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(54) Titre : COMPOSITIONS ET METHODES POUR INHIBER LES KINASES
(54) Title: COMPOSITIONS AND METHODS FOR INHIBITING KINASES

MPTP Mouse Model: Compound 809 Summary

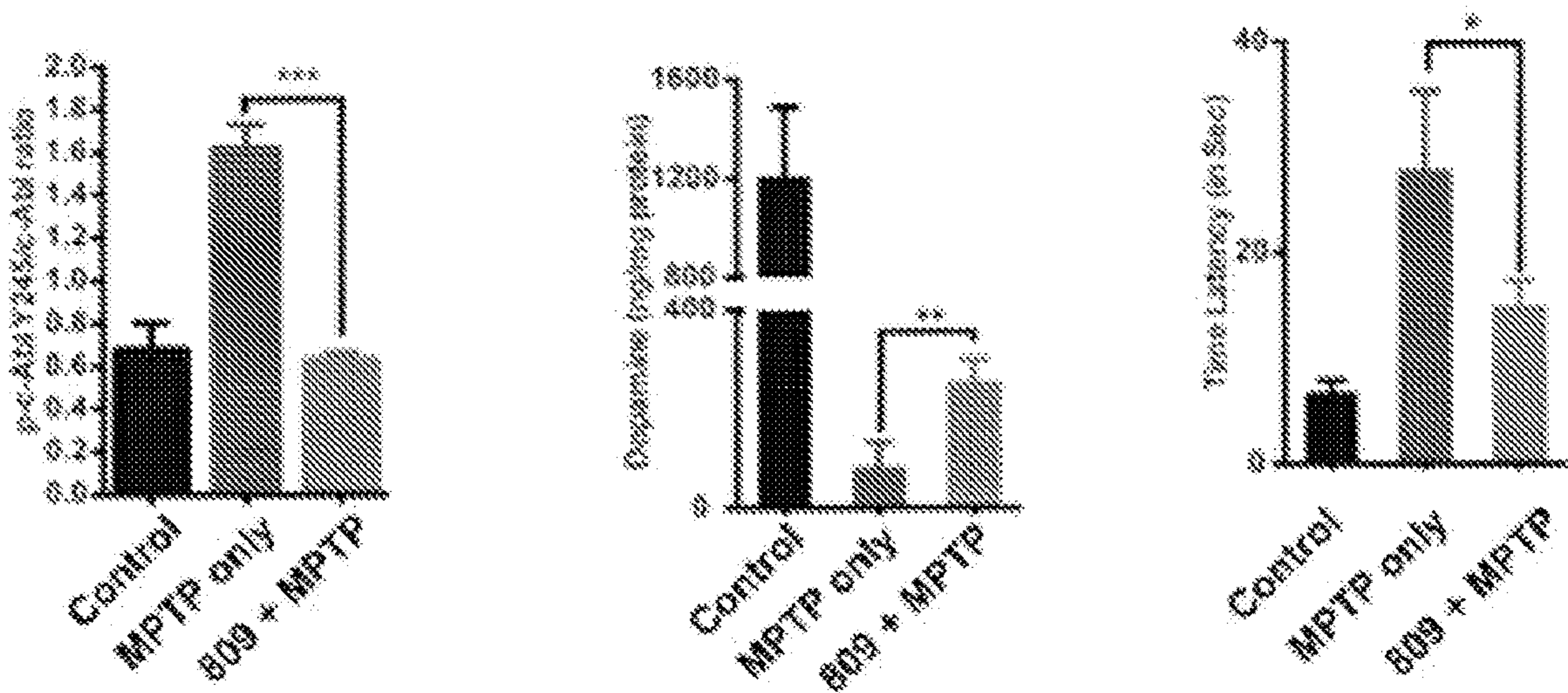


Figure 7

(57) **Abrégé/Abstract:**
The present invention provides methods for the prevention or treatment of Parkinson's Disease using Abelson-family tyrosine kinase inhibitors.

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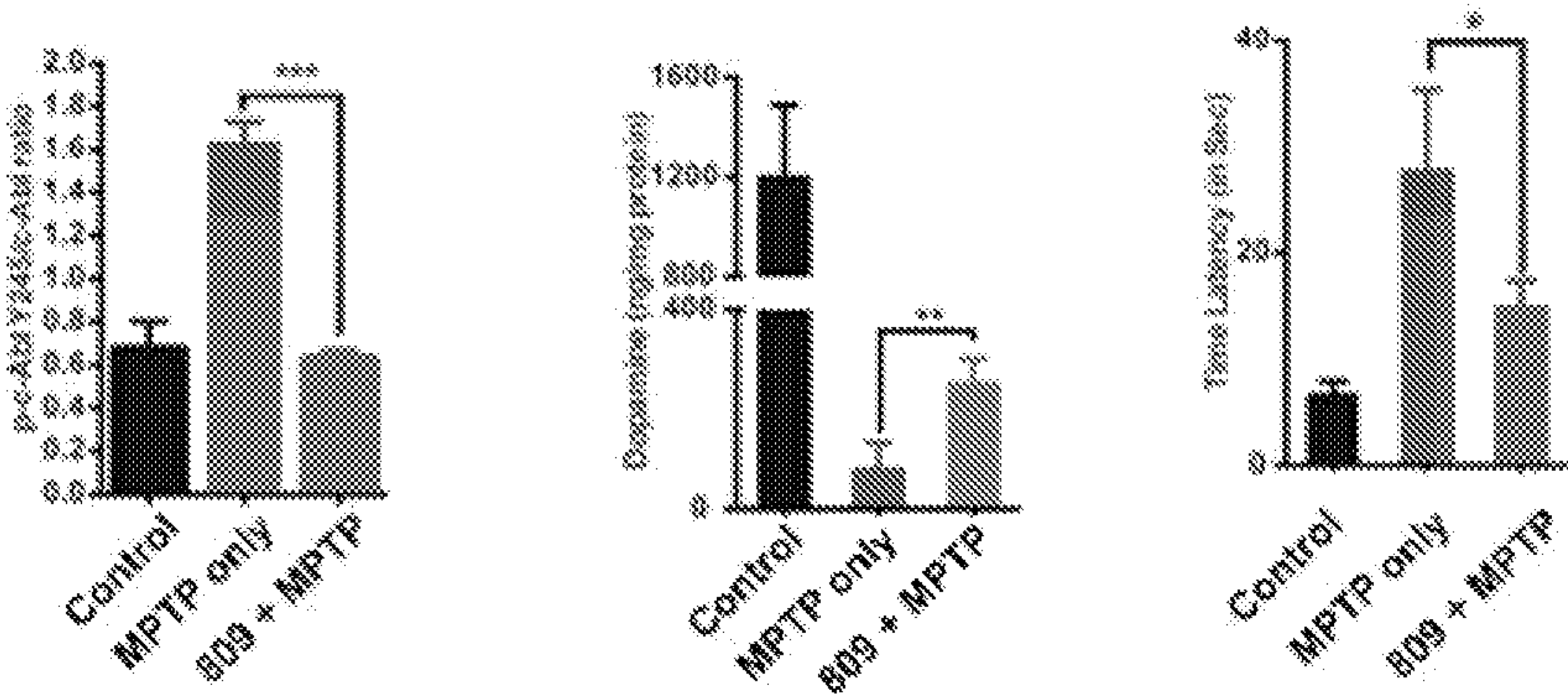


Figure 7

(57) Abstract: The present invention provides methods for the prevention or treatment of Parkinson's Disease using Abelson-family tyrosine kinase inhibitors.

COMPOSITIONS AND METHODS FOR INHIBITING KINASES

REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of U.S. Provisional Application No. 62/412600, filed October 25, 2016, the contents of which are fully incorporated by reference herein in
5 their entirety.

Background of the Invention

Parkinson's Disease

Parkinson's Disease is a progressive neurodegenerative disorder that affects approximately 1 million Americans and 7 to 10 million people worldwide. With people
10 living longer, more people are developing this common, debilitating neurological disorder. Parkinson's disease is characterized by disorders of movement, which are caused by the progressive loss of dopamine-secreting neurons in the substantia nigra pars compacta (SNpc), along with autonomic nervous system dysfunction, anxiety, depression, sleep disorders and cognitive impairment that are due to the degeneration and dysfunction of
15 other neuronal populations. To date there are no pharmaceutical therapies that impede or prevent the relentless neurodegeneration in PD. Although dopamine replacement alleviates symptomatic motor dysfunction, its effectiveness is reduced as the disease progresses, leading to unacceptable side effects, such as severe motor fluctuations and dyskinesias. Moreover, this palliative therapeutic approach does not address the underlying mechanisms
20 of the disease. Current treatments for PD are symptomatic therapies with many limitations.

Abelson-family tyrosine kinases (ATKs), such as c-Abl1, c-Abl2, c-Kit (also known as SCF), PDGFRa, and PGDFRb, collectively referred to as c-Abl hereafter, have been implicated in certain neurological diseases, including Parkinson's disease. For example, parkin is a protein that plays a role in targeting other proteins for degradation, and is
25 believed to have a protective function against Parkinson's disease. Aberrant activation of c-Abl can down-regulate parkin activity by phosphorylation. Thus ATK inhibitors may be useful as a therapy to prevent or treat Parkinson's disease. Similarly, c-Abl phosphorylation of alpha-synuclein both promotes aggregation of alpha-synuclein and is linked to the deleterious effects of alpha-synuclein on neurons in the brain.

30 The known ATK inhibitors, such as imatinib, were for the most part developed as cancer drugs, so measures of their risk:benefit ratio are skewed to higher risk when ATK inhibitors are applied to a life or death indication. A drug for Parkinson's Disease, on the

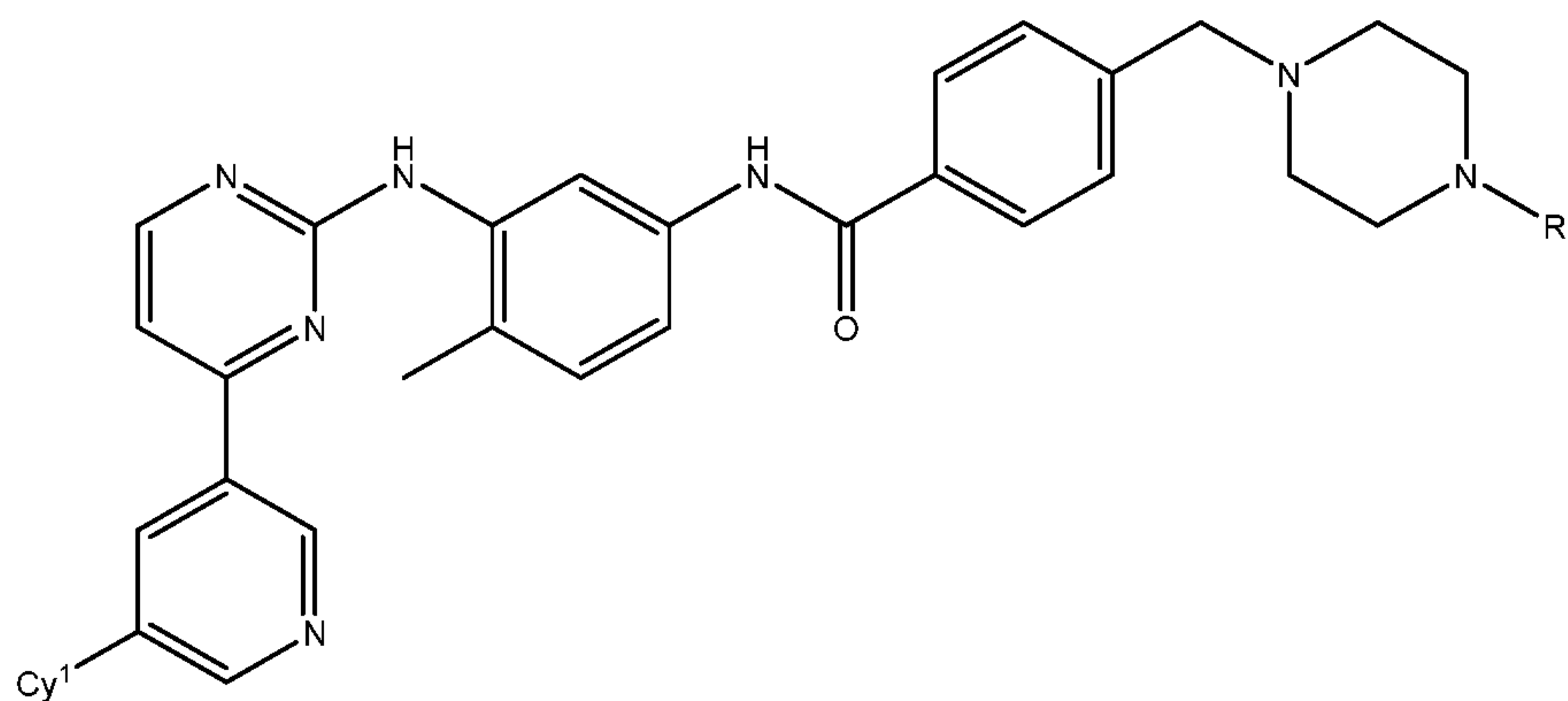
other hand, would have to meet a more stringent standard of risk:benefit because the side effects would be experienced by patients chronically, often over a period of several decades. Moreover, ability to cross the blood brain barrier is important for a therapeutic to treat Parkinson's disease, but not relevant to treat most cancers that can currently be treated
5 with ATK inhibitors.

The known ATK inhibitors imatinib and nilotinib appear effective in animal models of Parkinson's Disease (J. Neurosci. 31(1):157-163, doi 10.1523/JNEUROSCI.1833-10.2011; Scientific Reports 4:4874, doi 10.1038/srep04874). However, the brain penetration of nilotinib is only 0.5% by mass when considering the amount of drug that
10 crosses the blood brain barrier relative to the constant amount that exists in the blood. Another known ATK inhibitor, dasatinib, has a similar brain penetration. And imatinib's brain:blood ratio is just 5% by mass. All three drugs have serious side effects making them incompatible with their chronic use in Parkinson's patients.

Improved agents for treating Parkinson's Disease are needed.

15 Summary of the Invention

In certain aspects, the invention provides methods of treating or preventing Parkinson's Disease comprising administering a therapeutically effective amount of an ATK inhibitor. In certain embodiments, the ATK inhibitor is a compound represented by general formula (I) or a pharmaceutically acceptable salt thereof:



Formula (I)

wherein, independently for each occurrence,
R¹ is selected from hydrogen or lower alkyl; and

Cy¹ is selected from substituted or unsubstituted aryl, substituted or unsubstituted heteroaryl, and substituted or unsubstituted heterocyclyl, provided that Cy¹ is not unsubstituted pyrid-4-yl.

5 **Brief Description of the Drawings**

Figure 1 shows the experimental design of a study investigating certain compounds of the invention in a mouse model for Parkinson's disease.

Figure 2 shows the effects of certain compounds of the invention on body weight in the MPTP model for Parkinson's disease.

10 **Figure 3** shows the effects of certain compounds of the invention on pole test results in the MPTP model for Parkinson's disease.

Figure 4 shows the effects of certain compounds of the invention on dopamine levels in the MPTP model for Parkinson's disease.

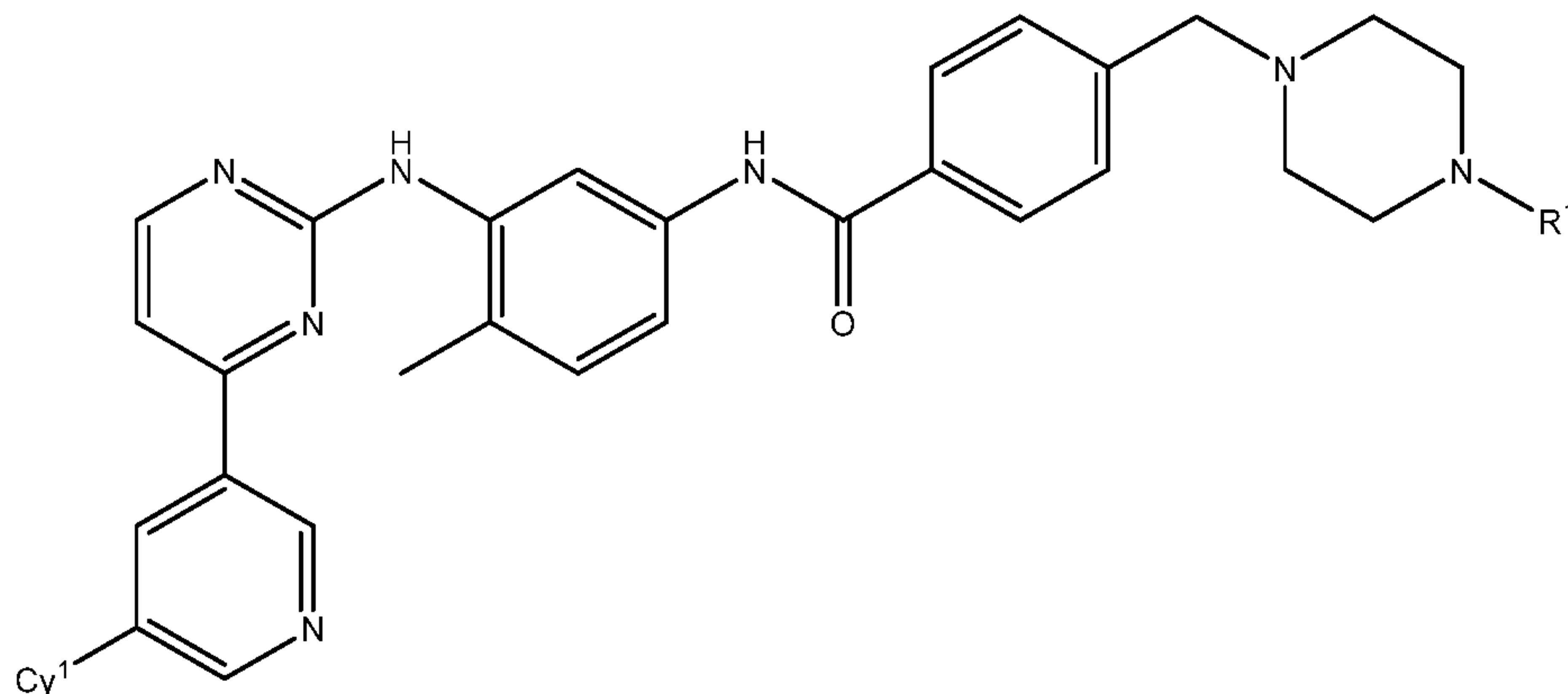
15 **Figure 5** shows the effects of certain compounds of the invention on certain metabolite levels in the MPTP model for Parkinson's disease.

Figure 6 shows the effects of certain compounds of the invention on dopamine turnover ratios in the MPTP model for Parkinson's disease.

20 **Figure 7** shows results from the MPTP model regarding (left) the effects of Compound 809 on c-Abl phosphorylation levels in the ventral midbrain; (center) the effects of Compound 809 on dopamine levels; and (right) the effects of Compound 809 on pole test latency.

Detailed Description of the Invention

In one aspect, the invention relates to compounds represented by formula (I) or a pharmaceutically acceptable salt thereof:



5

Formula (I)

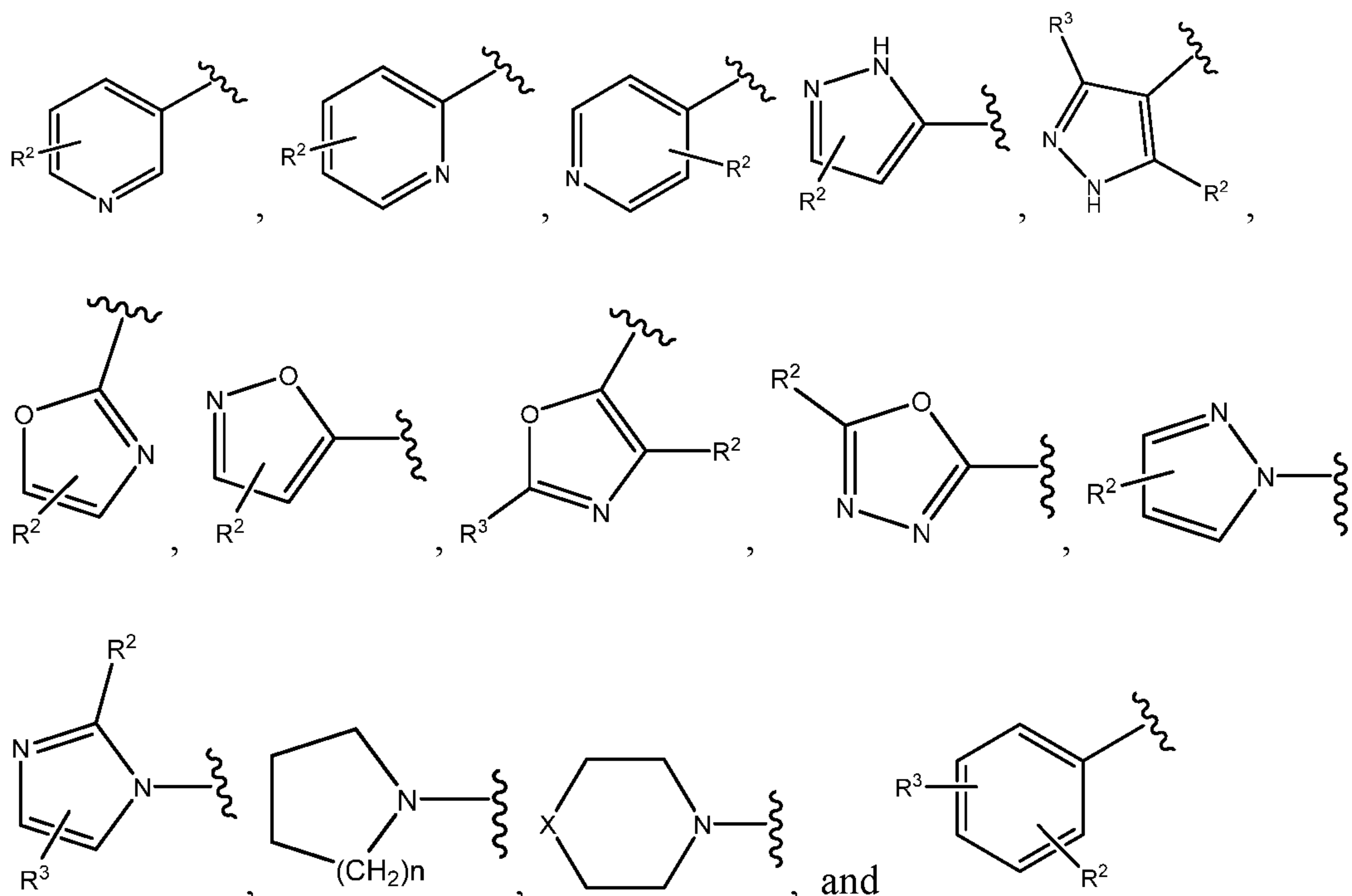
wherein, independently for each occurrence,

R¹ is selected from hydrogen or lower alkyl; and

Cy¹ is selected from substituted or unsubstituted aryl, substituted or unsubstituted heteroaryl, and substituted or unsubstituted heterocyclyl,

10 provided that Cy¹ is not unsubstituted pyrid-4-yl.

In certain embodiments, Cy¹ is selected from:



wherein, independently for each occurrence,

R^2 and R^3 are selected from hydrogen, alkyl, amino, monoalkylamino, dialkylamino, cycloalkyl, halo, cyano, alkoxy, $-C(O)OH$, and $-C(O)N(R^4)(R^4)$;

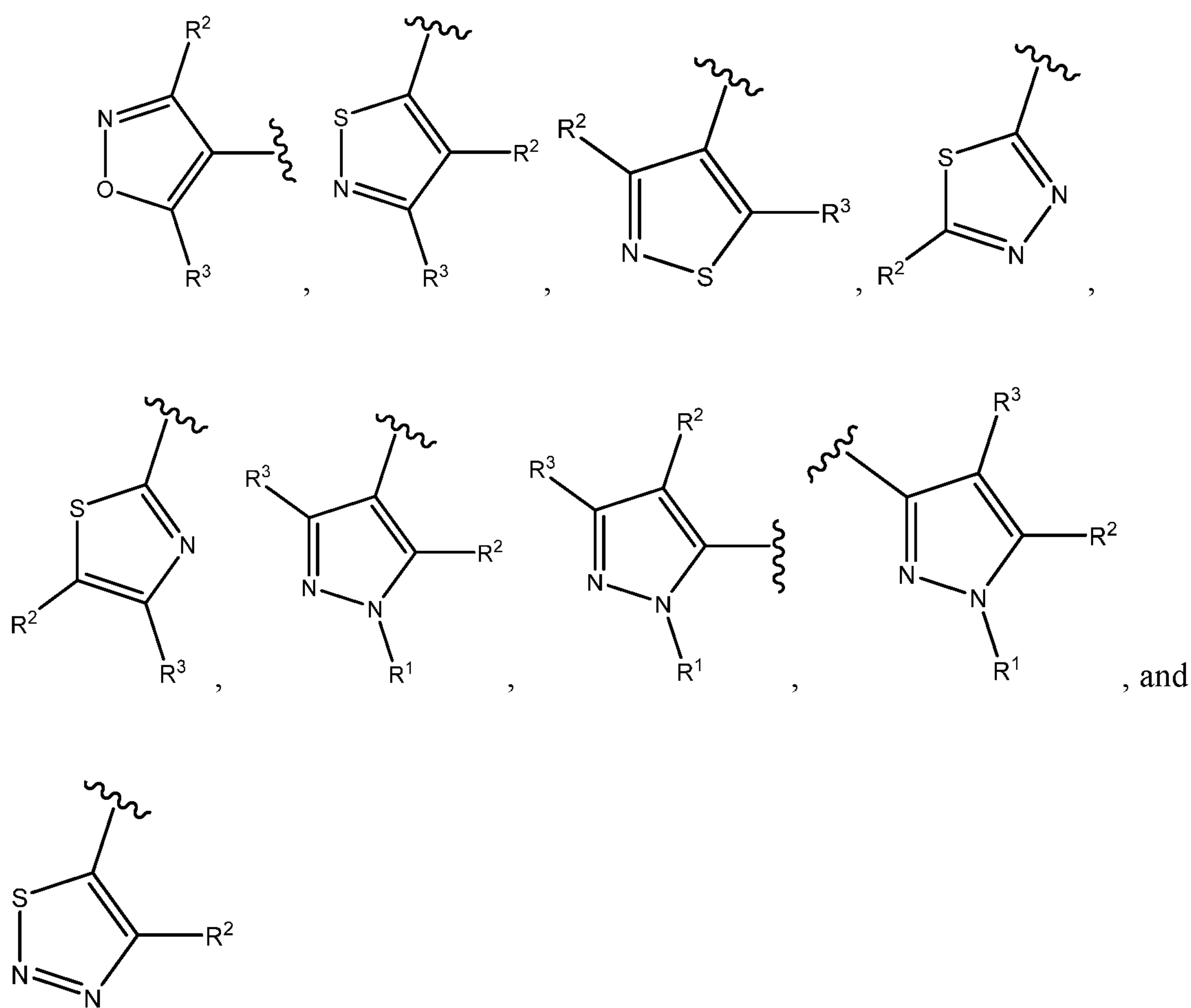
n is 1, 2, 3 or 4;

5 X is $C(R^4)_2$, S, O, or NR^4 ;

R^4 is selected from hydrogen and substituted or unsubstituted alkyl, aralkyl, cycloalkyl, heterocyclyl, aryl, heteroaryl, heteroaralkyl, cycloalkylalkyl, or heterocyclalkyl.

In certain embodiments, Cy^1 is selected from:

10



wherein, independently for each occurrence,

R^1 , each independently, is selected from hydrogen or lower alkyl;

R^2 and R^3 are selected from hydrogen, alkyl, amino, monoalkylamino, dialkylamino, cycloalkyl, halo, cyano, alkoxy, $-C(O)OH$, and $-C(O)N(R^4)(R^4)$;

R^4 is selected from hydrogen and substituted or unsubstituted alkyl, aralkyl, cycloalkyl, heterocyclyl, aryl, heteroaryl, heteroaralkyl, cycloalkylalkyl, or heterocyclalkyl.

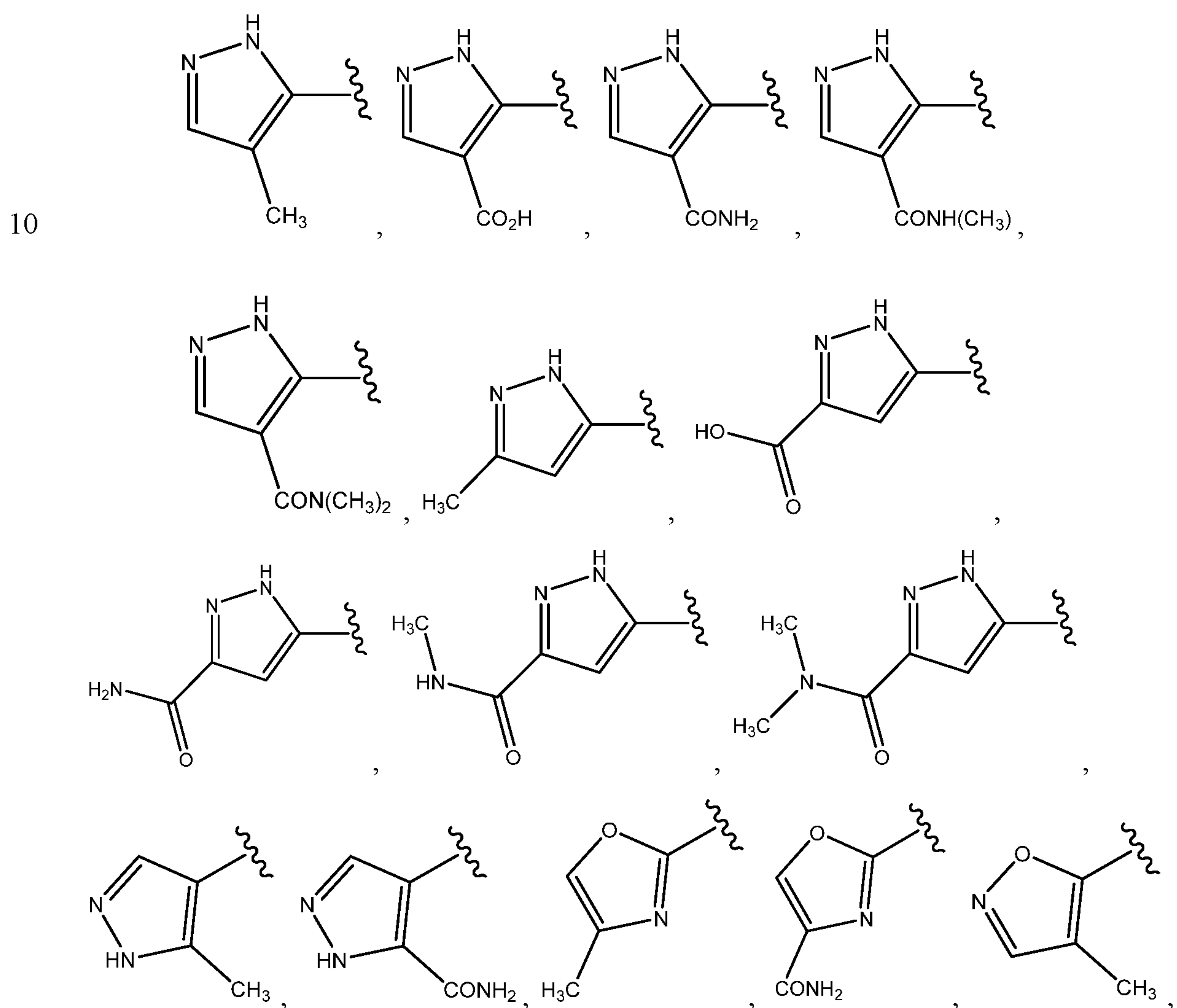
In certain embodiments, Cy^1 is not substituted or unsubstituted pyrid-4-yl.

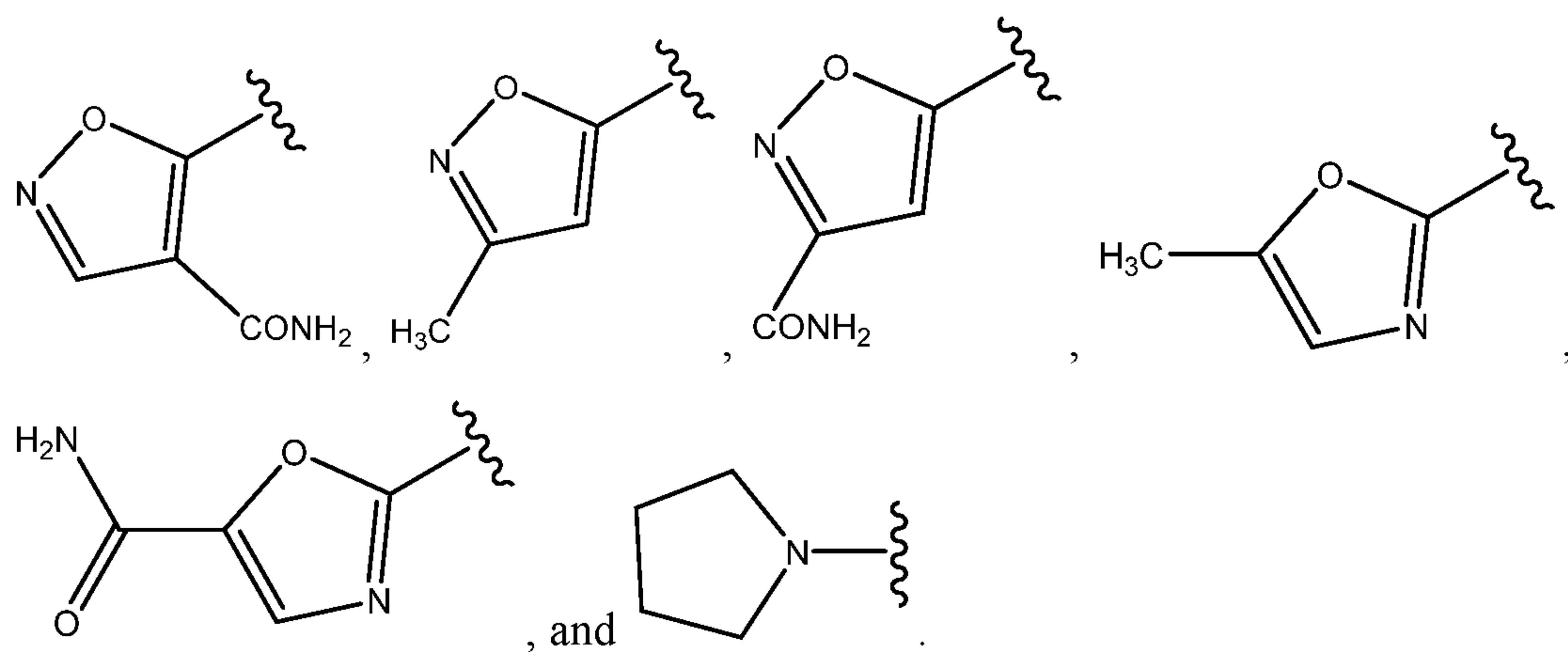
5 In certain embodiments, Cy^1 is not unsubstituted pyrid-4-yl or unsubstituted phenyl.

