanism for regioselective synthesis of pyrrolo[1,2-*a*]imidazoles and imidazo[1,2-*a*]-pyridines.

Conclusions

In summary, we have successfully developed a novel highly regioselective method for the preparation of pyrrolo[1,2-*a*]imidazoles or imidazo[1,2-*a*]-pyridines under catalyst-free conditions. The ring sizes of the HKA have a significant influence on the products. For five-membered HKAs, they can

exclusively react with **4** to provide imidazo[1,2-*a*]-pyridines, and the yields and the reaction time of these reactions are related to the substituents of the HKAs. For the six- or seven-membered HKAs, they can react with **4** to give the corresponding pyrrolo[1,2-*a*]imidazoles. In addition, six-membered HKAs and HKAs bearing electron-donating groups could provide higher yields. Features of this strategy include some important aspects, like highly regioselective, convenient operation, short reaction times, the absence of catalysts, satisfactory yields and simple purification by washing the crude products with minimum amounts of common solvents.

Experimental Section

All compounds were fully characterised by spectroscopic data. The NMR spectra were recorded on a Bruker DRX400 (^{1}H: 400 MHz, ^{13}C: 100 MHz). The chemical shifts (δ) are expressed in ppm and J values are given in Hz. Deuterated $CDCl_3$ was used as a solvent. IR spectra were recorded on a FT-IR Thermo Nicolet Avatar 360 using a KBr pellet. The melting points were determined on a XT-4A melting point apparatus and are uncorrected. HRMs were performed on an Agilent LC/Msd TOF instrument. All chemicals and solvents were used as received without further purification unless otherwise stated. Compounds **1**, **2**, and **3** were prepared according to the literature.[23] Materials **4** were purchased from Adamas-beta Corporation Limited.

General Procedure: HKA derivatives **1**, **2** or **3** (1.0 mmol), Michael reaction acceptors **4** (1.1 mmol) and CH_3CN (10 ml) were placed in a 25 mL round-bottom flask and the mixture was stirred at reflux for 30–120 min. Completion of the reaction was monitored by TLC. The reaction mixture was then filtered to obtain the pure crude product, which was further washed with Hexane/EtOH (10:1) to give pure products **5**–**8** with a yield of 81–98%. The products were further identified using FTIR, NMR and HRMS.

8-(4-Methoxybenzoyl)-7-(2-oxo-2-phenylethyl)-1,3,4,7-tetra -hydropyrrolo[1,2-*a*]pyrimidin-6(2*H*)-one (5a). Red solid; Mp 90.5–92.9 °C; IR (KBr): 3440, 2930, 1634, 1518, 1443, 1253, 1165, 1025 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.99–2.06 (m, 2H, CH_2), 3.00–3.21 (m, 2H, $COCH_2$), 3.39–3.47 (m, 2H, CH_2N), 3.55–3.70 (m, 2H, NCH_2), 3.73 (s, 3H, OCH_3), 3.90–3.96 (m, 1H, CH), 6.70–6.87 (m, 2H, ArH), 7.14–7.29 (m, 2H, ArH), 7.31–7.41 (m, 3H, ArH), 7.41–7.51 (m, 2H, ArH), 9.89 (br, 1H, NH); ^{13}C NMR (100 MH_Z, $CDCl_3$): δ = 20.1, 37.3, 38.2, 38.6, 41.1, 55.3, 88.5, 113.6, 127.9, 128.3, 128.5, 133.0, 134.1, 136.5, 158.9, 160.7, 177.4, 184.0, 197.4; HRMS (TOF ES$^+$): *m/z* calcd for $C_{23}H_{22}N_2NaO_4$ [(M+Na)$^+$], 413.1472; found, 413.1469.

8-(4-Methylbenzoyl)-7-(2-oxo-2-phenylethyl)-1,3,4,7-tetra-hydropyrrolo[1,2-*a*]pyrimidin-6(2*H*)-one (5b). Red solid; Mp 87.9–88.5 °C; IR (KBr): 3394, 2923, 1636, 1522, 1443, 1262, 1164, 1093 cm^{-1}; ^{1}H NMR (400 MH_Z, $CDCl_3$): δ = 2.03–2.09 (m, 2H, CH_2), 2.29 (s, 3H, $ArCH_3$), 2.97–3.16 (m, 2H, $COCH_2$), 3.40–3.50 (m, 2H, CH_2N), 3.61–3.74 (m, 2H, NCH_2), 3.89–3.91 (m, 1H, CH), 7.05–7.07 (m, 2H, ArH), 7.19–7.29 (m, 4H, ArH), 7.39–7.43 (m, 3H, ArH), 9.89 (br, 1H, NH); ^{13}C NMR (100 MH_Z, $CDCl_3$): δ = 20.1, 21.4, 37.3, 38.2, 38.6, 41.0, 88.8, 126.7, 127.9, 128.3, 129.0, 133.0, 136.5, 138.8, 139.6, 159.0, 177.5, 184.8, 197.4; HRMS (TOF ES$^+$): *m/z* calcd for $C_{23}H_{22}N_2NaO_3$ [(M+Na)$^+$], 397.1523; found, 397.1525.

