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MW-Assisted Synthesis of Eight New 6-Nitrilmethyl Pyrrolo[3,4-*b*]pyridin-5-Ones via a Domino Process: *aza* Diels–Alder/*N*-Acylation/Aromatization †

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Abstract: An efficient Microwave (MW)-assisted synthesis of eight new 6-nitrilmethyl-pyrrolo[3,4-*b*]pyridin-5-ones via a domino process: *aza* Diels–Alder/*N*-acylation/aromatization (dehydration–decarboxylation) from their corresponding 2-aminonitrile-oxazoles and maleic anhydride are described. The use of MW as a heat source and scandium (III) triflate as a catalyst to promote the cycloaddition process was crucial to construct these polyfunctionalized products in very good yields (51–79%), considering both their molecular complexity and that only one domino-type experimental procedure was required for their synthesis. It is worth noting that all products reported herein have not been synthesized nor isolated anywhere. However, they can be of high interest for the synthetic and medicinal chemistry community because pyrrolo[3,4-*b*]pyridin-5-one is the structural core of various bioactive compounds. In the same context, it can be considered as a privileged *aza* analogue of the isoindolin-1-one, which in turn is the core of numerous anticancer agents.

Keywords: multicomponent reactions; Ugi-three-component reactions; pyrrolo[3,4-*b*]pyridin-5-ones; domino processes; *aza* Diels–Alder cycloadditions; *N*-acylations; aromatization processes

1. Introduction

The fused-type polyheterocyclic pyrrolo[3,4-*b*]pyridin-5-one system **1** is the structural core of various synthetic products showing interesting biological properties, such as the antiepileptic **2** [1] and the antihypoglycemic **3** [2] agents. Besides, the polyheterocyclic framework **1** is considered as a privileged *aza* analogue of the isoindolin-1-one system **4** [3]. In the same context, some natural products of high interest in medicinal chemistry such as (±)-Nuevamine (**5**) [4], (±)-Lennoxamine (**6**) [5] and Magallanesine (**7**) [6] are structurally based on the isoindolin-1-one moiety, as shown in Figure 1. Thus, the aim of this communication is to describe an efficient MW-assisted synthesis of eight new 6-nitrilmethyl-pyrrolo[3,4-*b*]pyridin-5-ones **8a–h** via a domino process: *aza* Diels–Alder/*N*-acylation/aromatization (dehydration-decarboxylation) from their corresponding 2-aminonitrile-oxazoles and maleic anhydride. Most of the reported methods to assemble pyrrolo[3,4-*b*]pyridin-5-one based architectures involve multistep strategies as well as the use of harsh conditions—see for example the synthetic methodology reported by Devasthale et al. [2]. However, various

multicomponent reaction (MCR)-based synthetic strategies toward series of novel pyrrolo[3,4-*b*]pyridin-5-one-containing polyheterocycles have been reported in the last decade by us [7–14] as an integral part of our ongoing research program. It is important to note that MCRs are highly convergent one-pot processes in which three or more reagents are combined sequentially to assemble complex products [15] like polyheterocycles [16], eventually in good yields, obeying most of the green chemistry principles [17].