In certain embodiments, Cy^1 is not substituted or unsubstituted pyrid-4-yl or substituted or unsubstituted phenyl.

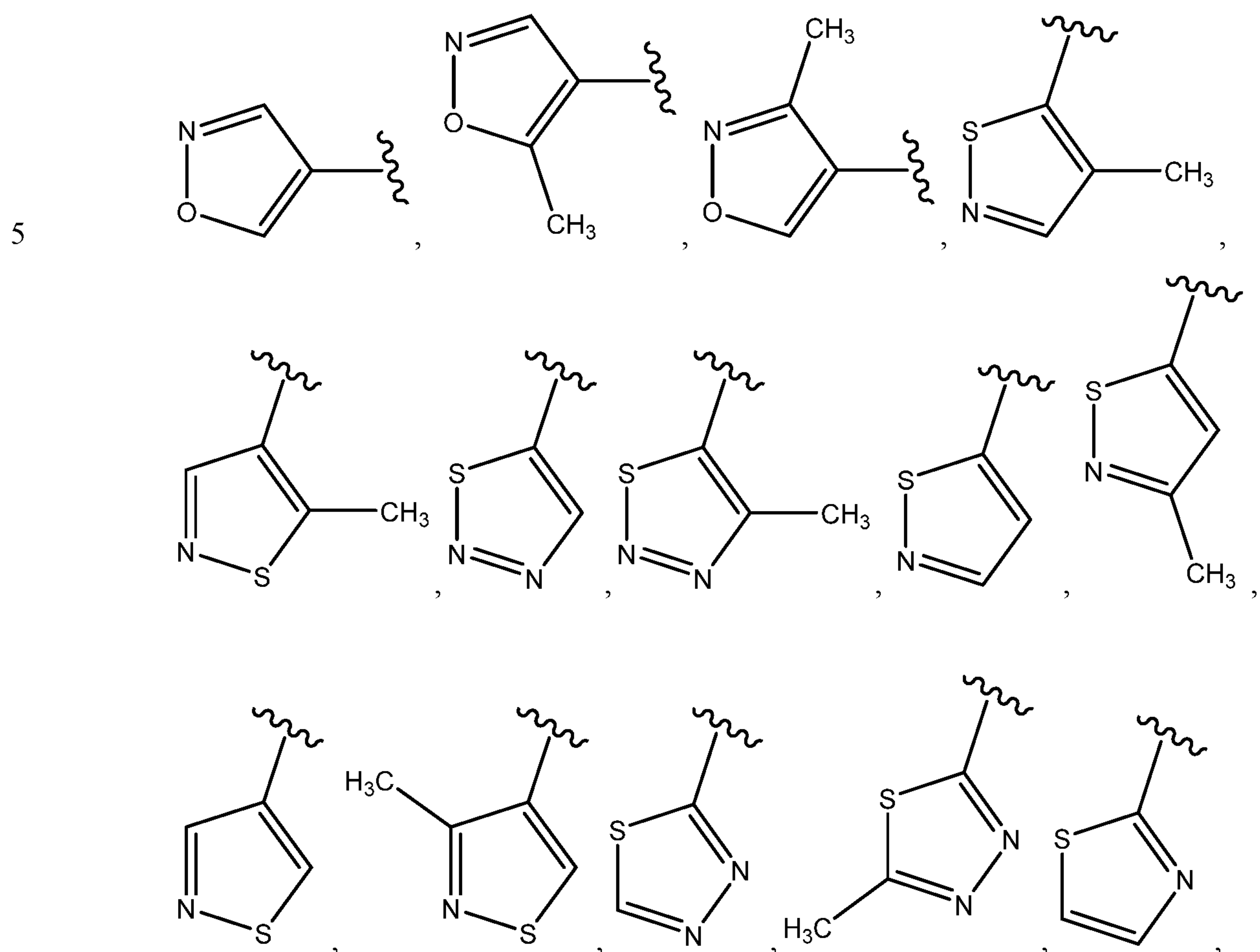
In certain embodiments, Cy^1 is 5-membered heteroaryl, aryl or heterocyclyl.

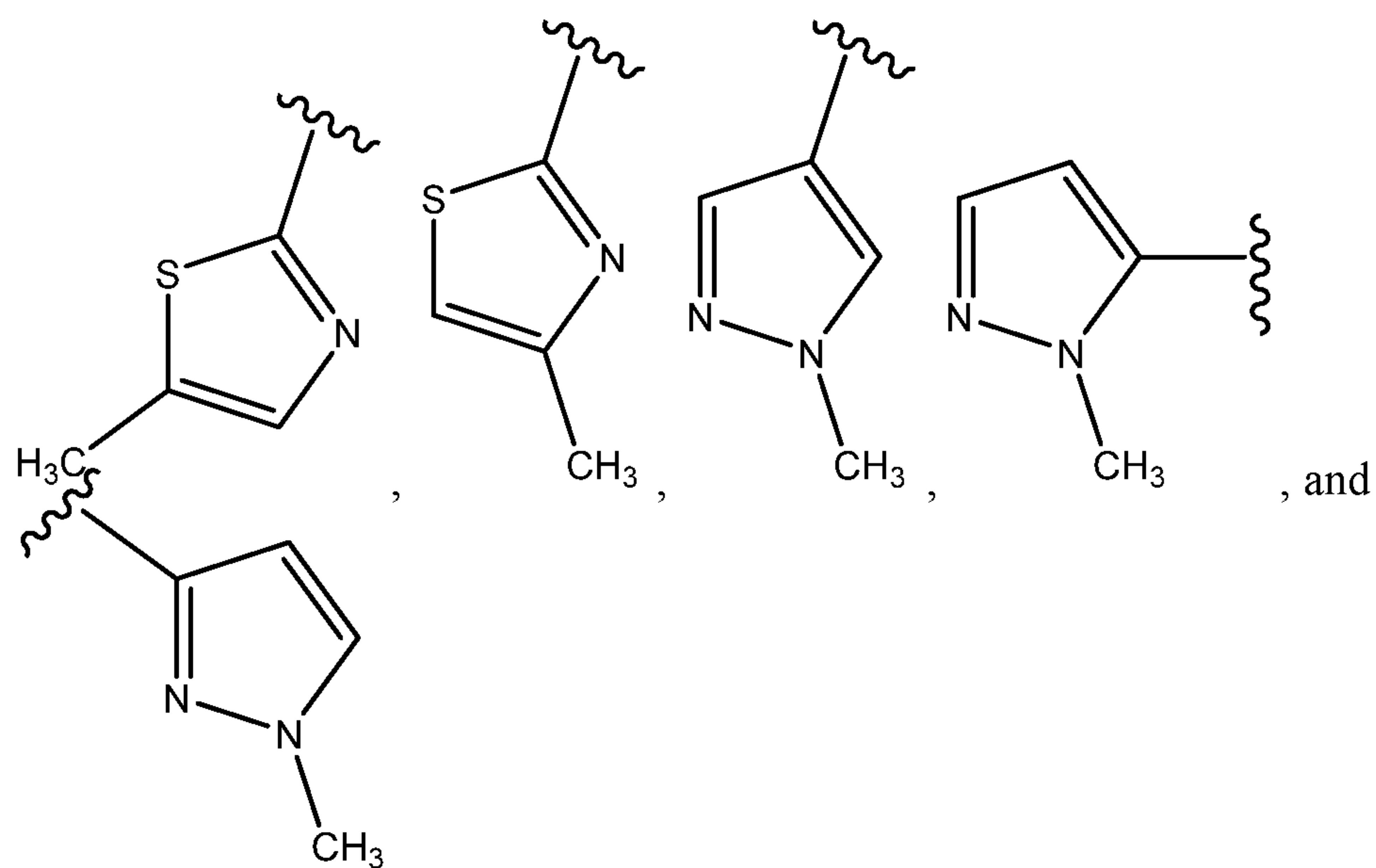
In certain embodiments, Cy^1 is selected from:



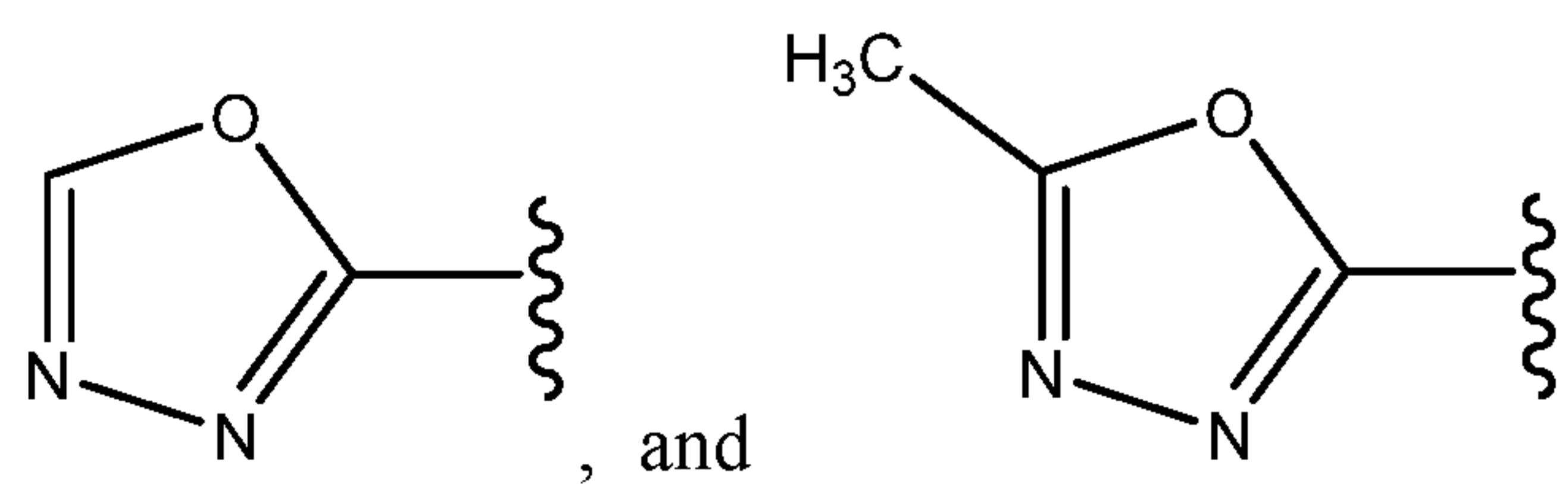


In certain embodiments, Cy¹ is selected from:

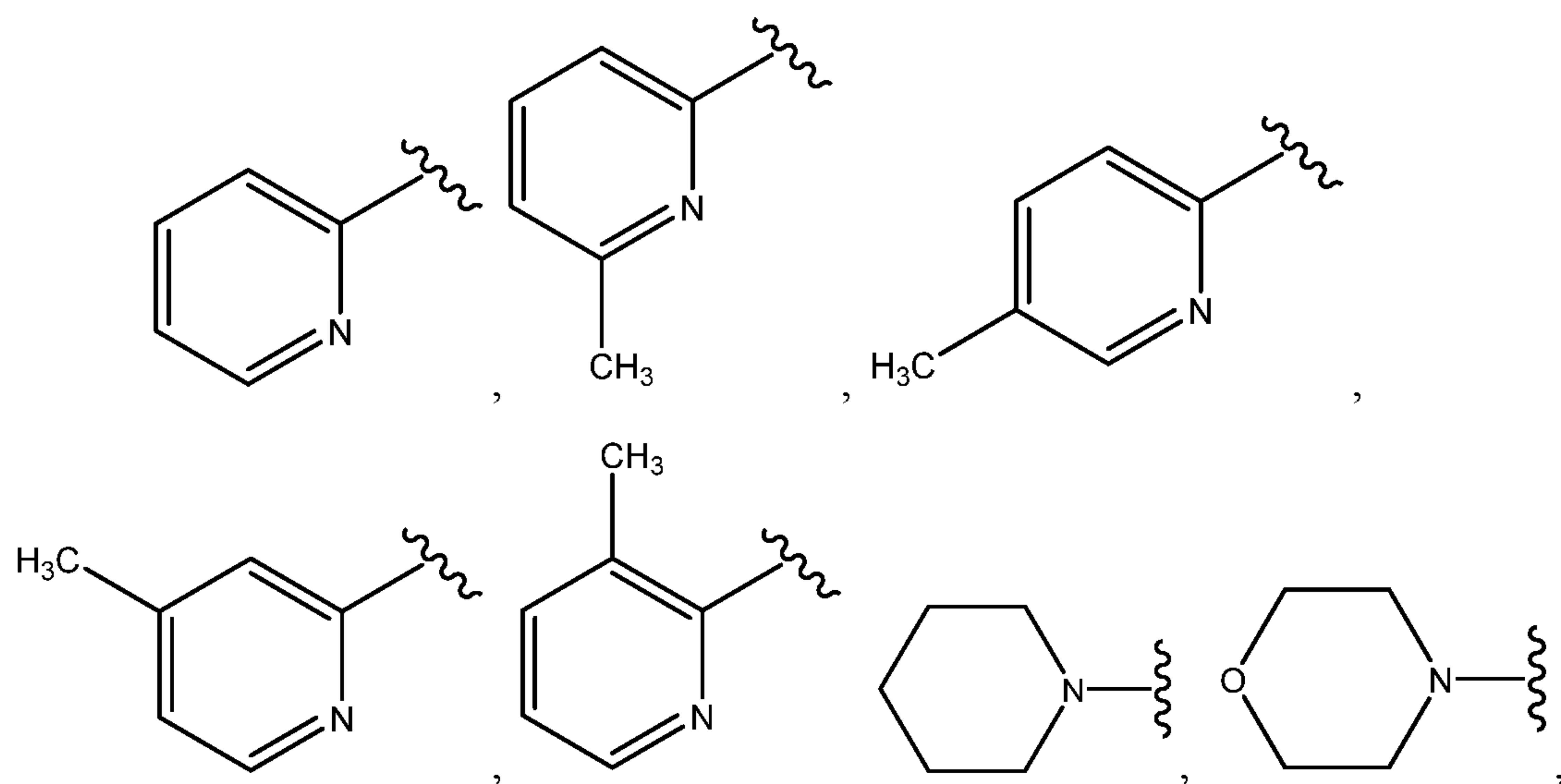


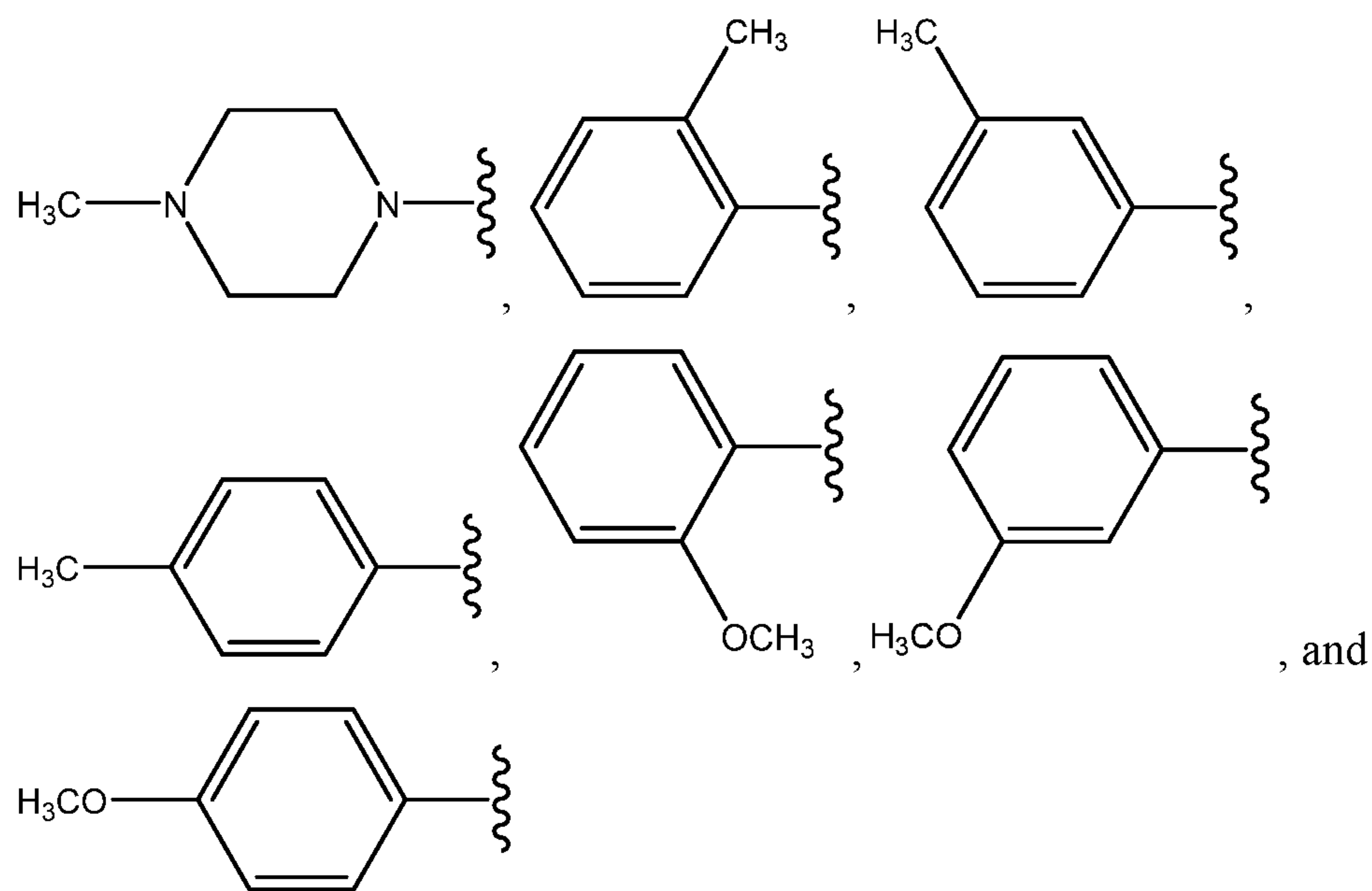


In certain embodiments, Cy¹ is selected from:



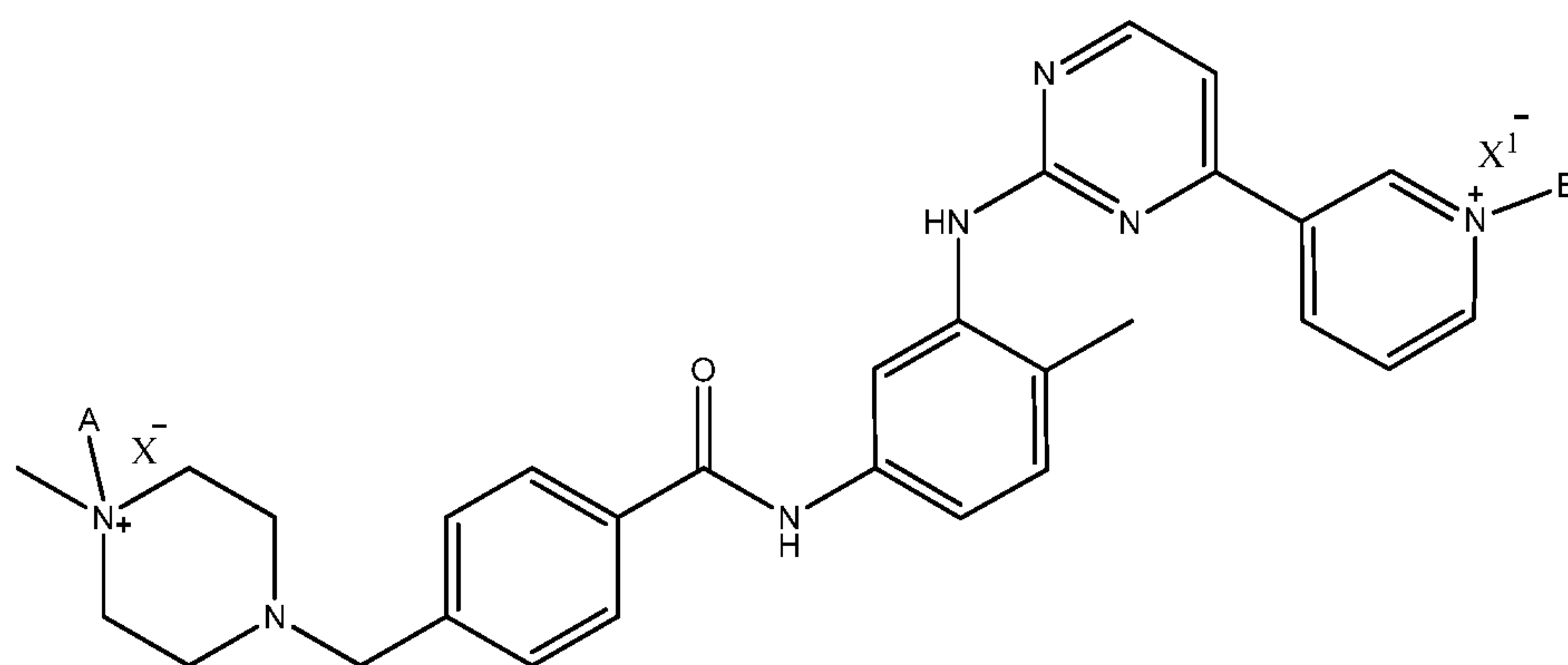
5 In certain embodiments, Cy¹ is selected from:





5 In certain embodiments, R¹ is selected from hydrogen or lower alkyl, which may optionally be deuterated. In certain preferred embodiments, R¹ is methyl, e.g., -CH₃, -CDH₂, -CD₂H, or -CD₃.

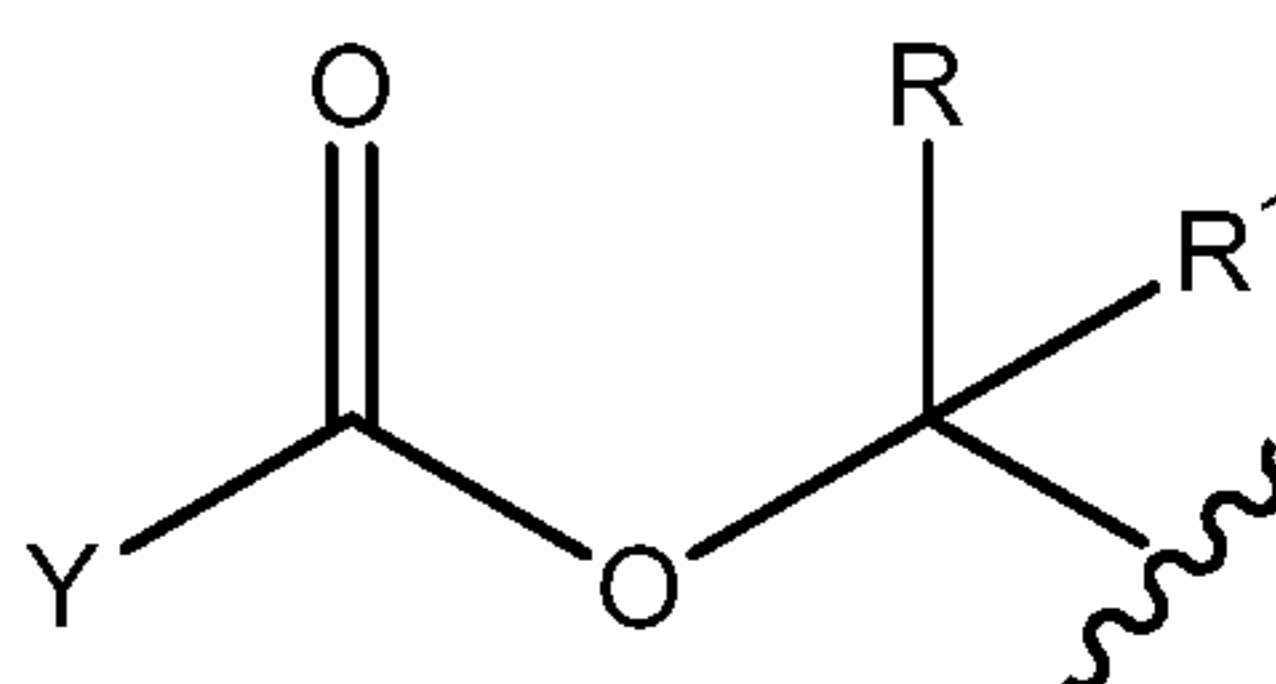
In one aspect, the invention relates to compounds of formula (II) or their pharmaceutically acceptable salts. These compounds were also described in U.S. Patent Application Publication No. 2014/0100225, which is hereby incorporated herein by reference



(II)

wherein:

A and B are independently selected from absent, H or a moiety of Formula (II), with the proviso that at least one of A and B is a moiety of Formula (III);



(III)

wherein:

R and R¹ are each independently selected from H, alkenyl, alkynyl, alkoxy, aryl, heteroaryl, C₁-C₈ alkyl and C₃-C₇ cycloalkyl, wherein in each of the C₁-C₈ alkyl and C₃-C₇ cycloalkyl optionally up to three carbon atoms are replaced by a heteroatom group independently selected from O, NR⁴, S, SO and SO₂ (i.e., thereby making a heteroalkyl or heterocyclyl substituent), and wherein the C₁-C₈ alkyl and C₃-C₇ cycloalkyl are each optionally substituted with from 1 to 4 C₁-C₈ alkyl, alkoxy, aryl and heteroaryl substituents; or R and R¹ taken together with the atom to which they are attached form a 3- to 7-membered ring, wherein the 3- to 7-membered ring optionally contains up to two heteroatom groups selected from O, N R⁴, S, SO and SO₂, and is optionally substituted with 1 to 4 alkoxy, F or Cl substituents;

Y is selected from R², OR², NH₂, NHR², and NR²R³;

R² is selected from alkoxy, aryl, heteroaryl, C₁-C₈ alkyl and C₃-C₇ cycloalkyl, wherein in each of the C₁-C₈ alkyl and C₃-C₇ cycloalkyl optionally up to three carbon atoms are replaced by a heteroatom group independently selected from O, NR⁴, S, SO and SO₂ (i.e., thereby making a heteroalkyl or heterocyclyl substituent), and wherein the C₁-C₈ alkyl and C₃-C₇ cycloalkyl are each optionally substituted with from 1 to 4 C₁-C₈ alkyl, alkoxy, aryl or heteroaryl substituents;

R³ is selected from alkoxy, aryl, heteroaryl, C₁-C₈ alkyl and C₃-C₇ cycloalkyl, wherein in each of the C₁-C₈ alkyl and C₃-C₇ cycloalkyl optionally up to three carbon atoms are replaced by a heteroatom group independently selected from O, NR⁴, S, SO and SO₂ (i.e., thereby making a heteroalkyl or heterocyclyl substituent), and wherein the C₁-C₈ alkyl and C₃-C₇ cycloalkyl are each optionally substituted with from 1 to 4 C₁-C₈ alkyl, alkoxy, aryl or heteroaryl; or

R^2 and R^3 may be taken together with the nitrogen atom to which they are attached to form a 3- to 7-membered ring, wherein the 3- to 7-membered ring optionally contains up to three heteroatom groups selected from O, NR^4 , S, SO and SO_2 , and is optionally substituted with alkoxy, F or Cl;

5 R^4 is, independently for each occurrence, selected from H or C_1 - C_8 alkyl; and

X and X^1 are each independently an anion or absent, provided that X is absent only when A is absent, and X^1 is absent only when B is absent.

In some embodiments, R and R^1 are each independently selected from H and C_1 - C_8 alkyl, such as H or methyl. Preferably both R and R^1 are H.

10 In some embodiments, R^2 and R^3 are independently selected from C_1 - C_8 alkyl and aralkyl. In some such embodiments, R^2 and R^3 are independently selected from methyl, ethyl, isopropyl, *tert*-butyl, isobutyl, *sec*-butyl, 3-methylbut-2-yl, 1-phenylethyl, benzyl or cyclobutyl.

In some embodiments, R^4 , independently for each occurrence, is selected from H
15 and C_1 - C_8 alkyl.

In some embodiments, X and X^1 are each independently halide or sulfonate, such as mesylate and iodide.

Because anions are not covalently attached to the molecule, it should be understood that X and X^1 are not necessarily located proximal to the atom bearing A or B, and should
20 be viewed as interchangeable within any given molecule when both are present.

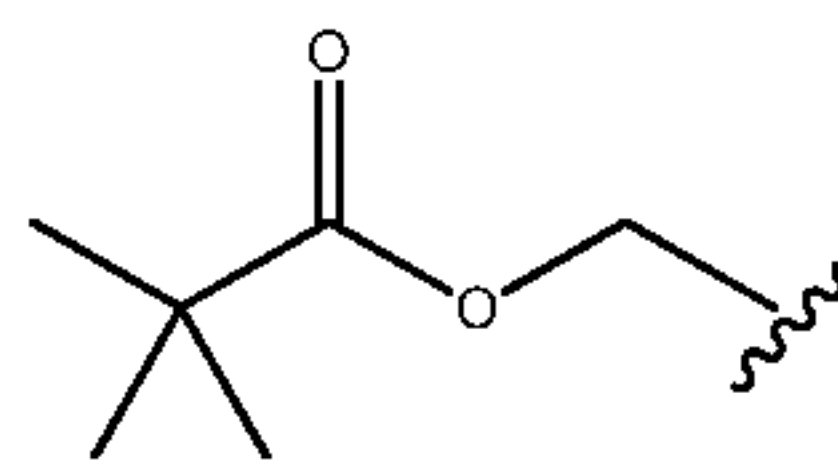
In some embodiments, A is H and B is a moiety of Formula (III).

In some embodiments, A is a moiety of Formula (III) and B is H.

In other embodiments, A is a moiety of Formula (III) and B is absent.

In yet other embodiments, A is absent and B is a moiety of Formula (III).

