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Lewis Acid-Catalyzed Intermolecular Annulation: Three-Component Reaction toward Imidazo[1,2-*a*]pyridine Thiones

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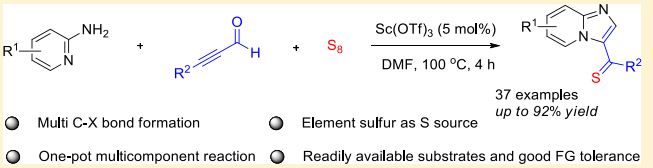
Supporting Information

ABSTRACT: A Lewis acid-catalyzed three-component annulation reaction of 2-aminopyridines and ynals with elemental sulfur was established. A series of imidazo[1,2-*a*]pyridine thiones was obtained in moderate to excellent yields. The merits of this transformation include easily available starting materials, multiple C-heteroatom bond formation in one pot, good functional group tolerance, elemental sulfur as S source, operational simplicity, etc.



Imidazopyridines are a class of important nitrogen-fused heterocycles and have attracted considerable attention owing to their outstanding application value in natural products and pharmaceuticals.[1] Many imidazo[1,2-*a*]pyridine derivatives exhibit broad biological activities, including anticancer, antifungal, antibacterial, and antiviral activities.[2] Moreover, several commercially available drugs such as zolpidem, alpidem, olprinone, zolimidine, necopidem, and saripidem all contain the key structure of imidazo[1,2-*a*]pyridines.[3] As a consequence, numerous synthetic strategies have been developed for the construction of these skeletal structures over the past decades. Two regular methods involve the direct functionalization of pre-existing imidazo[1,2-*a*]-pyridine compounds[4] and the establishment of this framework from acyclic starting materials.[5] Aminopyridines as key building blocks have been applied widely to couple with carbonyl compounds,[6] alkenes,[7] or alkynes[8] to construct structurally diverse imidazo[1,2-*a*]pyridines. Despite the significant advancement, the development of novel and powerful transformations for imidazo[1,2-*a*]pyridine synthesis is vital to the synthetic chemistry community.

Sulfur-containing molecules have found extensive applications in materials science and pharmaceutical chemistry.[9] Among the various synthetic strategies toward sulfur-containing compounds, the most attractive protocols involve the direct functionalization of the stable and nontoxic elemental sulfur.[10] Recently, some strategies have been established for the preparation of imidazo[1,2-*a*]pyridine derivatives based on three-component reaction from 2-aminopyridines, ynals, and coupling partners. These reagents include alcohols or thiols,[11] molecular oxygen,[12] and sodium benzenesulfinates[13] (Schemes 1a−c). Herein, we described the first direct synthesis of imidazo[1,2-*a*]pyridine thiones from 2-aminopyridines, aromatic ynals, and elemental sulfur catalyzed by Lewis acids (Scheme 1d).

Initially, we employed 2-aminopyridine **1a** and phenylpropiolaldehyde **2a** as a model reaction to optimize the reaction conditions, and the results are shown in Table 1. When the reaction was carried out without any catalyst and additive, the desired product **3a** was formed in 35% yield (entry 1). To further improve the reaction yield, various Lewis acid catalysts were tested, and all of the catalysts had positive effects on the transformation (entries 2−10). To our surprise, the rare-earth-metal catalysts[14] were effective to the reaction, and $Sc(OTf)_3$ was found to provide the best results in 89% isolated yield (entries 8−10). Then, a variety of aprotic and protic solvents was evaluated, and the results showed that solvents were essential for the transformation. Aprotic solvents were beneficial to the reaction and afforded the product in good yields (entries 11−19). Finally, it was disadvantageous when the reaction was conducted at higher or lower temperatures (entries 20 and 21). After some attempts, the optimized conditions were considered as follows: **1a** (0.2 mmol) with **2a** (0.2 mmol) and $Sc(OTf)_3$ (5 mol %) in DMF (1 mL) at 100 °C for 4 h.

With the optimal reaction conditions established, the substrate scope was screened, and the results are summarized in Scheme 2. We first explored the scope of 2-aminopyridines by reacting with phenylpropiolaldehyde **2a** and elemental sulfur under the standard conditions. In general, the three-component annulation reaction has good functional group tolerance. Both electron-rich and electron-deficient groups on the pyridine ring were well-tolerated and delivered the desired products in moderate to excellent yields (**3b−p**). The yields were not affected obviously with the methyl group on the different position of the 2-aminopyridine (**3b−d**). Interestingly, the reaction afforded excellent yield when a methoxy group substituted 2-aminopyridine was employed (**3f**). Halogen substituents such as fluoro, chloro, bromo, and iodo were smooth to generate the products in 48−75% yield (**3h−l**). Especially, the aryl bromide and iodide could be further functionalized under transition-metal-catalyzed conditions. In

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Scheme 1. Synthesis of Imidazo[1,2-*a*]pyridines from 2-Aminopyridines, Ynals, and Various Coupling Reagents

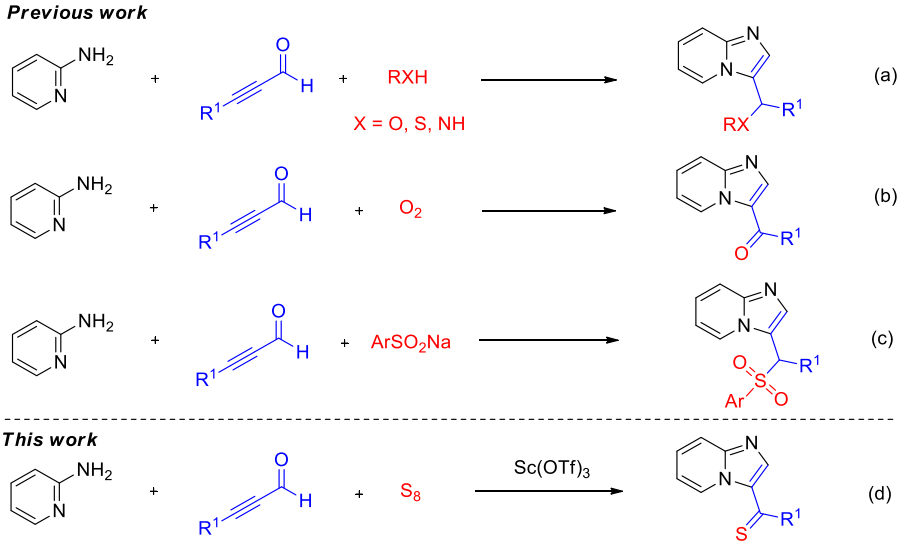
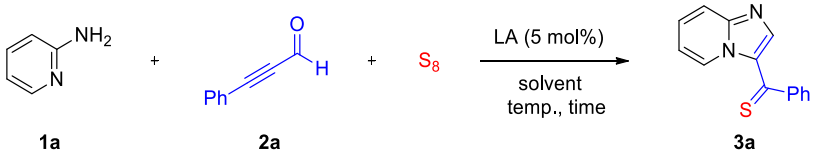


Table 1. Optimization of the Reaction Conditions[a]



1a **2a** **3a**

entry	Lewis acid	solvent	temperature	yield (%)
1		DMF	100	35
2	LiCl	DMF	100	51
3	$ZnCl_2$	DMF	100	74
4	$FeCl_3$	DMF	100	82
5	CuI	DMF	100	62
6	$AgNO_3$	DMF	100	76
7	$BF_3{\cdot}OEt_2$	DMF	100	80
8	$Sc(OTf)_3$	DMF	100	89
9	$Ce(OTf)_3$	DMF	100	83
10	$Sm(OTf)_3$	DMF	100	72
11	$Sc(OTf)_3$	DMSO	100	86
12	$Sc(OTf)_3$	THF	100	82
13	$Sc(OTf)_3$	MeCN	100	71
14	$Sc(OTf)_3$	toluene	100	84
15	$Sc(OTf)_3$	DCE	100	78
16	$Sc(OTf)_3$	dioxane	100	82
17	$Sc(OTf)_3$	H_2O	100	np
18	$Sc(OTf)_3$	HOAc	100	np
19	$Sc(OTf)_3$	EtOH	100	np
20	$Sc(OTf)_3$	DMF	120	87
21	$Sc(OTf)_3$	DMF	80	81

[a]Reaction conditions: **1a** (0.2 mmol), **2a** (0.2 mmol), S_8 (12.8 mg, 0.05 mmol) with catalyst (5 mol %) in solvent (1.0 mL) under argon for 4 h. np = no product.

addition, moderate to good yields were obtained when the reactants containing the strong electron-withdrawing group were used (**3m**–**p**). We were quite pleased to observe that the trisubstituted 2-aminopyridine was also suitable and gave the product in 51% yield (**3q**). To our delight, the reaction could be carried out on large scale synthesis and delivered the product in good yield (**3a**).