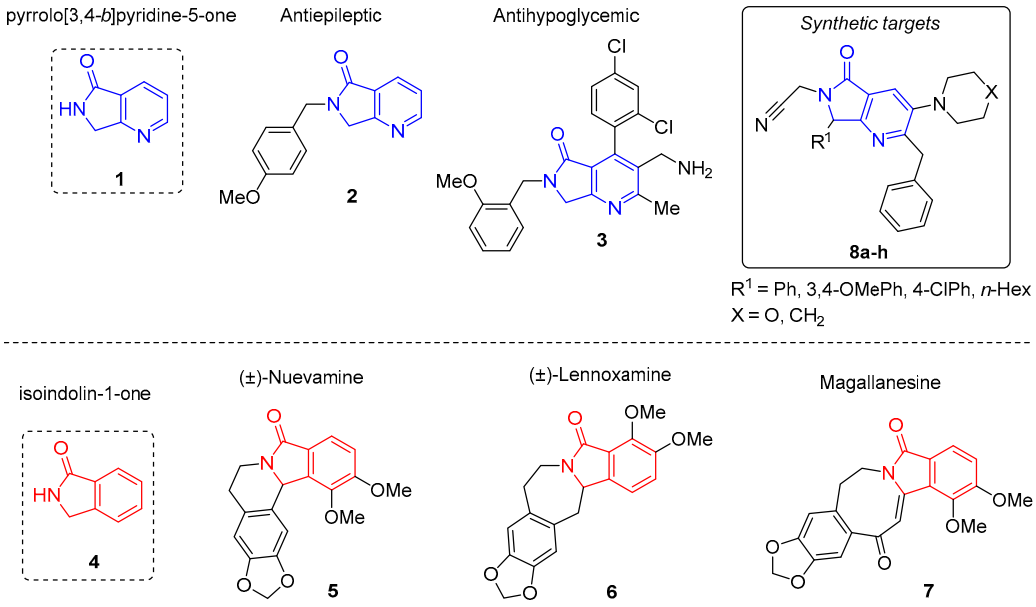
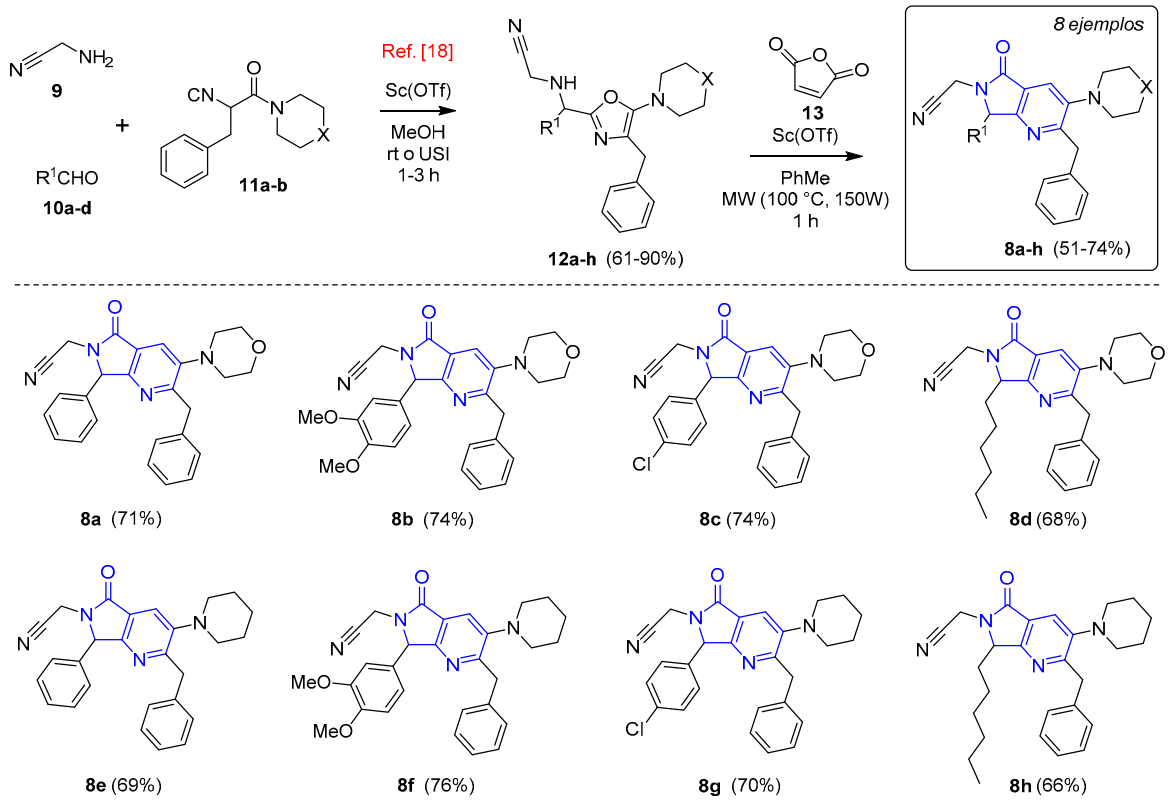


Figure 1. Pyrrolo[3,4-*b*]pyridin-5-ones and isoindolin-1-ones of interest.