25 In certain embodiments, neither A nor B is



The compounds of formula III may be divided in three classes i.e. Type I, where $Y = OR^2$; Type II, where $Y = R^2$ and Type III, where $Y = NR^2R^3$, wherein R^2 and R^3 are as defined above. In some embodiments, formula III is selected from the moieties that would remain after displacing chlorine from the reagents listed below:

Type I Reagents

- i. chloromethyl isopropyl carbonate
- ii. benzyl chloromethyl carbonate
- iii. chloromethyl morpholinomethyl carbonate
- 5 iv. chloromethyl isobutyl carbonate
- v. chloromethylmethyl carbonate
- vi. (S)-sec-butyl chloromethyl carbonate
- vii. (R)-sec-butyl chloromethyl carbonate
- viii. chloromethyl ((3S,5R)-3,5-dimethylmorpholino)methyl carbonate
- 10 ix. chloromethyl 2-methylcyclopropyl carbonate
- x. chloromethyl 2-methoxyethyl carbonate
- xi. chloromethyl propyl carbonate
- xii. chloromethyl cyclobutyl carbonate
- xiii. chloromethyl cyclopropyl carbonate
- 15 xiv. chloromethyl 2,2-dimethylcyclobutyl carbonate
- xv. chloromethyl cyclopentyl carbonate
- xvi. chloromethyl oxetan-3-yl carbonate
- xvii. (S)-chloromethyl tetrahydrofuran-3-yl carbonate
- xviii. chloromethyl cyclohexylmethyl carbonate
- 20 xix. chloromethyl 3-methoxycyclohexyl carbonate
- xx. (R)-chloromethyl tetrahydrofuran-3-yl carbonate
- xxi. chloromethyl ethoxymethyl carbonate
- xxii. chloromethyl oxepan-4-yl carbonate
- xxiii. (1R,2S,4S)-bicyclo[2.2.1]heptan-2-yl chloromethyl carbonate
- 25 xxiv. chloromethyl 2,3-dihydro-1H-inden-1-yl carbonate
- xxv. benzyl chloromethyl carbonate
- xxvi. (S)-chloromethyl 1-phenylethyl carbonate
- xxvii. chloromethyl cyclohexyl carbonate
- xxviii. chloromethyl isobutyl carbonate
- 30 xxix. chloromethyl 4-methylcyclohexyl carbonate
- xxx. chloromethyl 2-(methylthio)ethyl carbonate
- xxxi. chloromethyl 3-methylcyclohexyl carbonate
- xxxii. chloromethylpentan-2-yl carbonate

- xxxiii. chloromethyl neopentyl carbonate
- xxxiv. methyl 1-((chloromethoxy)carbonyloxy)cyclopropanecarboxylate
- xxxv. chloromethyl cyclopropylmethyl carbonate
- xxxvi. chloromethyl 2,2-diethoxyethyl carbonate
- 5 xxxvii. chloromethyl cyclopentylmethyl carbonate
- xxxviii. methyl 2-((chloromethoxy)carbonyloxy)propanoate
- xxxix. (S)-chloromethyl 2,2,4-trimethylcyclopent-3-enyl carbonate
- xl. chloromethyl 1,3-dioxolan-2-yl carbonate
- xli. chloromethyl (2,6-dimethylcyclohexyl)methyl carbonate
- 10 xlii. chloromethyl 2-(tetrahydro-2H-pyran-2-yl)ethyl carbonate
- xliii. chloromethyl(tetrahydro-2H-pyran-4-yl)methyl carbonate
- xliv. chloromethyl tetrahydro-2H-pyran-4-yl carbonate
- xlv. chloromethyl 1-methylcyclopentyl carbonate
- xlvi. chloromethyl 1-cyclopentylethyl carbonate
- 15 xlvii. chloromethyl 3-methylcyclopentyl carbonate
- xlviii. chloromethyl 3,3-dimethylcyclohexyl carbonate
- xlix. chloromethyl 2,5-dimethylcyclohexyl carbonate
- l. chloromethyl 1-(4-methylcyclohexyl)ethyl carbonate
- li. chloromethyl (3-methyloxetan-3-yl)methyl carbonate
- 20 lii. chloromethyl (3-methyloxetan-3-yl)methyl carbonate
- liii. chloromethyl 2-isopropoxyethyl carbonate
- liv. (chloromethyl carbonic) 5-((3aS,4S,6aR)-2-oxohexahydro-1H-thieno[3,4-d]imidazol-4-yl)pentanoic anhydride
- lv. 4-((chloromethoxy)carbonyloxy)-2-hydroxy-4-oxobutanoic acid
- 25 lvi. chloromethyl 4-formyl-2-methoxyphenyl carbonate
- lvii. chloromethyl 3-oxobutan-2-yl carbonate
- lviii. methyl 4-((chloromethoxy)carbonyloxy)benzoate
- lix. (R)-2-amino-3-((chloromethoxy)carbonyloxy)propanoic acid
- lx. 3-tert-butyl-4-methoxyphenyl chloromethyl carbonate
- 30 lxi. (R)-2-amino-3-(4-((chloromethoxy)carbonyloxy)phenyl)propanoic acid
- lxii. (R)-2-amino-4-((chloromethoxy)carbonyloxy)-4-oxobutanoic acid
- lxiii. (E)-chloromethyl 3,7-dimethylocta-2,6-dienyl carbonate
- lxiv. methyl 4-((chloromethoxy)carbonyloxy)benzoate

- lxv. chloromethyl 2-(4-methylcyclohex-3-enyl)propan-2-yl carbonate
- lxvi. chloromethyl 3,7-dimethylocta-1,6-dien-3-yl carbonate
- lxvii. 4-allyl-2-methoxyphenyl chloromethyl carbonate
- lxviii. chloromethyl (1R,2S,5R)-2-isopropyl-5-methylcyclohexyl carbonate
- 5 lxix. propyl 4-((chloromethoxy)carbonyloxy)benzoate
- lxx. (E)-chloromethyl 3,7-dimethylocta-2,6-dienyl carbonate

Type II Reagents

- i. chloromethyl cyclohexanecarboxylate
- ii. chloromethyl 2-cyclohexylacetate
- 10 iii. chloromethyl 4-methylcyclohexanecarboxylate
- iv. chloromethyl 1-methylcyclohexanecarboxylate
- v. chloromethyl cyclopentanecarboxylate
- vi. chloromethyl 1-(trifluoromethyl)cyclopentanecarboxylate
- vii. chloromethyl cyclobutanecarboxylate
- 15 viii. chloromethyl 2-ethylhexanoate
- ix. chloromethyl 3-cyclopentylpropanoate
- x. chloromethyl cyclopropanecarboxylate
- xi. chloromethyl pentanoate
- xii. chloromethyl 2-methylpentanoate
- 20 xiii. chloromethyl 3,5,5-trimethylhexanoate
- xiv. chloromethyl 2,2-dimethylbutanoate
- xv. chloromethyl 2-methylbutanoate
- xvi. chloromethyl hexanoate
- xvii. chloromethyl 2-ethylbutanoate
- 25 xviii. chloromethyl butyrate
- xix. chloromethyl 3-phenylpropanoate
- xx. chloromethyl 2-phenylpropanoate
- xxi. (R)-chloromethyl 2-phenylpropanoate
- xxii. (S)-chloromethyl 2-phenylpropanoate
- 30 xxiii. (1r,4r)-chloromethyl 4-methylcyclohexanecarboxylate
- xxiv. chloromethyl 4-methoxycyclohexanecarboxylate
- xxv. chloromethyl 4,4-difluorocyclohexanecarboxylate

- xxvi. chloromethyl 3-methoxycyclohexanecarboxylate
- xxvii. (2R)-chloromethyl 2-methylcyclopentanecarboxylate
- xxviii. (R)-chloromethyl 2-methylbutanoate
- xxix. (S)-chloromethyl 2-methylbutanoate
- 5 xxx. (S)-chloromethyl 2-methoxy-2-phenylacetate
- xxxi. (S)-chloromethyl 2-phenylpropanoate
- xxxii. (S)-chloromethyl 2-phenylbutanoate
- xxxiii. (S)-chloromethyl 3-phenylbutanoate
- xxxiv. bis(chloromethyl) 2,2-dimethylmalonate
- 10 xxxv. bis(chloromethyl) oxalate
- xxxvi. chloromethyl 2-cyclopropylacetate
- xxxvii. chloromethyl 2-cyclobutylacetate
- xxxviii. chloromethyl 2-cyclopentylacetate
- xxxix. chloromethyl 2-(tetrahydrofuran-3-yl)acetate
- 15 xl. chloromethyl 2-(tetrahydro-2H-pyran-4-yl)acetate
- xli. chloromethyl 2-methylcyclopropanecarboxylate
- xlii. chloromethyl 2-(1-methylcyclobutyl)acetate
- xliii. chloromethyl 2-(1-methylcyclopropyl)'acetate
- xliv. chloromethyl propionate
- 20 xlv. chloromethyl acetate
- xlvi. chloromethyl isobutyrate
- xlvii. chloromethyl 2-isopropyl-3-methylbutanoate
- xlviii. chloromethyl 3,5-dimethylcyclohexanecarboxylate
- xlix. chloromethyl 2-propylpentanoate
- 25 1. chloromethyl 4-methoxybenzoate
- li. chloromethyl 4-methylbenzoate
- lii. chloromethyl 3-methylbenzoate
- liii. chloromethyl 2,2,2-trifluoroacetate
- liv. chloromethyl 5,5-dimethyl-3-oxohexanoate
- 30 lv. bis(chloromethyl) cyclopropane-1,1-dicarboxylate
- lvi. chloromethyl 1,2-dihydrocyclobutabenzene-1-carboxylate
- lvii. chloromethyl 2-cyclopentenylacetate
- lviii. chloromethyl 2-phenylbutanoate

- lix. chloromethyl 2,2-difluoroacetate
- lx. chloromethyl 4-fluorobenzoate
- lxi. chloromethyl 3-cyclohexylpropanoate
- lxii. chloromethyl 2-cyclohexylacetate
- 5 lxiii. chloromethyl 3-(tetrahydro-2H-pyran-4-yl)propanoate
- lxiv. chloromethyl 2-(tetrahydro-2H-pyran-3-yl)acetate
- lxv. chloromethyl 3-(tetrahydro-2H-pyran-3-yl)propanoate
- lxvi. chloromethyl nicotinate

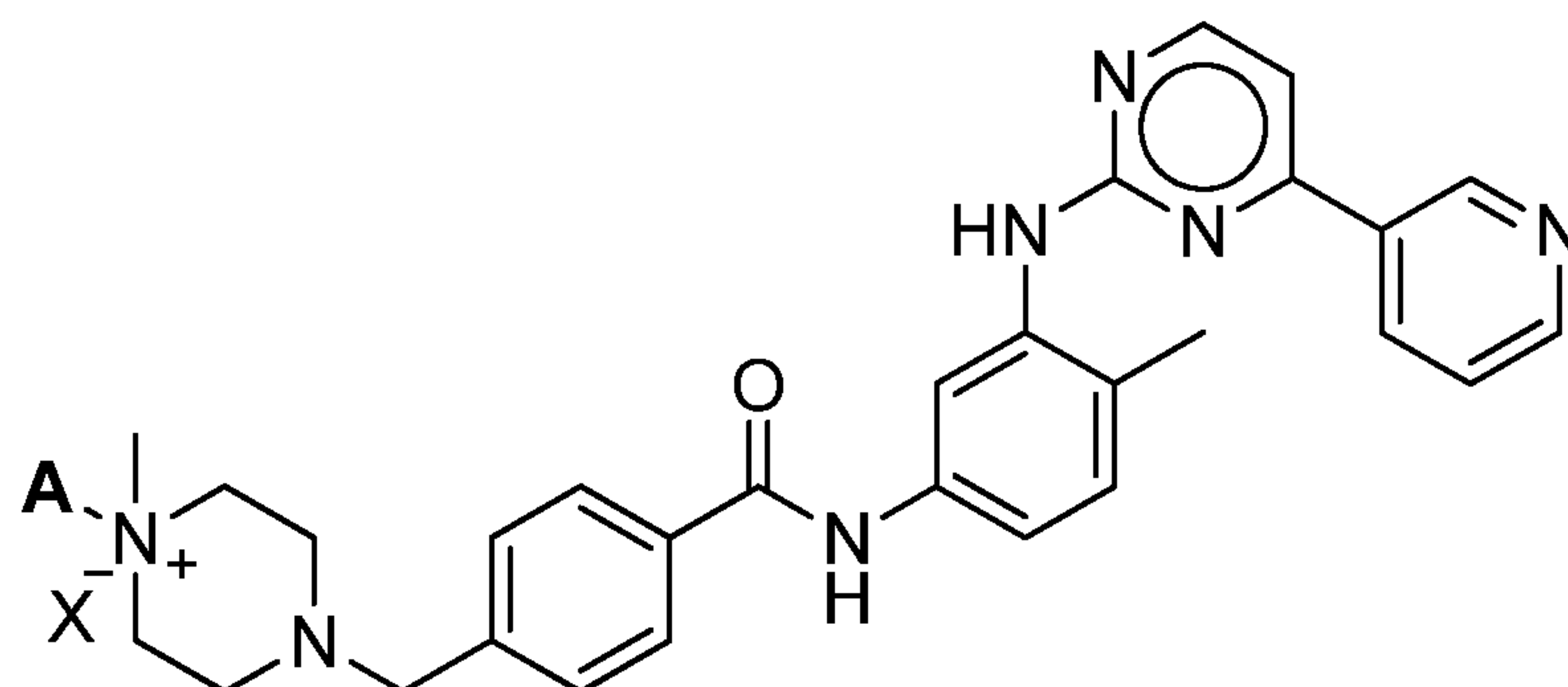
Type III Reagents

- 10 i. chloromethyl isopropylcarbamate
- ii. chloromethyl diisopropylcarbamate
- iii. chloromethyl dimethylcarbamate
- iv. chloromethyl isobutylcarbamate
- v. chloromethyl methylcarbamate
- 15 vi. chloromethyl ethyl(isopropyl)carbamate
- vii. chloromethylisobutyl(methyl)carbamate
- viii. (S)-chloromethyl sec-butylcarbamate
- ix. chloromethyl methylcarbamate
- x. chloromethyl isopropyl(methyl)carbamate
- 20 xi. chloromethyl propylcarbamate
- xii. chloromethyl 2-methoxyethylcarbamate
- xiii. chloromethyl methyl(propyl)carbamate
- xiv. chloromethyl diisobutylcarbamate
- xv. chloromethyl tert-butyl(isopropyl)carbamate
- 25 xvi. chloromethyl di-sec-butylcarbamate
- xvii. chloromethyl aziridine-1-carboxylate
- xviii. chloromethyl 2-methylcyclopropylcarbamate
- xix. chloromethyl cyclopropylcarbamate
- xx. chloromethyl cyclopropylmethyl(propyl)carbamate
- 30 xxi. chloromethyl cyclopropyl(methyl)carbamate
- xxii. chloromethyl azetidine-1-carboxylate
- xxiii. chloromethyl cyclobutylcarbamate

- xxiv. chloromethyl 2,2-dimethylcyclobutylcarbamate
- xxv. chloromethyl 3-methoxyazetidine-1-carboxylate
- xxvi. chloromethyl cyclobutyl(methyl)carbamate
- xxvii. chloromethyl oxetan-3-ylcarbamate
- 5 xxviii. (S)-chloromethyl 2-methylpyrrolidine-1-carboxylate
- xxix. chloromethyl cyclopentylcarbamate
- xxx. chloromethyl cyclopentyl(methyl)carbamate
- xxxi. chloromethyl tetrahydrofuran-3-ylcarbamate
- xxxii. chloromethyl piperidine-1-carboxylate
- 10 xxxiii. (2R,6S)-chloromethyl 2,6-dimethylpiperidine-1-carboxylate
- xxxiv. (R)-chloromethyl 2-methylpiperidine-1-carboxylate
- xxxv. chloromethyl piperidine-1-carboxylate
- xxxvi. chloromethyl 3-methoxycyclohexylcarbamate
- xxxvii. chloromethyl cyclohexylmethylcarbamate
- 15 xxxviii. chloromethyl cyclohexylmethyl(methyl)carbamate
- xxxix. chloromethyl morpholine-4-carboxylate
- xl. (3S,5R)-chloromethyl 3,5-dimethylmorpholine-4-carboxylate
- xli. (3R,5S)-chloromethyl 3,5-dimethylmorpholine-4-carboxylate
- xlii. (2S,6R)-chloromethyl 2,6-dimethylmorpholine-4-carboxylate
- 20 xliii. chloromethyl 4-methylpiperazine-1-carboxylate
- xliv. chloromethylazepane-1-carboxylate
- xlv. chloromethylcycloheptylcarbamate
- xlvi. chloromethyl oxepan-4-ylcarbamate
- xlvii. chloromethyl (1R,2S,4S)-bicyclo[2.2.1]heptan-2-ylcarbamate
- 25 xlviii. chloromethyl 2,3-dihydro-1H-inden-1-ylcarbamate
- xliv. chloromethyl benzylcarbamate
- 1. (S)-chloromethyl 1-phenylethylcarbamate
- li. ethyl 2-((chloromethoxy)carbonylamino)-3-methylbutanoate
- lii. ethyl 2-((chloromethoxy)carbonylamino)-3-phenylpropanoate
- 30 liii. (S)-diethyl 2-((chloromethoxy)carbonylamino)pentanedioate
- liv. ethyl((chloromethoxy)carbonylamino)propanoate
- lv. ethyl 2-amino-6-((chloromethoxy)carbonylamino)hexanoate
- lvi. ethyl 2-((chloromethoxy)carbonylamino)-4-methylpentanoate

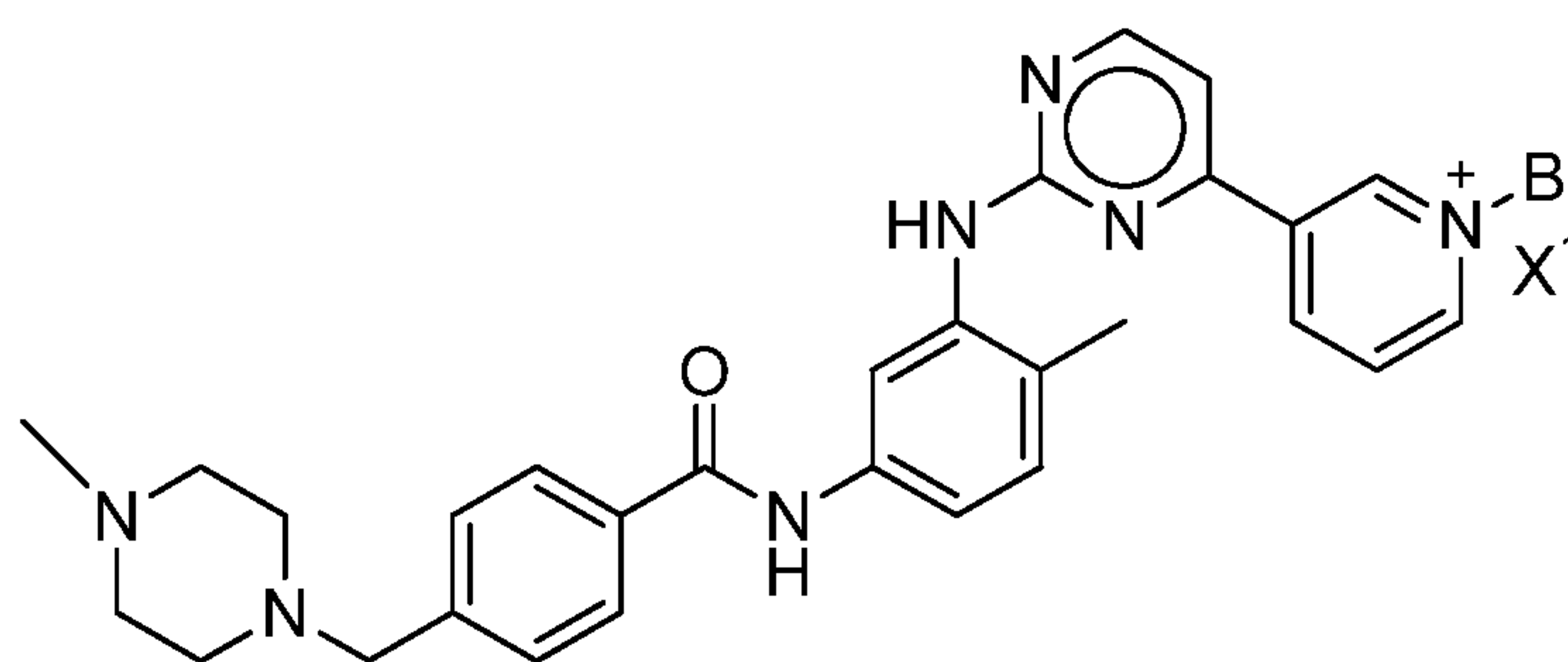
- lvii. ethyl 2-((chloromethoxy)carbonylamino)-3-methylpentanoate
- lviii. (S)-dimethyl 2-((chloromethoxy)carbonylamino)succinate
- lix. (S)-ethyl 2-((chloromethoxy)carbonylamino)-5-guanidinopentanoate
- lx. (S)-ethyl 4-amino-2-((chloromethoxy)carbonylamino)-4-oxobutanoate
- 5 lxi. (S)-ethyl 2-amino-5-((chloromethoxy)carbonylamino)pentanoate
- lxii. (S)-ethyl 5-amino-2-((chloromethoxy)carbonylamino)-5-oxopentanoate
- lxiii. ethyl 2-((chloromethoxy)carbonylamino)-4-(methylthio)butanoate
- lxiv. 1-chloromethyl 3-methyl 2-methyl-5,6-dihydropyridine-1,3(2H)-dicarboxylate
- lxv. (S)-chloromethyl (1-methylpyrrolidin-2-yl)methyl carbonate
- 10 lxvi. (R)-chloromethyl (1-methylpyrrolidin-2-yl)methyl carbonate
- lxvii. (S)-(1-benzylpyrrolidin-2-yl)methyl chloromethyl carbonate
- lxviii. chloromethyl 1H-pyrrole-1-carboxylate
- lxix. chloromethyl 2-nicotinoylhydrazinecarboxylate
- lxx. (6S)-3-chloro-7-((chloromethoxy)carbonylamino)-8-oxo-5-thia-1-
- 15 azabicyclo[4.2.0]oct-2-ene-2-carboxylic acid
- lxxi. (6S)-7-((chloromethoxy)carbonylamino)-8-oxo-3-vinyl-5-thia-1-
- azabicyclo[4.2.0]oct-2-ene-2-carboxylic acid
- lxxii. (6S)-7-((chloromethoxy)carbonylamino)-3-(methoxymethyl)-8-oxo-5-thia-1-
- azabicyclo[4.2.0]oct-2-ene-2-carboxylic acid
- 20 lxxiii. (6R,7R)-7-((chloromethoxy)carbonylamino)-3-methoxy-8-oxo-5-thia-1-
- azabicyclo[4.2.0]oct-2-ene-2-carboxylic acid
- lxxiv. chloromethyl 3-(4-chlorophenyl)-1H-pyrazole-1-carboxylate
- lxxv. chloromethyl 3-(4-fluorophenyl)-1H-pyrazole-1-carboxylate
- lxxvi. chloromethyl 3-phenyl-1H-pyrazole-1-carboxylate
- 25 lxxvii. chloromethyl 3-(4bromophenyl)-1H-pyrazole-1-carboxylate
- lxxviii. chloromethyl 2-cyano-1H-pyrrole-1-carboxylate
- lxxix. chloromethyl 4-oxopiperidine-1-carboxylate
- lxxx. 1-chloromethyl 3-ethyl 2-oxopiperidine-1,3-dicarboxylate
- lxxxi. chloromethyl 2,2,6,6-tetramethyl-4-oxopiperidine-1-carboxylate
- 30 lxxxii. chloromethyl 2-oxopiperidine-1-carboxylate

In some embodiments, the compounds of Formula (II) are selected from compounds of Formula (IV) or Formula (V):



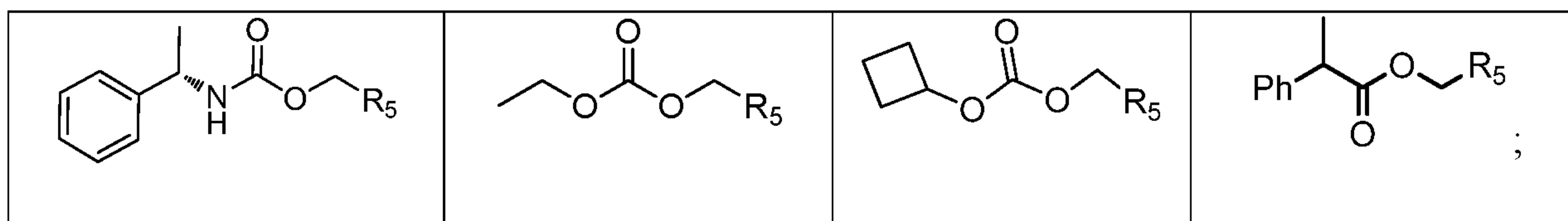
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Formula (IV)



Formula (V)

wherein A and B are independently selected from:



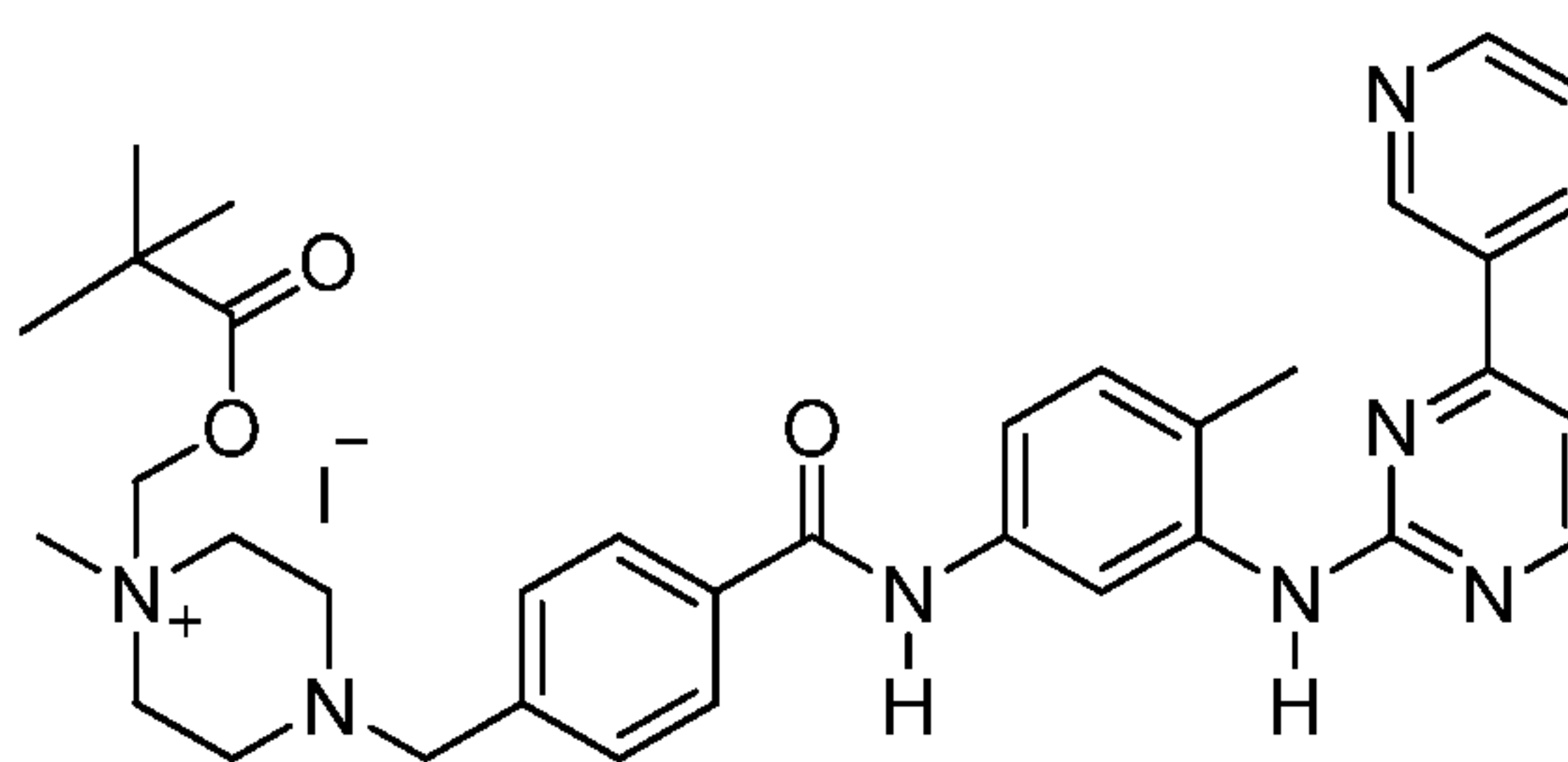
wherein R⁵ represents a nitrogen atom of the imatinib moiety linked to A or B, and

X may be iodide, chloride, bromide, mesylate, tosylate, or any other pharmaceutically acceptable anion to provide a pharmaceutically acceptable salt.

- 5 The compounds of Formula (II) may be present as a single stereoisomer (e.g., enriched to at least 95% purity relative to the total amount of all stereoisomers present), a racemate, or a mixture of enantiomers or diastereomers in any ratio.

In some embodiments, the compound of Formula (II) is selected from the compounds listed below:

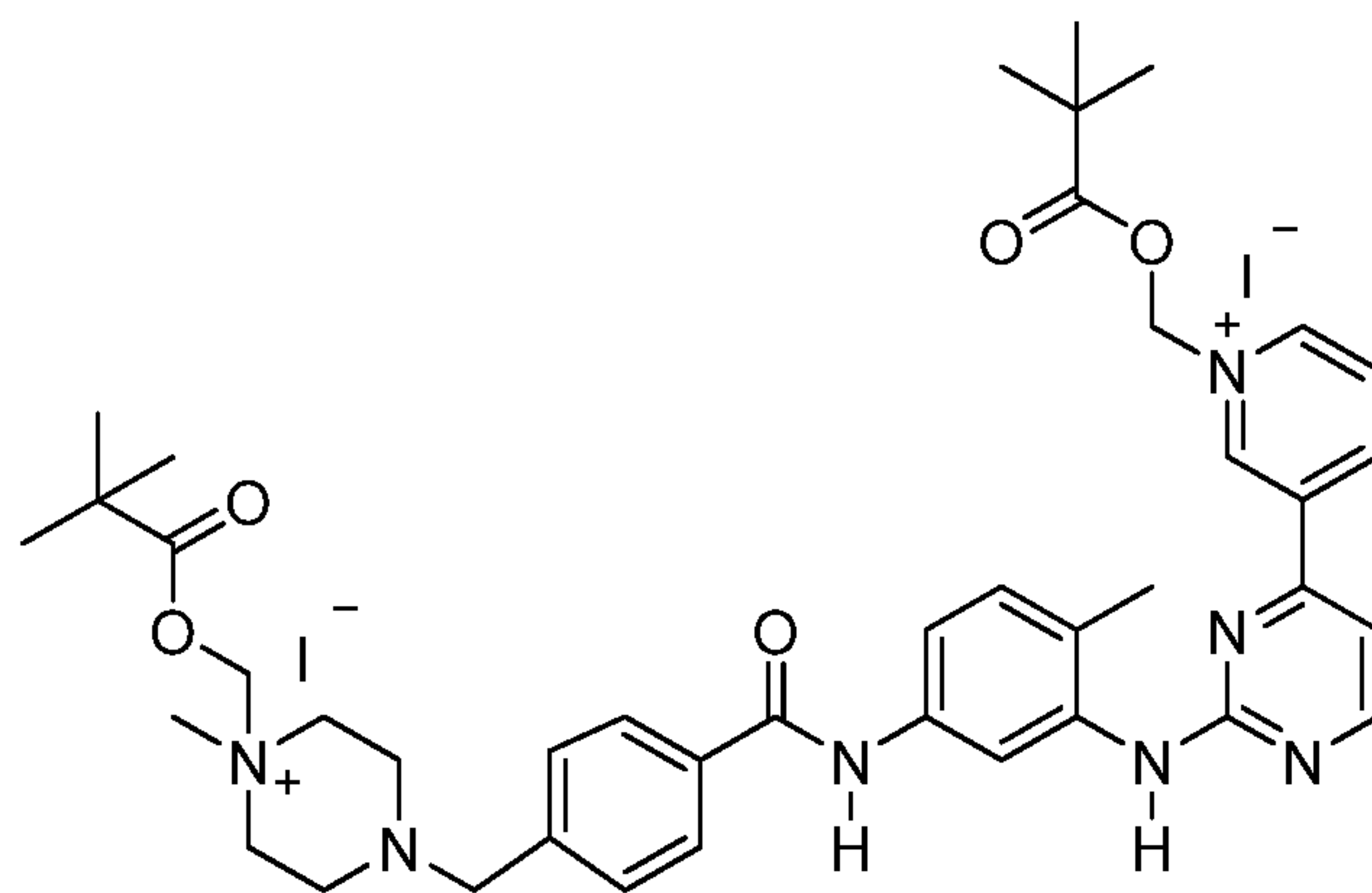
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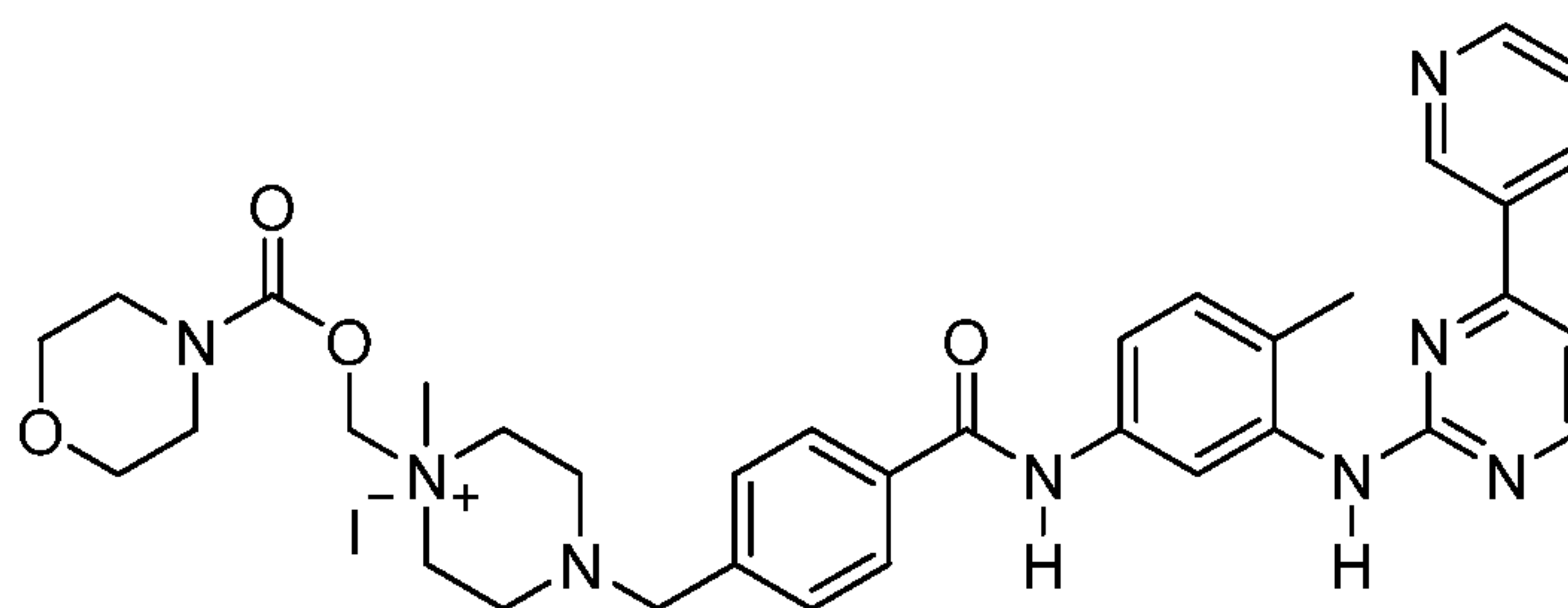
1002

1-methyl-4-(4-((4-methyl-3-((4-(pyridin-3-yl)pyrimidin-2-yl)amino)phenyl)carbamoyl)benzyl)-1-((pivaloyloxy)methyl)piperazin-1-ium iodide,

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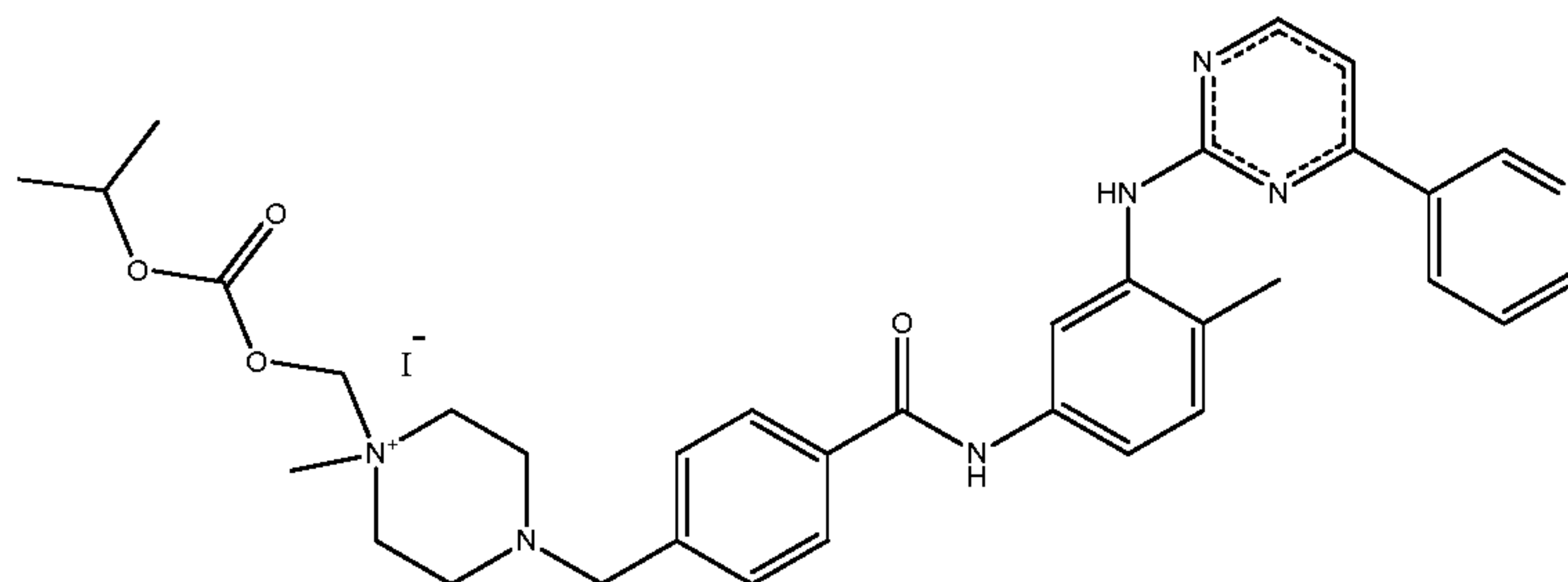
**1003**

1-methyl-4-(4-((4-methyl-3-((4-(1-((pivaloyloxy)methyl)pyridin-1-ium-3-yl)pyrimidin-2-yl)amino)phenyl)carbamoyl)benzyl)-1-((pivaloyloxy)methyl)piperazin-1-ium diiodide