In continuous evaluation of the scope and generality of the three-component reaction, a set of ynals proceeded smoothly with 2-aminopyridine **1a** to yield the corresponding products under the given conditions (**4a**–**q**). As illustrated in Scheme 3, the annulation reaction was compatible with a handful of substituents such as alkyl, aryl, alkoxy, fluoro, chloro, trifluoromethyl, acetyl, and ester groups (**4a**–**p**). The ynal bearing a bulky *tert*-butyl group produced the product in good yield (**4e**). Satisfactory yields were obtained when two fluoro groups attached to the benzene ring, which achieved **4l** and **4m** in 63 and 72% yields, respectively. It is worth noting that the

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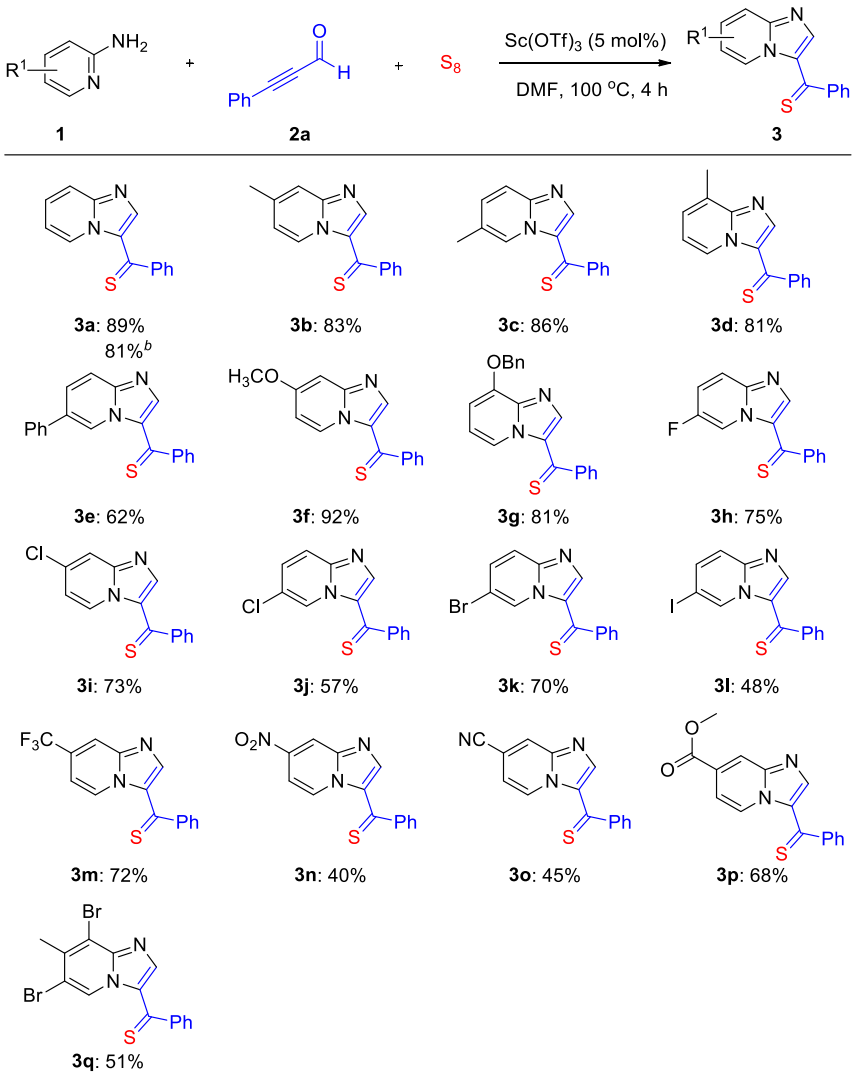
Scheme 2. Substrate Scope of 2-Aminopyridines[a]



[a]Reaction conditions: **1** (0.2 mmol), **2a** (0.2 mmol), S_8 (12.8 mg, 0.05 mmol) with $Sc(OTf)_3$ (5 mol %) in DMF (1.0 mL) under argon at 100 °C for 4 h. [b]2 mmol scale of the reaction.

products bearing acetyl and ester groups could be further functionalized, which may be applicable in the pharmaceutical chemistry (**4o** and **4p**). In addition, the heteroaryl substituted ynal worked well to deliver the product in 75% yield (**4q**). To our delight, pyridine ring bearing electron-donating (methoxy group) and electron-withdrawing groups (iodo group) reacted successfully to render the corresponding products in good yields, irrespective of the ynals contained electron-rich or electron-deficient substituents on the benzene ring (**4r**–**u**). Those results clearly indicated that this three-component annulation reaction is general and effective for the imidazo[1,2-*a*]pyridine thione library. Unfortunately, we found the reaction did not form the corresponding product with the aliphatic ynal (**4v**).

Some control experiments were performed to investigate the reaction mechanism (Scheme 4). The reaction of imidazo[1,2-*a*]pyridin-3-yl(phenyl)methanone **5a** with elemental sulfur in the presence or absence of Lewis acid could not generate imidazo[1,2-*a*]pyridin-3-yl(phenyl)methanethione **3a**, which indicated that the direct thiation of the C═O bond was not involved in the reaction process. Taking the possible radical pathway of elemental sulfur into account, different radical scavengers TEMPO, DPE, and BHT were introduced into the reaction system, and the generation of **3a** was not suppressed. These results suggested that the reaction did not proceed via a radical mechanism.

On the basis of the previous reports and above experimental results,[10] a plausible mechanism for this three-component annulation reaction has been proposed in Scheme 5. First, aminal intermediate **A** was generated from the nucleophilic addition of **1a** and **2a** by the promotion of Lewis acid. Subsequently, successive nucleophilic attack of the pyridine nitrogen to the triple bond and the activation of sulfur powder was followed by a dehydration process that led to intermediate **B**. Finally, the elimination process of **B** achieved the imidazo[1,2-*a*]pyridine thione **3a**. It is likely that the Lewis acid accelerates the nucleophilic addition and nucleophilic attack of the pyridine nitrogen to the triple bond of the alkyne.

In summary, we described a novel and highly efficient annulation reaction of 2-aminopyridines, ynals, and elemental sulfur catalyzed by a Lewis acid. A wide range of imidazo[1,2-*a*]pyridine thiones bearing electron-rich or electron-deficient