2. Results and Discussion

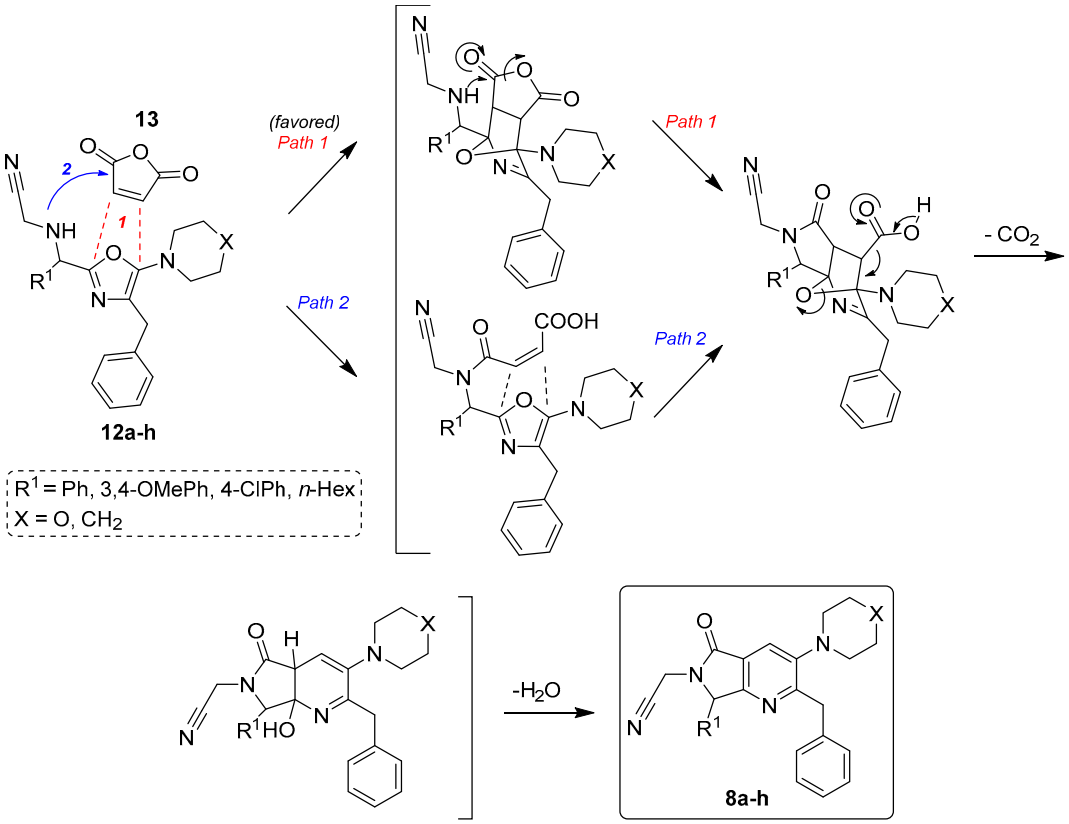
In 2017, at the 21st international Electronic Conference on Synthetic Organic Chemistry (ECSOC), we reported an ultrasound-assisted synthesis of eight new and highly functionalized 2-aminonitrile oxazoles **12a–h** via an Ugi-three-component reaction (3CR) by combining aminoacetonitrile (**9**) with the corresponding aldehydes **10a–d** and the chain-ring tautomerizable isocyanides **11a–b** in MeOH as the solvent, Scheme 1. Then, we combined just the oxazole-based compounds **12a–h** with maleic anhydride (**13**) to synthesize the corresponding eight new 6-nitrilmethyl-pyrrolo[3,4-*b*]pyridin-5-ones **8a–h** via a domino process: *aza* Diels–Alder/*N*-acylation/aromatization (dehydration-decarboxylation), Scheme 1. Choosing the 2-aminonitrile oxazole **12a** as a starting reagent, we screened the acid catalyst, heat source, temperature, solvent and oncentration to find the optimal reaction parameters toward the new 6-nitrilmethyl-pyrrolo[3,4-*b*]pyridin-5-one **8a**. Thus, after various attempts, the use of scandium (III) triflate as the catalyst (3% mol), toluene as the solvent [0.3 M] and microwaves as the heat source at 100 °C and 150 W of power gave the best yield for the product **8a** (71%). So, by using these optimal conditions, the other analogues **8b–h** were synthesized successfully in closer yields (66–76%) with respect to the product **8a** (71%). As seen, the substrate scope was studied by using aromatic aldehydes with electron-releasing and electron-withdrawing groups (R^1 = Ph, 3,4-OMePh, 4-ClPh), as well as with an aliphatic substituent (R^1 = *n*-Hex), Scheme 1. The best yields were observed for the analogues **8b** (74%, R^1 = 3,4-OMePh; X = O) and **8f** (76%, R^1 = 3,4-OMePh; X = CH_2), while the lowest yields were observed for the alkylic analogues, **8d** (68%, R^1 = *n*-Hex; X = O) and **8h** (66%, R^1 = *n*-Hex; X = CH_2). This behavior is attributed to a little difference in the stereoelectronic nature between aromatic and aliphatic substituents, favorable to aromatic ones. This observation matches also with our previous report [18], Scheme 1.