**1004**

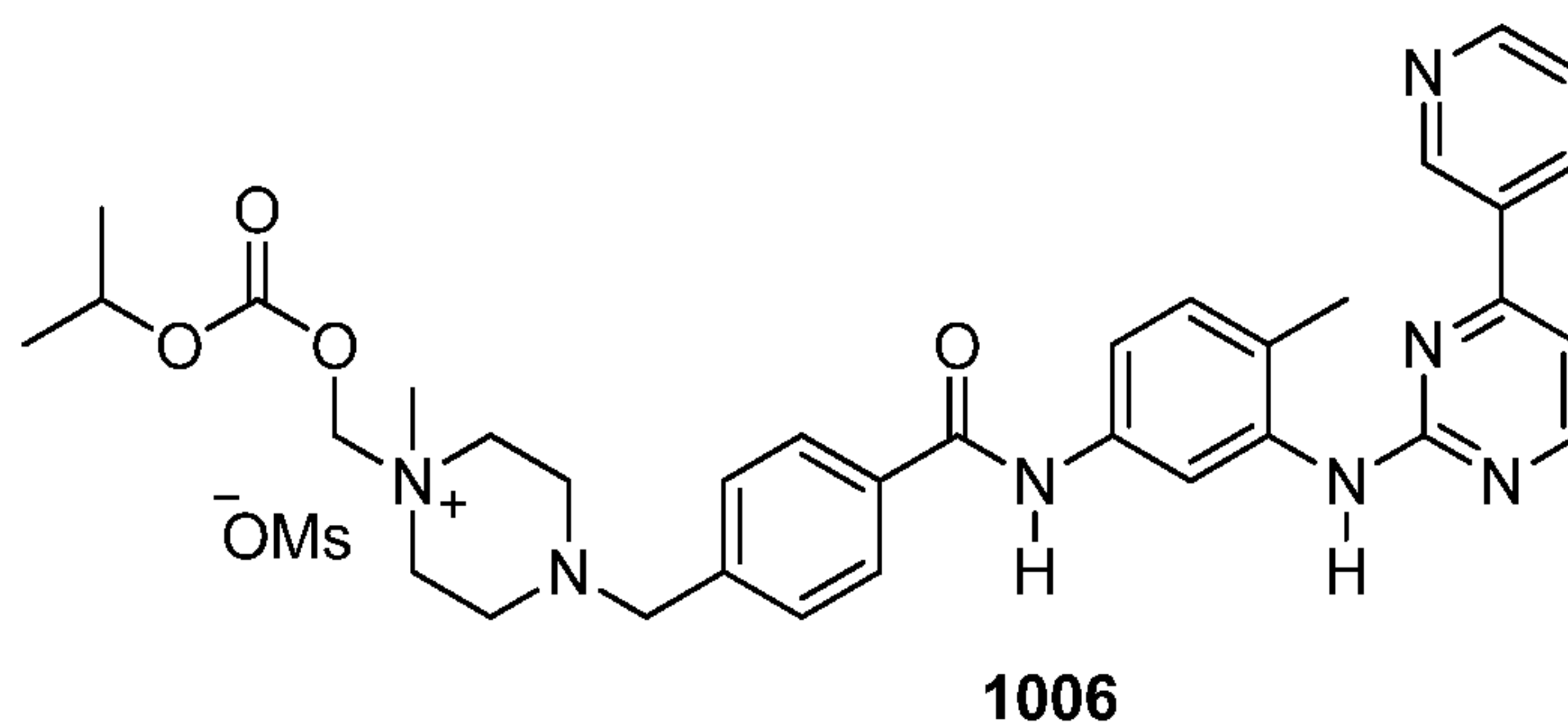
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1-methyl-4-(4-((4-methyl-3-((4-(pyridin-3-yl)pyrimidin-2-yl)amino)phenyl)carbamoyl)benzyl)-1-(((morpholine-4-carbonyl)oxy)methyl)piperazin-1-ium iodide

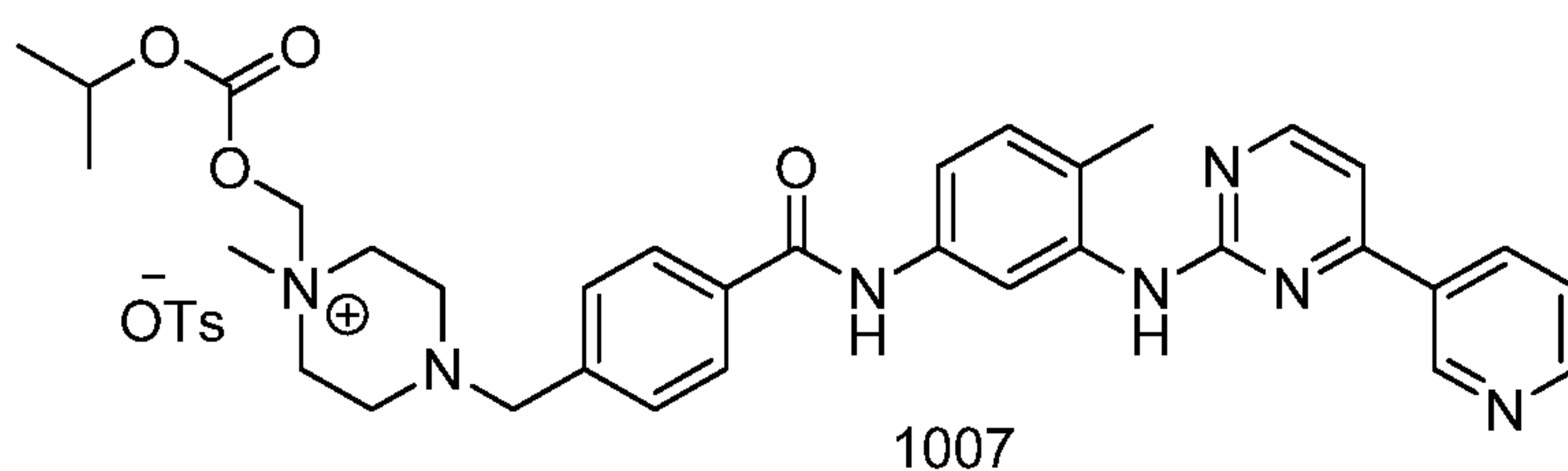
**1005**

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1-(((isopropoxycarbonyl)oxy)methyl)-1-methyl-4-(4-((4-methyl-3-((4-(pyridin-3-yl)pyrimidin-2-yl)amino)phenyl)carbamoyl)benzyl)piperazin-1-ium iodide



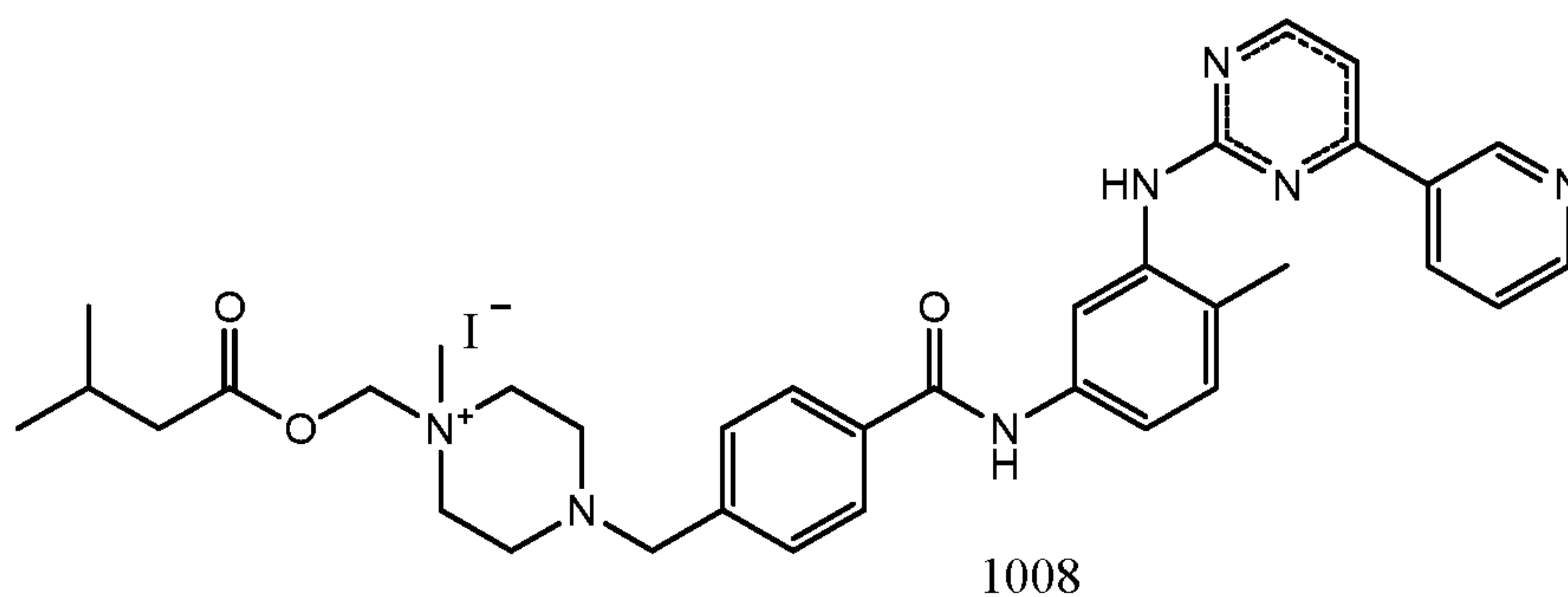
1-(((isopropoxycarbonyl)oxy)methyl)-1-methyl-4-(4-((4-methyl-3-((4-(pyridin-3-yl)pyrimidin-2-yl)amino)phenyl)carbamoyl)benzyl)piperazin-1-ium methane sulfonate



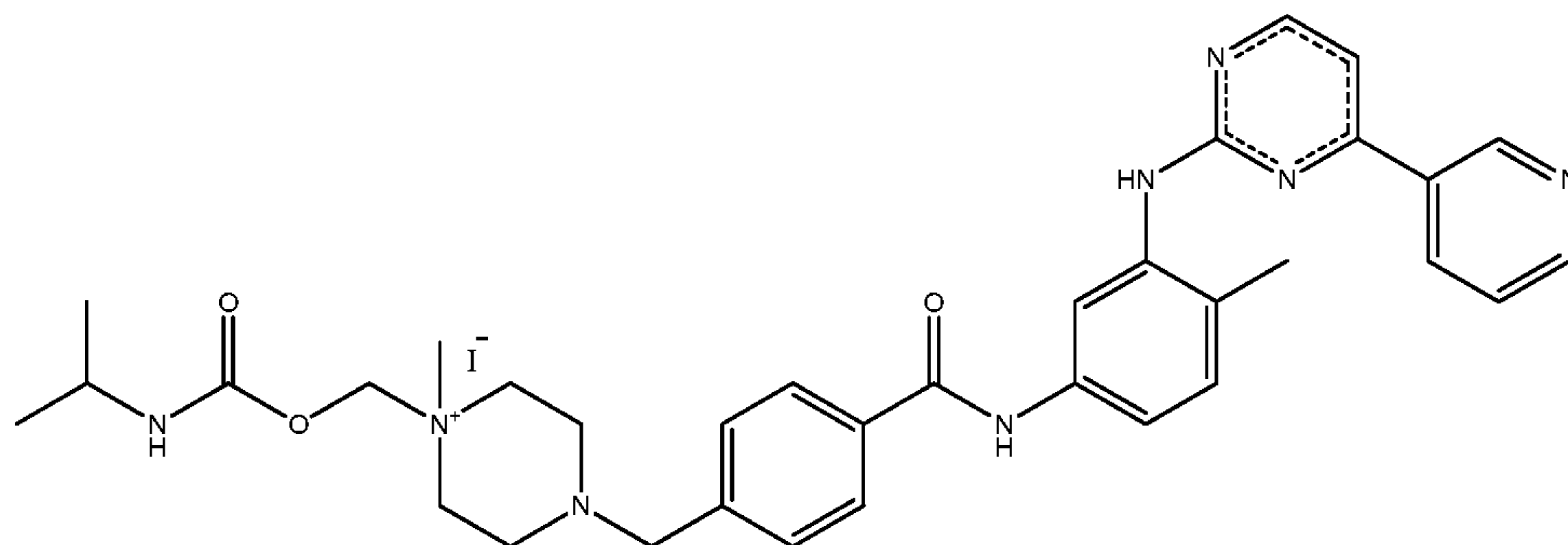
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1-(((isopropoxycarbonyl)oxy)methyl)-1-methyl-4-(4-((4-methyl-3-((4-(pyridin-3-yl)pyrimidin-2-yl)amino)phenyl)carbamoyl)benzyl)piperazin-1-ium p-tolyl sulfonate

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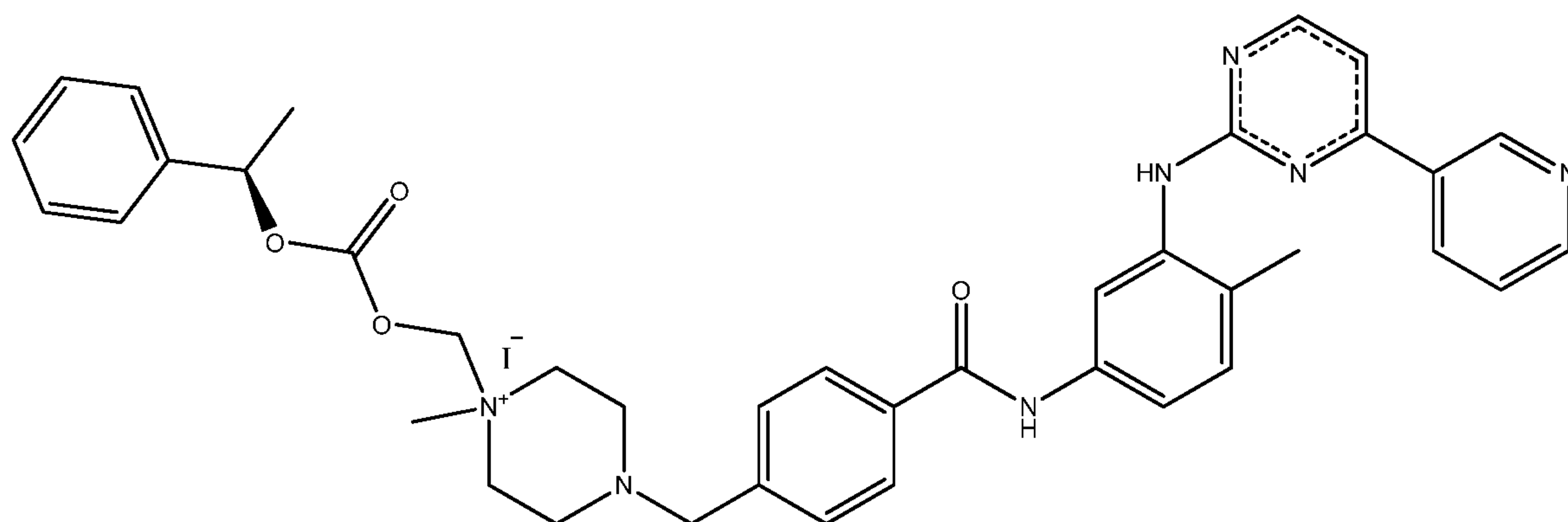


1-methyl-4-(4-(4-methyl-3-(4-(pyridin-3-yl)pyrimidin-2-ylamino)phenylcarbamoyl)benzyl)-1-((3-methylbutanoyloxy)methyl)piperazin-1-ium iodide



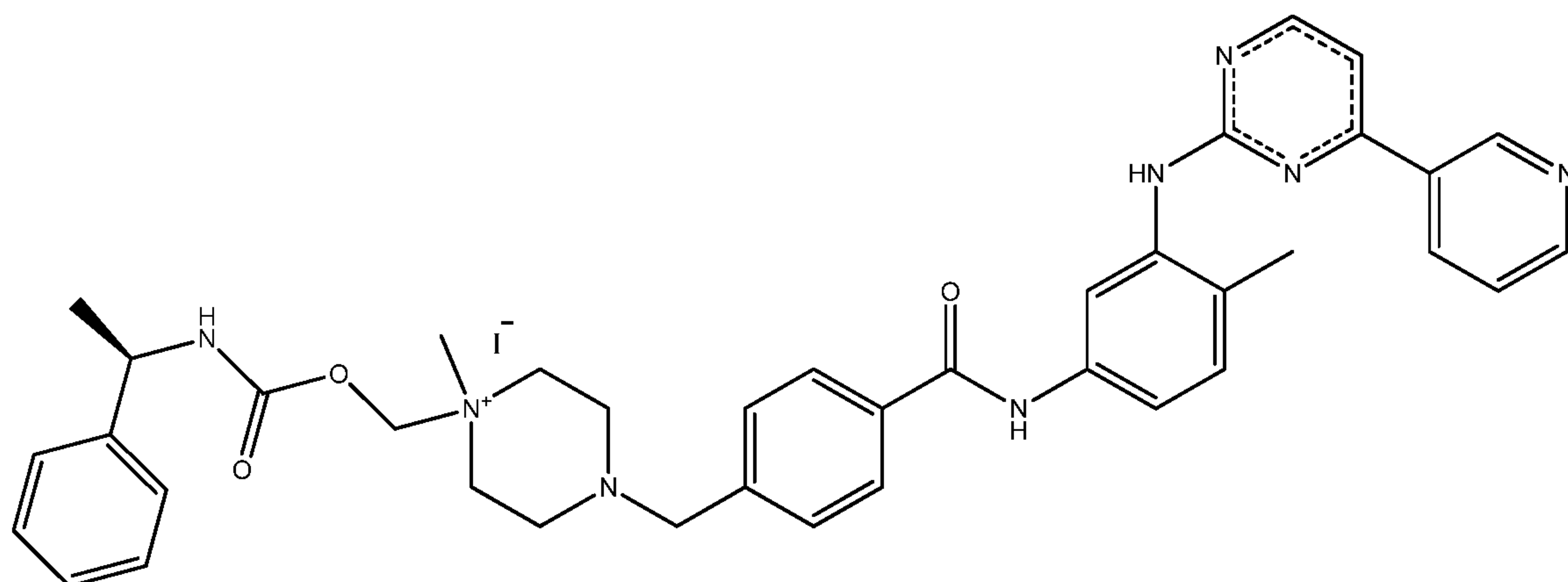
1009

1-((isopropylcarbamoyloxy)methyl)-1-methyl-4-(4-(4-methyl-3-(4-(pyridin-3-yl)pyrimidin-
 5 2-ylamino)phenylcarbamoyl)benzyl)piperazin-1-ium iodide



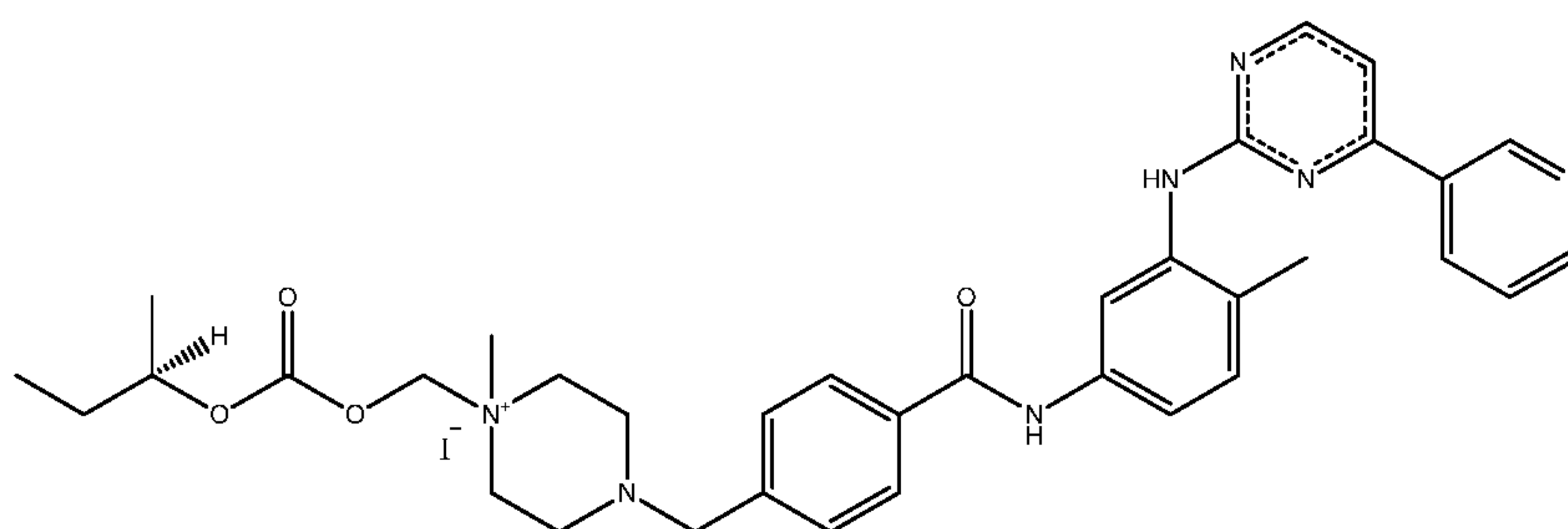
1010

(R)-1-methyl-4-(4-(4-methyl-3-(4-(pyridin-3-yl)pyrimidin-2-
 10 ylamino)phenylcarbamoyl)benzyl)-1-(((1-phenylethoxy)carbonyloxy)methyl)piperazin-1-
 ium iodide



1011

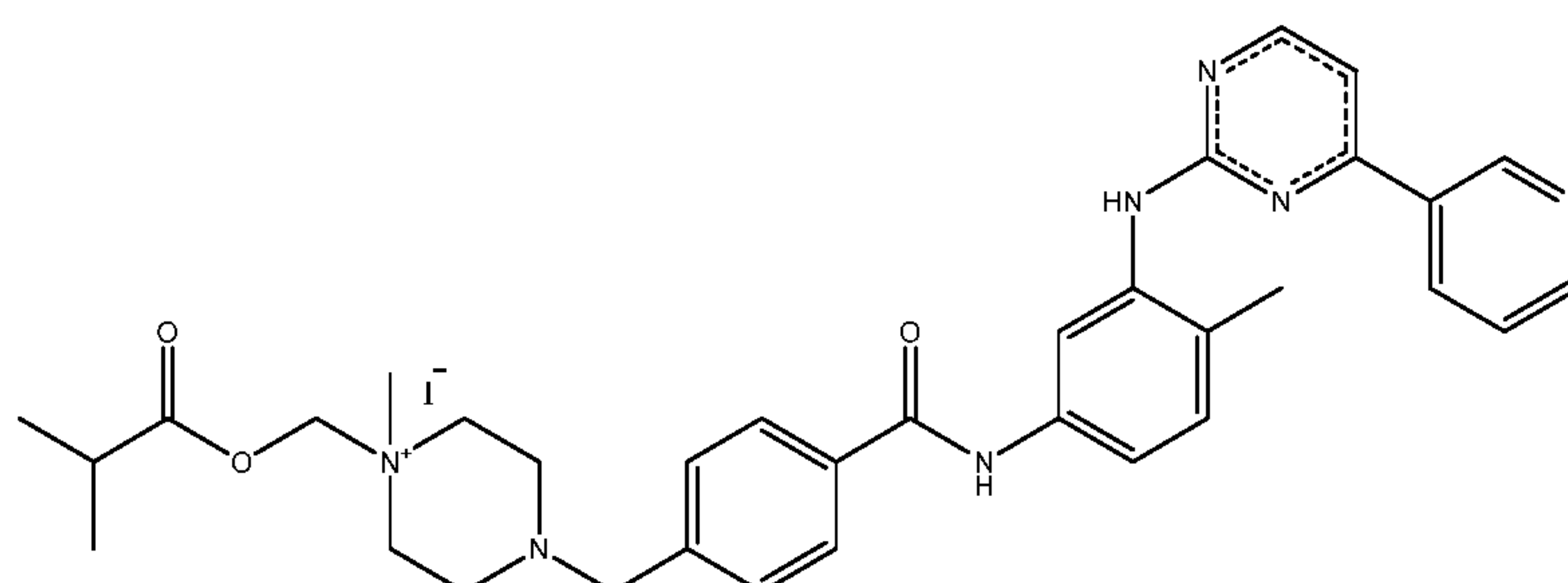
(R)-1-methyl-4-(4-(4-methyl-3-(4-(pyridin-3-yl)pyrimidin-2-ylamino)phenylcarbamoyl)benzyl)-1-((1-phenylethylcarbamoyloxy)methyl)piperazin-1-ium
5 iodide



1012

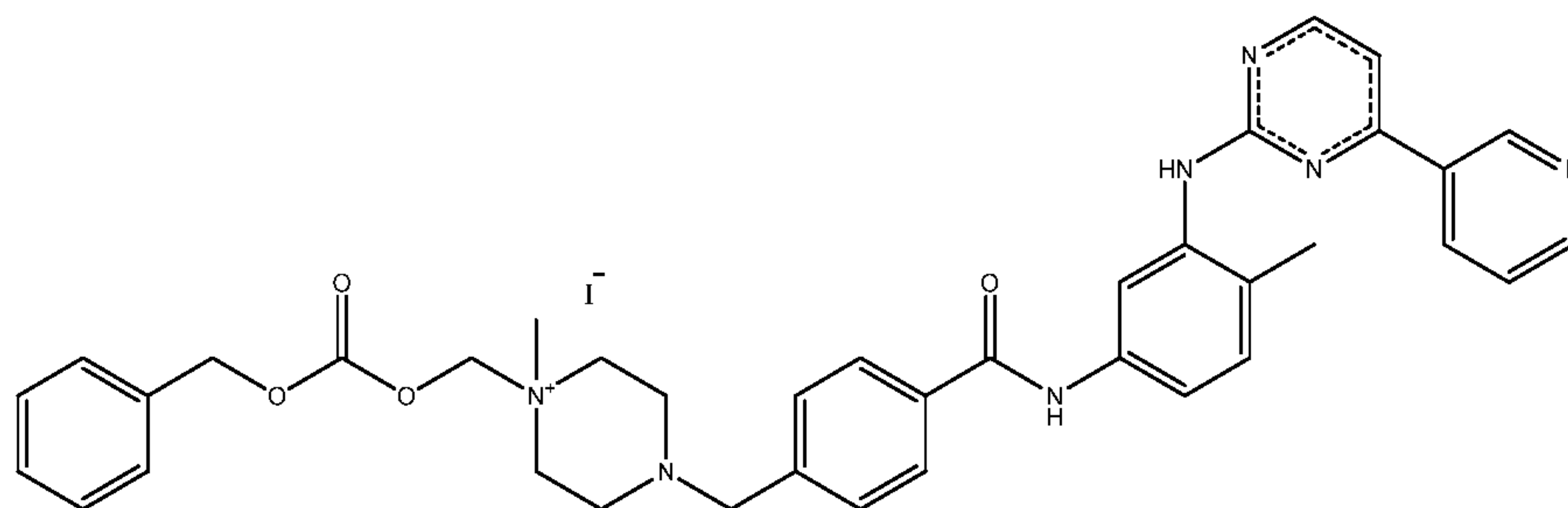
(R)-1-((sec-butoxycarbonyloxy)methyl)-1-methyl-4-(4-(4-methyl-3-(4-(pyridin-3-yl)pyrimidin-2-ylamino)phenylcarbamoyl)benzyl)piperazin-1-ium iodide

10



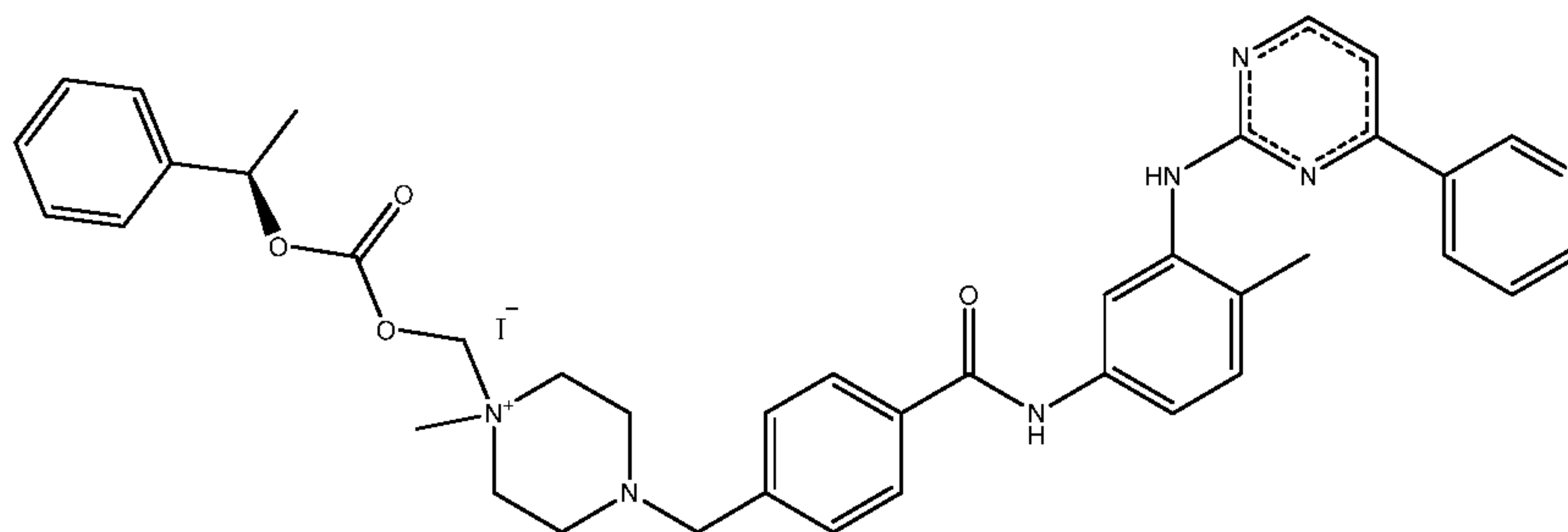
1013

1-(isobutyryloxymethyl)-1-methyl-4-(4-(4-methyl-3-(4-(pyridin-3-yl)pyrimidin-2-ylamino)phenylcarbamoyl)benzyl)piperazin-1-ium iodide



1014

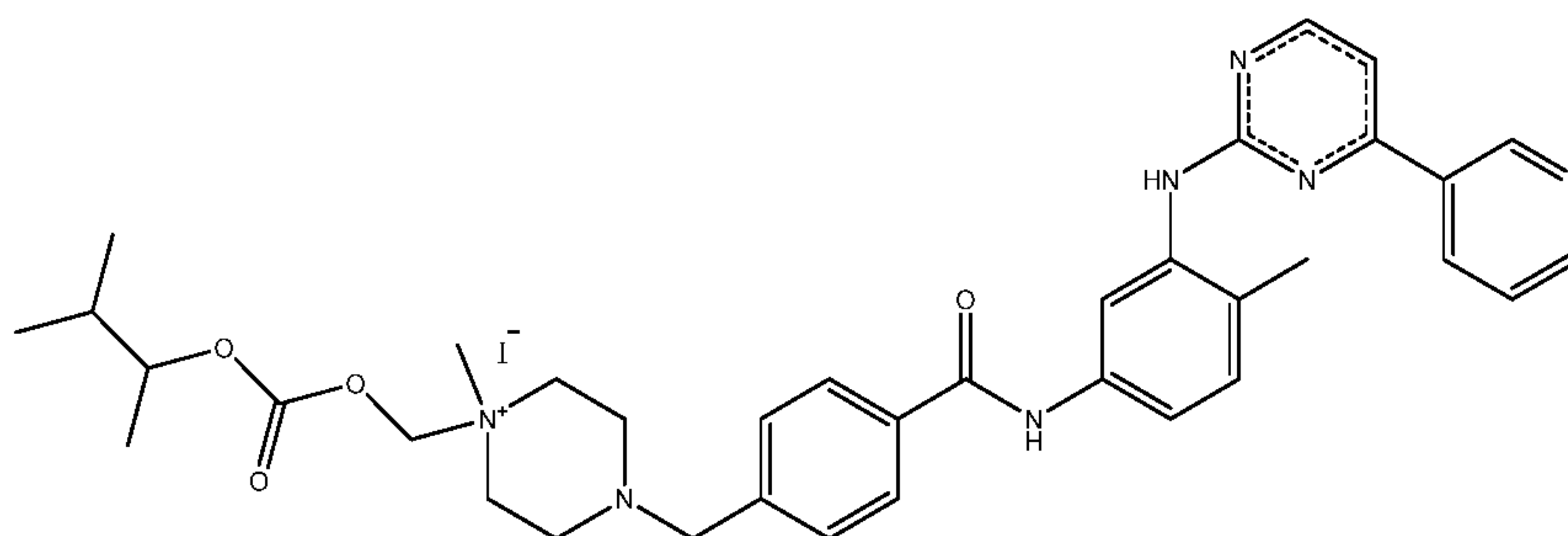
5 1-((benzyloxycarbonyloxy)methyl)-1-methyl-4-(4-(4-methyl-3-(4-(pyridin-3-yl)pyrimidin-2-ylamino)phenylcarbamoyl)benzyl)piperazin-1-ium iodide



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1015

(R)-1-methyl-4-(4-(4-methyl-3-(4-(pyridin-3-yl)pyrimidin-2-ylamino)phenylcarbamoyl)benzyl)-1-(((1-phenylethoxy)carbonyloxy)methyl)piperazin-1-ium iodide

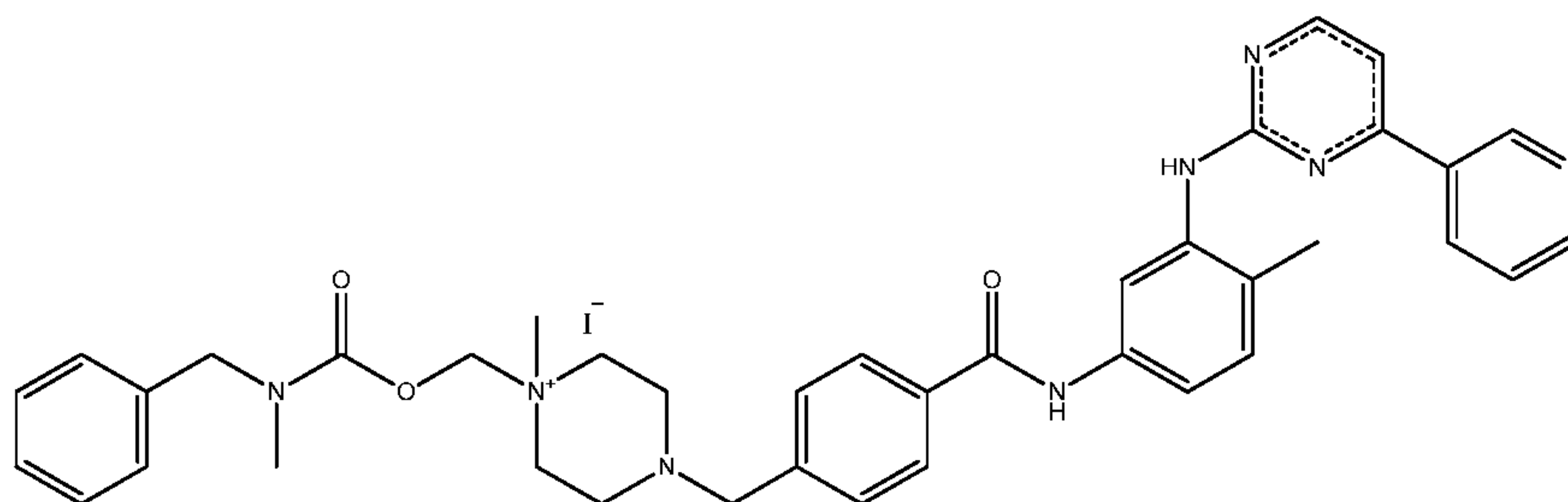


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1016

1-methyl-4-(4-(4-methyl-3-(4-(pyridin-3-yl)pyrimidin-2-ylamino)phenylcarbamoyl)benzyl)-1-(((3-methylbutan-2-yloxy)carbonyloxy)methyl)piperazin-1-ium iodide