8-Benzoyl-7-(2-oxo-2-phenylethyl)-1,3,4,7-tetrahydropyrr-olo[1,2-*a*]pyrimidin-6(2*H*)-one (5c). Red solid; Mp 126.4–126.9 °C; IR (KBr): 3438, 2894, 1729, 1528, 1443, 1265, 1158, 745 cm^{-1}; ^{1}H NMR (400 MH_Z, $CDCl_3$): δ = 2.07–2.14 (m, 2H, CH_2), 3.03–3.13 (m, 2H, $COCH_2$), 3.47–3.53 (m, 2H, CH_2N), 3.70–3.78 (m, 2H, NCH_2), 3.92–3.94 (m, 1H, CH), 7.27–7.48 (m, 10H, ArH), 9.95 (br, 1H, NH); ^{13}C NMR (100 MH_Z, $CDCl_3$): δ = 20.1, 37.3, 38.1, 38.6, 40.9, 88.8, 126.5, 127.9, 128.3, 128.4, 129.5, 133.1, 136.4, 141.7, 159.1, 177.4, 184.7, 197.3; HRMS (TOF ES$^+$): *m/z* calcd for $C_{22}H_{21}N_2O_3$ [(M+H)$^+$], 361.1547; found, 361.1545.

8-(4-Chlorobenzoyl)-7-(2-oxo-2-phenylethyl)-1,3,4,7-tetra-hydropyrrolo[1,2-*a*]pyrimidin-6(2*H*)-one (5d). Red solid; Mp 141.9–143.0 °C; IR (KBr): 3441, 2911, 1729, 1631, 1527, 1440, 1265, 760 cm^{-1}; ^{1}H NMR (400 MH_Z, $CDCl_3$): δ = 1.98–2.07 (m, 2H, CH_2), 3.00–3.13 (m, 2H, $COCH_2$), 3.38–3.47 (m, 2H, CH_2N), 3.60–3.72 (m, 2H, NCH_2), 3.84–3.86 (m, 1H, CH), 7.20–7.28 (m, 4H, ArH), 7.26–7.30 (m, 2H, ArH), 7.38–7.45 (m, 3H, ArH), 9.90 (br, 1H, NH); ^{13}C NMR (100 MH_Z, $CDCl_3$): δ = 20.0, 37.3, 38.2, 38.7, 40.7, 88.8, 127.8, 128.1, 128.4, 128.6, 133.2, 135.4, 136.3, 140.0, 159.4, 177.2, 183.0, 197.1; HRMS (TOF ES$^+$): *m/z* calcd for $C_{22}H_{19}ClN_2NaO_3$ [(M+Na)$^+$], 417.0976; found, 417.0976.

8-(4-Fluorobenzoyl)-7-(2-oxo-2-phenylethyl)-1,3,4,7-tetra-hydropyrrolo[1,2-*a*]pyrimidin-6(2*H*)-one (5e). Red solid; Mp 117.6–118.7 °C; IR (KBr): 3221, 3059, 2878, 1728, 1636, 1526, 1270, 1092 cm^{-1}; ^{1}H NMR (400 MH_Z, $CDCl_3$): δ = 2.00–2.10 (m, 2H, CH_2), 3.00–3.14 (m, 2H, $COCH_2$), 3.41–3.51 (m, 2H, CH_2N), 3.62–3.76 (m, 2H, NCH_2), 3.85–3.88 (m, 1H, CH), 6.92–6.97 (m, 2H, ArH), 7.19–7.27 (m, 2H, ArH), 7.34–7.46 (m, 5H, ArH), 9.88 (br, 1H, NH); ^{13}C NMR (100 MH_Z, $CDCl_3$): δ = 20.1, 37.3, 38.2, 38.7, 40.8, 88.7, 115.2 (J = 21.3 Hz), 115.5 (J = 21.3 Hz), 127.8, 128.4, 128.7 (J = 8.2 Hz), 128.8 (J = 8.2 Hz), 133.2, 136.3, 137.8, 159.3, 162.1 (J = 247.8 Hz), 164.6 (J = 247.8 Hz), 177.3, 183.3, 197.1; HRMS (TOF ES$^+$): *m/z* calcd for $C_{22}H_{19}FN_2NaO_3$ [(M+Na)$^+$], 401.1272; found, 401.1268.

8-Nitro-7-(2-oxo-2-phenylethyl)-1,3,4,7-tetrahydropyrrolo-[1,2-*a*]pyrimidin-6(2*H*)-one (5f). Red solid; Mp 147.4–148.1 °C; IR (KBr): 3464, 3265, 2971, 1748, 1668, 1515, 1310, 1155 cm^{-1}; ^{1}H NMR (400 MH_Z, $CDCl_3$): δ = 2.00–2.13 (m, 2H, CH_2), 3.48–3.52 (m, 2H, $COCH_2$), 3.52–3.67 (m, 2H, CH_2N), 3.72–

3.78 (m, 2H, CH_2N), 4.30–4.35 (m, 1H, CH), 7.34–7.38 (m, 2H, ArH), 7.45–7.48 (m, 1H, ArH), 7.80–7.83 (m, 2H, ArH), 9.13 (br, 1H, NH); ^{13}C NMR (100 MH_Z, $CDCl_3$): δ = 19.4, 36.4, 37.3, 39.3, 39.9, 105.0, 128.1, 128.7, 133.6, 135.9, 154.2, 137.4, 197.5; HRMS (TOF ES^+): *m/z* calcd for $C_{15}H_{15}N_3NaO_4$ [$(M+Na)^+$], 324.0955; found, 324.0954.