Scheme 1. Synthesis of pyrrolo[3,4-*b*]pyridin-5-ones (substrate scope). [18] Islas-Jácome, A. *et al.* Ultrasound-assisted synthesis of eight novel and highly functionalyzed 2-aminonitrile oxazoles via Ugi-3CR. In Proceedings of the 21st International Electronic Conference on Synthetic Organic Chemistry, 1–30 November 2017; Sciforum Electronic Conference Series; Volume 21, doi:10.3390/ecsoc-21-04818.

With respect to the reaction mechanisms, the synthesis of the 2-aminonitrile oxazoles **12a–h** via Ugi-3CR was reported in our previous work [18]. However, the conversion of **12a–h** into **8a–h** can take two possible pathways, as discussed in a mechanistic study from Density Functional Theory (DFT)-based calculations published in 2016, also by us [19], from similar structural polyheterocyclic systems. Thus the 2-aminonitrile oxazoles **12a–h** may react with the maleic anhydride **13** via a domino sequence 1, intermolecular *aza* Diels–Alder cycloaddition/intramolecular *N*-acylation/aromatization (dehydration-decarboxylation), or sequence 2, intermolecular *N*-acylation/intramolecular *aza* Diels–Alder cycloaddition/aromatization (dehydration-decarboxylation), Scheme 2. Thus, based on the structural similarities to the polyheterocycles previously studied, we assume that the most plausible pathway for the synthesis of our current products is the domino sequence 1.

Finally, all of the products were characterized by their physicochemical properties, as well as by the classical spectroscopic techniques (see the experimental section for further details). The product **8a** was chosen to succinctly discuss its ^{1}H and ^{13}C NMR spectra, as shown in Figure 2. Thus, with respect to the ^{1}H NMR key signals, we here highlight a couple of singlets—one of them at 7.90 ppm, attributed to the C–H of pyridine ring, and the other at 5.62 ppm, attributed to the C–H from its pyrrolodin-5-one ring, see Figure 2a. The latter discussed signal is the most important because that C–H is where all the components converge. Besides, with respect to the ^{13}C NMR key signals, there is a peak at 166.5 ppm attributed to the carbonyl from its pyrrolodin-5-one system, Figure 2b. This signal indicates that the γ-lactam was created in the synthetic process, Figure 2b.



Scheme 2. Plausible reaction mechanism.

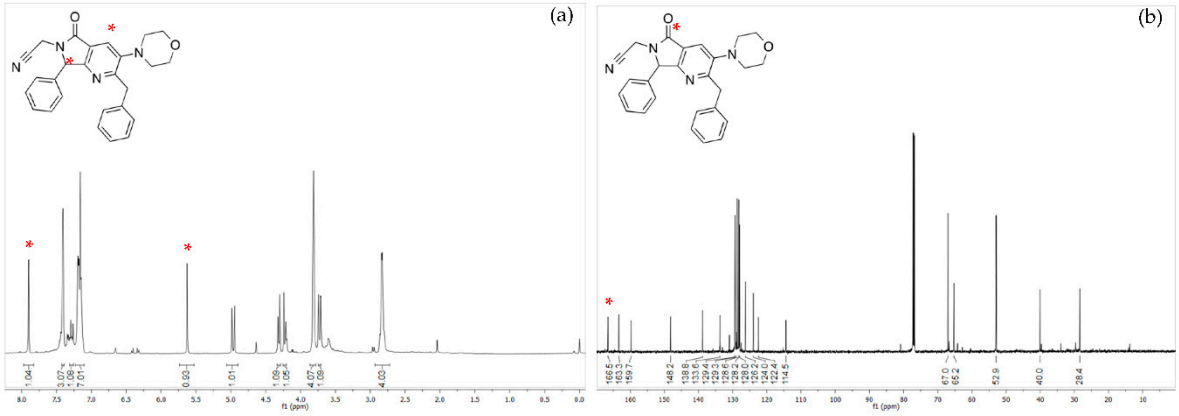


Figure 2. (**a**) ^{1}H NMR spectrum of compound **8a**, (**b**) ^{13}C NMR spectrum of compound **8a**. * Key signals.