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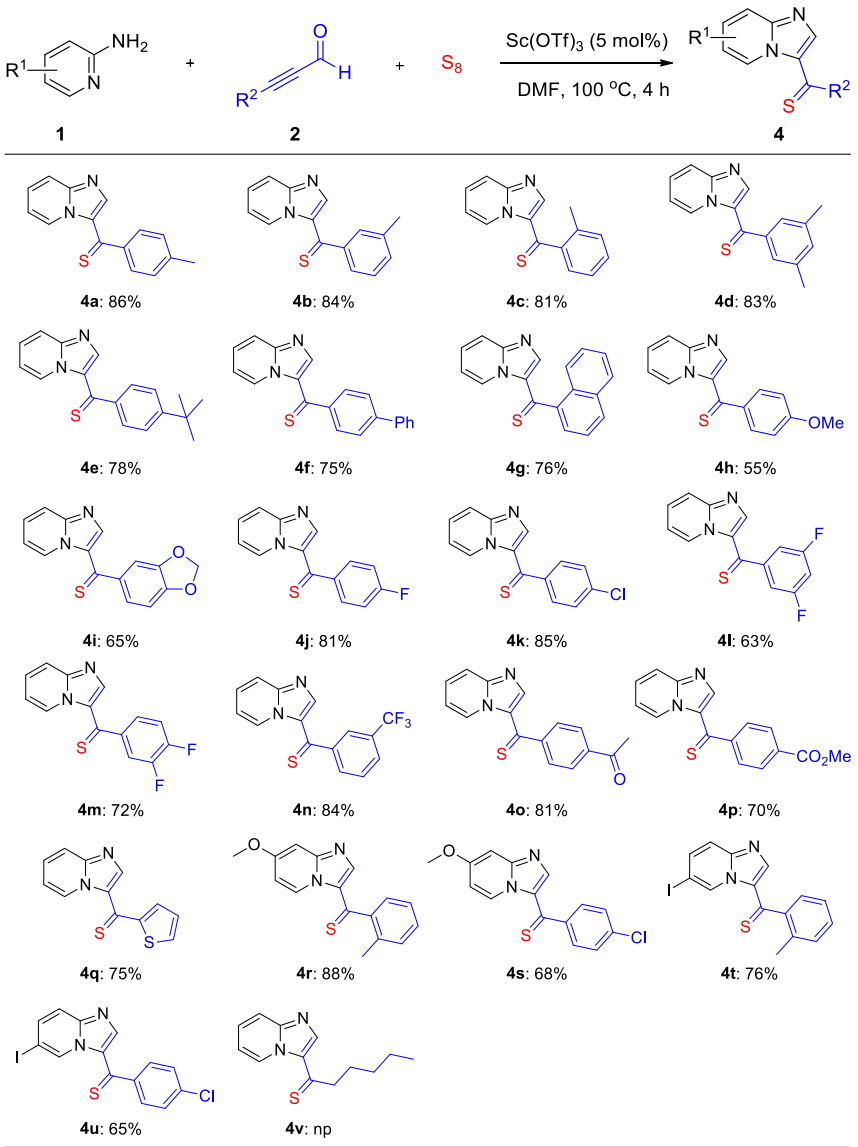
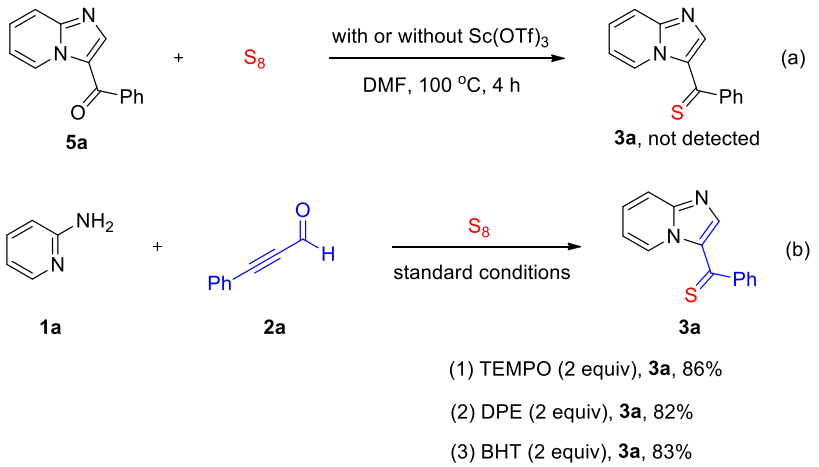
Scheme 3. Substrate Scope of 2-Aminopyridines and Ynals[a]



[a]Reaction conditions: **1** (0.2 mmol), **2** (0.2 mmol), S_8 (12.8 mg, 0.05 mmol) with $Sc(OTf)_3$ (5 mol %) in DMF (1.0 mL) under argon at 100 °C for 4 h.

Scheme 4. Control Experiments



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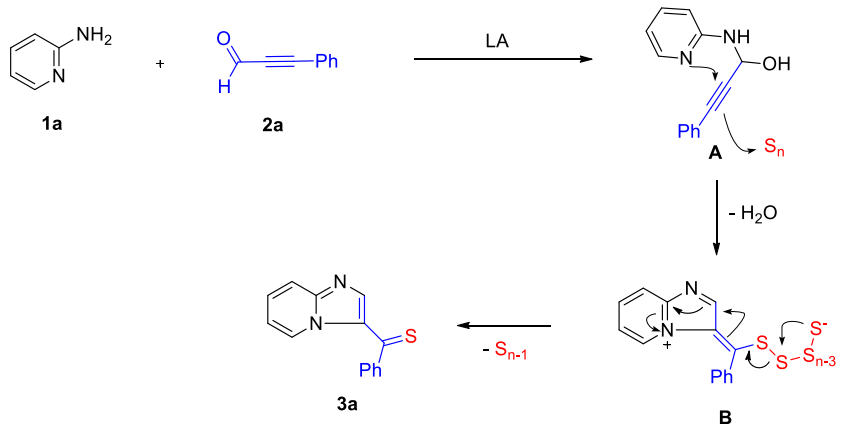
Scheme 5. Possible Mechanism



substituents was obtained in moderate to excellent yields. This transformation features readily available raw materials, is additive-free, has good functional tolerance, simple operation, etc. In addition, it provides a new strategy for the use of elemental sulfur for sulfur-containing molecules. Further utilization of this approach in synthetic and pharmaceutical chemistry and mechanistic studies is currently underway in our laboratory.

EXPERIMENTAL SECTION

General Information. ^{1}H and ^{13}C{^{1}H} NMR spectra were obtained on a 400 and 100 MHz NMR spectrometer. The chemical shifts are referenced to signals at 7.26 and 77.0 ppm, respectively, and chloroform was used as the solvent with TMS as the internal standard unless otherwise noted. Mass spectra were recorded on a GC-MS spectrometer at an ionization voltage of 70 eV equipped with a DB-WAX capillary column (internal diameter: 0.25 mm, length: 30 m). Elemental analyses were performed with a Vario EL elemental analyzer. High resolution mass spectra (HRMS) (TOF) were measured using an electrospray ionization (ESI) mass spectrometry. Silica gel (300−400 mesh) was used for flash column chromatography, eluting (unless otherwise stated) with ethyl acetate/petroleum ether (PE) (60−90 °C) mixture.

The 2-aminopyridines and propargyl aldehyde **2a** were commercially available from Sigma-Aldrich China. Others propargyl aldehydes were synthesized according to the literature[15] and data of known compounds were compared with the reported data.[16]

General Procedure for the Preparation of Imidazo[1,2-*a*]pyridine Thiones. A mixture of 2-aminopyridines (0.2 mmol), ynal (0.2 mmol), elemental sulfur (12.8 mg, 0.05 mmol), and $Sc(OTf)_3$ (0.01 mmol, 5 mol %) in DMF (1.0 mL) was stirred in a preheated oil bath at 100 °C for 4 h in a sealed tube under argon atmosphere. After the reaction was finished, water (5 mL) was added, and the solution was extracted with ethyl acetate (3 × 5 mL), and the combined extract was dried with anhydrous $MgSO_4$. Solvent was removed, and the residue was separated by column chromatography to give the pure sample.

Large Scale Synthesis. An oven-dried 25 mL screw cap test tube was charged with a magnetic stir bar, **1a** (188 mg, 2 mmol), **2a** (260 mg, 2 mmol), elemental sulfur (128 mg, 0.5 mmol), $Sc(OTf)_3$ (0.1 mmol, 5 mol %), and DMF (6.0 mL). The tube was then evacuated and backfilled with argon three times. Then, the tube was placed in a preheated oil bath at 100 °C for 4 h. After being cooled to room temperature, water (10 mL) was added; the solution was extracted with ethyl acetate (3 × 10 mL), and the combined extract was dried with anhydrous $MgSO_4$. Solvent was removed, and the residue was separated by column chromatography (ethyl acetate/petroleum ether = 1:3) to give **3a** (386 mg, 81%).

Imidazo[1,2-a]pyridin-3-yl(phenyl)methanethione ***(3a)***. Red solid (42 mg, 89%); mp 89−91 °C; R_f = 0.28 (ethyl acetate/petroleum ether = 1:3); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 10.80 (dd, J = 6.9, 0.8 Hz, 1H), 8.07 (s, 1H), 7.82 (dd, J = 8.8, 0.8 Hz, 1H), 7.68−7.59 (m, 3H), 7.46 (dd, J = 10.6, 4.1 Hz, 1H), 7.39 (dd, J = 8.0, 7.2 Hz, 2H), 7.19 (t, J = 6.9 Hz, 1H). ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$): δ 210.7, 150.6, 148.3, 145.8, 134.6, 131.4, 130.3, 128.5, 127.9, 126.8, 117.8, 116.1. MS (EI) m/z: 238, 205, 161, 119, 78, 51. HRMS (ESI): calcd for $C_{14}H_{11}N_2S$ $[M + H]^+$ 239.0637; found 239.0634.