8-(2-Chlorobenzoyl)-7-(2-oxo-2-phenylethyl)-1,3,4,7-tetrahydropyrrolo[1,2-*a*]pyrimidin-6(2*H*)-one (5g). White solid; Mp 266.9–268.2 °C; IR (KBr): 3434, 3246, 2888, 1731, 1630, 1526, 1365, 1094 cm^{-1}; ^1H NMR (400 MH_Z, $CDCl_3$): δ = 2.08–2.15 (m, 2H, CH_2), 2.76–2.81 (m, 1H, $COCH_2$), 3.02–3.08 (m, 1H, $COCH_2$), 3.46–3.51 (m, 2H, CH_2N), 3.55–3.58 (m, 1H, CH), 3.64–3.76 (m, 2H, NCH_2), 6.97–7.05 (m, 2H, ArH), 7.15–7.30 (m, 4H, ArH), 7.42–7.45 (m, 1H, ArH), 7.49–7.52 (m, 2H, ArH), 9.63 (br, 1H, NH); ^{13}C NMR (100 MH_Z, $CDCl_3$): δ = 20.0, 37.3, 38.1, 38.7, 39.8, 90.0, 126.9, 127.8, 128.1, 128.4, 129.6, 129.7, 130.1, 133.2, 136.1, 140.9, 158.9, 177.3, 182.7, 196.6; HRMS (TOF ES^+): *m/z* calcd for $C_{22}H_{19}ClN_2NaO_3$ [$(M+Na)^+$], 417.0976; found, 417.0976.

8-(4-Methylbenzoyl)-7-(2-oxopropyl)-1,3,4,7-tetrahydropyr-rolo[1,2-*a*]pyrimidin-6(2*H*)-one (5h). White solid; Mp 228.7–229.5 °C; IR (KBr): 3435, 2922, 1719, 1626, 1532, 1440, 1272, 1162 cm^{-1}; ^1H NMR (400 MH_Z, $CDCl_3$): δ = 1.75 (s, 3H, $COCH_3$), 1.98–2.02 (m, 2H, CH_2), 2.30 (s, 3H, $ArCH_3$), 2.37–2.43 (m, 1H, $COCH_2$), 2.56–2.62 (m, 1H, $COCH_2$), 3.39–3.43 (m, 2H, CH_2N), 3.58–3.63 (m, 2H, NCH_2), 3.72–3.75 (m, 1H, CH), 7.10–7.12 (m, 2H, ArH), 7.31–7.33 (m, 2H, ArH), 9.88 (br, 1H, NH); ^{13}C NMR (100 MH_Z, $CDCl_3$): δ = 20.1, 21.4, 30.1, 37.3, 38.6, 40.7, 42.9, 88.5, 126.6, 129.0, 138.8, 139.7, 158.8, 177.2, 184.6, 205.6; HRMS (TOF ES^+): *m/z* calcd for $C_{18}H_{20}N_2NaO_3$ [$(M+Na)^+$], 335.1366; found, 335.1365.

8-Benzoyl-7-(2-oxopropyl)-1,3,4,7-tetrahydropyrrolo[1,2-*a*]pyrimidin-6(2*H*)-one (5i). White solid; Mp 195.0–196.7 °C; IR (KBr): 3205, 3050, 2967, 1720, 1628, 1536, 1363, 1079 cm^{-1}; ^1H NMR (400 MH_Z, $CDCl_3$): δ = 1.72 (s, 3H, $COCH_3$), 1.98–2.01 (m, 2H, CH_2), 2.30–2.36 (m, 1H, $COCH_2$), 2.54–2.59 (m, 1H, $COCH_2$), 3.38–3.43 (m, 2H, CH_2N), 3.58–3.63 (m, 2H, NCH_2), 3.70–3.72 (m, 1H, CH), 7.29–7.32 (m, 3H, ArH), 7.39–7.42 (m, 2H, ArH), 9.87 (br, 1H, NH); ^{13}C NMR (100 MH_Z, $CDCl_3$): δ = 20.0, 30.0, 37.2, 38.6, 40.6, 42.8, 88.7, 126.4, 128.4, 129.6, 141.6, 158.9, 177.2, 184.5, 205.6; HRMS (TOF ES^+): *m/z* calcd for $C_{17}H_{18}N_2NaO_3$ [$(M+Na)^+$], 321.1210; found, 321.1210.

8-(4-Fluorobenzoyl)-7-(2-oxopropyl)-1,3,4,7-tetrahydropyr-rolo[1,2-*a*]pyrimidin-6(2*H*)-one (5j). White solid; Mp 237.7–238.8 °C; IR (KBr): 3231, 3064, 2876, 1724, 1629, 1536, 1263, 1083 cm^{-1}; ^1H NMR (400 MH_Z, $CDCl_3$): δ = 1.77 (s, 3H, $COCH_3$), 2.01–2.07 (m, 2H, CH_2), 2.36–2.43 (m, 1H, $COCH_2$), 2.59–2.64 (m, 1H, $COCH_2$), 3.42–3.47 (m, 2H, CH_2N), 3.61–3.66 (m, 2H, NCH_2), 3.70–3.73 (m, 1H, CH), 6.98–7.03 (m, 2H, ArH), 7.42–7.45 (m, 2H, ArH), 9.88 (br, 1H, NH); ^{13}C NMR (100 MH_Z, $CDCl_3$): δ = 20.0, 30.0, 37.3, 38.6, 40.6, 42.9, 88.5, 115.3 (*J* = 21.4 Hz), 115.5 (*J* = 21.4 Hz), 128.7 (*J* = 8.4 Hz), 128.8 (*J* = 8.4 Hz), 137.7, 159.2, 162.2 (*J* = 248.0 Hz), 164.6 (*J* = 248.0 Hz), 177.0, 183.1, 205.4; HRMS (TOF ES^+): *m/z* calcd for $C_{17}H_{17}FN_2NaO_3$ [$(M+Na)^+$], 339.1115; found, 339.1115.