3. Conclusions

The synthetic strategy described herein allowed a rapid preparation of eight new 6-aminonitril pyrrolo[3,4-*b*]pyridin-5-ones in good yields (66–76%) considering the molecular complexity of the final products, that only one domino-type one-pot process was required for the synthesis and that the products were polyfunctionalized, which in turn can be exploited for further reactions. For example, the nitrile group can be converted easily into a tetrazole ring via a Huisgen-type [3 + 2] dipolar cycloaddition. These kinds of compounds are being synthesized and the results will be communicated soon.

4. Experimental Section

4.1. General Information, Instrumentation and Chemicals

^{1}H and ^{13}C NMR spectra were acquired on Bruker Advance III (Fällande, Uster, Switzerland) spectrometers (500 or 400 MHz). The solvent used was deuterated chloroform ($CDCl_3$). Chemical shifts are reported in parts per million (δ/ppm). The internal reference for 1H NMR spectra is expressed with respect to tetramethyl silane (TMS) at 0.0 ppm. The internal reference for ^{13}C NMR spectra is expressed with respect to $CDCl_3$ at 77.0 ppm. Coupling constants are reported in Hertz (*J*/Hz). Multiplicities of the signals are reported using the standard abbreviations: singlet (s), doublet (d), triplet (t), quartet (q) and multiplet (m). NMR spectra were analyzed using the MestreNova software version 10.0.1-14719. IR spectra were acquired on a Perkin Elmer 100 spectrometer. The absorbance peaks are reported in reciprocal centimeters (υ_{max}/cm^{-1}). Microwave-assisted reactions were performed on a CEM Discover™ Synthesis Unit in close vessel mode. Reaction progress was monitored by Thin-Layer Chromatography (TLC) on precoated Silica-gel 60 F_{254} plates and the spots were visualized under UV light at 254 or 365 nm. Mixtures of hexane with ethyl acetate (AcOEt) were used to run TLC and to measure retention factors (R_f). Flash column chromatography was performed using silica gel (230–400 mesh) and mixtures of hexane with AcOEt in different proportions (*v*/*v*) as the mobile phase. All starting materials were purchased from Sigma-Aldrich (Toluca, México) and were used without further purification. Chemical names and drawings were obtained using the ChemBioDraw Ultra 13.0.2.3020 software package. The purity for all the synthesized products (up to 99%) was assessed by NMR.

4.2. Synthesis and Characterization of the Pyrrolo[3,4-b]pyridin-6-yl-Acetonitriles **8a–h**

General procedure (GP): The corresponding 2-aminonitrile oxazoles **12a–h** (1.0 equiv.), maleic anhydride (**13**) (2.0 equiv.) and $Sc(OTf)_3$ (3% mol) were placed in a 10 mL sealed CEM Discover™ microwave reaction tube and diluted in 1.0 mL of dry toluene. Then, the mixture was irradiated (MW, 100 °C, 150 W) for 60 min and the solvent was removed to dryness under reduced pressure. The crude was dissolved in CH_2Cl_2 (5.0 mL) and washed with aqueous $NaHCO_3$ (3 × 25 mL) and brine (3 × 25 mL). The organic layer was dried with Na_2SO_4 and filtered. The solvent was removed to dryness under vacuum. The residue was purified by silica-gel chromatoflash using mixtures of hexane:EtOAc (*v*/*v*) in different proportions to afford the corresponding 6-aminonitril pyrrolo[3,4-*b*]pyridin-5-ones (**8a–h**).

2-(2-Benzyl-3-morpholino-5-oxo-7-phenyl-5,7-dihydro-6*H*-pyrrolo[3,4-*b*]pyridin-6-yl)acetonitrile (**8a**)

According to the GP: 2-aminonitrile oxazole (**12a**) (136.0 mg, 0.303 mmol), maleic anhydride (59.4 mg, 0.606 mmol) and scandium triflate (4.5 mg, 0.009 mmol) were reacted together in toluene (1.0 mL) to afford the pyrrolo[3,4-*b*]pyridin-6-yl-acetonitrile **8a** (109.0 mg, 71%) as a yellow gum; R_f = 0.25 (hexane:AcOEt = 3:2 *v*/*v*); FT-IR (ATR) υ_{max}/cm^{-1} 1702 (C=O); ^{1}H NMR (500 MHz, $CDCl_3$, 25 °C): δ 7.90 (s, 1H) 7.43–7.39 (m, 3H), 7.31–7.26 (m, 1H), 7.23–7.10 (m, 7H), 5.62 (s, 1H), 4.96 (d, *J* = 17.5 Hz, 1H), 4.31 (d, *J* = 13.9 Hz, 1H), 4.23 (d, *J* = 13.8 Hz, 1H), 3.88–3.78 (m, 4H), 3.73 (d, *J* = 17.5 Hz, 1H), 2.93–2.72 (m, 4H) ppm; ^{13}C NMR (126 MHz, $CDCl_3$, 25 °C): δ 166.5, 163.3, 159.7, 148.2, 138.8, 133.6, 129.4, 129.3, 128.6, 128.2, 128.0, 126.2, 124.0, 122.4, 114.5, 67.0, 65.2, 52.9, 40.0, 28.4 ppm.