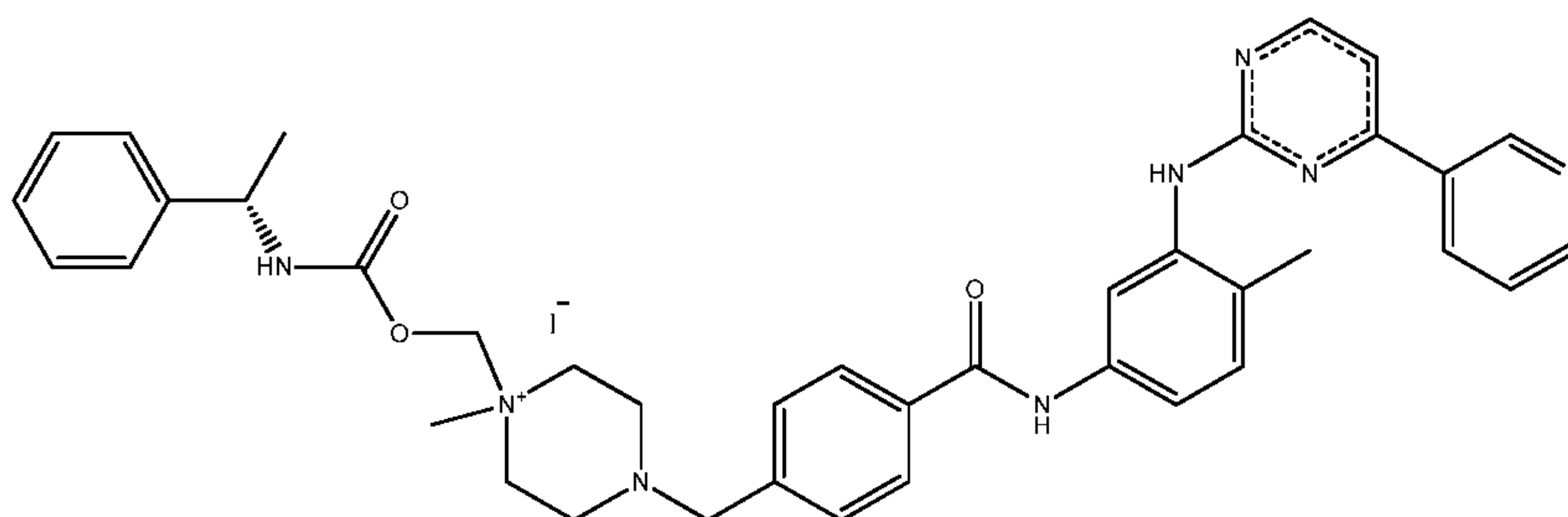
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1017

1-((benzyl(methyl)carbamoyloxy)methyl)-1-methyl-4-(4-(4-methyl-3-(4-(pyridin-3-yl)pyrimidin-2-ylamino)phenylcarbamoyl)benzyl)piperazin-1-ium iodide

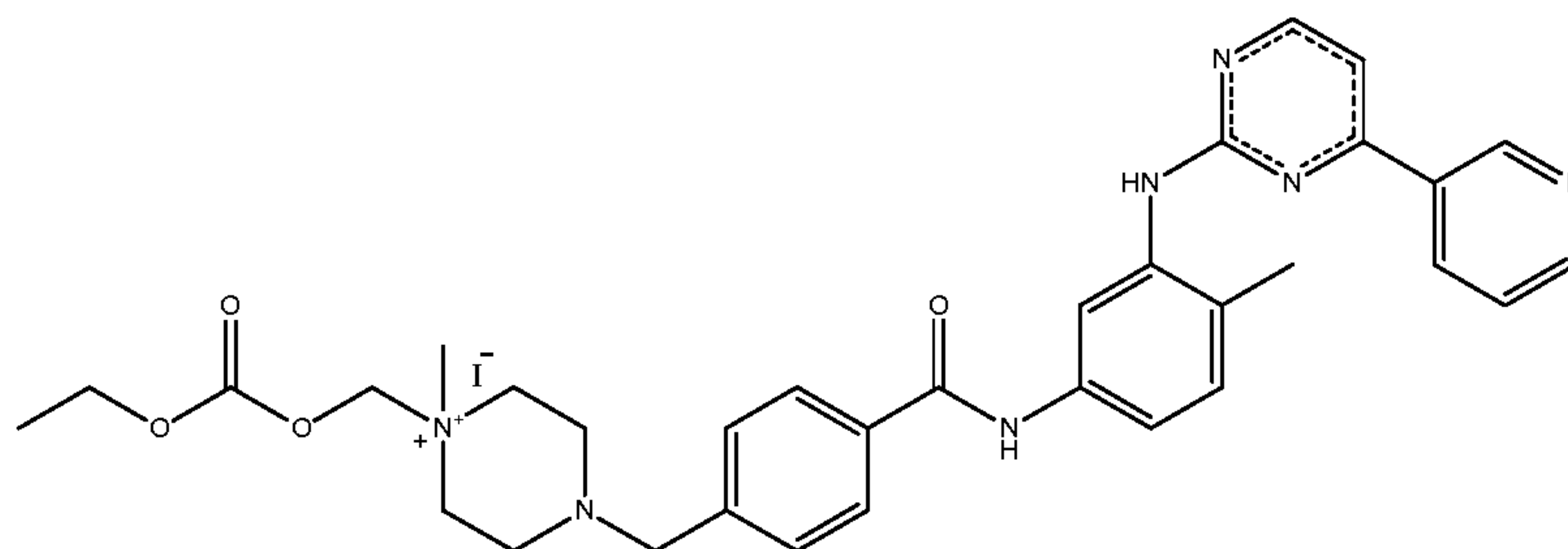
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1018

(S)-1-methyl-4-(4-(4-methyl-3-(4-(pyridin-3-yl)pyrimidin-2-ylamino)phenylcarbamoyl)benzyl)-1-((1-phenylethylcarbamoyloxy)methyl)piperazin-1-ium iodide

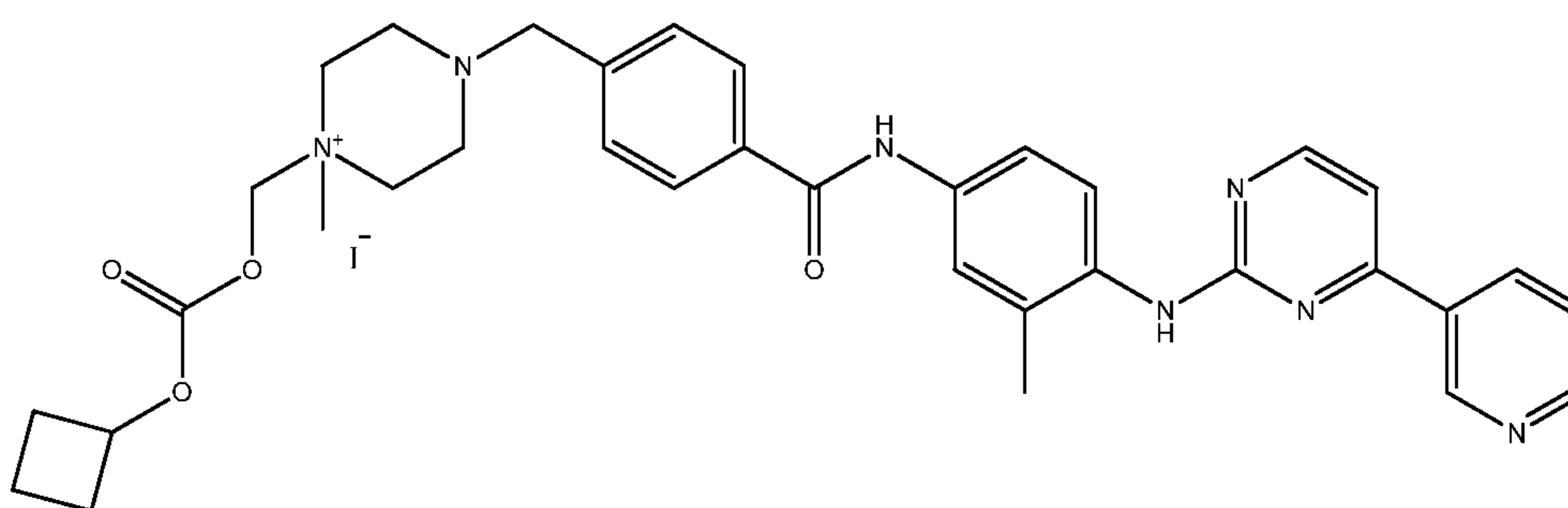
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1019

1-((ethoxycarbonyloxy)methyl)-1-methyl-4-(4-(4-methyl-3-(4-(pyridin-3-yl)pyrimidin-2-ylamino)phenylcarbamoyl)benzyl)piperazin-1-ium iodide

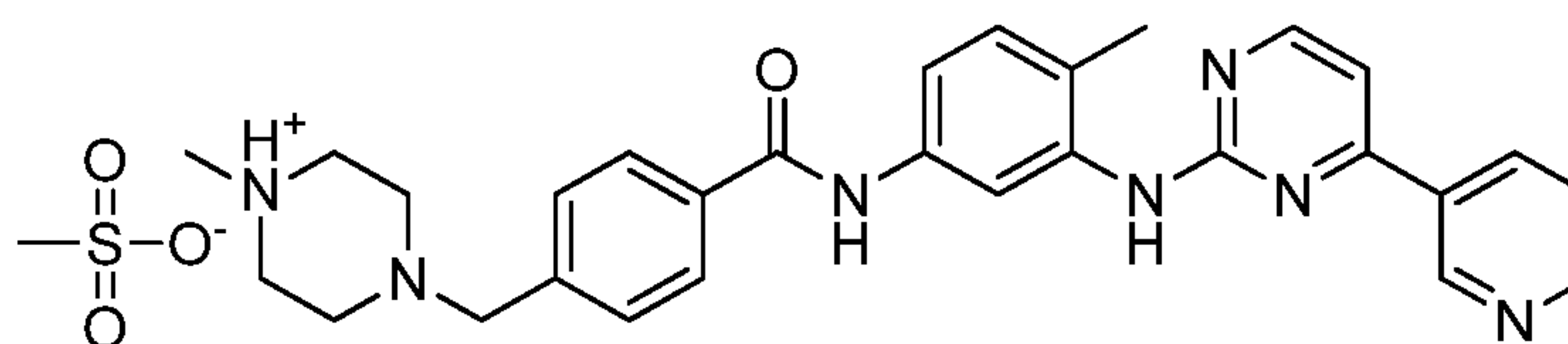
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1020

1-((cyclobutoxycarbonyloxy)methyl)-1-methyl-4-(4-(3-methyl-4-(4-(pyridin-3-yl)pyrimidin-2-ylamino)phenylcarbamoyl)benzyl)piperazin-1-ium iodide

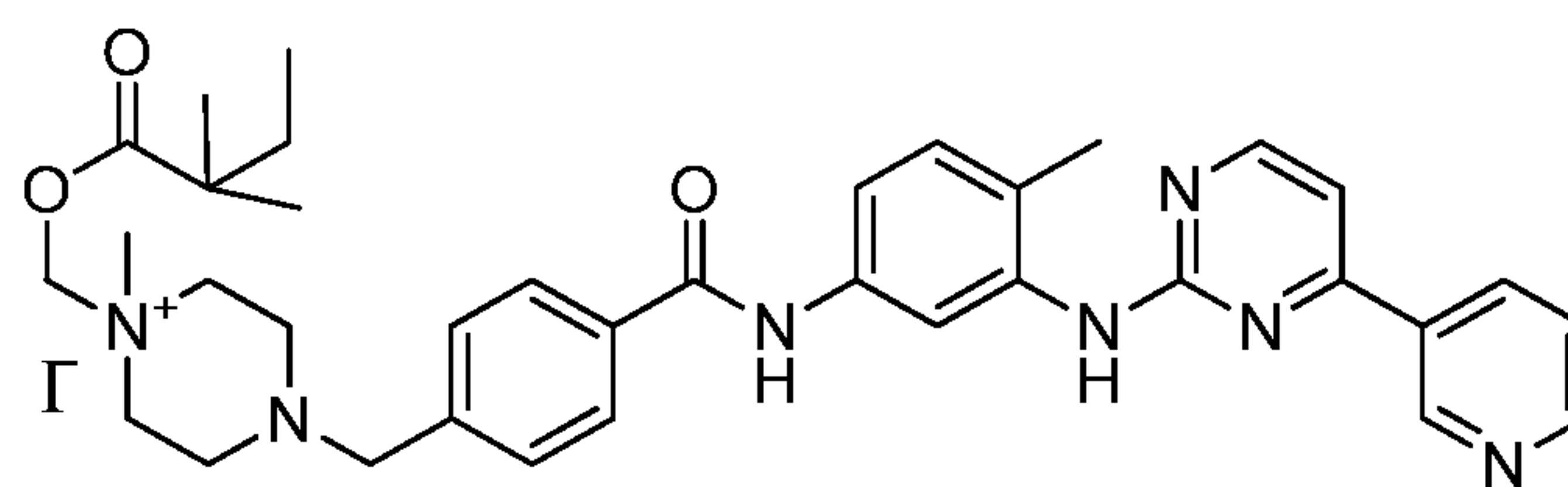
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1026

1-methyl-4-(4-((4-methyl-3-((4-(pyridin-3-yl)pyrimidin-2-ylamino)phenyl)carbamoyl)benzyl)piperazin-1-ium methanesulfonate

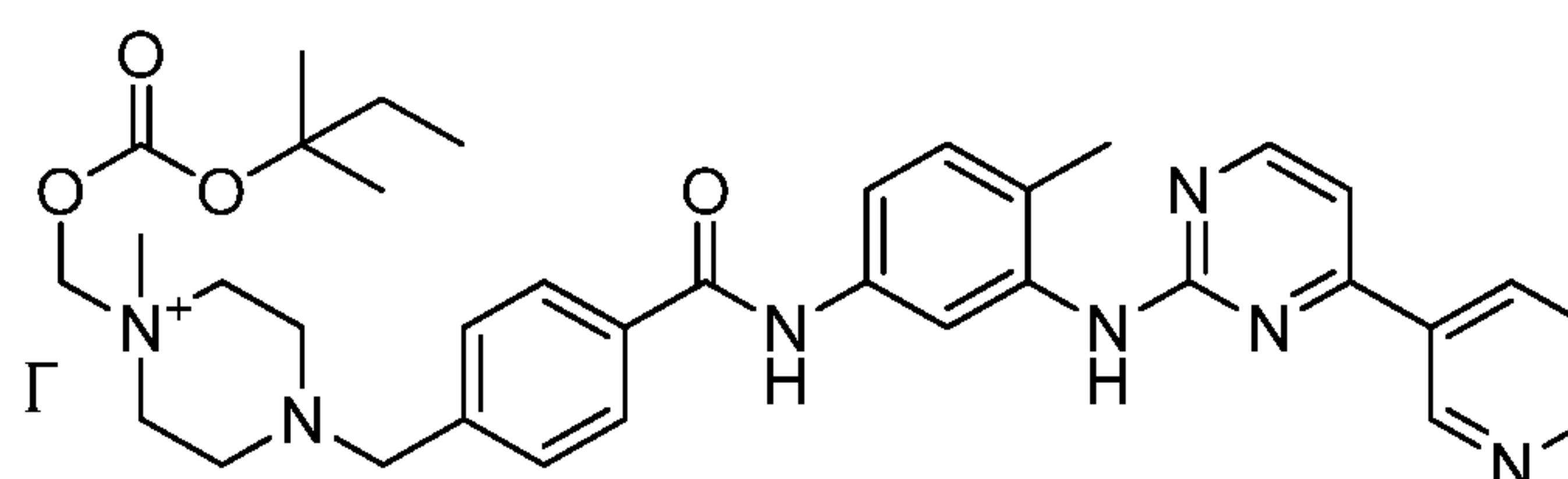
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1027

1-((2,2-dimethylbutanoyloxy)methyl)-1-methyl-4-(4-(4-methyl-3-(4-(pyridin-3-yl)pyrimidin-2-ylamino)phenylcarbamoyl)benzyl)piperazin-1-ium iodide

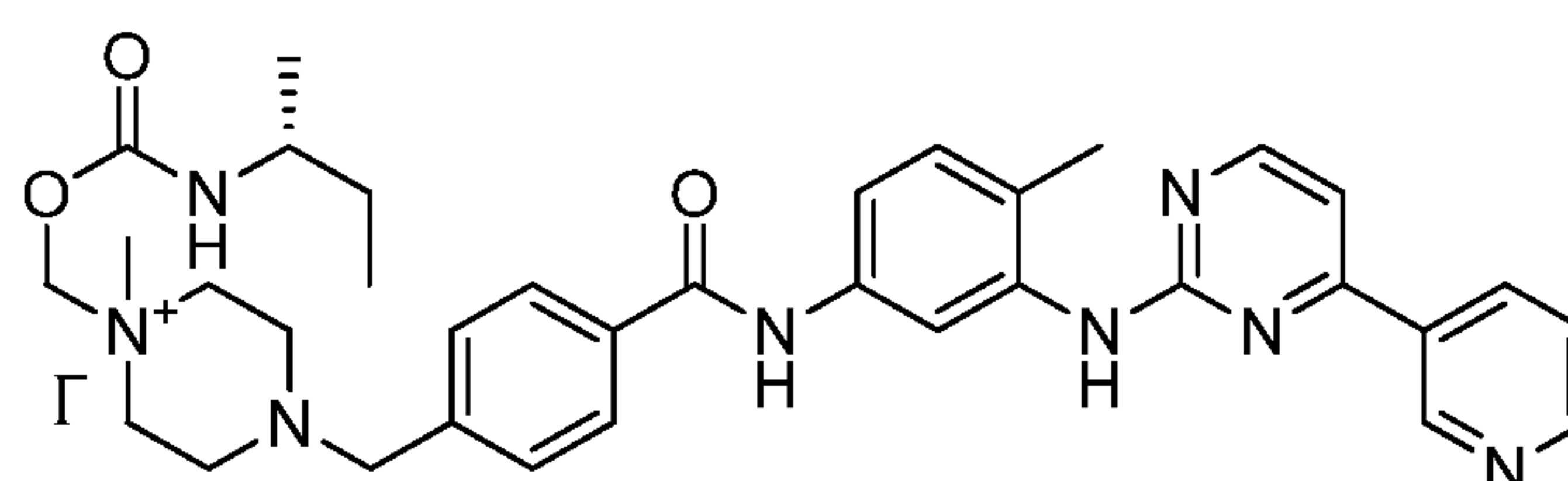
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1028

1-methyl-4-(4-(4-methyl-3-(4-(pyridin-3-yl)pyrimidin-2-ylamino)phenylcarbamoyl)benzyl)-1-((tert-pentyloxycarbonyloxy)methyl)piperazin-1-ium iodide

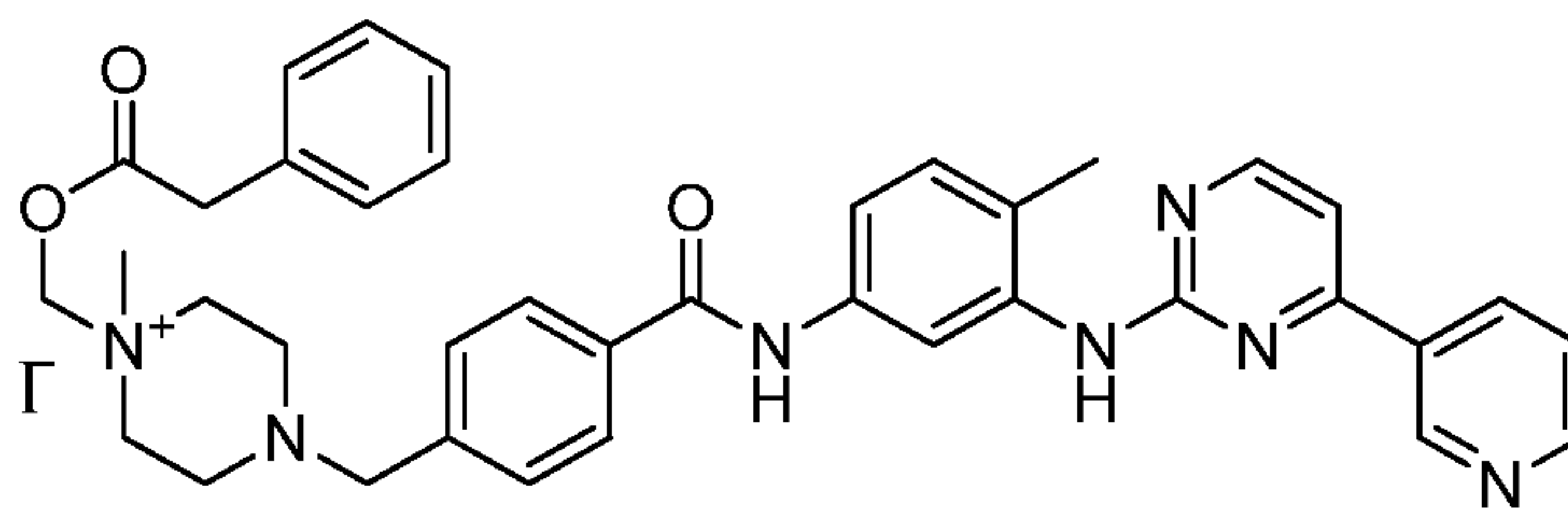
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1029

(R)-1-((sec-butylcarbamoyloxy)methyl)-1-methyl-4-(4-(4-methyl-3-(4-(pyridin-3-yl)pyrimidin-2-ylamino)phenylcarbamoyl)benzyl)piperazin-1-ium iodide

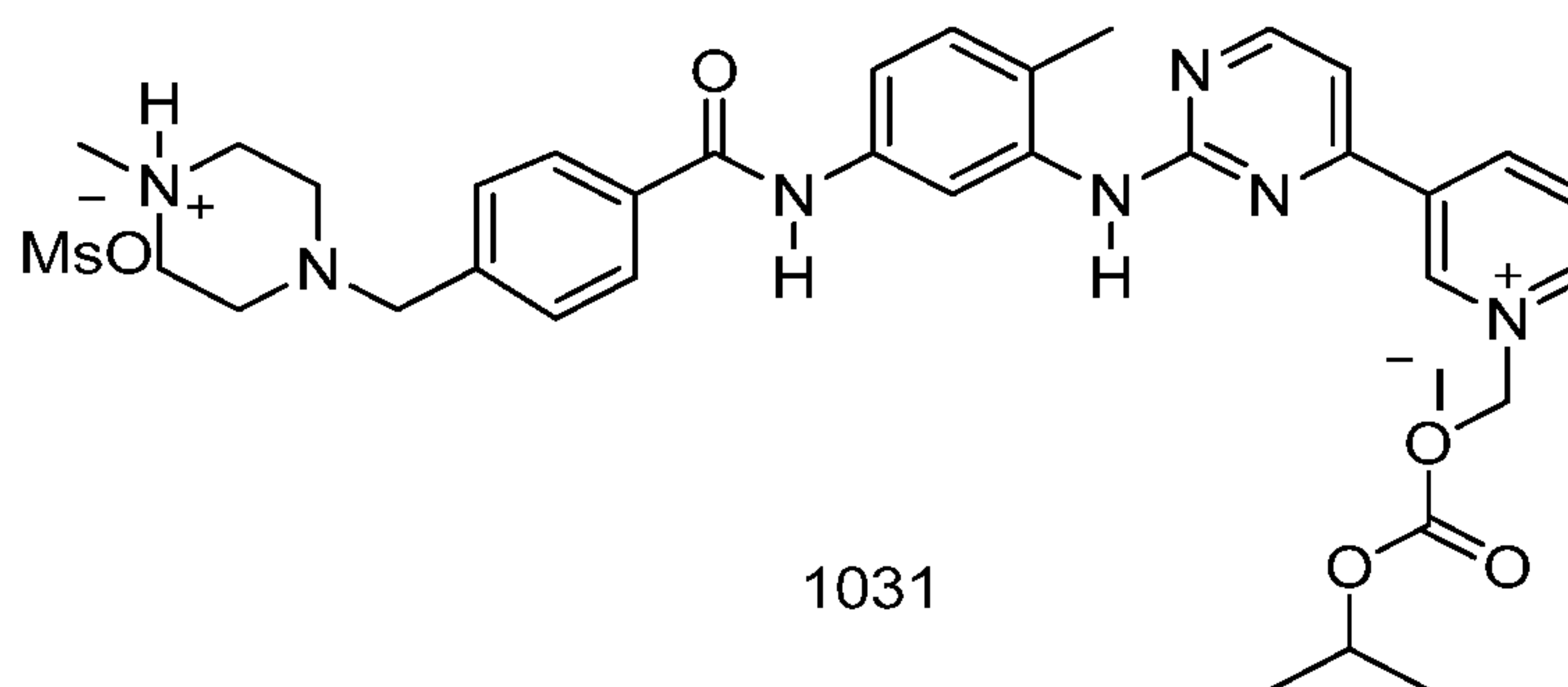
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1030

1-methyl-4-(4-(4-methyl-3-(4-(pyridin-3-yl)pyrimidin-2-ylamino)phenylcarbamoyl)benzyl)-1-((2-phenylacetoxy)methyl)piperazin-1-ium iodide

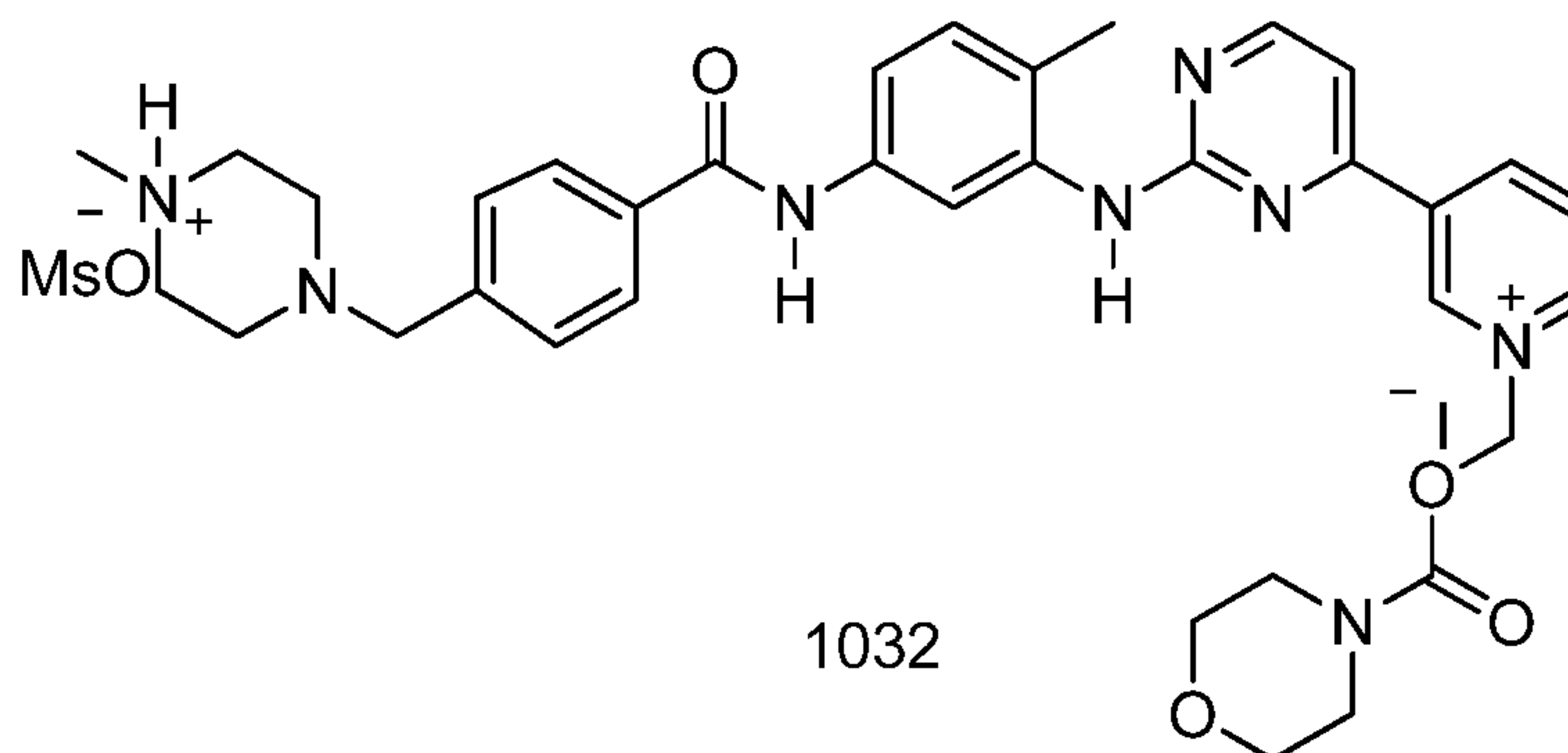
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1031

4-(4-((3-((4-(1-(((isopropoxycarbonyl)oxy)methyl)pyridin-1-ium-3-yl)pyrimidin-2-yl)amino)-4-methylphenyl)carbamoyl)benzyl)-1-methylpiperazin-1-ium monoiodide monomesylate