9-(4-Methylbenzoyl)-8-(2-oxo-2-phenylethyl)-1,2,3,4,5,8-hexahydro-7*H*-pyrrolo[1,2-*a*][1,3]diazepin-7-one (6a). Red solid; Mp 164.0–164.9 °C; IR (KBr): 3436, 2941, 1732, 1680, 1532, 1443, 1237, 1141 cm^{-1}; ^1H NMR (400 MH_Z, $CDCl_3$): δ = 1.99–2.09 (m, 4H, CH_2CH_2), 2.29 (s, 3H, $ArCH_3$), 2.96–3.09 (m, 2H, $COCH_2C$), 3.46–3.54 (m, 2H, CH_2N), 3.77–3.91 (m, 1H, NCH_2), 3.93–3.95 (m, 1H, CH), 3.96–4.00 (m, 1H, NCH_2), 7.05–7.07 (m, 2H, ArH), 7.20–7.25 (m, 4H, ArH), 7.38–7.44 (m, 2H, ArH), 10.71 (br, 1H, NH); ^{13}C NMR (100 MH_Z, $CDCl_3$): δ = 21.4, 24.9, 27.4, 38.6, 41.1, 41.2, 42.7, 90.6, 126.6, 127.9, 128.3, 129.0, 133.0, 136.5, 138.9, 139.6, 165.2, 178.8, 185.0, 197.2; HRMS (TOF ES^+): *m/z* calcd for $C_{24}H_{24}N_2NaO_3$ [$(M+Na)^+$], 411.1679; found, 411.1679.

9-Benzoyl-8-(2-oxo-2-phenylethyl)-1,2,3,4,5,8-hexahydro-7*H*-pyrrolo[1,2-*a*][1,3]diazepin-7-one (6b). Red solid; Mp 159.4–160.9 °C; IR (KBr): 3454, 3054, 2903, 1735, 1617, 1447, 1275, 1142, cm^{-1}; ^1H NMR (400 MH_Z, $CDCl_3$): δ = 1.92–2.08 (m, 4H, CH_2CH_2), 2.95–2.97 (m, 2H, $COCH_2$), 3.44–3.51 (m, 2H, CH_2N), 3.78–3.85 (m, 1H, NCH_2), 3.83–3.85 (m, 1H, CH), 3.90–3.96 (m, 1H, NCH_2), 7.18–7.30 (m, 7H, ArH), 7.30–7.40 (m, 3H, ArH), 10.71 (br, 1H, NH); ^{13}C NMR (100 MH_Z, $CDCl_3$): δ = 24.8, 27.3, 38.5, 41.0, 41.2, 42.6, 90.5, 126.5, 127.9, 128.3, 128.4, 129.4, 133.1, 136.3, 141.8, 165.3, 178.7, 184.9, 197.1; HRMS (TOF ES^+): *m/z* calcd for $C_{23}H_{22}N_2NaO_3$ [$(M+Na)^+$], 397.1523; found, 397.1519.

9-(4-Chlorobenzoyl)-8-(2-oxo-2-phenylethyl)-1,2,3,4,5,8-hex-ahydro-7*H*-pyrrolo[1,2-*a*][1,3]diazepin-7-one (6c). Red solid; Mp 175.9–177.4 °C; IR (KBr): 3454, 3061, 2929, 1736, 1616, 1441, 1275, 1142 cm^{-1}; ^1H NMR (400 MH_Z, $CDCl_3$): δ = 2.00–2.19 (m, 4H, CH_2CH_2), 3.10–3.12 (m, 2H, $COCH_2$), 3.56–3.64 (m, 2H, CH_2N), 3.87–3.93 (m, 1H, NCH_2), 3.91–3.93 (m, 1H, CH), 4.01–4.07 (m, 1H, NCH_2), 7.28–7.36 (m, 6H, ArH), 7.46–7.55 (m, 3H, ArH), 10.83 (br, 1H, NH); ^{13}C NMR (100 MH_Z, $CDCl_3$): δ = 24.8, 27.2, 38.7, 40.9, 41.2, 42.7, 90.5, 127.9, 128.1, 128.4, 128.6, 133.2, 135.4, 136.2, 140.1, 165.6, 178.5, 183.2, 196.9; HRMS (TOF ES^+): *m/z* calcd for $C_{23}H_{21}ClN_2O_3$ [$(M+Na)^+$], 431.1133; found, 431.1140.