2-(2-Benzyl-7-(3,4-dimethoxyphenyl)-3-morpholino-5-oxo-5,7-dihydro-6*H*-pyrrolo[3,4-*b*]pyridin-6-yl)acetonitrile (**8b**)

According to the GP: 2-aminonitrile oxazole **12b** (94.0 mg, 0.242 mmol), maleic anhydride (47.0 mg, 0.483 mmol) and scandium triflate (3.5 mg, 0.007 mmol) were reacted together in toluene (1.0 mL) to afford the pyrrolo[3,4-*b*]pyridin-6-yl-acetonitrile **8b** (73.0 mg, 74%) as a yellow gum; R_f = 0.11 (hexanes:AcOEt = 3:2 *v*/*v*); FT-IR (ATR) υ_{max}/cm^{-1} 1709 (C=O); ^{1}H NMR (500 MHz, $CDCl_3$, 25 °C): δ 7.92 (s, 1H), 7.24–7.21 (m, 1H), 7.14–7.04 (m, 1H), 6.83–6.79 (m, 1H), 6.76–6.72 (m, 1H), 6.33 (s, 1H), 5.59 (s, 1H), 4.85 (d, *J* = 17.3 Hz, 1H), 4.31–4.23 (s, 2H), 3.82 (s, 3H), 3.78–3.74 (m, 4H), 3.72 (s, 3H), 3.67

(d, *J* = 17.1 Hz, 1H) 2.91–2.65 (m, 1H) ppm; ^{13}C NMR (126 MHz, $CDCl_3$, 25 °C): δ 166.1, 162.9, 158.7, 150.0, 149.8, 148.4, 138.8, 135.5, 134.6, 128.8, 128.2, 126.3, 121.1, 114.6, 111.6, 110.6, 67.1, 65.0, 56.1, 56.0, 54.5 , 39.7, 28.5 ppm.

2-(2-Benzyl-7-(4-chlorophenyl)-3-morpholino-5-oxo-5,7-dihydro-6*H*-pyrrolo[3,4-*b*]pyridin-6-yl)acetonitrile (**8c**)

According to the GP: 2-aminonitrile oxazole **12c** (101.0 mg, 0.239 mmol), maleic anhydride (46.8 mg, 0.477 mmol) and scandium triflate (3.5 mg, 0.007 mmol) were reacted together in toluene (1.0 mL) to afford the pyrrolo[3,4-*b*]pyridin-6-yl-acetonitrile **8c** (81.0 mg, 74%) as a white solid; R_f = 0.21 (hexane:AcOEt = 3:2 *v*/*v*); m.p. 168–171 °C; FT-IR (ATR) υ_{max}/cm^{-1} 1699 (C=O); ^{1}H NMR (500 MHz, $CDCl_3$, 25 °C): δ 7.88 (s, 1H), 7.42–7.37 (m, 2H), 7.31–7.26 (m, 1H), 7.20–7.13 (m, 6H), 5.59 (s, 1H), 4.98 (d, *J* = 17.6 Hz, 1H), 4.31 (d, *J* = 13.9 Hz, 1H), 4.22 (d, *J* = 13.9 Hz, 1H), 3.88–2.78 (m, 4H), 3.74 (d, *J* = 17.3 Hz, 1H), 3.01–2.65 (m, 4H) ppm; ^{13}C NMR (126 MHz, $CDCl_3$, 25 °C): δ 166.5, 163.5, 159.3, 148.4, 138.8, 135.5, 132.3, 129.7, 129.4, 128.7, 128.3, 126.4, 124.0, 122.3, 114.4, 67.1, 64.6, 53.0, 40.1, 28.5 ppm.