10

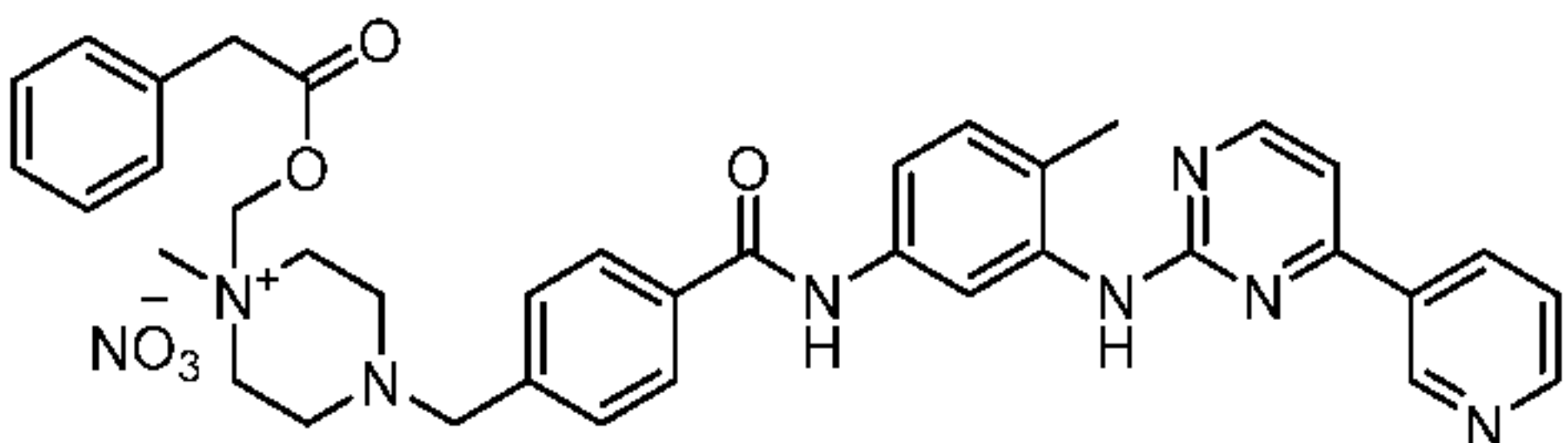
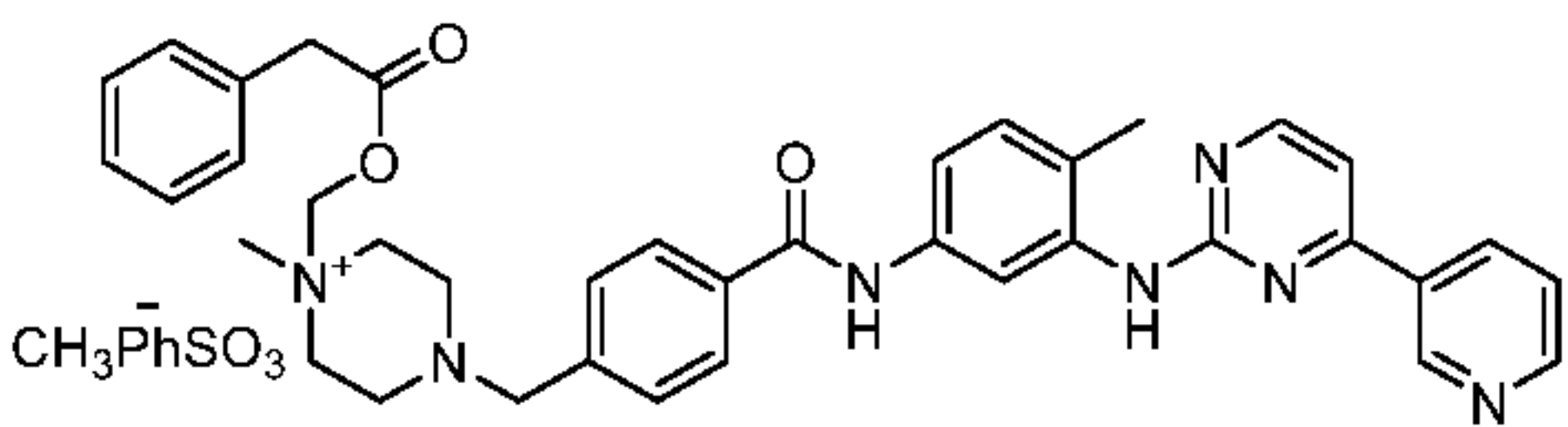
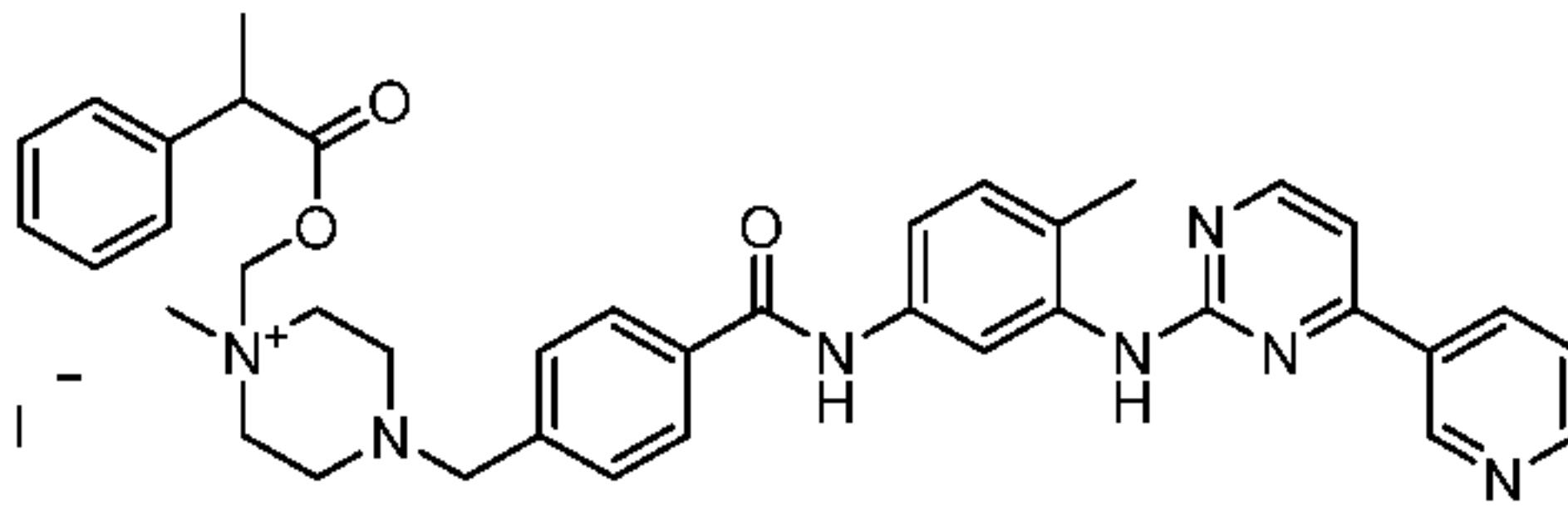
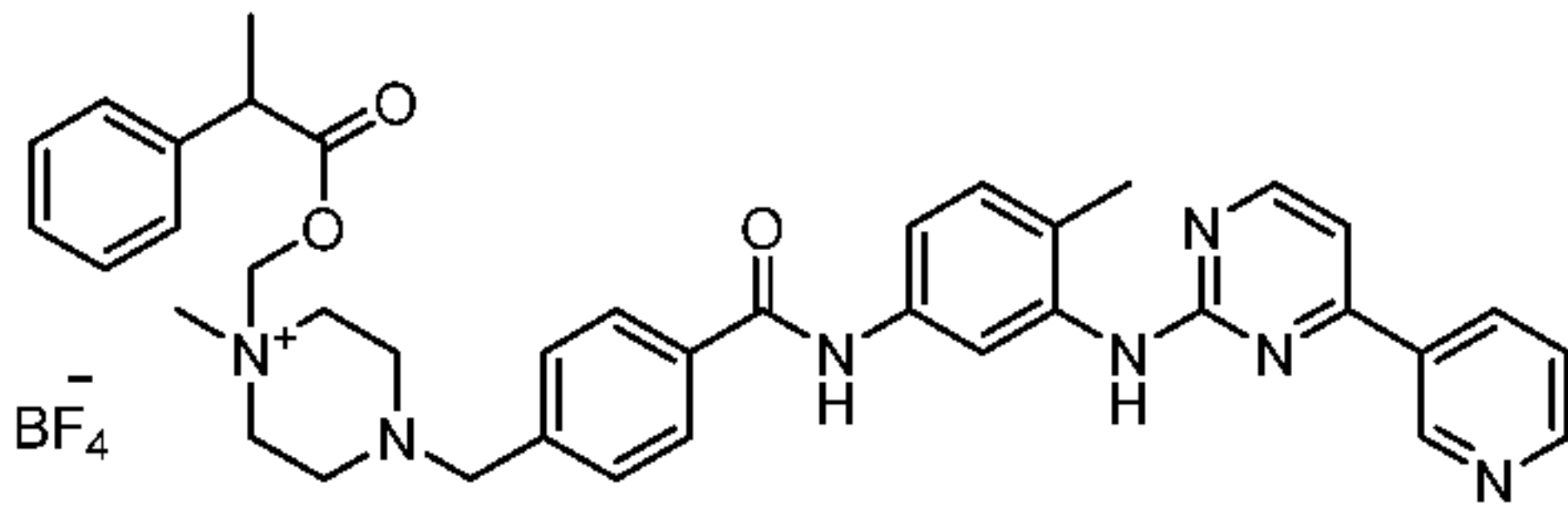


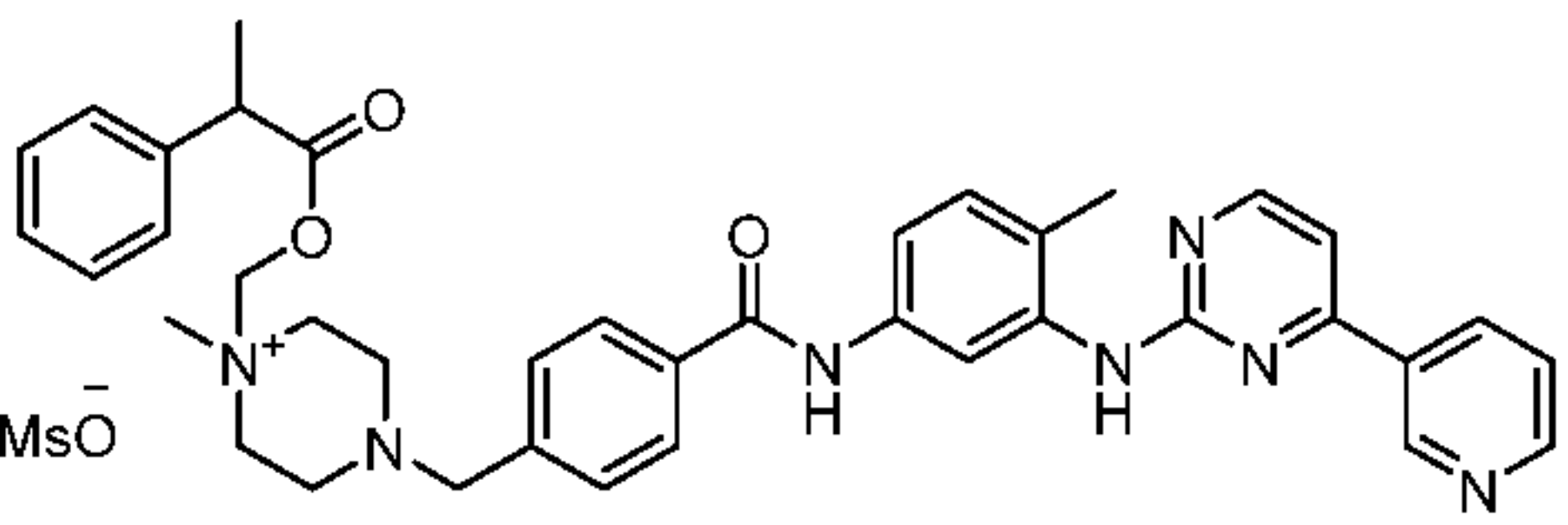
1032

3-(2-((2-methyl-5-(4-((4-methylpiperazin-1-yl) methyl) benzamido)phenyl)amino)pyrimidin-4-yl)-1-(((morpholine-4-carbonyl)oxy)methyl)pyridin-1-ium monoiodide monomesylate

15

No.	Structure	IUPAC name	m/z
1030		1-methyl-4-(4-((4-methyl-3-((4-(pyridin-3-yl)pyrimidin-2-yl)amino)phenyl)carbamoyl)benzyl)-1-((2-phenylacetoxy)methyl)piperazin-1-ium iodide	643
10737.02		1-methyl-4-(4-((4-methyl-3-((4-(pyridin-3-yl)pyrimidin-2-yl)amino)phenyl)carbamoyl)benzyl)-1-((2-phenylacetoxy)methyl)piperazin-1-ium methanesulfonate	643
10737.04		1-methyl-4-(4-((4-methyl-3-((4-(pyridin-3-yl)pyrimidin-2-yl)amino)phenyl)carbamoyl)benzyl)-1-((2-phenylacetoxy)methyl)piperazin-1-ium tetrafluoroborate	643
10737.06		1-methyl-4-(4-((4-methyl-3-((4-(pyridin-3-yl)pyrimidin-2-yl)amino)phenyl)carbamoyl)benzyl)-1-((2-phenylacetoxy)methyl)piperazin-1-ium trifluoromethanesulfonate	643

10737.07		1-methyl-4-(4-((4-methyl-3-((4-(pyridin-3-yl)pyrimidin-2-yl)amino)phenyl)carbamoyl)benzyl)-1-((2-phenylacetoxy)methyl)piperazin-1-ium nitrate	643
10737.08		1-methyl-4-(4-((4-methyl-3-((4-(pyridin-3-yl)pyrimidin-2-yl)amino)phenyl)carbamoyl)benzyl)-1-((2-phenylacetoxy)methyl)piperazin-1-ium p-toluene sulfonate	643
11124.01		1-methyl-4-(4-((4-methyl-3-((4-(pyridin-3-yl)pyrimidin-2-yl)amino)phenyl)carbamoyl)benzyl)-1-(((2-phenylpropanoyl)oxy)methyl)piperazin-1-ium iodide	657
11124.02		1-methyl-4-(4-((4-methyl-3-((4-(pyridin-3-yl)pyrimidin-2-yl)amino)phenyl)carbamoyl)benzyl)-1-(((2-phenylpropanoyl)oxy)methyl)piperazin-1-ium tetrafluoroborate	657

11124.03		1-methyl-4-(4-((4-methyl-3-((4-(pyridin-3-yl)pyrimidin-2-yl)amino)phenyl)carbamoyl)benzyl)-1-(((2-phenylpropanoyl)oxy)methyl)piperazin-1-ium methanesulfonate	657
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In one aspect, the invention provides a pharmaceutical composition comprising a compound as disclosed herein.

In certain embodiments, the pharmaceutical composition further comprises one or more pharmaceutically acceptable excipients.

In one aspect, the invention provides a compound or composition, as disclosed herein, for conjoint administration with one or more compounds independently selected from central nervous system drugs, such as CNS/respiratory stimulants, analgesics, narcotic agonists, narcotic antagonists, nonsteroidal anti-inflammatory/analgesic agents, behavior-modifying agents, tranquilizers/sedatives, anesthetic agents, inhalants, narcotics, reversal agents, anticonvulsants, skeletal muscle relaxants, smooth muscle relaxants, cardiovascular agents, inotropic agents, antiarrhythmic drugs, anticholinergics, vasodilating agents, agents used in treatment of shock, alpha-adrenergic blocking agents, beta-adrenergic blocking agents, respiratory drugs, bronchodilators, sympathomimetics, antihistamines, antitussives, agents for urinary incontinence/retention, urinary alkalinizers, urinary acidifiers, cholinergic stimulants, agents for urolithiasis, gastrointestinal agents, antiemetic agents, antacids, histamine H2 antagonists, gastromucosal protectants, proton pump inhibitors, appetite stimulants, GI antispasmodics-anticholinergics, GI stimulants, laxatives, saline, lubricant, surfactant, antidiarrheals, hormones/endocrine/reproductive agents, sex hormones, anabolic steroids, posterior pituitary hormones, adrenal cortical steroids, glucocorticoids, antidiabetic agents, thyroid drugs, thyroid hormones, endocrine/reproductive drugs, prostaglandins, anti-infective drugs, antiparasitics, anticoccidial agents, antibiotics, anti-tuberculosis, aminocyclitols, cephalosporins,

macrolides, penicillins, tetracyclines, lincosamides, quinolones, sulfonamides, antibacterials, antifungal agents, antiviral agents, blood modifying agents, clotting agents, anticoagulants, erythropoietic agents, antineoplastics/immunosuppressives, alkylating agents, antidotes, bone/joint agents, dermatologic agents (systemic), vitamins and
5 minerals/nutrients, systemic acidifiers, systemic alkalinizers, anti-cancer agents, and anti-viral agents.

Definitions

The term “alkyl” refers to the radical of saturated aliphatic groups, including
10 straight-chain alkyl groups, and branched-chain alkyl groups. In preferred embodiments, a straight chain or branched chain alkyl has 30 or fewer carbon atoms in its backbone (*e.g.*, C₁-C₃₀ for straight chains, C₃-C₃₀ for branched chains), and more preferably 20 or fewer. In certain embodiments, alkyl groups are lower alkyl groups, *e.g.* methyl, ethyl, *n*-propyl, *i*-propyl, *n*-butyl and *n*-pentyl.

15 Moreover, the term “alkyl” (or “lower alkyl”) as used throughout the specification, examples, and claims is intended to include both “unsubstituted alkyls” and “substituted alkyls”, the latter of which refers to alkyl moieties having substituents replacing a hydrogen on one or more carbons of the hydrocarbon backbone. In certain embodiments, a straight chain or branched chain alkyl has 30 or fewer carbon atoms in its backbone (*e.g.*, C₁-C₃₀ for
20 straight chains, C₃-C₃₀ for branched chains). In preferred embodiments, the chain has ten or fewer carbon (C₁-C₁₀) atoms in its backbone. In other embodiments, the chain has six or fewer carbon (C₁-C₆) atoms in its backbone.

The term “alkenyl”, as used herein, refers to an aliphatic group containing at least one double bond and is intended to include both “unsubstituted alkenyls” and “substituted
25 alkenyls”, the latter of which refers to alkenyl moieties having substituents replacing a hydrogen on one or more carbons of the alkenyl group. Such substituents may occur on one or more carbons that are included or not included in one or more double bonds. Moreover, such substituents include all those contemplated for alkyl groups, as discussed below, except where stability is prohibitive. For example, substitution of alkenyl groups by
30 one or more alkyl, carbocyclyl, aryl, heterocyclyl, or heteroaryl groups is contemplated. In preferred embodiments, a straight chain or branched chain alkenyl has 1-12 carbons in its

backbone, preferably 1-8 carbons in its backbone, and more preferably 1-6 carbons in its backbone. Exemplary alkenyl groups include allyl, propenyl, butenyl, 2-methyl-2-butenyl, and the like.

5 The term “alkynyl”, as used herein, refers to an aliphatic group containing at least one triple bond and is intended to include both “unsubstituted alkynyls” and “substituted alkynyls”, the latter of which refers to alkynyl moieties having substituents replacing a hydrogen on one or more carbons of the alkynyl group. Such substituents may occur on one or more carbons that are included or not included in one or more triple bonds. Moreover, such substituents include all those contemplated for alkyl groups, as discussed
10 above, except where stability is prohibitive. For example, substitution of alkynyl groups by one or more alkyl, carbocyclyl, aryl, heterocyclyl, or heteroaryl groups is contemplated. In preferred embodiments, an alkynyl has 1-12 carbons in its backbone, preferably 1-8 carbons in its backbone, and more preferably 1-6 carbons in its backbone. Exemplary alkynyl groups include propynyl, butynyl, 3-methylpent-1-ynyl, and the like.

15 The term “aralkyl”, as used herein, refers to an alkyl group substituted with one or more aryl groups.

The term “aryl”, as used herein, include substituted or unsubstituted single-ring aromatic groups in which each atom of the ring is carbon. Preferably the ring is a 5- to 7-membered ring, more preferably a 6-membered ring. Aryl groups include phenyl, phenol,
20 aniline, naphthyl, biphenyl, anthracenyl and the like.

The term “cycloalkyl”, as used herein, refers to the radical of a saturated aliphatic ring. In preferred embodiments, cycloalkyls have from 3-10 carbon atoms in their ring structure, and more preferably from 5-7 carbon atoms in the ring structure. Suitable cycloalkyls include cycloheptyl, cyclohexyl, cyclopentyl, cyclobutyl and cyclopropyl.

25 The terms "cycloalkyl" and "cycloalkenyl" refer to cyclic hydrocarbon groups of 3 to 12 carbon atoms.

The terms "halogen", “halide” and "halo", as used herein, mean halogen and include fluoro, chloro, bromo and iodo.

The terms “heterocyclyl”, “heterocycle”, “heterocyclo” and “heterocyclic” refer to
30 substituted or unsubstituted non-aromatic ring structures, preferably 3- to 10-membered

rings, more preferably 3- to 7-membered rings, whose ring structures include at least one heteroatom, preferably one to four heteroatoms, more preferably one or two heteroatoms. The heterocyclic group may be attached at any heteroatom or carbon atom of the ring or ring system. Exemplary monocyclic heterocyclic groups include pyrrolidinyl, pyrrolyl, pyrazolyl, oxetanyl, pyrazolinyl, imidazolyl, imidazoliny, imidazolidinyl, oxazolyl, oxazolidinyl, isoxazoliny, isoxazolyl, thiazolyl, thiadiazolyl, thiazolidinyl, isothiazolyl, isothiazolidinyl, furyl, tetrahydrofuryl, thienyl, oxadiazolyl, piperidinyl, piperazinyl, 2-oxopiperazinyl, 2-oxopiperidinyl, 2-oxopyrrolodiny, 2-oxoazepiny, azepiny, 4-piperidonyl, pyridiny, pyraziny, pyrimidinyl, pyridaziny, tetrahydropyrany, morpholinyl, thiamorpholinyl, thiamorpholinyl sulfoxide, thiamorpholinyl sulfone, 1,3-dioxolane and tetrahydro-1,1-dioxothienyl, triazolyl, triazinyl, and the like. Exemplary bicyclic heterocyclic groups include indolyl, benzothiazolyl, benzoxazolyl, benzodioxolyl, benzothienyl, quinuclidiny, quinolinyl, tetra-hydroisoquinolinyl, isoquinolinyl, benzimidazolyl, benzopyrany, indoliziny, benzofuryl, chromonyl, coumariny, benzopyrany, cinnolinyl, quinoxaliny, indazolyl, pyrrolopyridyl, furopyridiny (such as furo [2,3-c] pyridiny, furo [3,2-b] pyridiny] or furo [2,3-b] pyridiny), dihydroisoindolyl, dihydroquinazoliny (such as 3,4-dihydro-4-oxo-quinazoliny), tetrahydroquinolinyl and the like. Exemplary tricyclic heterocyclic groups include carbazolyl, benzindolyl, phenanthroliny, acridiny, phenanthridiny, xanthenyl and the like.

The term "heteroalkyl", as used herein, refers to a saturated or unsaturated chain of carbon atoms including at least one heteroatom (e.g., O, S, or NR⁴, such as where R⁴ is H or lower alkyl).

The term "heteroaryl" includes substituted or unsubstituted aromatic single ring structures, preferably 5- to 7-membered rings, more preferably 5- to 6-membered rings, whose ring structures include at least one heteroatom (e.g., O, N, or S), preferably one to four or one to 3 heteroatoms, more preferably one or two heteroatoms. When two or more heteroatoms are present in a heteroaryl ring, they may be the same or different. The term "heteroaryl" also includes polycyclic ring systems having two or more cyclic rings in which two or more carbons are common to two adjoining rings wherein at least one of the rings is heteroaromatic, e.g., the other cyclic rings can be cycloalkyls, cycloalkenyls, cycloalkynyls, aryls, heteroaryls, and/or heterocyclyls. Preferred polycyclic ring systems have two cyclic rings in which both of the rings are aromatic. Exemplary heteroaryl groups include

pyrrolyl, pyrazolyl, imidazolyl, oxazolyl, isoxazolyl, thiazolyl, thiadiazolyl, isothiazolyl, furyl, thienyl, oxadiazolyl, pyridinyl, pyrazinyl, pyrimidinyl, quinolinyl, pyridazinyl, triazolyl, triazinyl, and the like.

The term "alkoxy" is intended to mean an alkyl radical, as defined herein, attached
5 directly to an oxygen atom. Some embodiments are 1 to 5 carbons, some embodiments are 1 to 4 carbons, some embodiments are 1 to 3 carbons and some embodiments are 1 or 2 carbons. Examples include methoxy, ethoxy, n-propoxy, isopropoxy, n-butoxy, tert-butoxy, 5- isobutoxy, sec-butoxy, and the like.

The term "heteroatom", as used herein, means an atom of any element other than
10 carbon or hydrogen. Preferred heteroatoms are nitrogen, oxygen, and sulfur.

The term "substituted" refers to moieties having substituents replacing a hydrogen on one or more carbons of the backbone. It will be understood that "substitution" or "substituted with" includes the implicit proviso that such substitution is in accordance with permitted valence of the substituted atom and the substituent, and that the substitution
15 results in a stable compound, *e.g.*, which does not spontaneously undergo transformation such as by rearrangement, cyclization, elimination, etc. As used herein, the term "substituted" is contemplated to include all permissible substituents of organic compounds. In a broad aspect, the permissible substituents include acyclic and cyclic, branched and unbranched, carbocyclic and heterocyclic, aromatic and non-aromatic substituents of
20 organic compounds. The permissible substituents can be one or more and the same or different for appropriate organic compounds. For purposes of the invention, the heteroatoms such as nitrogen may have hydrogen substituents and/or any permissible substituents of organic compounds described herein which satisfy the valences of the heteroatoms. Substituents can include any substituents described herein, for example, a
25 halogen, a hydroxyl, a carbonyl (such as a carboxyl, an alkoxycarbonyl, a formyl, or an acyl), a thiocarbonyl (such as a thioester, a thioacetate, or a thioformate), an alkoxyl, an alkylthio, an acyloxy, a phosphoryl, a phosphate, a phosphonate, an amino, an amido, an amidine, an imine, a cyano, a nitro, an azido, a sulfhydryl, an alkylthio, a sulfate, a sulfonate, a sulfamoyl, a sulfonamido, a sulfonyl, a heterocyclyl, an aralkyl, or an aromatic
30 or heteroaromatic moiety.

Unless specifically stated as “unsubstituted,” references to chemical moieties herein are understood to include substituted variants. For example, reference to an “aryl” group or moiety implicitly includes both substituted and unsubstituted variants. Similarly, references to elements are understood to include any suitable isotope of that element. Thus, for
5 example, a hydrogen substituent could be protium, deuterium, or tritium, or a carbon atom could be ^{12}C , ^{13}C , or ^{14}C . In certain embodiments of the compounds disclosed herein, certain atoms may be isotopically enriched, e.g., for radioisotopic labelling or for a metabolically beneficial isotope effect (e.g., by isotopically enriching for deuterium at a hydrogen substituent). In such embodiments, the compound may be isotopically enriched
10 for the desired isotope such that at least 15%, at least 25%, at least 50%, at least 60%, at least 75%, or even at least 90% more of the molecules of the compound in the composition have the desired isotope at the indicated position.

The term “unsaturated ring” includes partially unsaturated and aromatic rings.

As used herein, the term “tumoral disease” refers to a hyperproliferative disease,
15 such as cancer.

As used herein, the term “conjoint administration” means administration of two or more agents to a subject of interest as part of a single therapeutic regimen. The administration(s) can be either simultaneous or sequential, i.e., administering one agent followed by administering of a second (and/or a third one, etc.) at a later time, as long as
20 the agents administered co-exist in the subject being treated, or at least one agent will have the opportunity to act upon the same target tissues of other agents while said target tissues are still under the influence of said other agents. In a certain embodiment, agents to be administered can be included in a single pharmaceutical composition and administered together. In a certain embodiment, the agents are administered simultaneously, including
25 through separate routes. In a certain embodiment, one or more agents are administered continuously, while other agents are administered only at predetermined intervals (such as a single large dosage, or twice a week at smaller dosages, etc.).

The present invention includes within its scope the salts and isomers. Compounds of the present invention may in some cases form salts, which are also within the scope of this
30 invention. The term “salt(s)”, as employed herein, denotes acidic and/or basic salts formed with inorganic and/or organic acids and bases. Zwitterions (internal or inner salts) are

included within the term "salt(s)" as used herein (and may be formed, for example, where the R substituents comprise an acid moiety such as a carboxyl group). Also included herein are quaternary ammonium salts such as alkylammonium salts. Pharmaceutically acceptable (i.e., non-toxic, physiologically acceptable) salts are preferred, although other salts are
5 useful, for example, in isolation or purification steps which may be employed during preparation. Salts of the compounds may be formed, for example, by reacting a compound with an amount of acid or base, such as an equivalent amount, in a medium such as one in which the salt precipitates or in an aqueous medium followed by lyophilization.

Exemplary acid addition salts include acetates (such as those formed with acetic
10 acid or trihaloacetic acid, for example, trifluoroacetic acid), adipates, alginates, ascorbates, aspartates, benzoates, benzenesulfonates, bisulfates, borates, butyrates, citrates, camphorates, camphorsulfonates, cyclopentanepropionates, digluconates, dodecylsulfates, ethanesulfonates, fumarates, glucoheptanoates, glycerophosphates, hemisulfates, heptanoates, hexanoates, hydrochlorides, hydrobromides, hydroiodides, 2-hydroxy
15 ethanesulfonates, lactates, maleates, methanesulfonates, 2-naphthalenesulfonates, nicotines, nitrates, oxalates, pectinates, persulfates, 3-phenylpropionates, phosphates, picrates, pivalates, propionates, salicylates, succinates, sulfates (such as those formed with sulfuric acid), sulfonates (such as those mentioned herein), tartrates, thiocyanates, toluenesulfonates, undecanoates, and the like.

Exemplary basic salts (formed, for example, wherein the substituent comprise an
20 acidic moiety such as a carboxyl group) include ammonium salts, alkali metal salts such as sodium, lithium, and potassium salts, alkaline earth metal salts such as calcium and magnesium salts, salts with organic bases (for example, organic amines) such as benzathines, dicyclohexylamines, hydrabamines, N-methyl-D-glucamines, N-methyl-D-
25 glucamides, t-butyl amines, and salts with amino acids such as arginine, lysine and the like. The basic nitrogen-containing groups may be quaternized with agents such as lower alkyl halides (e.g., methyl, ethyl, propyl, and butyl chlorides, bromides and iodides), dialkyl sulfates (e.g., dimethyl, diethyl, dibutyl, and diamyl sulfates), long chain halides (e.g., decyl, lauryl, myristyl and stearyl chlorides, bromides and iodides), aralkyl halides (e.g.,
30 benzyl and phenethyl bromides), and others.

Solvates of the compounds of the invention are also contemplated herein. Solvates of the compounds of formula I are preferably hydrates or other pharmaceutically acceptable solvates.

5 All stereoisomers of the present compounds, such as those which may exist due to asymmetric carbons on the R substituents of the compound, including enantiomeric and diastereomeric forms, are contemplated within the scope of this invention. Individual stereoisomers of the compounds of the invention may, for example, be substantially free of other isomers, or may be admixed, for example, as racemates or with all other, or other selected, stereoisomers. The chiral centers of the present invention may have the S or R
10 configuration.

As used herein, the term “treating” or “treatment” includes reversing, reducing, or arresting the symptoms, clinical signs, and underlying pathology of a condition in manner to improve or stabilize a subject's condition. As used herein, and as well understood in the art, “treatment” is an approach for obtaining beneficial or desired results, including clinical
15 results. Beneficial or desired clinical results can include, but are not limited to, alleviation or amelioration of one or more symptoms or conditions, diminishment of extent of disease, stabilized (i.e., not worsening) state of disease, preventing spread of disease, delay or slowing of disease progression, amelioration or palliation of the disease state, and remission (whether partial or total), whether detectable or undetectable. “Treatment” can also mean
20 prolonging survival as compared to expected survival if not receiving treatment.

As used herein, a therapeutic that “prevents” a disorder or condition refers to a compound that, in a statistical sample, reduces the occurrence of the disorder or condition in the treated sample relative to an untreated control sample, or delays the onset or reduces the severity of one or more symptoms of the disorder or condition relative to the untreated
25 control sample.

The present application also envisages within its scope the effect of selection of suitable counterions. The counterion of the compounds of the present invention may be chosen by selecting the dissociation constant for the drug capable of ionization within the said pH range. By estimating the ionized and un-ionized drug concentration of any
30 compound (using well established equations such a Henderson-Hasselbach equation), the solubility and consequently the absorption of the drug may be altered.

The compounds generated may be present as a single stereoisomer (e.g., enriched to at least 95% purity relative to the total amount of all stereoisomers present), a racemate, or a mixture of enantiomers or diastereomers in any ratio.

Pharmaceutical Compositions

5 The present invention further provides pharmaceutical compositions comprising a compound of formula (I) or (II) or its pharmaceutically acceptable salt thereof as an active ingredient along with pharmaceutically acceptable additives/ excipients/ adjuvants/ vehicles.

10 Compounds of the present invention may be used in a pharmaceutical composition, e.g., combined with a pharmaceutically acceptable carrier, for administration to a patient. Such a composition may also contain diluents, fillers, salts, buffers, stabilizers, solubilizers, and other materials well known in the art. The term “pharmaceutically acceptable” means a non-toxic material that does not interfere with the effectiveness of the biological activity of the active ingredient(s). The characteristics of the carrier will depend on the route of
15 administration. Such additional factors and/or agents may be included in the pharmaceutical composition to produce a synergistic effect with compounds of the invention, or to minimize side effects caused by the compound of the invention.

20 The pharmaceutical compositions of the invention may be in the form of a liposome or micelles in which compounds of the present invention are combined, in addition to other pharmaceutically acceptable carriers, with amphipathic agents such as lipids which exist in aggregated form as micelles, insoluble monolayers, liquid crystals, or lamellar layers in aqueous solution. Suitable lipids for liposomal formulation include, without limitation, monoglycerides, diglycerides, sulfatides, lysolecithin, phospholipids, saponin, bile acids, and the like. Preparation of such liposomal formulations is within the level of skill in the
25 art, as disclosed, for example, in U.S. Pat. Nos. 4,235,871; 4,501,728; 4,837,028; and 4,737,323, all of which are incorporated herein by reference.

30 The composition may be administered in a variety of ways including orally, nasally, buccally, sublingually, intravenously, transmucosally, parenterally, by inhalation, spray, transdermally, subcutaneously, intrathecally, topically or rectally and may be formulated according to methods known in the art.

The effective dosage form for a mammal may be about 0.1- 100 mg/ kg of body weight of active compound, which may be administered as a single dose or in the form of individual doses, such as from 1 to 4 times a day.

The mammal may be an adult human.

5 The compounds of the present invention may optionally be administered with one or more additional agents. Exemplary additional agents include one or more compounds independently selected from central nervous system drugs, such as CNS/respiratory stimulants, analgesics, narcotic agonists, narcotic antagonists, nonsteroidal anti-inflammatory/analgesic agents, behavior-modifying agents, tranquilizers/sedatives,
 10 anesthetic agents, inhalants, narcotics, reversal agents, anticonvulsants, skeletal muscle relaxants, smooth muscle relaxants, cardiovascular agents, inotropic agents, antiarrhythmic drugs, anticholinergics, vasodilating agents, agents used in treatment of shock, alpha-adrenergic blocking agents, beta-adrenergic blocking agents, respiratory drugs, bronchodilators, sympathomimetics, antihistamines, antitussives, agents for urinary
 15 incontinence/retention, urinary alkalinizers, urinary acidifiers, cholinergic stimulants, agents for urolithiasis, gastrointestinal (GI) agents, antiemetic agents, antacids, histamine H₂ antagonists, gastromucosal protectants, proton pump inhibitors, appetite stimulants, GI antispasmodics-anticholinergics, GI stimulants, laxatives, saline, bulk producing, lubricant, surfactant, antidiarrheals, hormones/endocrine/reproductive agents, sex hormones, anabolic
 20 steroids, posterior pituitary hormones, adrenal cortical steroids, glucocorticoids, antidiabetic agents, thyroid drugs, thyroid hormones, misc. endocrine/reproductive drugs, prostaglandins, antiinfective drugs, antiparasitics, anticoccidial agents, antibiotics, anti-tuberculosis, aminocyclitols, cephalosporins, macrolides, penicillins, tetracyclines, lincosamides, quinolones, sulfonamides, antibacterials, antifungal agents, antiviral agents,
 25 blood modifying agents, clotting agents, anticoagulants, erythropoietic agents, antineoplastics/immunosuppressives, alkylating agents, antidotes, bone/joint agents, dermatologic agents (systemic), vitamins and minerals/nutrients, systemic acidifiers, systemic alkalinizers, anti-cancer agents, and anti-viral agents.

METHODS OF USE

The present invention further provides a method of prophylaxis and/or treatment of, and/or ameliorating the symptoms of, diseases, comprising administering a therapeutically effective amount of a compound of formula (I) or (II) or pharmaceutically acceptable salts thereof or pharmaceutical compositions comprising the compound of formula (I) or (II) as the active ingredient.

METHODS OF TREATING PARKINSON'S DISEASE

In one aspect, the present invention provides methods of treating, inhibiting, or preventing Parkinson's disease or its symptoms comprising administering to a subject in need thereof a therapeutically effective amount of an Abelson-family tyrosine kinase (ATK) inhibitor. In some embodiments, the methods comprise administering a pharmaceutical composition comprising an ATK inhibitor as described herein.

In some embodiments, the ATK inhibitor is a compound of formula (I). In certain preferred embodiments, the ATK inhibitor is selected from Compound 207, 832, 8270, or 809.

In some embodiments, the ATK inhibitor is a compound of formula (II).

In some embodiments of this aspect, the ATK inhibitor is selected from bafetinib, dasatinib, flumatinib, imatinib, metatinib, nilotinib, pexmetinib, ponatinib, rebastinib, tozasertib, XL228, ON 146040, TG100598, SUN-K706, SUN-K954, SGX393, SAR103168, PHA680626, ON044580, ON012380, NRCAN019, LS104, KW2449, HM95091, AT9283, AEG41174, ACTB1011, or ACTB1011, or their pharmaceutically acceptable salts. In preferred embodiments, the ATK inhibitor is selected from imatinib, nilotinib, dasatinib, or bafetinib, or their pharmaceutically acceptable salts.