9-(4-Fluorobenzoyl)-8-(2-oxo-2-phenylethyl)-1,2,3,4,5,8-hex-ahydro-7*H*-pyrrolo[1,2-*a*][1,3]diazepin-7-one (6d). Red solid; Mp 178.3–179.0 °C; IR (KBr): 3449, 3065, 2917, 1734, 1685, 1540, 1369, 1144 cm^{-1}; ^1H NMR (400 MH_Z, $CDCl_3$): δ =

2.02–2.11 (m, 4H, CH_2CH_2), 3.01–3.02 (m, 2H, $COCH_2$), 3.47–3.56 (m, 2H, CH_2N), 3.78–3.82 (m, 1H, NCH_2), 3.81–3.83 (m, 1H, CH), 3.84–3.99 (m, 1H, NCH_2), 6.92–6.96 (m, 2H, ArH), 7.22–7.46 (m, 7H, ArH), 10.73 (br, 1H, NH); ^{13}C NMR (100 MH_Z, $CDCl_3$): δ = 24.8, 27.3, 38.6, 40.9, 41.2, 42.6, 90.4, 115.2 (J = 21.3 Hz), 115.5 (J = 21.3 Hz), 127.8, 128.4, 128.7 (J = 8.3 Hz), 128.8 (J = 8.3 Hz) , 133.2, 136.3, 137.9 (J = 2.6 Hz), 137.9 (J = 2.6 Hz), 162.0 (J = 247.7 Hz), 164.5 (J = 247.7 Hz), 165.5, 178.6, 183.4, 196.9; HRMS (TOF ES$^+$): *m/z* calcd for $C_{23}H_{21}FN_2NaO_3$ [(M+Na)$^+$], 415.1428; found, 415.1429.

9-(4-Methylbenzoyl)-8-(2-oxopropyl)-1,2,3,4,5,8-hexahydro-7*H*-pyrrolo[1,2-*a*][1,3]diazepin-7-one (6e). Yellow solid; Mp 202.0–203.8 °C; IR (KBr): 3445, 2940, 1722, 1618, 1541, 1437, 1265, 1151 cm^{-1}; ^{1}H NMR (400 MH_Z, $CDCl_3$): δ = 1.75 (s, 3H, $COCH_3$), 1.87–2.06 (m, 4H, CH_2CH_2), 2.30 (s, 3H, $ArCH_3$), 2.32–2.37 (m, 1H, $COCH_2$), 2.56–2.61 (m, 1H, $COCH_2$), 3.46–3.52 (m, 2H, CH_2N), 3.71–3.73 (m, 1H, CH), 3.71–3.79 (m, 1H, NCH_2), 3.87–3.93 (m, 1H, NCH_2), 7.10–7.13 (m, 2H, ArH), 7.29–7.31 (m, 2H, ArH), 10.70 (br, 1H, NH); ^{13}C NMR (100 MH_Z, $CDCl_3$): δ = 21.4, 24.8, 27.3, 30.0, 40.9, 41.1, 42.6, 43.2, 90.4, 126.5, 129.0, 138.9, 139.7, 165.1, 178.5, 184.9, 205.5; HRMS (TOF ES$^+$): *m/z* calcd for $C_{19}H_{22}N_2NaO_3$[(M+Na)$^+$], 349.1523; found, 349.1527.

9-Benzoyl-8-(2-oxopropyl)-1,2,3,4,5,8-hexahydro-7*H*-pyrrolo[1,2-*a*][1,3]diazepin-7-one (6f). Yellow solid; Mp 169.9–170.6 °C; IR (KBr): 3445, 2933, 1723, 1619, 1543, 1444, 1262, 1148 cm^{-1}; ^{1}H NMR (400 MH_Z, $CDCl_3$): δ = 1.73 (s, 3H, $COCH_3$), 1.89–2.04 (m, 4H, CH_2CH_2), 2.24–2.30 (m, 1H, $COCH_2$), 2.55–2.60 (m, 1H, $COCH_2$), 3.49–3.53 (m, 2H, CH_2N), 3.68–3.69 (m, 1H, CH), 3.70–3.80 (m, 1H, NCH_2), 3.87–3.93 (m, 1H, NCH_2), 7.31–7.33 (m, 3H, ArH), 7.37–7.40 (m, 2H, ArH), 10.71 (br, 1H, NH); ^{13}C NMR (100 MH_Z, $CDCl_3$): δ = 24.8, 27.3, 29.9, 40.8, 41.1, 42.6, 43.2, 90.4, 126.4, 128.5, 129.5, 141.7, 165.2, 178.5, 184.9, 205.4; HRMS (TOF ES$^+$): *m/z* calcd for $C_{18}H_{20}N_2NaO_3$ [(M+Na)$^+$], 335.1366; found, 335.1369.

9-(4-Chlorobenzoyl)-8-(2-oxopropyl)-1,2,3,4,5,8-hexahydro-7*H*-pyrrolo[1,2-*a*][1,3]diazepin-7-one (6g). Yellow solid; Mp 242.3–243.5 °C; IR (KBr): 3452, 2943, 1727, 1619, 1543, 1267, 1152, 1089 cm^{-1}; ^{1}H NMR (400 MH_Z, $CDCl_3$): δ = 1.78 (s, 3H, $COCH_3$), 1.88–2.07 (m, 4H, CH_2CH_2), 2.30–2.39 (m, 1H, $COCH_2$), 2.60–2.65 (m, 1H, $COCH_2$), 3.50–3.55 (m, 2H, CH_2N), 3.67–3.69 (m, 1H, CH), 3.75–3.81 (m, 1H, NCH_2), 3.88–3.94 (m, 1H, NCH_2), 7.29–7.32 (m, 2H, ArH), 7.31–7.37 (m, 2H, ArH), 10.76 (br, 1H, NH); ^{13}C NMR (100 MH_Z, $CDCl_3$): δ = 24.7, 27.2, 30.0, 40.6, 41.1, 42.6, 43.3, 90.4, 128.0, 128.7, 135.5, 140.0, 165.5, 178.3, 183.0, 205.3; HRMS (TOF ES$^+$): *m/z* calcd for $C_{18}H_{19}ClN_2NaO_3$ [(M+Na)$^+$], 369.0976; found, 369.0979.