2-(2-Benzyl-7-hexyl-3-morpholino-5-oxo-5,7-dihydro-6*H*-pyrrolo[3,4-*b*]pyridin-6-yl)acetonitrile (**8d**)

According to the GP: 2-aminonitrile oxazole **12d** (110.0 mg, 0.277 mmol), maleic anhydride (54.4 mg, 0.555 mmol) and scandium triflate (4.1 mg, 0.008 mmol) were reacted together in toluene (1.0 mL) to afford the pyrrolo[3,4-*b*]pyridin-6-yl-acetonitrile **8d** (81.0 mg, 68%) as a brown gum; R_f = 0.25 (hexane:AcOEt = 3:2 *v*/*v*); FT-IR (ATR) υ_{max}/cm^{-1} 1701 (C=O); ^{1}H NMR (500 MHz, $CDCl_3$, 25 °C): δ 7.88 (s, 1H), 7.30–7.18 (m, 5H), 4.85 (d, *J* = 16.3 Hz, 1H), 4.80–4.59 (m, 1H), 4.56–4.42 (m, 1H), 4.42–4.29 (m, 1H), 4.23 (d, *J* = 13.1 Hz, 1H), 3.92–3.76 (m, 4H), 3.03–2.70 (m, 4H), 2.46–2.27 (m, 1H), 2.10–1.87 (m, 1H), 1.35–1.04 (m, 8H), 0.84 (t, *J* = 6.75 Hz, 3H) ppm; ^{13}C NMR (126 MHz, $CDCl_3$, 25 °C): δ 166.5, 162.2, 159.1, 148.2, 138.9, 128.9, 128.4, 126.5, 124.5, 123.6, 114.6, 67.1, 61.2, 53.1, 38.8, 31.5, 29.4, 29.0, 28.7, 22.7, 22.5, 14.0 ppm.

2-(2-Benzyl-5-oxo-7-phenyl-3-(piperidin-1-yl)-5,7-dihydro-6*H*-pyrrolo[3,4-*b*]pyridin-6-yl)acetonitrile (**8e**)

According to the GP: 2-aminonitrile oxazole **12e** (236.0 mg, 0.610 mmol), maleic anhydride (119.7 mg, 1.220 mmol) and scandium triflate (9.0 mg, 0.018 mmol) were reacted together in toluene (1.0 mL) to afford the pyrrolo[3,4-*b*]pyridin-6-yl-acetonitrile **8e** (180.0 mg, 69%) as a pale yellow gum; R_f = 0.61 (hexane:AcOEt = 3:2 *v*/*v*); FT-IR (ATR) υ_{max}/cm^{-1} 1704 (C=O); ^{1}H NMR (500 MHz, $CDCl_3$, 25 °C): δ 7.82 (s, 1H), 7.39–7.30 (m, 3H), 7.21–7.04 (m, 7H), 5.57 (s, 1H), 4.89 (d, *J* = 16.8 Hz, 1H), 4.42–4.07 (m, 2H), 3.65 (d, *J* = 17.3 Hz, 1H), 2.95–2.46 (m, 4H), 1.85–1.56 (m, 4H), 1.56–1.48 (m, 2H) ppm; ^{13}C NMR (126 MHz, $CDCl_3$, 25 °C): δ 166.5, 163.1, 158.9, 149.3, 138.9, 133.7, 129.5, 129.4, 129.0, 128.3, 128.2, 126.3, 124.1, 122.6, 114.5, 65.4, 54.6, 40.0, 28.6, 26.2, 23.8 ppm.

2-(2-Benzyl-7-(3,4-dimethoxyphenyl)-5-oxo-3-(piperidin-1-yl)-5,7-dihydro-6*H*-pyrrolo[3,4-*b*]pyridin-6-yl)acetonitrile (**8f**)