(7-Methylimidazo[1,2-a]pyridin-3-yl)(phenyl)methanethione ***(3b)***. Red solid (42 mg, 83%); mp 144−146 °C; R_f = 0.53 (ethyl acetate/petroleum ether = 1:2); ^{1}H NMR (400 MHz, $CDCl_3$): δ 10.70 (d, J = 7.0 Hz, 1H), 8.03 (s, 1H), 7.61 (d, J = 7.8 Hz, 3H), 7.47 (t, J = 7.3 Hz, 1H), 7.39 (t, J = 7.4 Hz, 2H), 7.03 (d, J = 7.0 Hz, 1H), 2.51 (s, 3H). ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$): δ 209.5, 151.3, 148.3, 146.3, 143.7, 134.7, 130.2, 128.5, 127.9, 126.3, 118.4, 116.8, 21.7. MS (EI) m/z: 252, 219, 175, 126, 92, 65, 39. HRMS (ESI): calcd for $C_{15}H_{13}N_2S$ $[M + H]^+$ 253.0794; found 253.0799.

(6-Methylimidazo[1,2-a]pyridin-3-yl)(phenyl)methanethione ***(3c)***. Red solid (43 mg, 86%); mp 139−141 °C; R_f = 0.51 (ethyl acetate/petroleum ether = 1:2); ^{1}H NMR (400 MHz, $CDCl_3$): δ 10.67 (s, 1H), 8.01 (s, 1H), 7.71 (d, J = 8.9 Hz, 1H), 7.62−7.57 (m, 2H), 7.52−7.43 (m, 2H), 7.38 (t, J = 7.4 Hz, 2H), 2.44 (s, 3H). ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$): δ 210.1, 149.6, 148.4, 145.8, 134.5, 134.2, 130.1, 128.5, 127.8, 126.5, 124.8, 117.0, 18.4. MS (EI) m/z: 252, 237, 219, 175, 126, 92, 65, 39. Anal. Calcd for $C_{15}H_{12}N_2S$: C, 71.40; H, 4.79; N, 11.10; Found: C, 71.06; H, 4.85; N, 11.16.

(8-Methylimidazo[1,2-a]pyridin-3-yl)(phenyl)methanethione ***(3d)***. Red solid (41 mg, 81%); mp 110−112 °C; R_f = 0.47 (ethyl acetate/petroleum ether = 1:2); ^{1}H NMR (400 MHz, $CDCl_3$): δ 10.67 (d, J = 6.9 Hz, 1H), 8.05 (s, 1H), 7.64−7.60 (m, 2H), 7.48 (dd, J = 10.6, 4.2 Hz, 2H), 7.40 (t, J = 7.5 Hz, 2H), 7.11 (t, J = 7.0 Hz, 1H), 2.70 (s, 3H). ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$): δ 210.7, 150.7, 148.5, 145.2, 135.2, 130.7, 130.3, 128.6, 127.9, 127.8, 124.7, 116.1, 16.8. MS (EI) m/z: 252, 219, 175, 126, 92, 65, 39. HRMS (ESI): calcd for $C_{15}H_{13}N_2S$ $[M + H]^+$ 253.0794; found 253.0794.

Phenyl(6-phenylimidazo[1,2-a]pyridin-3-yl)methanethione ***(3e)***. Red solid (39 mg, 62%); mp 125−127 °C; R_f = 0.51 (ethyl acetate/petroleum ether = 1:2; ^{1}H NMR (400 MHz, $CDCl_3$): δ 11.20 (s, 1H), 8.12 (s, 1H), 7.96 (dt, J = 17.8, 5.3 Hz, 2H), 7.67 (t, J = 6.7 Hz, 4H), 7.54 (t, J = 7.7 Hz, 3H), 7.45 (q, J = 7.6 Hz, 3H). ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$): δ 211.1, 149.9, 148.6, 146.2, 136.5, 135.0, 131.5, 131.0, 130.4, 129.3, 128.6, 128.5, 128.1, 127.2, 124.5, 117.7. MS (EI) m/z: 314, 281, 237, 157, 127, 102, 77, 51. HRMS (ESI): calcd for $C_{20}H_{15}N_2S$ $[M + H]^+$ 315.0950; found 315.0945.

(7-Methoxyimidazo[1,2-a]pyridin-3-yl)(phenyl)methanethione ***(3f)***. Red solid (49 mg, 92%); mp 150−152 °C; R_f = 0.23 (ethyl acetate/petroleum ether = 1:2); ^{1}H NMR (400 MHz, $CDCl_3$): δ 10.70 (d, J = 7.6 Hz, 1H), 7.99 (s, 1H), 7.65−7.60 (m, 2H), 7.50−7.45 (m, 1H), 7.40 (t, J = 7.4 Hz, 2H), 7.13 (d, J = 2.6 Hz, 1H), 6.87 (dd, J = 7.6, 2.6 Hz, 1H), 3.96 (s, 3H). ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$): δ 208.2, 162.4, 153.7, 148.3, 147.0, 134.8, 130.1, 128.6,

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128.3, 127.9, 109.2, 96.7, 56.0. MS (EI) *m/z*: 268, 235, 224, 191, 176, 134, 121, 77, 51. HRMS (ESI): calcd for $C_{15}H_{13}N_2OS$ $[M + H]^+$ 269.0743; found 269.0749.

*(8-(Benzyloxy)imidazo[1,2-a]pyridin-3-yl)(phenyl)-methanethione (**3g**).* Red solid (56 mg, 81%); mp 115−117 °C; R_f = 0.60 (ethyl acetate/petroleum ether = 1:2); ^{1}H NMR (400 MHz, $CDCl_3$): δ 10.36 (dd, J = 6.1, 1.6 Hz, 1H), 8.03 (s, 1H), 7.66−7.62 (m, 2H), 7.49 (d, J = 7.3 Hz, 3H), 7.43−7.31 (m, 5H), 7.06−6.99 (m, 2H), 5.39 (s, 2H). $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$): δ 211.8, 148.6, 147.7, 144.6, 144.3, 135.6, 135.4, 130.4, 128.6, 128.6, 128.2, 128.0, 127.3, 119.9, 116.0, 110.9, 71.2. MS (EI) *m/z*: 344, 267, 253, 172, 121, 91, 65, 39. HRMS (ESI): calcd for $C_{21}H_{17}N_2OS$ $[M + H]^+$ 345.1056; found 345.1058.

*(6-Fluoroimidazo[1,2-a]pyridin-3-yl)(phenyl)methanethione (**3h**).* Red solid (38 mg, 75%); mp 121−123 °C; R_f = 0.39 (ethyl acetate/petroleum ether = 1:2); ^{1}H NMR (400 MHz, $CDCl_3$): δ 10.94 (dd, J = 5.2, 2.1 Hz, 1H), 8.11 (s, 1H), 7.83 (dd, J = 9.6, 5.1 Hz, 1H), 7.64−7.57 (m, 3H), 7.54−7.48 (m, 1H), 7.41 (dd, J = 10.3, 4.7 Hz, 2H). $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$): δ 211.8, 155.2 (d, J = 239 Hz), 148.2, 148.1, 146.0 (d, J = 3 Hz), 135.0, 130.6, 128.6, 128.1, 122.3 (d, J = 25 Hz), 118.1 (d, J = 9 Hz), 114.2 (d, J = 22.5 Hz). MS (EI) *m/z*: 256, 223, 179, 128, 96, 51. HRMS (ESI): calcd for $C_{14}H_{10}FN_2S$ $[M + H]^+$ 257.0543; found 257.0540.