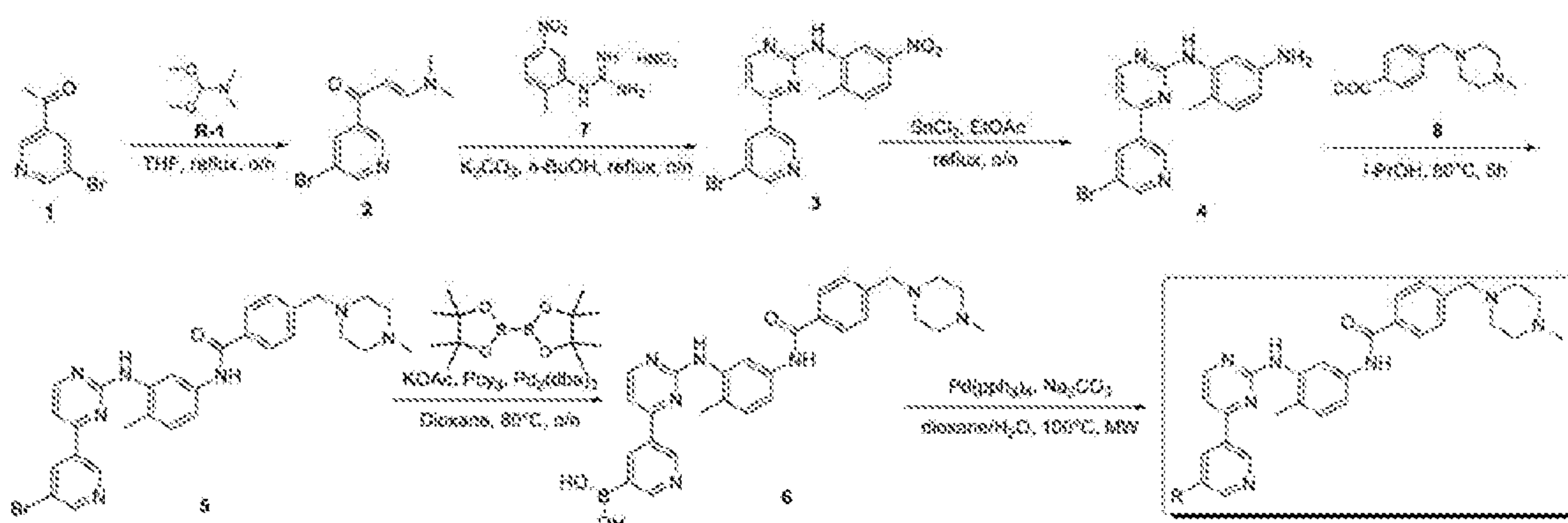
The ATK inhibitor may be administered by any route known to those of skill in the art. In certain preferred embodiments, the ATK inhibitor or pharmaceutical composition is administered orally, nasally, buccally, sublingually, intravenously, transmucosally, parenterally, by inhalation, spray, transdermally, subcutaneously, topically or rectally. In certain preferred embodiments, the ATK inhibitor or pharmaceutical composition is administered orally.

Exemplification

The invention now being generally described, it will be more readily understood by reference to the following examples, which are included merely for purposes of illustration of certain aspects and embodiments of the present invention, and are not intended to limit the invention.

Example 1: Synthetic Protocols

Scheme 1: Synthesis of Intermediates 5 and 6



Synthesis of *(E)*-1-(5-bromopyridin-3-yl)-3-(dimethylamino)prop-2-en-1-one (**2**)

A solution of **1** (40.0 g, 200 mmol) and **R-1** (119.0 g, 1000 mmol) in 500 mL of THF was stirred at 70 °C overnight. TLC indicated the reaction was completed. The mixture was cooled to room temperature and removed the solvent at reduced pressure. The resulting solid was washed with hexane to afford **2** as a yellow solid (47.2 g, 93%).

Synthesis of 4-(5-bromopyridin-3-yl)-N-(2-methyl-5-nitrophenyl)pyrimidin-2-amine (**3**)

A mixture of **2** (45 g, 176.5 mmol), **7** (40.6 g, 159.2 mmol), K₂CO₃ (44.0 g, 318.8 mmol) in 500 mL of n-BuOH was heated at 120°C for 16 hours. The reaction mixture was filtered, and the solvent was removed at reduced pressure. The residue was purified by chromatography column (silica gel, eluted with petroleum ether (PE)/ethyl acetate (EA), PE/EA = 2:1) to afford **3** (47.0 g, 70%) was a light yellow solid.

Synthesis of *N*¹-(4-(5-bromopyridin-3-yl)pyrimidin-2-yl)-6-methylbenzene-1,3-diamine (**4**)

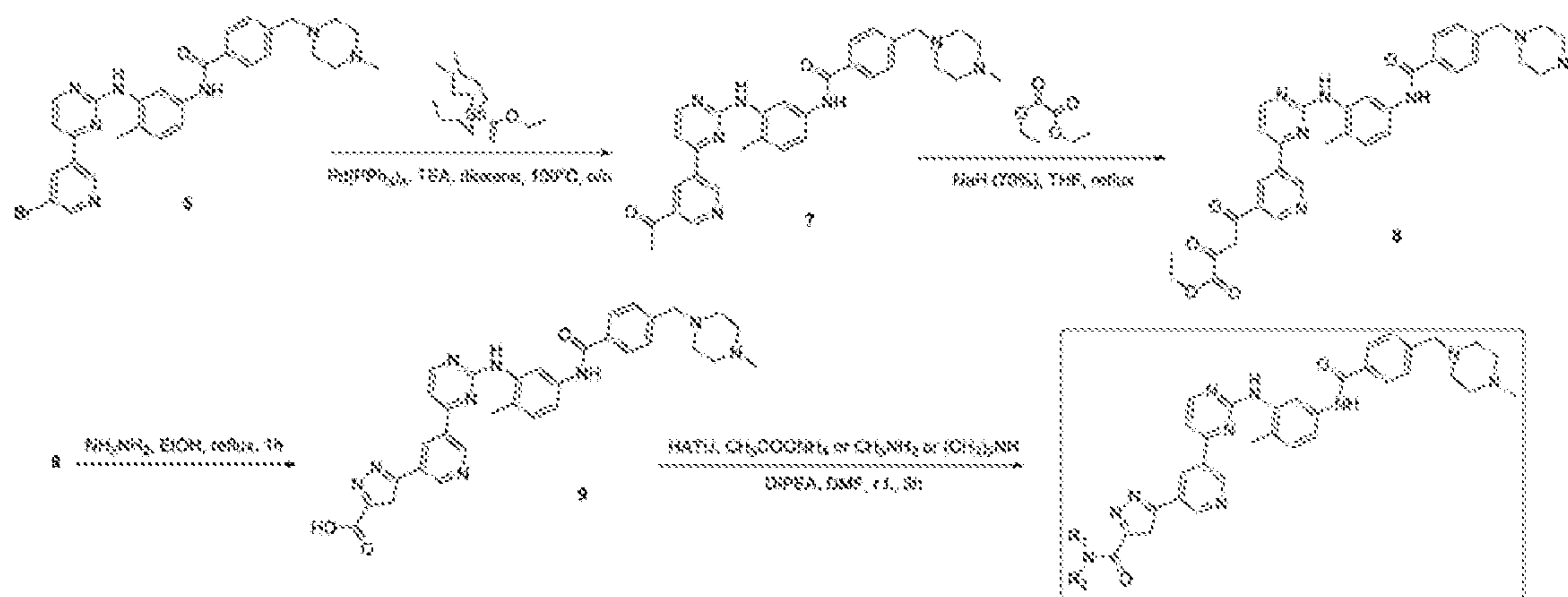
A solution of **3** (45.0 g, 116.9 mmol) and SnCl₂ (132.0 g, 585 mmol) in 300 mL of EtOAc was heated to reflux overnight, then the reaction was cooled to room temperature, filtered
 5 and the solution was concentrated at reduced pressure to afford **4** (44.0 g, 100%). It was directly used for the next step without any further purification.

Synthesis of *N*-(3-(4-(5-bromopyridin-3-yl)pyrimidin-2-ylamino)-4-methylphenyl)-4-((4-methylpiperazin-1-yl)methyl)benzamide (**5**)

10 The above crude **4** (30.0 g, 84.5 mmol) and **8** (40.0 g, 123.0 mmol) were dissolved in 300 mL of *i*-BuOH, then the resulting solution was warmed to 80°C for about 5 hours, after completion of the reaction, the mixture was cooled to room temperature, and removed the solvent under reduced pressure. The resulting residue was purified by flash chromatography on silica gel (Hexane/EA = 2:1) to afford **5** (45.0 g, 93%) as a yellow solid.

15 Synthesis of 5-(2-(2-methyl-5-(4-((4-methylpiperazin-1-yl)methyl)benzamido)phenylamino)pyrimidin-4-yl)pyridin-3-ylboronic acid (**6**)

A mixture of **5** (10.0 g, 17.5 mmol), KOAc (2.8 g, 28.1 mmol), PCy₃ (0.3 g, 1.1 mmol), Pd₂(dba)₃ (0.4 g, 0.5 mmol) and 4,4,4',4',5,5,5',5'-octamethyl-2,2'-bi(1,3,2-dioxaborolane) (7.1 g, 28.0 mmol) in dioxane (150 mL), was stirred at 80°C overnight, after completion of
 20 the reaction. The reaction solution was removed at reduced pressure to afford crude **6** (11.0 g, yield 100%) as yellow solid. It was directly used for next step without further purification.

Scheme 2: Synthesis of Intermediates 7, 8 and 9

Synthesis of *N*-(3-(4-(5-acetylpyridin-3-yl)pyrimidin-2-ylamino)-4-methylphenyl)-4-((4-methylpiperazin-1-yl)methyl)benzamide (7)

A solution of **5** (1.1 g, 2.0 mmol), tributyl(1-ethoxyvinyl)stannane (0.9 g, 2.6 mmol),
5 Pd(PPh₃)₄ (0.2 g, 0.1 mmol) and triethylamine (0.3 g, 3.0 mmol) in degassed dioxane (50 mL) was heated to reflux for 24 hours. The solvent was then evaporated *in vacuo* and the residue was filtered through a thick pad of SiO₂. The solid obtained was taken up in dry THF (60 mL), cooled to 0°C, and treated with 1N HCl. The solution was stirred for 2 hours at room temperature and then neutralized with sat. aq. NaHCO₃. The mixture was extracted
10 with EA and the organic layers were washed with brine, dried over Na₂SO₄, and concentrated *in vacuo*. The residue was purified by flash chromatography (silica gel, eluted with PE/EA = 2:1) to afford **7** (1.0 g, 94%) as a white solid.

Synthesis of ethyl 4-(5-(2-(2-methyl-5-(4-((4-methylpiperazin-1-yl)methyl)benzamido)phenylamino)pyrimidin-4-yl)pyridin-3-yl)-2,4-dioxobutanoate (**8**)

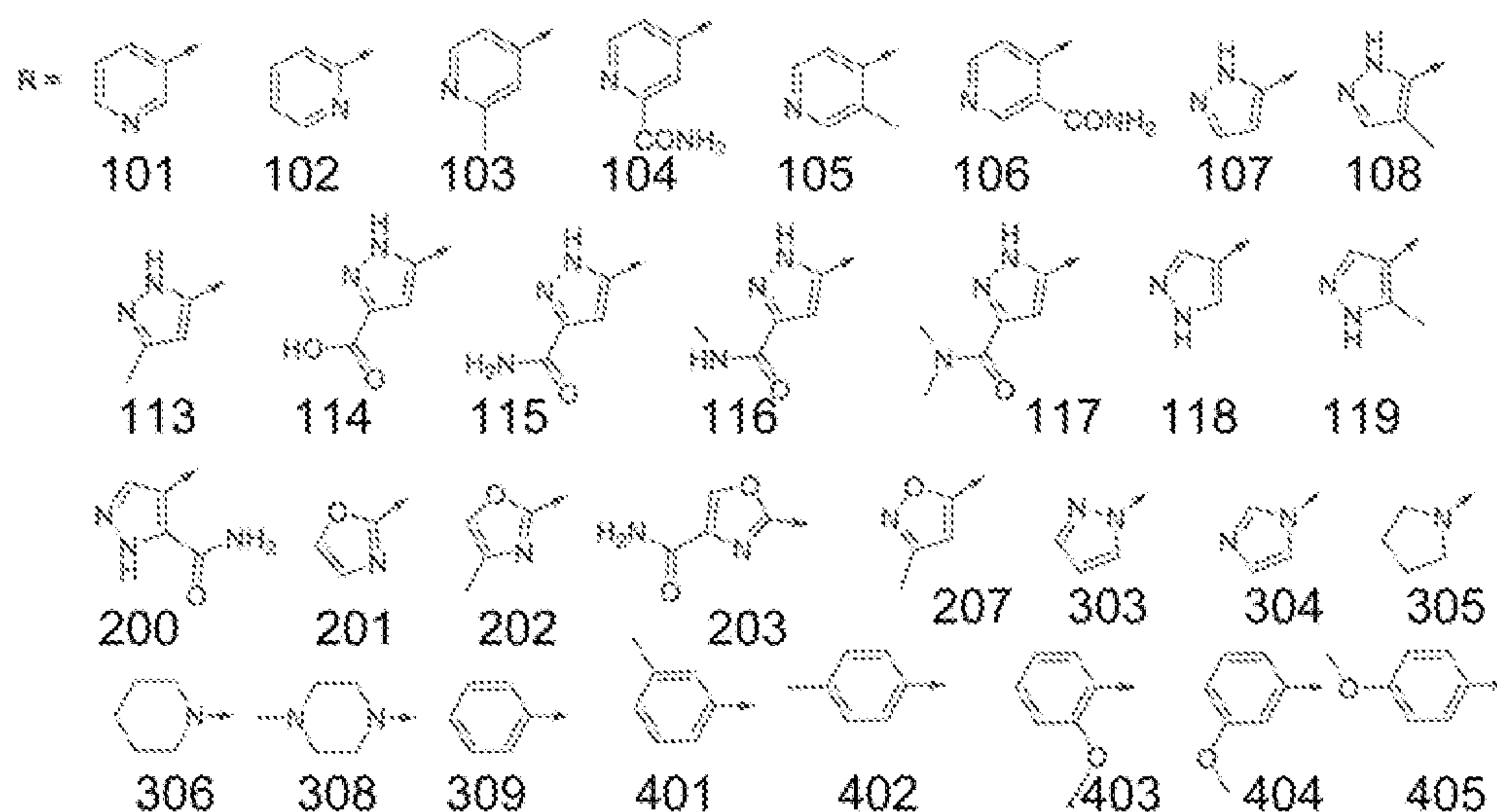
Diethyl oxalate (0.4 g, 2.3 mmol) was added to a suspension of sodium hydride (70 percent, 0.2 g) in 15 mL of tetrahydrofuran, and refluxed for about 15 min. Then a solution of **7** (1.0 g, 1.9 mmol) in 5 mL of tetrahydrofuran was added dropwise over 30 min, and refluxed for 90 min. After cooling down, the reaction mixture was poured into ice-cold water, which
20 was neutralized with diluted hydrochloric acid and extracted with ethyl acetate, dried over

Na₂SO₄, and concentrated. The crude product **8** (0.8 g, 67%) was used for the next step without any further purification.

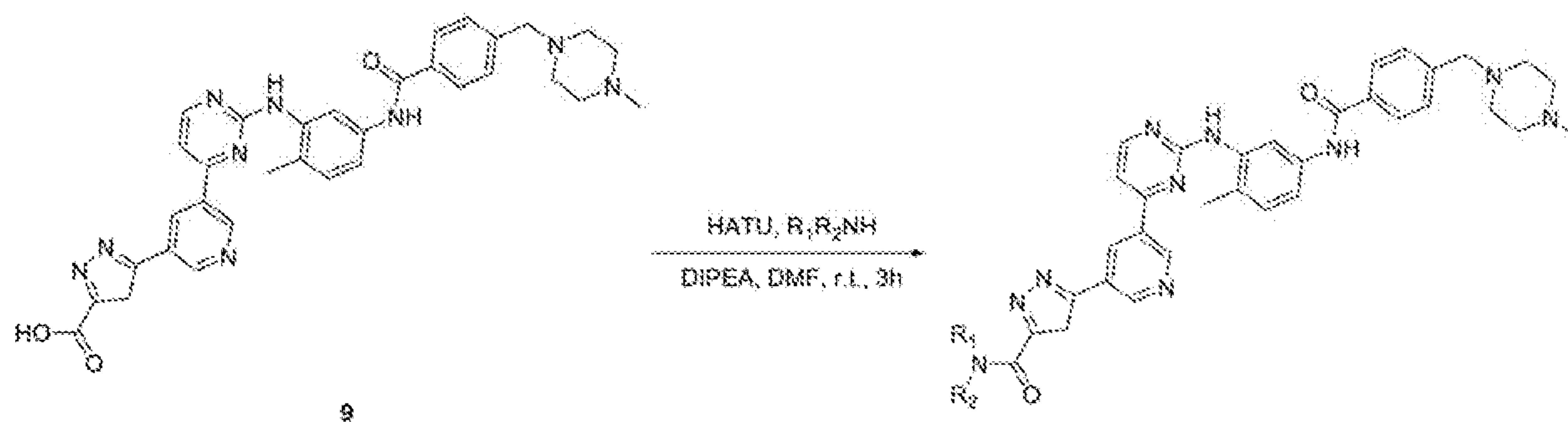
Synthesis of 5-(5-(2-(2-methyl-5-(4-((4-methylpiperazin-1-yl)methyl)benzamido)phenylamino)pyrimidin-4-yl)pyridin-3-yl)-4H-pyrazole-3-carboxylic acid (**9**)

To a solution of **8** (0.8 g, 1.26 mmol) in 20 mL of EtOH, hydrazine (0.1 g, 2.54 mmol) was added. The resulting mixture was heated to reflux for 60 min. The solution was removed under reduced pressure, and the residue was purified by *prep*-HPLC (basic) to afford **9** (0.6 g, 78%) as a white solid.

Synthesis of library compounds

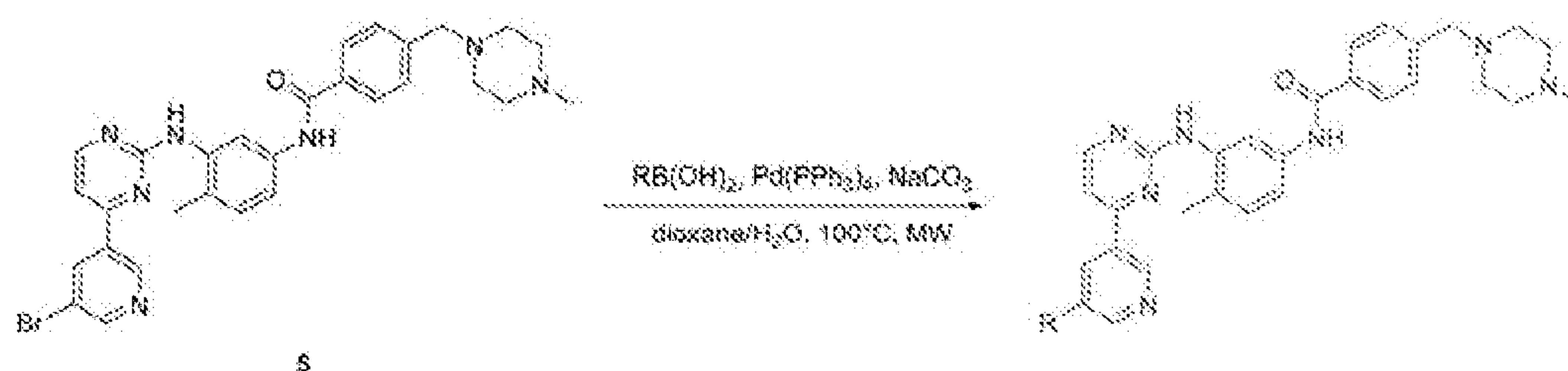


General procedure: A solution of **9** (160 mg, 0.26 mmol), HATU (148 mg, 0.39 mmol), R₁R₂NH (1.2 e.q.) and DIPEA (70 mg, 0.54 mmol) in 2 mL of DMF was stirred for 3 hours at room temperature. The resulting mixture was evaporated under reduced pressure and the residue was purified by *prep*-HPLC to afford desired library compounds.



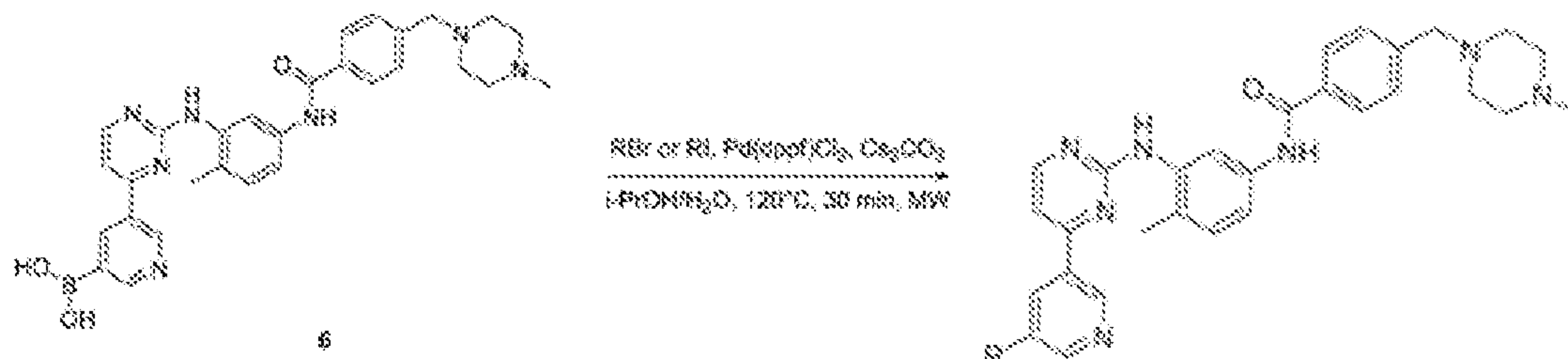
Compounds 115, 116 and 117 were prepared using this general procedure.

General procedure: A mixture of **5** (200 mg, 0.35 mmol), RB(OH)_2 (2.0 eq.), $\text{Pd(PPh}_3)_4$ (40 mg, 0.03 mmol), Na_2CO_3 (112 mg, 1.05 mmol) in dioxane (4 mL) and water (1 mL), The resulting reaction mixture was irradiated for 90 min in a microwave oven. Then the reaction mixture was cooled to room temperature and concentrated at reduced pressure. The residue was purified by *prep*-HPLC to afford desired library compounds as a solid.



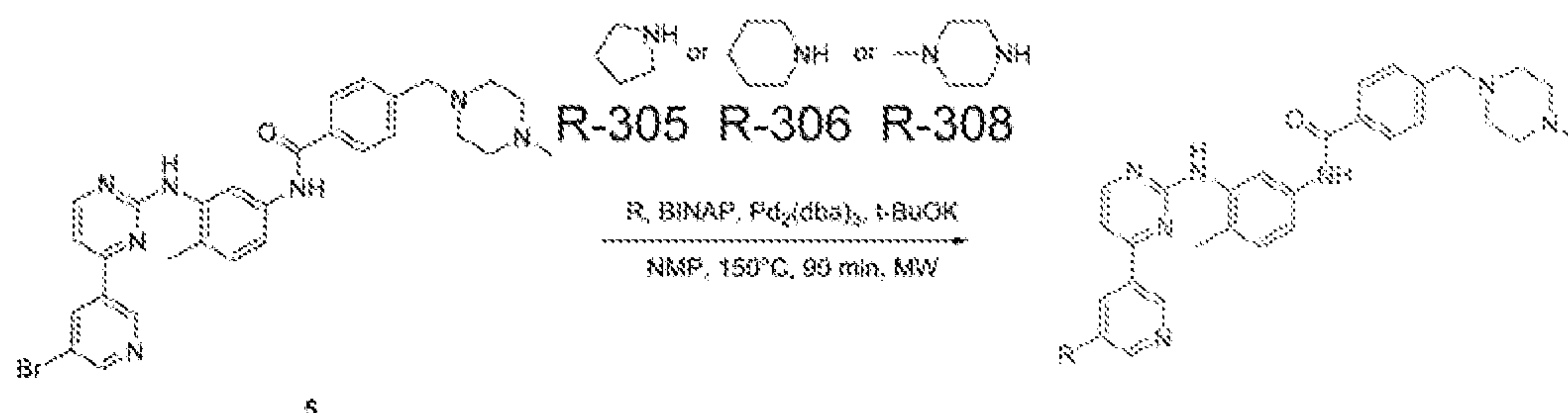
Compounds 101, 102, 103, 118, 201, 202, 309, 401, 402, 403, 404 and 405 were prepared using this general procedure.

General procedure: A mixture of **6** (150 mg, 0.34 mmol), RBr or RI (2.0 eq.), Pd(dppf)Cl_2 (57 mg, 0.07 mmol), Cs_2CO_3 (280 mg, 0.85 mmol) in *i*-PrOH (4 mL) and water (1 mL) was irradiated for 30 min in a microwave oven. Then the reaction solution was cooled to room temperature and concentrated at reduced pressure. The residue was purified by *prep*-HPLC to give desired library compounds as a solid.



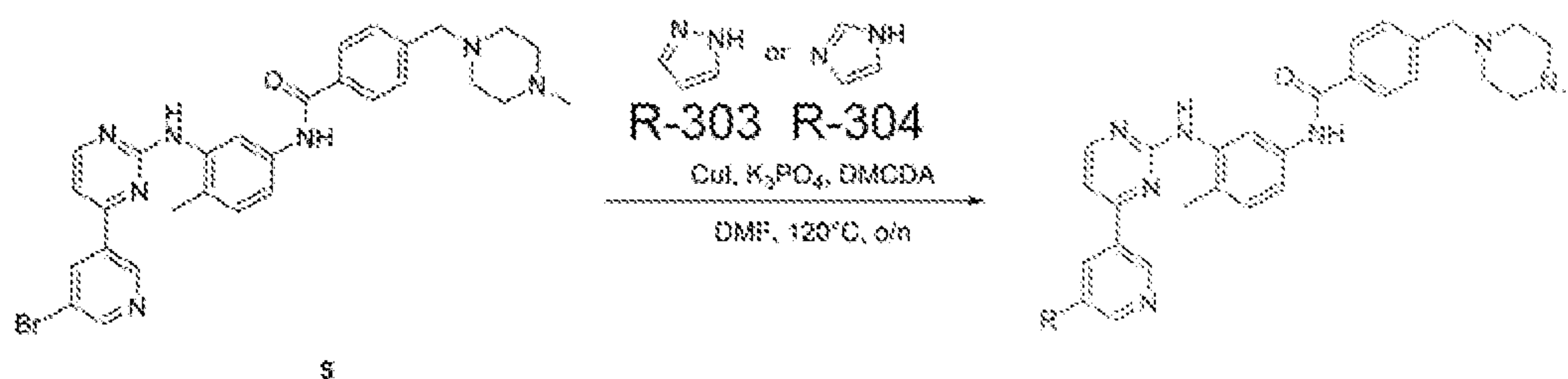
Compounds 104, 105, 106, 108, 113, 119, 203 were prepared using this general procedure.

General procedure: A solution of **5** (200 mg, 0.35 mmol), **R-305**, **R-306**, or **R308** (3.0 eq.), Pd₂(dba)₃ (25 mg, 0.03 mmol), t-BuOK (157 mg, 1.40 mmol), BINAP (22 mg, 0.03 mmol) in 5 mL of NMP was irradiated for 90 min at 150⁰C in a microwave oven. Then the reaction solution was cooled to room temperature and concentrated at reduced pressure. The residue was purified by *prep*-HPLC to desired compounds as a solid.



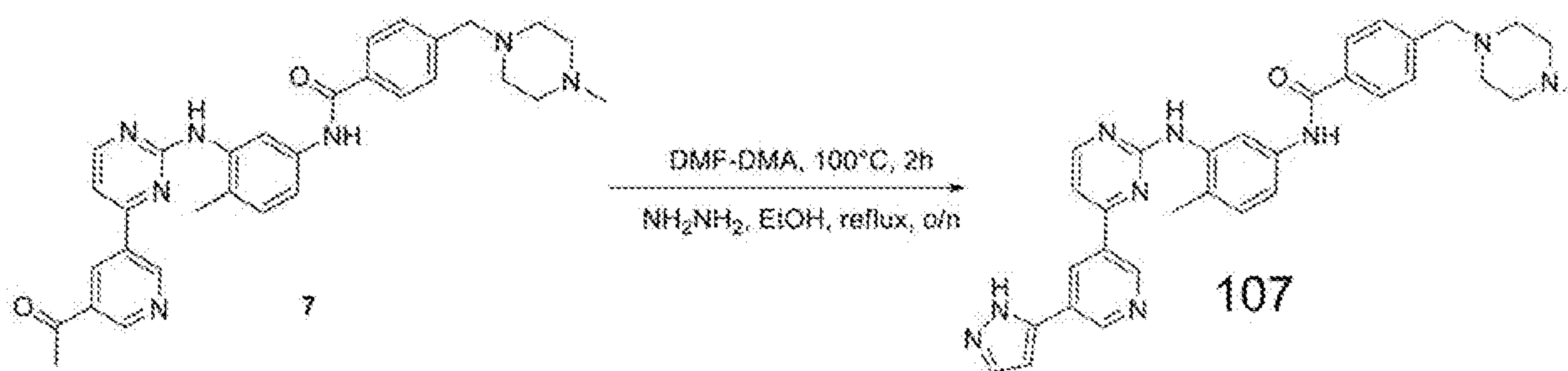
Compounds 305, 306, 308 were prepared using this general procedure.

General Procedures: To a solution of **5** (200 mg, 0.35 mmol), K₃PO₄ (149 mg, 0.70 mmol), DMCD A (7 mg, 0.05 mmol) and CuI (10 mg, 0.05 mmol) in 2 mL of DMF was added **R-303** or **R-304** (2.0 e.q). The resulting mixture was stirred at 120⁰C overnight. The reaction mixture was cooled to room temperature, and water (0.5 mL) was added and extracted with EA (3 mL*3). The combined organic layers were dried over Na₂SO₄ and concentrated *in vacuo*. And the residue was purified by *prep*-HPLC to afford desired library compounds as a solid.

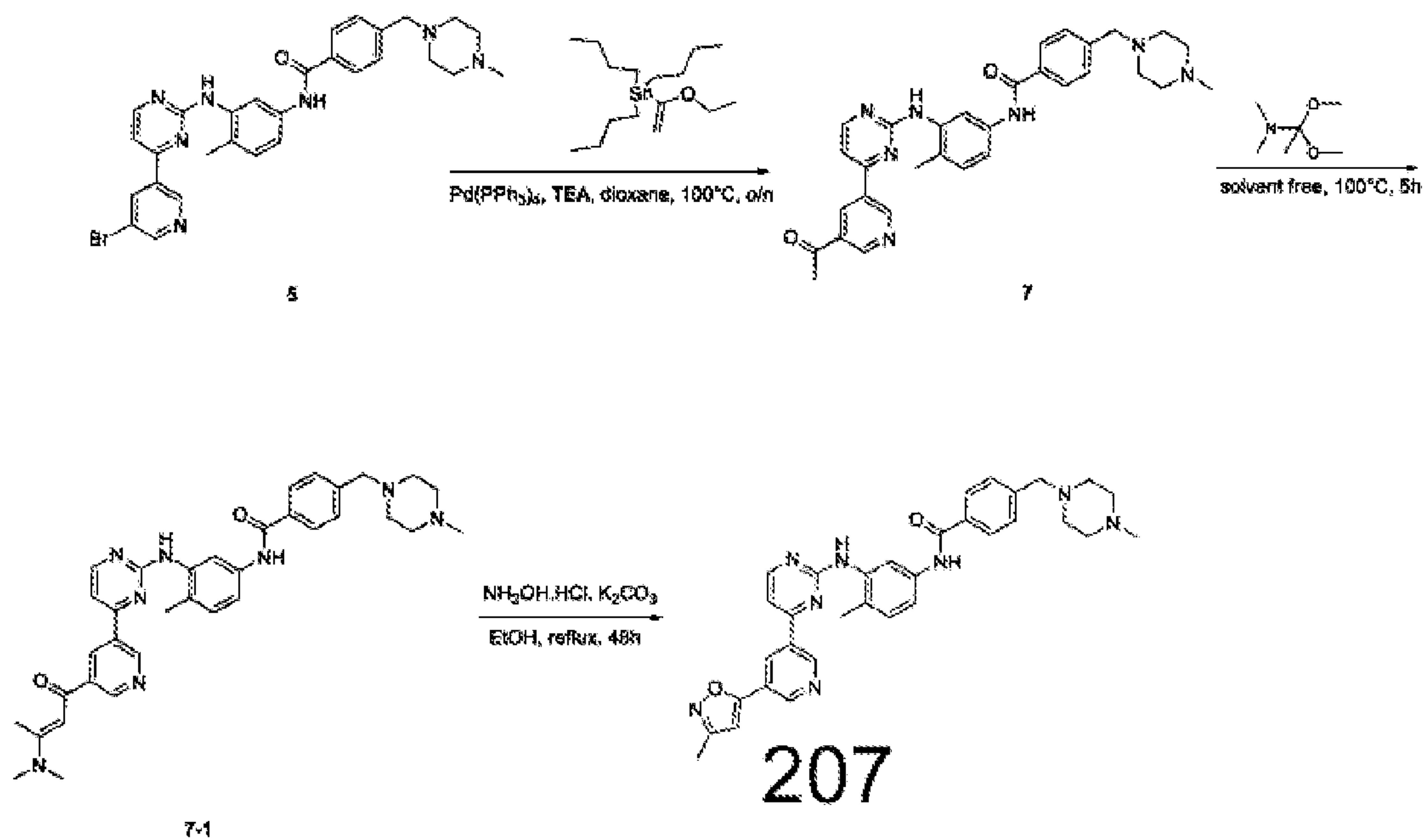


Compounds 303 and 304 were prepared using this general procedure.