Ethyl-5-hydroxy-8-(4-methoxybenzoyl)-5-phenyl-1,2,3,5,6,7-hexahydroimidazo[1,2-*a*]pyridine-7-carboxylate (7a). Yellow solid; Mp 80.5–81.9 °C; IR (KBr): 3427, 2971, 1729, 1599, 1384, 1247, 1168, 1027 cm^{-1}; ^{1}H NMR (400 MH_Z, $CDCl_3$): δ = 0.93–0.96 (t, 3H, CCH_3), 2.25–2.27 (m, 2H, CH_2), 3.08–3.09 (m, 1H, CHCO), 3.42–3.47 (m, 2H, NCH_2), 3.50–3.53 (m, 1H, CH_2N), 3.73 (s, 3H, OCH_3), 3.76–3.80 (m, 1H, CH_2N), 3.78–3.85 (q, 2H, OCH_2), 6.19 (s, 1H, OH), 6.78–6.80 (m, 2H, ArH), 7.19–7.22 (m, 2H, ArH), 7.23–7.25 (m, 1H, ArH), 7.28–7.33 (m, 2H, ArH), 7.45–7.47 (m, 2H, ArH), 9.68 (br, 1H, NH); ^{13}C NMR (100 MH_Z, $CDCl_3$): δ = 13.7, 39.0, 40.5, 41.8, 42.9, 55.3, 61.5, 82.3, 82.7, 113.4, 126.0, 128.1, 128.1, 128.6, 135.3, 142.6, 159.7, 161.2, 178.4, 189.9; HRMS (TOF ES$^+$): *m/z* calcd for $C_{24}H_{27}N_2O_5$ [(M+H)$^+$], 423.1914; found, 429.1914.

Ethyl-8-(4-ethylbenzoyl)-5-hydroxy-5-phenyl-1,2,3,5,6,7-hexahydroimidazo[1,2-*a*]pyridine-7-carboxylate (7b). Yellow solid; Mp 91.0–91.9 °C; IR (KBr): 3291, 2968, 2353, 1728, 1599, 1512, 1387, 1169 cm^{-1}; ^{1}H NMR (400 MH_Z, $CDCl_3$): δ = 0.83–0.95 (t, 3H, CCH_3), 1.11–1.17 (t, 3H, CCH_3), 2.19–2.30 (m, 2H, CH_2), 2.54–2.60 (q, 2H, $ArCH_2$), 3.08–3.10 (t, 1H, CHCO), 3.42–3.53 (m, 2H, NCH_2), 3.51–3.65 (m, 1H, CH_2N), 3.74–3.78 (q, 2H, OCH_2), 3.80–3.87 (m, 1H, CH_2N), 6.16 (s, 1H, OH), 7.08–7.18 (m, 4H, ArH), 7.24–7.36 (m, 3H, ArH), 7.31–7.47 (m, 2H, ArH), 9.72 (br, 1H, NH); ^{13}C NMR (100 MH_Z, $CDCl_3$): δ = 13.7, 15.6, 28.7, 39.0, 40.4, 41.8, 42.9, 61.4, 82.4, 82.7, 126.0, 126.4, 127.5, 128.1, 128.6, 140.1, 142.6, 144.3, 161.2, 178.5, 190.5; HRMS (TOF ES$^+$): *m/z* calcd for $C_{25}H_{29}N_2O_4$ [(M+H)$^+$], 421.2122; found, 421.2123.

Ethyl-5-hydroxy-8-(4-methylbenzoyl)-5-phenyl-1,2,3,5,6,7-hexahydroimidazo[1,2-*a*]pyridine-7-carboxylate (7c). Orange solid; Mp 95.0–96.3 °C; IR (KBr): 3287, 2975, 2352, 1727, 1588, 1512, 1386, 1170 cm^{-1}; ^{1}H NMR (400 MH_Z, $CDCl_3$): δ = 0.92–0.96 (t, 3H, CCH_3), 2.24–2.25 (d, 2H, CH_2), 2.27 (s, 3H, CCH_3), 3.07–3.12 (m, 1H, CHCO), 3.43–3.51 (m, 2H, NCH_2), 3.54–3.61 (m, 1H, CH_2N), 3.73–3.75 (q, 2H, OCH_2), 3.79–3.87 (m, 1H, CH_2N), 6.16 (s, 1H, OH), 7.06–7.08 (m, 2H, ArH), 7.12–7.14 (m, 2H, ArH), 7.24–7.26 (m, 1H, ArH), 7.29–7.33 (m, 2H, ArH), 7.45–7.47 (m, 2H, ArH), 9.71 (br, 1H, NH); ^{13}C NMR (100 MH_Z, $CDCl_3$): δ = 13.7, 21.3, 39.0, 40.4, 41.8, 42.9, 61.5, 82.3, 82.7, 126.0, 126.4, 128.1, 128.6, 128.7, 138.0, 139.9, 142.6, 161.2, 178.6, 190.5; HRMS (TOF ES$^+$): *m/z* calcd for $C_{24}H_{26}N_2NaO_4$ [(M+Na)$^+$], 429.1785; found, 429.1785.