*(7-Chloroimidazo[1,2-a]pyridin-3-yl)(phenyl)methanethione (**3i**).* Red solid (40 mg, 73%); mp 137−139 °C; R_f = 0.64 (ethyl acetate/petroleum ether = 1:4); ^{1}H NMR (400 MHz, $CDCl_3$): δ 10.74 (d, J = 7.3 Hz, 1H), 8.07 (s, 1H), 7.83 (s, 1H), 7.62 (d, J = 7.3 Hz, 2H), 7.53−7.49 (m, 1H), 7.42 (t, J = 7.4 Hz, 2H), 7.18 (d, J = 6.1 Hz, 1H). $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$): δ 211.5, 150.9, 148.2, 146.1, 137.5, 134.5, 130.7, 128.6, 128.1, 127.2, 117.3, 117.1. MS (EI) *m/z*: 272, 239, 195, 112, 89, 76, 51. HRMS (ESI): calcd for $C_{14}H_{10}ClN_2S$ $[M + H]^+$ 273.0248; found 273.0245.

*(6-Chloroimidazo[1,2-a]pyridin-3-yl)(phenyl)methanethione (**3j**).* Red solid (31 mg, 57%); mp 175−177 °C; R_f = 0.39 (ethyl acetate/petroleum ether = 1:3); ^{1}H NMR (400 MHz, $CDCl_3$): δ 10.95 (d, J = 1.5 Hz, 1H), 8.09 (s, 1H), 7.81 (d, J = 9.4 Hz, 1H), 7.65 (dd, J = 11.7, 7.3 Hz, 3H), 7.52 (t, J = 7.4 Hz, 1H), 7.43 (t, J = 7.5 Hz, 2H). $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$): δ 212.1, 148.9, 148.3, 145.6, 134.4, 132.3, 130.8, 128.6, 128.1, 124.8, 124.6, 118.1. MS (EI) *m/z*: 272, 239, 195, 112, 89, 76, 51 HRMS (ESI): calcd for $C_{14}H_{10}ClN_2S$ $[M + H]^+$ 273.0248; found 273.0240.

*(6-Bromoimidazo[1,2-a]pyridin-3-yl)(phenyl)methanethione (**3k**).* Red solid (44 mg, 70%); mp 194−196 °C; R_f = 0.35 (ethyl acetate/petroleum ether = 1:3); ^{1}H NMR (400 MHz, $CDCl_3$): δ 11.03 (s, 1H), 8.07 (s, 1H), 7.75 (s, 2H), 7.63 (d, J = 7.2 Hz, 2H), 7.52 (t, J = 7.4 Hz, 1H), 7.43 (t, J = 7.5 Hz, 2H). $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$): δ 212.1, 149.1, 148.3, 145.5, 134.5, 134.3, 130.8, 128.6, 128.1, 126.9, 118.4, 111.1. MS (EI) *m/z*: 317, 283, 239, 158, 89, 77, 51. HRMS (ESI): calcd for $C_{14}H_9BrN_2NaS$ $[M + Na]^+$ 338.9562; found 338.9568.

*(6-Iodoimidazo[1,2-a]pyridin-3-yl)(phenyl)methanethione (**3l**).* Red solid (35 mg, 48%); mp 198−200 °C; R_f = 0.38 (ethyl acetate/petroleum ether = 1:3); ^{1}H NMR (400 MHz, $CDCl_3$): δ 11.09 (s, 1H), 8.01 (s, 1H), 7.87 (dd, J = 9.2, 1.1 Hz, 1H), 7.65−7.61 (m, 3H), 7.52 (t, J = 7.3 Hz, 1H), 7.42 (t, J = 7.5 Hz, 2H). $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$): δ 212.0, 149.3, 148.3, 145.1, 139.2, 133.9, 131.6, 130.7, 128.6, 128.1, 118.8, 79.6. MS (EI) *m/z*: 364, 287, 236, 204, 160, 118, 89, 77, 51. HRMS (ESI): calcd for $C_{14}H_{10}IN_2S$ $[M + H]^+$ 364.9604; found 364.9607.

*Phenyl(7-(trifluoromethyl)imidazo[1,2-a]pyridin-3-yl)-methanethione (**3m**).* Red solid (44 mg, 72%); mp 99−101 °C; Rf = 0.56 (ethyl acetate/petroleum ether = 1:2); ^{1}H NMR (400 MHz, $CDCl_3$): δ 11.19 (s, 1H), 8.18 (s, 1H), 7.96 (d, J = 9.2 Hz, 1H), 7.85−7.80 (m, 1H), 7.65 (d, J = 7.2 Hz, 2H), 7.55 (t, J = 7.3 Hz, 1H), 7.44 (t, J = 7.6 Hz, 2H). $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$): δ 213.1, 150.3, 148.2, 146.1, 134.6, 131.1, 128.6, 128.2, 126.9 (q, J = 3 Hz), 125.7 (q, J = 5 Hz), 123.1 (q, J = 271 Hz), 120.2 (q, J = 34 Hz), 118.7. MS (EI) *m/z*: 306, 273, 229, 146, 121, 89, 69, 51. HRMS (ESI): calcd for $C_{15}H_{10}F_3N_2S$ $[M + H]^+$ 307.0511; found 307.0519.

*(7-Nitroimidazo[1,2-a]pyridin-3-yl)(phenyl)methanethione (**3n**).* Green solid (23 mg, 40%); mp 157−159 °C; R_f = 0.44 (ethyl acetate/petroleum ether = 1:2); ^{1}H NMR (400 MHz, $CDCl_3$): 11.77−11.73 (m, 1H), 8.41 (dd, J = 9.7, 2.2 Hz, 1H), 8.22 (s, 1H), 7.93 (d, J = 9.7 Hz, 1H), 7.67 (dd, J = 5.1, 3.3 Hz, 2H), 7.57 (dd, J = 10.6, 4.3 Hz, 1H), 7.45 (dd, J = 10.5, 4.7 Hz, 2H). $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$): δ 213.9, 150.3, 148.0, 146.6, 139.6, 134.9, 131.4, 128.7, 128.3, 126.6, 124.5, 117.7. MS (EI) *m/z*: 283, 266, 252, 236, 206, 192, 160, 134, 121, 89, 77, 51. Anal. Calcd for $C_{14}H_9N_3O_2S$: C, 59.35; H, 3.20; N, 14.83; Found: C, 59.02; H, 3.29; N, 14.76.

*3-(Phenylcarbonothioyl)imidazo[1,2-a]pyridine-7-carbonitrile (**3o**).* Green solid (24 mg, 45%); mp 162−164 °C; R_f = 0.44 (ethyl acetate/petroleum ether = 1:4); ^{1}H NMR (400 MHz, $CDCl_3$): δ 10.75 (d, J = 7.2 Hz, 1H), 8.21 (s, 2H), 7.67−7.64 (m, 2H), 7.57 (s, 1H), 7.45 (t, J = 7.7 Hz, 2H), 7.32 (dd, J = 7.2, 1.6 Hz, 1H). $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$): δ 214.2, 148.4, 148.2, 145.9, 134.6, 131.4, 128.7, 128.3, 127.2, 123.4, 116.6, 116.2, 113.1. MS (EI) *m/z*: 263, 230, 186, 159, 103, 77, 43. HRMS (ESI): calcd for $C_{15}H_{10}N_3S$ $[M + H]^+$ 264.0590; found 264.0596.

*Methyl 3-(Phenylcarbonothioyl)imidazo[1,2-a]pyridine-7-carboxylate (**3p**).* Green solid (40 mg, 68%); mp 166−168 °C; R_f = 0.29 (ethyl acetate/petroleum ether = 1:2); ^{1}H NMR (400 MHz, $CDCl_3$): δ 10.74 (d, J = 7.2 Hz, 1H), 8.51 (s, 1H), 8.17 (s, 1H), 7.77 (dd, J = 7.2, 1.5 Hz, 1H), 7.65 (d, J = 7.3 Hz, 2H), 7.52 (d, J = 7.5 Hz, 1H), 7.43 (t, J = 7.6 Hz, 2H), 4.02 (s, 3H). $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$): δ 213.0, 164.5, 149.8, 148.4, 146.2, 134.7, 131.8, 130.9, 128.7, 128.2, 126.4, 119.8, 115.3, 52.9. MS (EI) *m/z*: 296, 281, 263, 219, 121, 102, 77, 41. HRMS (ESI): calcd for $C_{16}H_{13}N_2O_2S$ $[M + H]^+$ 297.0692; found 297.0697.