According to the GP: 2-aminonitrile-oxazoles **12f** (227.0 mg, 0.508 mmol), maleic anhydride (99.7 mg, 1.02 mmol) and scandium triflate (7.5 mg, 0.015 mmol) were reacted together in toluene (1.0 mL) to afford the pyrrolo[3,4-*b*]pyridin-6-yl-acetonitrile **8f** (187.0 mg, 76%) as a brown gum; R_f = 0.28 (hexane:AcOEt = 3:2 *v*/*v*); FT-IR (ATR) υ_{max}/cm^{-1} 1715 (C=O); ^{1}H NMR (500 MHz, $CDCl_3$, 25 °C): δ 7.82 (s, 1H), 7.22–7.19 (m, 1H), 7.19–7.14 (m, 2H), 7.10–7.06 (m, 2H), 6.83–6.80 (m, 1H), 6.77–6.71 (m, 1H), 6.50 (s, 1H), 5.52 (s, 1H), 4.86 (d, *J* = 17.4 Hz, 1H), 4.29 (d, *J* = 13.7 Hz, 1H), 4.24 (d, *J* = 13.8 Hz, 1H), 3.82 (s, 3H), 3.71 (s, 3H), 3.67 (d, *J* = 17.6 Hz, 1H), 2.88–2.67 (m, 4H), 1.75–1.62 (m, 4H), 1.56–1.51 (m, 2H) ppm; ^{13}C NMR (126 MHz, $CDCl_3$, 25 °C): δ 166.1, 162.9, 158.7, 150.0, 149.8, 148.4, 138.8, 135.5, 134.6, 128.8, 128.2, 126.3, 121.1, 114.6, 111.6, 110.6, 65.0, 56.1, 56.0, 54.5 , 39.7, 28.4, 26.1, 23.7 ppm.

2-(2-Benzyl-7-(4-chlorophenyl)-5-oxo-3-(piperidin-1-yl)-5,7-dihydro-6*H*-pyrrolo[3,4-*b*]pyridin-6-yl)acetonitrile (**8g**)

According to the GP: 2-aminonitrile oxazoles **12g** (245.0 mg, 0.582 mmol), maleic anhydride (114.1 mg, 1.16 mmol) and scandium triflate (8.5 mg, 0.017 mmol) were reacted together in toluene

(1.0 mL) to afford the pyrrolo[3,4-*b*]pyridin-6-yl-acetonitrile **8g** (188.0 mg, 70%) as a yellow gum; R_f = 0.61 (hexane:AcOEt = 3:2 *v*/*v*); FT-IR (ATR) υ_{max}/cm^{-1} 1707 (C=O); ^{1}H NMR (500 MHz, $CDCl_3$, 25 °C): δ 7.77 (s, 1H), 7.33–7.28 (m, 2H), 7.15–7.03 (m, 7H), 5.51 (s, 1H), 4.88 (d, *J* = 17.5 Hz, 1H), 4.24 (d, *J* = 13.4 Hz, 1H), 4.14 (d, *J* = 13.5 Hz, 1H), 3.66 (d, *J* = 17.4 Hz, 1H), 2.88–2.63 (m, 4H), 1.77–1.63 (m, 4H), 1.54–1.49 ppm (m, 2H); ^{13}C NMR (126 MHz, $CDCl_3$, 25 °C): δ 166.5, 163.4, 158.4, 138.9, 135.4, 132.5, 129.6, 129.5, 128.9, 128.2, 127.5, 126.3, 123.6, 114.4, 64.5, 54.3, 28.5, 26.2, 23.8 ppm.

2-(2-benzyl-7-hexyl-5-oxo-3-(piperidin-1-yl)-5,7-dihydro-6*H*-pyrrolo[3,4-*b*]pyridin-6-yl)acetonitrile (**8h**)

According to the GP: 2-aminonitrile oxazole **12h** (137.0 mg, 0.347 mmol), maleic anhydride (68.1 mg, 0.694 mmol) and scandium triflate (5.1 mg, 0.010 mmol) were reacted together in toluene (1.0 mL) to afford the pyrrolo[3,4-*b*]pyridin-6-yl-acetonitrile **8h** (149.5 mg, 66%) as a brown gum; R_f = 0.64 (hexane:AcOEt = 3:2 *v*/*v*); FT-IR (ATR) υ_{max}/cm^{-1} 1720 (C=O); ^{1}H NMR (500 MHz, $CDCl_3$, 25 °C): δ 7.82 (s, 1H), 7.39–7.29 (m, 3H), 7.22–7.04 (m, 7H), 5.57 (s, 1H), 4.89 (d, *J* = 16.9 Hz, 1H), 4.42–4.07 (m, 2H), 3.65 (d, *J* = 17.7 Hz, 1H), 2.96–2.46 (m, 4H), 1.85–1.57 (m, 4H), 1.57–1.49 (m, 2H) ppm; ^{13}C NMR (126 MHz, $CDCl_3$, 25 °C): δ 173.0, 166.6, 158.8, 134.8, 134.2, 130.9, 129.1, 128.8, 128.7, 127.4, 115.8, 60.5, 39.3, 34.8, 31.7, 29.3, 28.8, 28.7, 25.0, 24.8, 24.3, 22.6, 14.0 ppm.

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Sample Availability: Samples of compounds **8a–h** are available from the authors.