Ethyl-8-benzoyl-5-hydroxy-5-phenyl-1,2,3,5,6,7-hexahydro-imidazo[1,2-*a*]pyri- dine-7-carboxylate (7d). Red solid; Mp 84.9–85.7 °C; IR (KBr): 3288, 2979, 1729, 1600, 1513, 1387, 1168, 1024 cm^{-1}; ^{1}H NMR (400 MH_Z, $CDCl_3$): δ = 0.91–0.94 (t, 3H, CCH_3), 2.23–2.26 (d, 2H, CH_2), 3.07–3.12 (m, 1H, CHCO), 3.42–3.56 (m, 2H, NCH_2), 3.58–3.61 (m, 1H, CH_2N), 3.70–3.75

(q, 2H, OCH_2), 3.77–3.87 (m, 1H, CH_2N), 6.17 (s, 1H, OH), 7.18–7.25 (m, 6H, ArH), 7.29–7.33 (m, 2H, ArH), 7.45–7.47 (m, 2H, ArH), 9.70 (br, 1H, NH); ^{13}C NMR (100 MH_Z, $CDCl_3$): δ = 13.7, 38.9, 40.4, 41.8, 42.9, 61.5, 82.4, 82.7, 126.0, 126.4, 128.1, 128.2, 128.3, 128.6, 142.6, 142.7, 161.3, 178.5, 190.2; HRMS (TOF ES$^+$): *m/z* calcd for $C_{23}H_{25}N_2O_4$ [$(M+H)^+$], 393.1809; found, 393.1806.

Ethyl-8-(4-bromobenzoyl)-5-hydroxy-5-phenyl-1,2,3,5,6,7-hexahydroimidazo-[1,2-*a*]pyridine-7-carboxylate (7e). Yellow solid; Mp 200.9–202.5 °C; IR (KBr): 3295, 2974, 2887, 1694, 1591, 1515, 1398, 1226 cm^{-1}; ^{1}H NMR (400 MH_Z, $CDCl_3$): δ = 0.96–0.99 (t, 3H, CCH_3), 2.26–2.28 (d, 2H, CH_2), 3.11–3.14 (m, 1H, CHCO), 3.46–3.57 (m, 2H, NCH_2), 3.59–3.70 (q, 2H, OCH_2), 3.79–3.91 (m, 2H, CH_2N), 6.17 (s, 1H, OH), 7.12–7.19 (m, 2H, ArH), 7.26–7.35 (m, 3H, ArH), 7.41–7.48 (m, 4H, ArH), 9.71 (br, 1H, NH); ^{13}C NMR (100 MH_Z, $CDCl_3$): δ = 13.7, 38.8, 40.3, 41.8, 42.9, 61.7, 82.2, 82.7, 122.3, 126.0, 128.1, 128.2, 128.6, 131.3, 141.5, 142.4, 161.3, 178.4, 188.7; HRMS (TOF ES$^+$): *m/z* calcd for $C_{23}H_{24}BrN_2O_4$ [$(M+H)^+$], 471.0914; found, 471.0913.

Ethyl-8-(4-chlorobenzoyl)-5-hydroxy-5-phenyl-1,2,3,5,6,7-hexahydroimidazo[1,2-*a*]pyridine-7-carboxylate (7f). White solid; Mp 190.5–192.4 °C; IR (KBr): 3302, 2977, 2885, 1695, 1593, 1398, 1226, 1022 cm^{-1}; ^{1}H NMR (400 MH_Z, $CDCl_3$): δ = 1.02–1.06 (t, 3H, CCH_3), 2.33–2.35 (d, 2H, CH_2), 3.17–3.22 (m, 1H, CHCO), 3.53–3.69 (m, 2H, NCH_2), 3.71–3.78 (q, 2H, OCH_2), 3.86–3.98 (m, 2H, CH_2N), 6.24 (s, 1H, OH), 7.26–7.27 (m, 3H, ArH), 7.32–7.34 (m, 2H, ArH), 7.35–7.42 (m, 2H, ArH), 7.53–7.55 (m, 2H, ArH), 9.79 (br, 1H, NH); ^{13}C NMR (100 MH_Z, $CDCl_3$): δ = 13.7, 38.9, 40.3, 41.8, 42.9, 61.7, 82.2, 82.7, 126.0, 128.0, 128.2, 128.3, 128.6, 134.1, 141.1, 142.5, 161.3, 178.4, 188.8; HRMS (TOF ES$^+$): *m/z* calcd for $C_{23}H_{24}ClN_2O_4$ [$(M+H)^+$], 427.1419; found, 427.1417.