*(6,8-Dibromo-7-methylimidazo[1,2-a]pyridin-3-yl)(phenyl)-methanethione (**3q**).* Red solid (42 mg, 51%); mp 171−173 °C; R_f = 0.41 (ethyl acetate/petroleum ether = 1:5); ^{1}H NMR (400 MHz, $CDCl_3$): δ 10.96 (s, 1H), 8.05 (s, 1H), 7.63 (d, J = 7.3 Hz, 2H), 7.53 (t, J = 7.4 Hz, 1H), 7.42 (t, J = 7.6 Hz, 2H), 2.75 (s, 3H). $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$): δ 212.4, 148.2, 147.9, 144.9, 141.8, 135.1, 131.0, 128.7, 128.2, 125.6, 113.8, 113.1, 23.6. MS (EI) *m/z*: 409, 377, 333, 249, 165, 145, 125, 121, 102, 90, 77, 51. Anal. Calcd for $C_{15}H_{10}Br_2N_2S$: C, 43.93; H, 2.46; N, 6.83; Found: C, 43.70; H, 2.53; N, 6.77.

*Imidazo[1,2-a]pyridin-3-yl(p-tolyl)methanethione (**4a**).* Red solid (44 mg, 87%); mp 153−155 °C; R_f = 0.42 (ethyl acetate/petroleum ether = 1:2); ^{1}H NMR (400 MHz, $CDCl_3$): δ 10.80 (d, J = 6.9 Hz, 1H), 8.11 (s, 1H), 7.85 (d, J = 8.8 Hz, 1H), 7.67 (t, J = 7.9 Hz, 1H), 7.57 (d, J = 8.0 Hz, 2H), 7.21 (t, J = 7.0 Hz, 3H), 2.41 (s, 3H). $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$): δ 211.0, 150.7, 146.0, 145.6, 141.2, 134.6, 131.2, 128.9, 128.7, 127.0, 117.9, 116.0, 21.3. MS (EI) *m/z*: 252, 219, 161, 78, 51. HRMS (ESI): calcd for $C_{15}H_{13}N_2S$ $[M + H]^+$ 253.0794; found 253.0792.

*Imidazo[1,2-a]pyridin-3-yl(m-tolyl)methanethione (**4b**).* Red solid (42 mg, 84%); mp 110−112 °C; R_f = 0.52 (ethyl acetate/petroleum ether = 1:2); ^{1}H NMR (400 MHz, $CDCl_3$): δ 10.82 (d, J = 6.9 Hz, 1H), 8.09 (s, 1H), 7.84 (d, J = 8.8 Hz, 1H), 7.70−7.65 (m, 1H), 7.45 (s, 1H), 7.40 (dd, J = 6.3, 1.8 Hz, 1H), 7.29 (d, J = 6.3 Hz, 2H), 7.21 (td, J = 6.9, 1.1 Hz, 1H), 2.39 (s, 3H). $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$): δ 211.4, 150.8, 148.5, 145.9, 137.8, 134.7, 131.4, 131.2, 129.3, 127.8, 127.0, 125.8, 117.9, 116.2, 21.2. MS (EI) *m/z*: 252, 237, 219, 161, 126, 91, 78, 51. HRMS (ESI): calcd for $C_{15}H_{13}N_2S$ $[M + H]^+$ 253.0794; found 253.0799.

*Imidazo[1,2-a]pyridin-3-yl(o-tolyl)methanethione (**4c**).* Red solid (41 mg, 81%); mp 129−131 °C; R_f = 0.52 (ethyl acetate/petroleum ether = 1:2); ^{1}H NMR (400 MHz, $CDCl_3$): δ 11.00 (d, J = 6.9 Hz, 1H), 7.88−7.83 (m, 2H), 7.75−7.70 (m, 1H), 7.30 (ddd, J = 7.8, 4.8, 2.1 Hz, 2H), 7.23 (dd, J = 4.0, 3.3 Hz, 3H), 2.23 (s, 3H). $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$): δ 212.8, 150.8, 147.8, 146.1, 134.8, 133.1, 131.8, 130.4, 128.4, 127.1, 127.1, 125.4, 118.0, 116.7, 19.3. MS (EI) *m/z*: 252, 219, 161, 134, 115, 79, 51. Anal. Calcd for $C_{15}H_{12}N_2S$: C, 71.40; H, 4.79; N, 11.10; Found: C, 71.12; H, 4.86; N, 11.05.

*(3,5-Dimethylphenyl)(imidazo[1,2-a]pyridin-3-yl)methanethione (**4d**).* Red solid (44 mg, 83%); mp 129−131 °C; R_f = 0.50 (ethyl acetate/petroleum ether = 1:2); ^{1}H NMR (400 MHz, $CDCl_3$): δ

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10.81 (d, J = 6.9 Hz, 1H), 8.10 (s, 1H), 7.83 (d, J = 8.8 Hz, 1H), 7.69−7.63 (m, 1H), 7.24 (s, 2H), 7.20 (t, J = 6.9 Hz, 1H), 7.13 (s, 1H), 2.35 (s, 6H). $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$): δ 211.6, 150.7, 148.6, 145.8, 137.5, 134.6, 132.1, 131.3, 126.9, 126.5, 117.8, 116.0, 21.1. MS (EI) m/z: 266, 233, 161, 78, 51. HRMS (ESI): calcd for $C_{16}H_{15}N_2S$ $[M + H]^+$ 267.0950; found 267.0946.

(4-(tert-Butyl)phenyl)(imidazo[1,2-a]pyridin-3-yl)methanethione ***(4e)***. Red solid (46 mg, 78%); mp 120−122 °C; R_f = 0.52 (ethyl acetate/petroleum ether = 1:2); ^1H NMR (400 MHz, $CDCl_3$): δ 10.82 (d, J = 6.9 Hz, 1H), 8.14 (s, 1H), 7.85 (d, J = 8.8 Hz, 1H), 7.70−7.65 (m, 1H), 7.61 (d, J = 8.4 Hz, 2H), 7.43 (d, J = 8.4 Hz, 2H), 7.21 (td, J = 6.9, 1.0 Hz, 1H), 1.36 (s, 9H). $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$): δ 211.0, 154.2, 150.7, 145.9, 145.7, 134.6, 131.2, 128.7, 127.0, 125.0, 117.9, 116.0, 34.8, 31.1. MS (EI) m/z: 294, 279, 263, 237, 161, 125, 78, 51. HRMS (ESI): calcd for $C_{18}H_{19}N_2S$ $[M + H]^+$ 295.1263; found 295.1257.

[1,1′-Biphenyl]-4-yl(imidazo[1,2-a]pyridin-3-yl)methanethione ***(4f)***. Red solid (47 mg, 75%); mp 172−174 °C; R_f = 0.45 (ethyl acetate/petroleum ether = 1:2); ^1H NMR (400 MHz, $CDCl_3$): δ 10.84 (d, J = 6.9 Hz, 1H), 8.19 (s, 1H), 7.88 (d, J = 8.8 Hz, 1H), 7.75 (d, J = 8.2 Hz, 2H), 7.71 (d, J = 7.9 Hz, 1H), 7.65 (d, J = 6.9 Hz, 4H), 7.48 (t, J = 7.5 Hz, 2H), 7.40 (t, J = 7.3 Hz, 1H), 7.27−7.21 (m, 1H). $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$): δ 210.2, 150.8, 147.2, 145.7, 143.4, 139.9, 134.7, 131.4, 129.3, 128.8, 127.8, 127.0, 127.0, 126.7, 118.0, 116.2. MS (EI) m/z: 314, 281, 161, 78, 44. Anal. Calcd for $C_{20}H_{14}N_2S$: C, 76.40; H, 4.49; N, 8.91; Found: C, 76.03; H, 4.58; N, 8.82.

Imidazo[1,2-a]pyridin-3-yl(naphthalen-1-yl)methanethione ***(4g)***. Red solid (44 mg, 76%); mp 163−165 °C; R_f = 0.33 (ethyl acetate/petroleum ether = 1:3); ^1H NMR (400 MHz, $CDCl_3$): δ 11.10 (d, J = 6.3 Hz, 1H), 7.88 (dd, J = 18.6, 9.7 Hz, 4H), 7.78 (s, 1H), 7.72 (t, J = 7.8 Hz, 1H), 7.50 (td, J = 15.1, 7.4 Hz, 3H), 7.38 (t, J = 7.5 Hz, 1H), 7.29 (t, J = 6.9 Hz, 1H). $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$): δ 210.8, 150.8, 146.6, 145.5, 135.5, 133.4, 131.9, 130.2, 128.8, 128.0, 127.1, 126.5, 126.0, 125.3, 124.8, 124.6, 118.0, 116.8. MS (EI) m/z: 288, 255, 209, 161, 144, 127, 78, 51. HRMS (ESI): calcd for $C_{18}H_{13}N_2S$ $[M + H]^+$ 289.0794; found 289.0797.

Imidazo[1,2-a]pyridin-3-yl(4-methoxyphenyl)methanethione ***(4h)***. Red solid (29 mg, 55%); mp 160−162 °C; R_f = 0.35 (ethyl acetate/petroleum ether = 1:2); ^1H NMR (400 MHz, $CDCl_3$): δ 10.71 (d, J = 6.9 Hz, 1H), 8.10 (s, 1H), 7.86 (d, J = 8.8 Hz, 1H), 7.68 (dd, J = 18.3, 8.4 Hz, 3H), 7.21 (t, J = 6.9 Hz, 1H), 6.94 (d, J = 8.7 Hz, 2H), 3.89 (s, 3H). $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$): δ 209.8, 162.3, 150.7, 145.1, 141.5, 134.5, 131.1, 131.0, 127.0, 117.9, 115.8, 113.4, 55.5. MS (EI) m/z: 268, 252, 235, 224, 192, 161, 134, 112, 89, 78, 51. Anal. Calcd for $C_{15}H_{12}N_2OS$: C, 67.14; H, 4.51; N, 10.44; Found: C, 66.80; H, 4.62; N, 10.51.

Benzo[d][1,3]dioxol-5-yl(imidazo[1,2-a]pyridin-3-yl)-methanethione ***(4i)***. Red solid (37 mg, 65%); mp 195−197 °C; R_f = 0.33 (ethyl acetate/petroleum ether = 1:2); ^1H NMR (400 MHz, $CDCl_3$): δ 10.63 (dt, J = 7.0, 1.1 Hz, 1H), 8.06 (s, 1H), 7.83−7.73 (m, 1H), 7.64−7.57 (m, 1H), 7.23 (d, J = 1.8 Hz, 1H), 7.17−7.11 (m, 2H), 6.76 (d, J = 8.1 Hz, 1H), 5.99 (s, 2H). $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$): δ 209.1, 150.8, 150.4, 147.8, 145.2, 143.0, 134.6, 131.1, 127.0, 124.1, 118.0, 115.9, 109.9, 107.4, 101.8. MS (EI) m/z: 282, 249, 223, 179, 161, 141, 112, 90, 78, 51. HRMS (ESI): calcd for $C_{15}H_{11}N_2O_2S$ $[M + H]^+$ 283.0536; found 283.0536.

(4-Fluorophenyl)(imidazo[1,2-a]pyridin-3-yl)methanethione ***(4j)***. Red solid (41 mg, 81%); mp 165−167 °C; R_f = 0.22 (ethyl acetate/petroleum ether = 1:3); ^1H NMR (400 MHz, $CDCl_3$): δ 10.77 (d, J = 6.9 Hz, 1H), 8.07 (s, 1H), 7.85 (d, J = 8.8 Hz, 1H), 7.72−7.67 (m, 1H), 7.67−7.62 (m, 2H), 7.23 (td, J = 6.9, 1.0 Hz, 1H), 7.13−7.06 (m, 2H). $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$): δ 208.9, 164.2 (d, J = 251 Hz), 150.9, 145.6, 144.6 (d, J = 3 Hz), 134.68 131.6, 130.7 (d, J = 9 Hz), 126.9, 118.0, 116.3, 115.1 (d, J = 22 Hz). MS (EI) m/z: 256, 223, 161, 128, 95, 78, 51. Anal. Calcd for $C_{14}H_9FN_2S$: C, 65.61; H, 3.54; N, 10.93; Found: C, 65.40; H, 3.59; N, 10.88.

(4-Chlorophenyl)(imidazo[1,2-a]pyridin-3-yl)methanethione ***(4k)***. Red solid (46 mg, 85%); mp 179−181 °C; R_f = 0.50 (ethyl acetate/petroleum ether = 1:2); ^1H NMR (400 MHz, $CDCl_3$): δ 10.79 (d, J = 6.9 Hz, 1H), 8.08 (s, 1H), 7.87 (d, J = 8.8 Hz, 1H), 7.74−7.68 (m, 1H), 7.60−7.55 (m, 2H), 7.39 (d, J = 8.4 Hz, 2H), 7.27−7.22 (m, 1H). $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$): δ 208.8, 150.9, 146.7, 145.7, 136.7, 134.6, 131.7, 129.9, 128.3, 126.9, 118.0, 116.4. MS (EI) m/z: 272, 239, 161, 136, 118, 78, 51. Anal. Calcd for $C_{14}H_9ClN_2S$: C, 61.65; H, 3.33; N, 10.27; Found: C, 61.32; H, 3.42; N, 10.35.

(3,5-Difluorophenyl)(imidazo[1,2-a]pyridin-3-yl)methanethione ***(4l)***. Red solid (35 mg, 63%); mp 185−187 °C; R_f = 0.30 (ethyl acetate/petroleum ether = 1:3); ^1H NMR (400 MHz, $CDCl_3$): δ 10.81 (dt, J = 7.0, 1.0 Hz, 1H), 8.12 (s, 1H), 7.92−7.87 (m, 1H), 7.79−7.74 (m, 1H), 7.29 (td, J = 7.0, 1.2 Hz, 1H), 7.19−7.13 (m, 2H), 6.94 (tt, J = 8.7, 2.3 Hz, 1H). $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$): δ 206.2, 162.2 (dd, J = 249, 12 Hz), 151.2, 150.6 (t, J = 9 Hz), 146.0, 134.6, 132.2, 127.0, 118.2, 116.8, 111.7 (d, J = 26 Hz), 105.3 (t, J = 25 Hz). MS (EI) m/z: 274, 241, 161, 137, 113, 78, 51. HRMS (ESI): calcd for $C_{14}H_9F_2N_2S$ $[M + H]^+$ 275.0449; found 275.0443.

(3,4-Difluorophenyl)(imidazo[1,2-a]pyridin-3-yl)methanethione ***(4m)***. Red solid (39 mg, 72%); mp 170−172 °C; R_f = 0.37 (ethyl acetate/petroleum ether = 1:2); ^1H NMR (400 MHz, $CDCl_3$): δ 10.77 (d, J = 6.9 Hz, 1H), 8.10 (s, 1H), 7.89 (d, J = 8.8 Hz, 1H), 7.76−7.71 (m, 1H), 7.57−7.50 (m, 1H), 7.39 (ddd, J = 8.1, 3.9, 1.8 Hz, 1H), 7.30−7.26 (m, 1H), 7.25−7.18 (m, 1H). $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$): δ 206.9, 151.9 (dd, J = 252, 12 Hz), 151.1, 149.8 (dd, J = 249, 13 Hz), 145.7, 145.0 (dd, J = 5, 4 Hz), 134.7, 131.9, 127.0, 124.9 (dd, J = 6, 3 Hz), 118.2, 118.2 (d, J = 19 Hz), 116.8 (d, J = 18 Hz), 116.6. MS (EI) m/z: 274, 241, 161, 137, 78, 51. HRMS (ESI): calcd for $C_{14}H_9F_2N_2S$ $[M + H]^+$ 275.0449; found 275.0460.

Imidazo[1,2-a]pyridin-3-yl(3-(trifluoromethyl)phenyl)-methanethione ***(4n)***. Red solid (51 mg, 84%); mp 126−128 °C; R_f = 0.47 (ethyl acetate/petroleum ether = 1:2); ^1H NMR (400 MHz, $CDCl_3$): δ 10.85−10.79 (m, 1H), 8.05 (s, 1H), 7.88 (dd, J = 5.1, 3.5 Hz, 2H), 7.80−7.71 (m, 3H), 7.55 (t, J = 7.8 Hz, 1H), 7.30−7.25 (m, 1H). $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$): δ 208.0, 151.0, 148.7, 145.9, 134.8, 132.1, 131.5, 130.5 (q, J = 33 Hz), 128.6, 126.9, 126.7 (q, J = 4 Hz), 125.2 (q, J = 4 Hz), 123.6 (q, J = 271 Hz), 118.1, 116.7. MS (EI) m/z: 306, 273, 161, 78, 51. Anal. Calcd for $C_{15}H_9F_3N_2S$: C, 58.82; H, 2.96; N, 9.15; Found: C, 58.54; H, 3.05; N, 9.22.