Ethyl-8-(4-fluorobenzoyl)-5-hydroxy-5-phenyl-1,2,3,5,6,7-hexahydroimidazo[1,2-*a*]pyridine-7-carboxylate (7g). Yellow solid; Mp 115.6–117.8 °C; IR (KBr): 3256, 2976, 1730, 1590, 1510, 1381, 1162, 1026 cm^{-1}; ^{1}H NMR (400 MH_Z, $CDCl_3$): δ = 0.93–0.97 (t, 3H, CCH_3), 2.25–2.26 (d, 2H, CH_2), 3.07–3.12 (m, 1H, CHCO), 3.43–3.54 (m, 2H, NCH_2), 3.56–3.69 (q, 2H, OCH_2), 3.77–3.90 (m, 2H, CH_2N), 6.17 (s, 1H, OH), 6.93–6.97 (m, 2H, ArH), 7.21–7.24 (m, 3H, ArH), 7.26–7.33 (m, 2H, ArH), 7.44–7.46 (m, 2H, ArH), 9.67 (br, 1H, NH); ^{13}C NMR (100 MH_Z, $CDCl_3$): δ = 13.7, 38.9, 40.4, 41.8, 42.9, 61.6, 82.3, 82.7, 114.9 (J = 21.3 Hz), 115.1 (J = 21.3 Hz), 126.0, 128.2, 128.4 (J = 8.1 Hz), 128.5 (J = 8.1 Hz), 128.6, 138.7 (J = 2.9 Hz), 138.8 (J = 2.9 Hz), 142.5, 161.3, 161.3 (J = 249.9 Hz), 163.8 (J = 249.9 Hz), 178.3, 188.9; HRMS (TOF ES$^+$): *m/z* calcd for $C_{23}H_{23}FN_2NaO_4$ [$(M+Na)^+$], 433.1534; found, 433.1533.

Ethyl-5-hydroxy-8-nitro-5-phenyl-1,2,3,5,6,7-hexahydro-imidazo[1,2-*a*]pyridine-7-carboxylate (7h). Yellow solid; Mp 193.9–□94.6 °C; IR (KBr): 3335, 2978, 2354, 1684, 1501, 1253, 1129, 1018 cm^{-1}; ^{1}H NMR (400 MH_Z, $CDCl_3$): δ = 1.24–1.27 (t, 3H, CCH_3), 2.25–2.42 (m, 2H, CH_2), 3.17–3.22 (m, 1H, CHCO), 3.51–3.66 (m, 2H, NCH_2), 3.70–3.73 (q, 1H, OCH_2), 4.04–4.07 (q, 1H, OCH_2), 4.19–4.23 (m, 2H, CH_2N), 5.52 (s, 1H, OH), 7.28–7.36 (m, 3H, ArH), 7.44–7.46 (m, 2H, ArH), 8.87 (br, 1H, NH); ^{13}C NMR (100 MH_Z, $CDCl_3$): δ = 13.0, 38.0, 38.3, 41.2, 43.1, 61.4, 82.4, 102.3, 124.9, 127.6, 127.7, 139.9, 156.6, 175.7; HRMS (TOF ES$^+$): *m/z* calcd for $C_{16}H_{19}N_3NaO_5$ [$(M+Na)^+$], 356.1217; found, 356.1217.

Methyl-8-benzoyl-5-methyl-1,2,3,5-tetrahydroimidazo[1,2-*a*]pyridine-7-carboxylate (8a). Yellow solid; Mp 200.9–201.4 °C; IR (KBr): 3234, 2954, 2897, 1739, 1530, 1473, 1157, 1014 cm^{-1}; ^{1}H NMR (400 MH_Z, $CDCl_3$): δ = 1.82 (s, 3H, CCH_3), 3.39 (s, 3H, OCH_3), 3.65–3.78 (m, 4H, CH_2CH_2), 4.01–4.02 (m, 1H, NCH), 4.58–4.60 (m, 1H, CCH), 7.16–7.20 (m, 2H, ArH), 7.22–7.25 (m, 3H, ArH), 9.32 (br, 1H, NH); ^{13}C NMR (100 MHZ, $CDCl_3$): δ = 17.0, 41.5, 41.7, 43.6, 50.8, 81.7, 98.1, 125.0, 127.1, 127.3, 132.4, 141.3, 157.3, 173.7, 191.3; HRMS (TOF ES$^+$): *m/z* calcd for $C_{17}H_{18}N_2NaO_3$ [$(M+Na)^+$], 321.1210; found, 321.1208.

Methyl-8-(4-chlorobenzoyl)-5-methyl-1,2,3,5-tetrahydro-imidazo[1,2-*a*]pyridine-7-carboxylate (8b). Yellow solid; Mp 180.3–181.1 °C; IR (KBr): 3236, 2898, 1733, 1605, 1472, 1328, 1223, 1090 cm^{-1}; ^{1}H NMR (400 MH_Z, $CDCl_3$): δ = 1.83 (s, 3H, CCH_3), 3.41 (s, 3H, OCH_3), 3.65–3.78 (m, 4H, CH_2CH_2), 3.96–3.98 (m, 1H, NCH), 4.60–4.62 (m, 1H, CCH), 7.12–7.14 (m, 2H, ArH), 7.19–7.23 (m, 3H, ArH), 9.30 (br, 1H, NH); ^{13}C NMR (100 MH_Z, $CDCl_3$): δ = 16.9, 41.3, 41.7, 43.6, 50.9, 81.6, 98.0, 126.6, 127.3, 132.4, 133.2, 139.7, 157.4, 173.5, 189.7; HRMS (TOF ES$^+$): *m/z* calcd for $C_{17}H_{17}ClN_2NaO_3$ [$(M+Na)^+$], 355.0820; found, 355.0825.

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