1-(4-(Imidazo[1,2-a]pyridine-3-carbonothioyl)phenyl)ethanone ***(4o)***. Green solid (45 mg, 81%); mp 159−161 °C; R_f = 0.28 (ethyl acetate/petroleum ether = 1:1); ^1H NMR (400 MHz, $CDCl_3$): δ 10.83 (d, J = 6.6 Hz, 1H), 8.04 (s, 1H), 7.98 (d, J = 7.9 Hz, 2H), 7.86 (d, J = 8.7 Hz, 1H), 7.72 (t, J = 7.8 Hz, 1H), 7.66 (d, J = 7.9 Hz, 2H), 7.26 (t, J = 6.6 Hz, 1H), 2.63 (s, 3H). $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$): δ 208.7, 197.3, 151.9, 150.9, 146.0, 137.7, 134.7, 132.0, 128.5, 128.0, 126.9, 118.0, 116.7, 26.7. MS (EI) m/z: 280, 236, 161, 132, 118, 89, 78, 51. HRMS (ESI): calcd for $C_{16}H_{12}N_2NaOS$ $[M + Na]^+$ 303.0563; found 303.0559.

Methyl 4-(Imidazo[1,2-a]pyridine-3-carbonothioyl)benzoate ***(4p)***. Red solid (41 mg, 70%); mp 180−182 °C; R_f = 0.37 (ethyl acetate/petroleum ether = 1:2); ^1H NMR (400 MHz, $CDCl_3$): δ 10.86 (d, J = 6.9 Hz, 1H), 8.11−8.05 (m, 3H), 7.89 (d, J = 8.8 Hz, 1H), 7.77−7.72 (m, 1H), 7.66 (d, J = 8.4 Hz, 2H), 7.28 (td, J = 7.1, 1.2 Hz, 1H), 3.96 (s, 3H). $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$): δ 209.0, 166.3, 151.9, 146.0, 134.7, 132.0, 131.2, 129.3, 128.6, 128.3, 127.0, 118.1, 116.6, 52.3. MS (EI) m/z: 296, 280, 263, 236, 161, 132, 118, 89, 78, 51. Anal. Calcd for $C_{16}H_{12}N_2O_2S$: C, 64.85; H, 4.08; N, 9.45; Found: C, 64.59; H, 4.17; N, 9.51.

Imidazo[1,2-a]pyridin-3-yl(thiophen-2-yl)methanethione ***(4q)***. Red solid (37 mg, 75%); mp 180−182 °C; R_f = 0.31 (ethyl acetate/petroleum ether = 1:2); ^1H NMR (400 MHz, $CDCl_3$): δ 10.30 (dt, J = 7.0, 1.1 Hz, 1H), 8.25 (s, 1H), 7.76 (dt, J = 8.9, 1.1 Hz, 1H), 7.64 (dd, J = 5.1, 1.2 Hz, 1H), 7.57−7.52 (m, 1H), 7.44 (dd, J = 3.8, 1.2 Hz, 1H), 7.09 (ddd, J = 11.3, 5.0, 1.2 Hz, 2H). $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$): δ 197.8, 154.5, 150.7, 143.6, 134.8, 133.2, 130.7, 129.3, 128.1, 126.9, 117.9, 115.4. MS (EI) m/z: 244, 211, 161, 122, 100, 78, 51. HRMS (ESI): calcd for $C_{12}H_9N_2S_2$ $[M + H]^+$ 245.0202; found 245.0201.

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*(7-Methoxyimidazo[1,2-a]pyridin-3-yl)(o-tolyl)methanethione (**4r**).* Red solid (50 mg, 88%); mp 120−122 °C; R_f = 0.24 (ethyl acetate/petroleum ether = 1:3); ^{1}H NMR (400 MHz, $CDCl_3$): δ 10.80 (d, J = 7.5 Hz, 1H), 7.71 (s, 1H), 7.28−7.24 (m, 1H), 7.22−7.18 (m, 3H), 7.12 (d, J = 2.6 Hz, 1H), 6.88 (dd, J = 7.6, 2.6 Hz, 1H), 3.93 (s, 3H), 2.23 (s, 3H). ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$): δ 209.4, 162.5, 153.6, 147.5, 146.9, 134.8, 133.1, 130.2, 128.3, 128.1, 127.1, 125.3, 109.3, 96.9, 55.9, 19.2. MS (EI) m/z: 282, 249, 206, 191, 134, 109, 79, 52. HRMS (ESI): calcd for $C_{16}H_{15}N_2OS$ $[M + H]^+$ 283.0900; found 283.0903.

*4-Chlorophenyl)(7-methoxyimidazo[1,2-a]pyridin-3-yl)-methanethione (**4s**).* Red solid (41 mg, 68%); mp 202−204 °C; R_f = 0.29 (ethyl acetate/petroleum ether = 1:3); ^{1}H NMR (400 MHz, $CDCl_3$): δ 10.66 (d, J = 7.6 Hz, 1H), 7.98 (s, 1H), 7.59−7.55 (m, 2H), 7.40−7.36 (m, 2H), 7.15 (d, J = 2.6 Hz, 1H), 6.88 (dd, J = 7.6, 2.6 Hz, 1H), 3.98 (s, 3H). ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$): δ 206.1, 162.7, 153.9, 146.7, 146.6, 136.4, 134.8, 129.9, 128.3, 128.2, 109.4, 96.9, 56.0. MS (EI) m/z: 302, 287, 269, 191, 176, 148, 108, 93, 69, 52. HRMS (ESI): calcd for $C_{15}H_{12}ClN_2OS$ $[M + H]^+$ 303.0353; found 303.0358.

*(6-Iodoimidazo[1,2-a]pyridin-3-yl)(o-tolyl)methanethione (**4t**).* Red solid (54 mg, 72%); mp 107−109 °C; R_f = 0.43 (ethyl acetate/petroleum ether = 1:3); ^{1}H NMR (400 MHz, $CDCl_3$): δ 11.27 (s, 1H), 7.89 (dd, J = 9.2, 1.6 Hz, 1H), 7.75 (s, 1H), 7.62 (d, J = 9.2 Hz, 1H), 7.33−7.28 (m, 1H), 7.21 (dd, J = 10.5, 5.2 Hz, 3H), 2.22 (s, 3H). ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$): δ 213.8, 149.3, 147.6, 145.3, 139.4, 133.8, 133.0, 131.6, 130.4, 128.5, 127.1, 125.5, 118.9, 80.2, 19.4. MS (EI) m/z: 378, 345, 249, 218. 160, 134, 125, 115, 89, 77, 51. HRMS (ESI): calcd for $C_{15}H_{12}IN_2S$ $[M + H]^+$ 378.9760; found 378.9765.

*(4-Chlorophenyl)(6-iodoimidazo[1,2-a]pyridin-3-yl)-methanethione (**4u**).* Red solid (52 mg, 65%); mp 165−167 °C; R_f = 0.56 (ethyl acetate/petroleum ether = 1:3); ^{1}H NMR (400 MHz, $CDCl_3$): δ 11.05 (d, J = 0.8 Hz, 1H), 8.01 (s, 1H), 7.89 (dd, J = 9.2, 1.6 Hz, 1H), 7.65 (d, J = 9.2 Hz, 1H), 7.57 (d, J = 8.5 Hz, 2H), 7.40 (d, J = 8.5 Hz, 2H). ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$): δ 209.8, 149.4, 146.5, 144.9, 139.4, 137.1, 133.8, 131.6, 129.9, 128.4, 118.9, 79.8. MS (EI) m/z: 397, 365, 287, 271, 235, 204, 160, 135, 118, 77, 50. HRMS (ESI): calcd for $C_{14}H_9ClIN_2S$ $[M + H]^+$ 398.9214; found 398.9218.

■ ASSOCIATED CONTENT

Supporting Information

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^{1}H and ^{13}C NMR spectra (PDF)

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