Synthesis of Compound 107

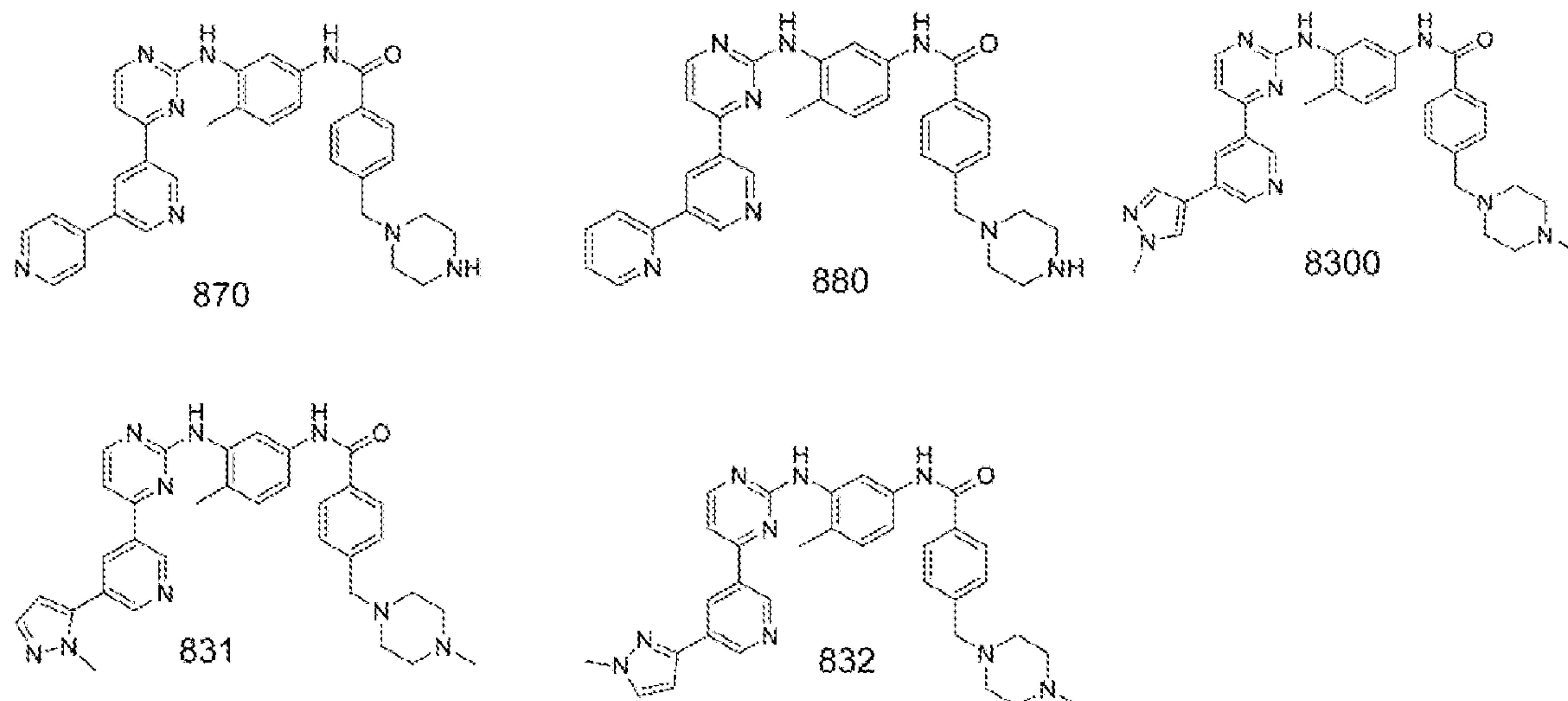


- 5 A solution of **7** (150 mg, 0.28 mmol) in DMF-DMA (3 mL) was stirred at 100°C for 2 hours. Then the solution was cooled to room temperature and the solvent removed at reduced pressure. The crude residue was dissolved in EtOH (10 mL), and hydrazine (45 mg, 1.40 mmol) was added. The resulting mixture was heated to reflux overnight. The solvent was cooled to room temperature and concentrated *in vacuo*. The residue was
- 10 purified by *prep*-HPLC to afford **107** (20 mg, 13%) as a solid.

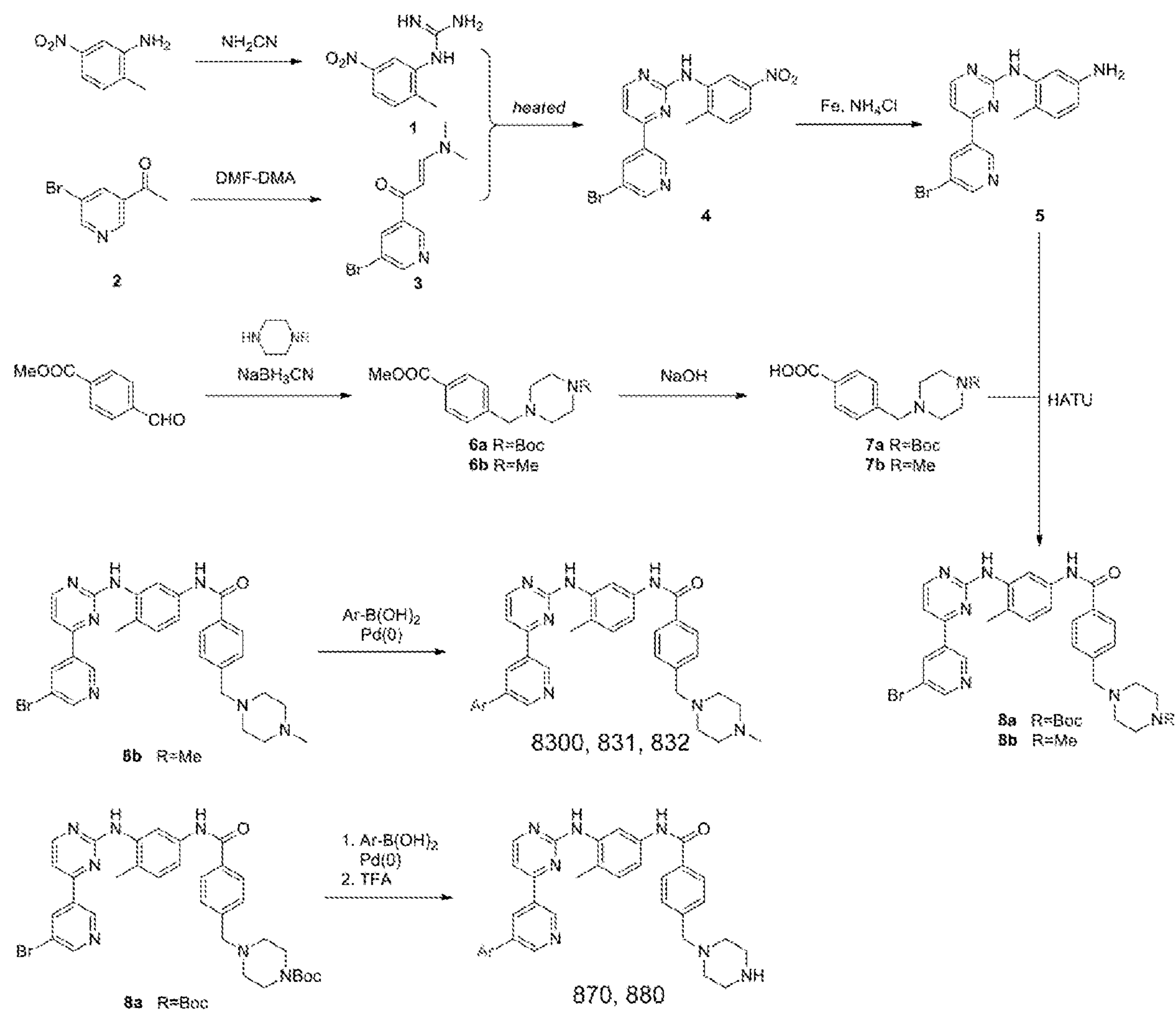
Synthesis of Compound 207

A solution of 7 (200mg, 0.37 mmol) in DMA-DMA (4 mL) was heated to 100°C and stirred for 2 hours. The excess DMA-DMA was evaporated *in vacuo*, and the residue was dissolved in ethanol (10 mL), to this solution was added K_2CO_3 (255 mg, 1.85 mmol) and hydroxylamine hydrochloride (77 mg, 1.11 mmol). The resulting mixture was refluxed overnight. After cooling, the mixture was filtered through celite and the filtrate was concentrated *in vacuo*. The residue was purified by *prep*-HPLC to afford compound 207 (18 mg, 8%) as a solid.

Synthesis of Compounds 870, 880, 8300, 831, 832



Methods



1-(2-Methyl-5-nitrophenyl)guanidine (1)

A mixture of 2-methyl-5-nitroaniline (152 g, 1.0 mol), cyanamide (247 mL, 6.0 mol) and isopropyl alcohol (1000 mL) were placed in a 3L flask. The mixture was heated to 80°C. Concentrated hydrochloric acid (57 mL) was slowly added dropwise over 80 min. The reaction mixture was stirred for 1 h while maintaining the temperature at 80°C. Another portion of concentrated hydrochloric acid (144 mL) was added dropwise at 80°C. The reaction mixture was then stirred for 12 h at 100°C. The mixture was cooled to room temperature and treated with aqueous NaOH (2.5 N, 1200 mL). The resulting solid was collected by filtration, washed with isopropyl alcohol (500 mL) and dried to afford compound **1** (145 g, 76% yield).

(E)-1-(5-Bromopyridin-3-yl)-3-(dimethylamino)prop-2-en-1-one (3)

A mixture of 3-acetyl-5-bromopyridine (126.7 g, 0.633 mol) and DMF-DMA (84 g, 70.6 mmol) was heated under reflux for 1 h. The mixture was cooled to room temperature and then directly purified by silica gel column chromatography. The resulting crude product after concentration was washed with diethyl ether (200 mL) and dried to afford compound **3** (122 g, 75.5% yield) as yellow crystals.

4-(5-Bromopyridin-3-yl)-N-(2-methyl-5-nitrophenyl)pyrimidin-2-amine (4)

A mixture of compound **1** (10.0 g, 51.5 mmol) and compound **3** (12.9 g, 50.8 mmol) in 2-propanol (150 mL) was heated under reflux for 18 h. The mixture was cooled to room temperature and the resulting precipitate was collected by filtration, washed with diethyl ether (100 mL) and dried to afford compound **4** (13.2 g, 67% yield) as pale yellow crystals.

N¹-(4-(5-Bromopyridin-3-yl)pyrimidin-2-yl)-6-methylbenzene-1,3-diamine (5)

A mixture of iron (5.08 g, 907 mmol), NH₄Cl (970 mg, 18.1 mmol) and SiO₂ (3 g) in ethanol/water (1:1, 140 mL) was heated at 55°C for 10 min. Then a suspension of

compound **4** (7.0 g, 18.1 mmol) in THF (70 mL) was added. The reaction mixture was stirred under reflux for 1 h and cooled to room temperature. The mixture was poured into water (100 mL) and then extracted with ethyl acetate (100 mL×2). The combined organic layers were washed with brine and water, dried over anhydrous sodium sulfate and concentrated to afford compound **5** (5.88 g, 91% yield) as yellow solid.

***tert*-Butyl 4-(4-(methoxycarbonyl)benzyl)piperazine-1-carboxylate (6a)**

TFA (10 mL) was added dropwise to a mixture of methyl 4-formylbenzoate (20 g, 121 mmol) and *tert*-butyl piperazine-1-carboxylate (25 g, 134 mmol) in acetonitrile (400 mL) at room temperature. The mixture was stirred for 1 h and NaBH₃CN (8.32 g, 134 mmol) was added. The reaction mixture was stirred overnight at room temperature and water was added. The resulting mixture was extracted with ethyl acetate (100 mL×2). The combined organic layers were washed with brine and water, dried over anhydrous sodium sulfate and concentrated to afford compound **6a** (14 g, 34.4% yield), which was used directly in the next step without further purification.

Methyl 4-(piperazin-1-ylmethyl)benzoate (6b)

Compound **6b** was prepared from 1-methylpiperazine following the same procedure for **6a**.

4-((4-(*tert*-Butoxycarbonyl)piperazin-1-yl)methyl)benzoic acid (7a)

A mixture of compound **6a** (7.0 g, crude, 21 mmol) and LiOH·H₂O (1.4 g, 31 mmol) in methanol/acetonitrile/water (100 mL, 1:2:2) was stirred 1 h at room temperature. The organic solvent was removed and the remaining aqueous solution was washed with ethyl acetate (100 mL) and then adjusted to pH=2-3 with 2*N* aqueous HCl. The resulting mixture was extracted with ethyl acetate (30 mL×2). The combined extracts were dried over anhydrous sodium sulfate and concentrated to afford compound **7a** (3.0 g, 44.8% yield) as a white solid.

4-(Piperazin-1-ylmethyl)benzoic acid (7b)

Compound **7b** was prepared from **6b** following the same procedure for **7a**

***tert*-Butyl 4-(4-(3-(4-(5-Bromopyridin-3-yl)pyrimidin-2-ylamino)-4-methylphenylcarbamoyl)benzyl)piperazine-1-carboxylate (**8a**)**

A mixture of compound **5** (1.0 g, 2.81 mmol), compound **7a** (0.98 g, 4.19 mmol), HATU (1.28 g, 3.37 mmol) in DMF (20 mL) was cooled to 0°C and DIPEA (1.95 mL, 11.24 mmol) was added. The reaction mixture was allowed to warm to room temperature and stirred for 15 min. Saturated aqueous sodium bicarbonate (20 mL) was added and the resulting mixture was extracted with ethyl acetate (50 mL×2). The combined extracts were dried over anhydrous sodium sulfate and concentrated. The residue was purified by flash column chromatography on silica gel (petroleum ether/ethyl acetate = 3:1 to 1:1) to afford compound **8a** (1.29 g, 80% yield) as a yellow solid.

***N*-(3-(4-(5-Bromopyridin-3-yl)pyrimidin-2-ylamino)-4-methylphenyl)-4-(piperazin-1-ylmethyl)benzamide (**8b**)**

Compound **8b** was prepared from **7b** following the same procedure for **8a**.

General procedure for the final compounds

8300, 831, 832: A mixture of compound **8a/b** (1.0 eq), the corresponding boronic acid (1.0 eq), Pd(dppf)Cl₂ (cat.) and Na₂CO₃ (2.5 eq) in 1,4-dioxane and water (5:1) was stirred at 80°C for 1 h under N₂. The mixture was cooled to room temperature and then diluted with ethyl acetate and water. The resulting mixture was filtered and the filtrate was separated. The aqueous phase was extracted with ethyl acetate. The combined organic phases were washed with brine, dried over anhydrous sodium sulfate and concentrated to dryness. The residue was purified by flash column chromatography on silica gel or prep-HPLC to afford compound **of interest** as a yellow solid.

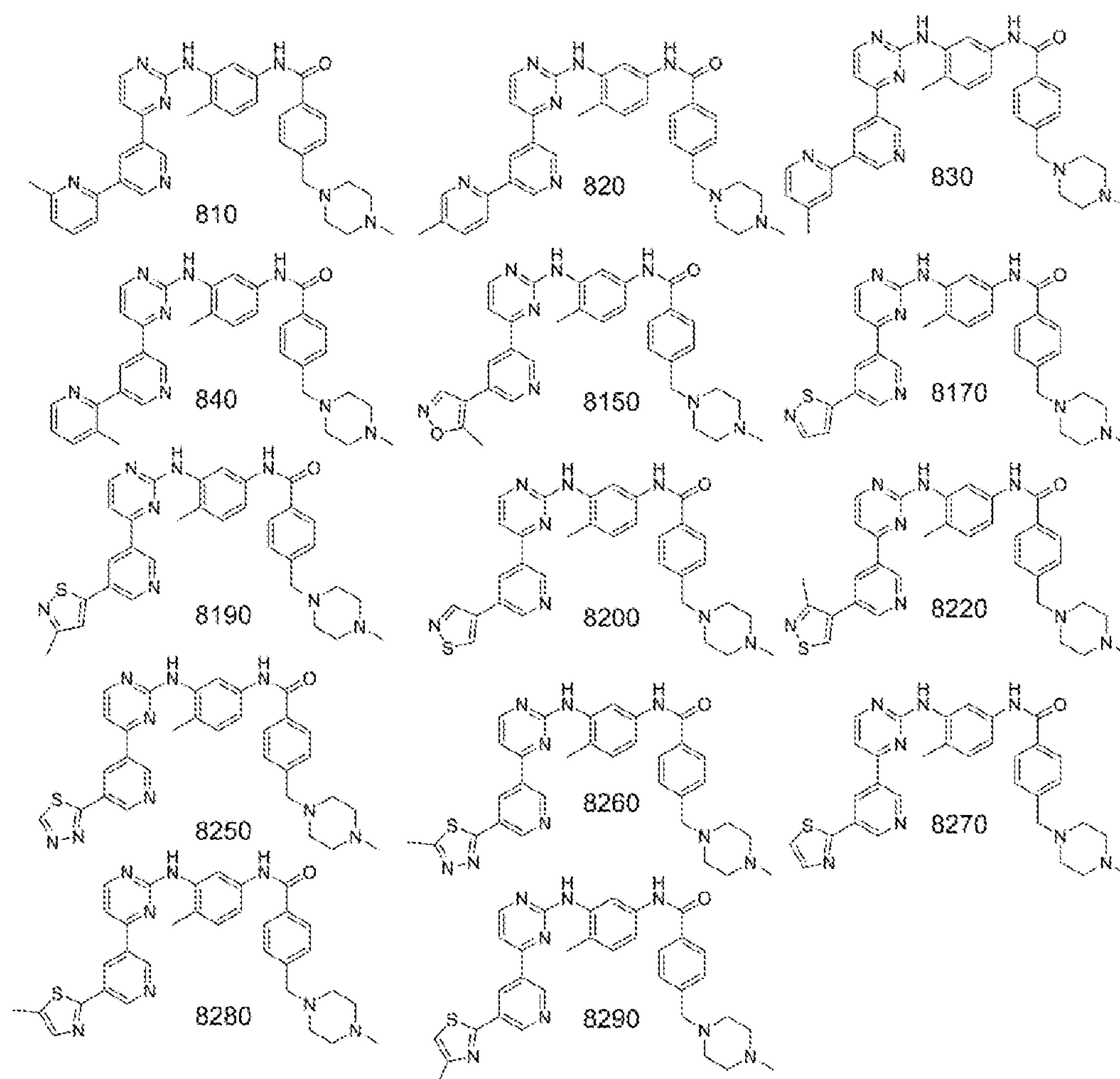
870: To a mixture of compound **8a** (100 mg, 0.152 mmol), pyridin-4-ylboronic acid (21 mg, 0.167 mmol), Pd(dppf)Cl₂ (15 mg, cat.) and Na₂CO₃ (40 mg, 0.608 mmol) in 1,4-dioxane (2.5 mL) and water (0.5 mL) was stirred at 80°C for 1 h under N₂. The mixture was cooled to room temperature and then diluted with ethyl acetate (10 mL) and water (10 mL). The resulting mixture was filtered and the filtrate was separated. The aqueous phase was

extracted with EtOAc (20 mL×2). The combined organic phases were washed with brine (20 mL×2), dried over anhydrous and concentrated to dryness. The residue was purified by flash column chromatography on silica gel (DCM/MeOH = 100:1 to 20:1) to afford compound **Boc-870** (100 mg) as a brown solid.

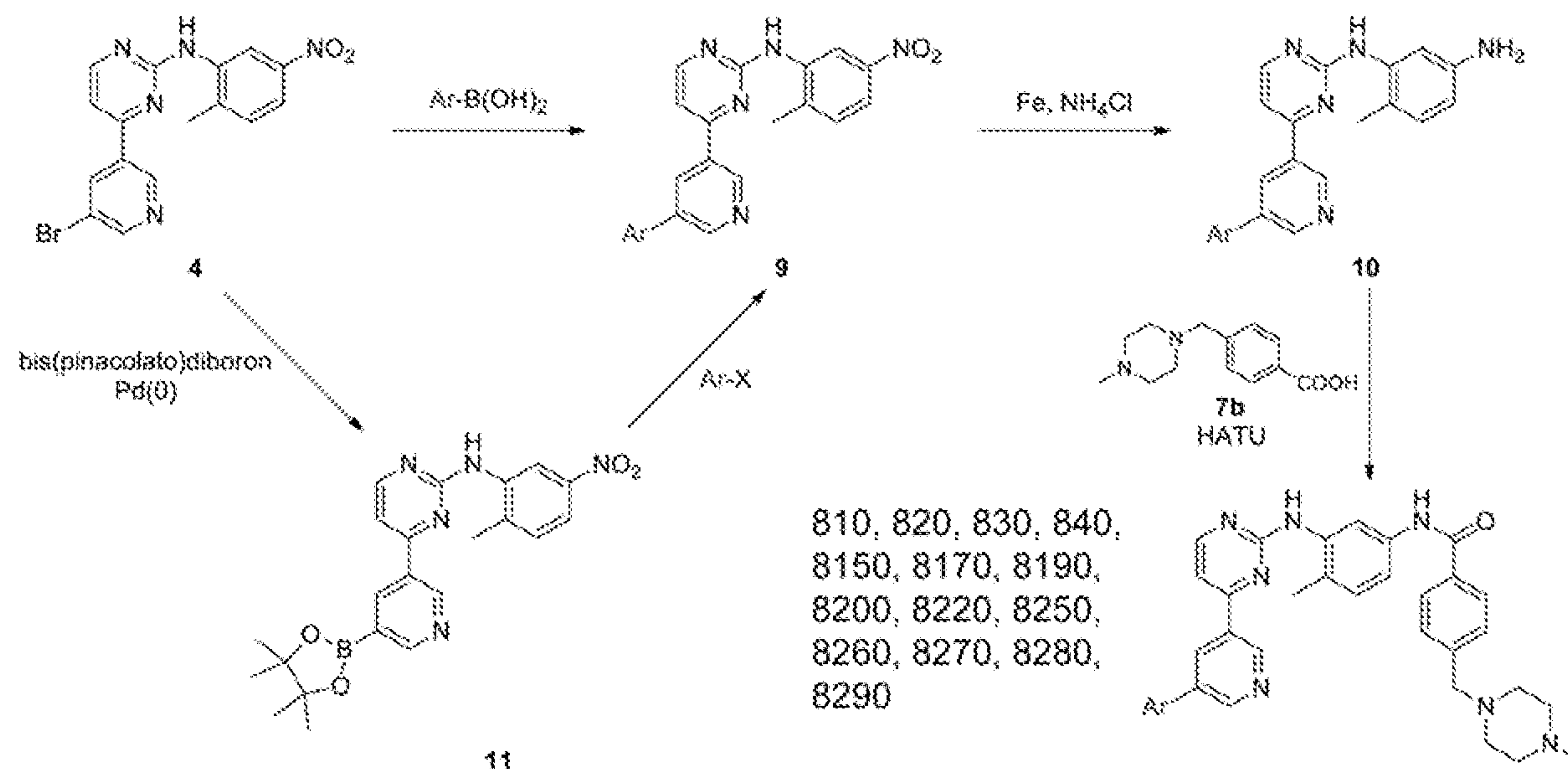
- 5 TFA (1 mL) was added to a solution of **Boc-870** (100 mg, 0.152 mmol) in CH₂Cl₂ (4 mL) at 0°C with stirring. The reaction mixture was stirred for 1 h and concentrated to dryness. The residue was treated with aqueous NaHCO₃ to adjust pH=9 and then extracted with ethyl acetate (5 mL×3). The combined organic layers were washed with water and brine, dried over anhydrous sodium sulfate and concentrated. The residue was purified by flash column
- 10 chromatography on silica gel (DCM/MeOH = 20:1 to 10:1) to afford compound **870** (66 mg, 78.4% yield) as an off-white solid.

880: Compound **880** was prepared from pyridin-2-ylboronic acid following the same procedure for **870**.

Synthesis of 810, 820, 830, 840, 8150, 8170, 8190, 8200, 8220, 8250, 8260, 8270, 8280, 8290



Methods



General procedure for compound 9 from compound 4

810, 820, 830, 840

- 5 To a mixture of compound **4** (1.0 eq), the corresponding boronic acid (1.0 eq), Pd(dppf)Cl₂ (cat.) and Na₂CO₃ (2.5 eq) in 1,4-dioxane and water (5:1) was stirred at 80°C for 1 h under N₂. The mixture was cooled to room temperature and then diluted with ethyl acetate and water. The resulting mixture was filtered and the filtrate was separated. The aqueous phase was extracted with ethyl acetate. The combined organic phases were washed with brine,
10 dried over anhydrous sodium sulfate and concentrated to afford compound **9**, which was used in the next step without further purification.

***N*-(2-Methyl-5-nitrophenyl)-4-(5-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)pyridin-3-yl)pyrimidin-2-amine (11)**

- A mixture of compound **4** (5.0 g, 12.95 mmol), bis(pinacolato)diboron (3.62 g, 14.25
15 mmol), Pd(dppf)Cl₂ (0.3 g, cat.) and KOAc (3.83 g, 38.87 mmol) in toluene (50 mL) was heated under reflux for 12 h under N₂. The mixture was cooled to room temperature and diluted with ethyl acetate (100 mL) and water (100 mL). The resulting mixture was filtered and the filtrate was separated. The aqueous phase was extracted with ethyl acetate (100 mL×2). The combined organic phases were washed with brine (30 mL), dried over
20 anhydrous sodium sulfate and concentrated to dryness. The residue was purified by flash

column chromatography on silica gel (Petroleum/EtOAc = 20:1) to afford compound **11** (4.77 g, 84.3% yield) as a brown solid.

General procedure for compound **9** from compound **11**

5 **8150, 8170, 8190, 8200, 8220, 8250, 8260, 8270, 8280, 8290**

A mixture of Ar-X (1.0 eq), compound **11** (1.1 eq), Pd(dppf)Cl₂ (cat.) and Na₂CO₃ (3.0 eq) in 1,4-dioxane and water (5:1) was stirred at 80°C for 1 h under N₂. The mixture was cooled to room temperature and diluted with ethyl acetate and water. The resulting mixture was filtered and the filtrate was separated. The aqueous phase was extracted with ethyl
10 acetate and the combined organic phases were washed with brine, dried over anhydrous sodium sulfate and concentrated to afford compound **9**, which was used in the next step without further purification.

General procedure for compound **10**

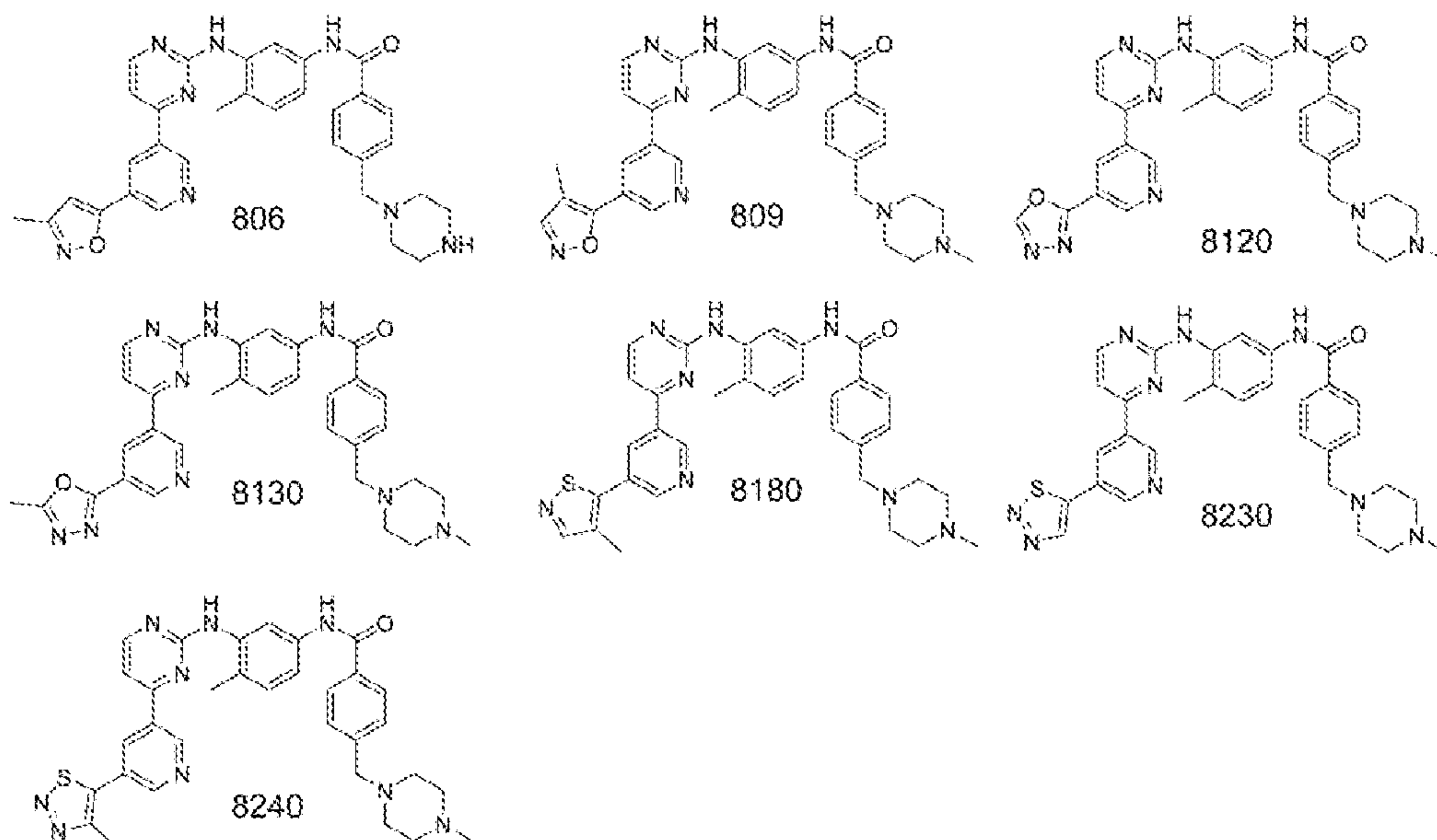
A mixture of iron (5.0 eq), NH₄Cl (1.0 eq) and SiO₂ (2.0 eq) in ethanol/water (1:1) was
15 heated at 55°C for 10 min. Then a suspension of compound **9** (1.0 eq) in THF was added. The reaction mixture was stirred under reflux for 1 h and cooled to room temperature. The mixture was poured into water and then extracted with ethyl acetate. The combined organic layers were washed with brine and water, dried over anhydrous sodium sulfate and concentrated to afford compound **10** as a yellow solid.

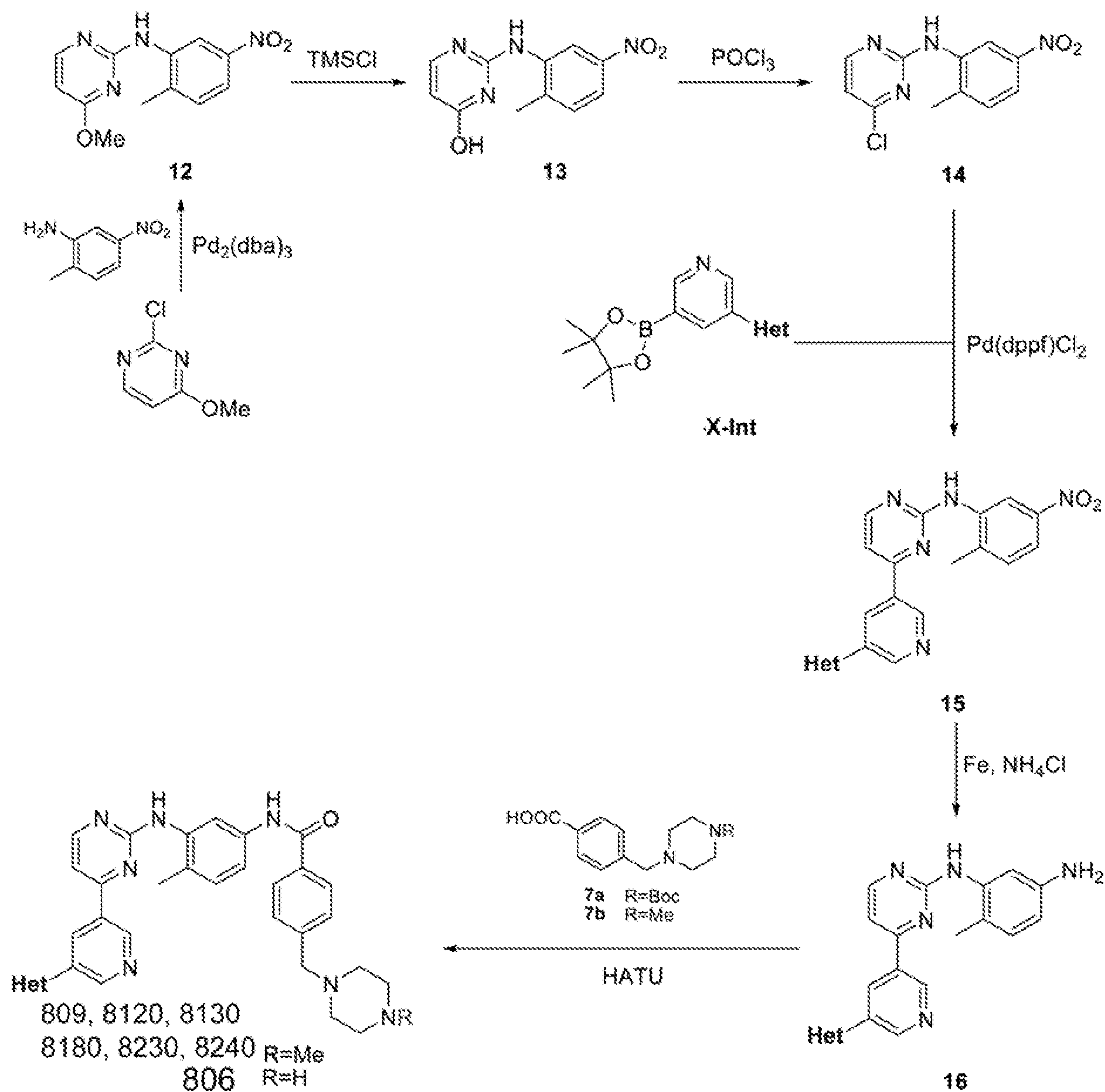
20

General procedure for the final compound

A mixture of compound **10** (1.0 eq), compound **7b** (1.2 eq) and HATU (1.2 eq) in DMF (20 mL) was cooled to 0°C and DIPEA (4.0 eq) was added. The reaction mixture was allowed to warm to room temperature and stirred for 15 min. Saturated aqueous sodium bicarbonate
25 was added and the resulting mixture was extracted with ethyl acetate. The combined extracts were dried over anhydrous sodium sulfate and concentrated. The residue was purified by flash column chromatography on silica gel to afford the desired compound as a solid.

Synthesis of 806, 809, 8120, 8130, 8180, 8230, 8140





4-Methoxy-N-(2-methyl-5-nitrophenyl)pyrimidin-2-amine (**12**)

To a mixture of 2-chloro-4-methoxypyrimidine (9.54 g, 66 mmol), 2-methyl-5-nitrobenzenamine (10.0 g, 66 mmol), Pd₂(dba)₃ (1.0 g), S-Phos (1.0 g, 24.4 mmol), and Cs₂CO₃ (31.8 g, 99 mmol) in 1,4-dioxane/water (140 mL/60 mL) was heated at 110°C overnight. The mixture was cooled to room temperature and then filtered through a pad of celite. The filtrate was diluted with ethyl acetate and washed with water. The organic phase was dried over anhydrous sodium sulfate and concentrated. The residue was purified by flash column chromatography on silica gel to afford compound **12** (12 g, 70.6% yield) as a light yellow solid.

2-(2-Methyl-5-nitrophenylamino)pyrimidin-4-ol (13)

A mixture of compound **12** (20 g, 77 mol), TMSCl (15 g, 136 mmol) and NaI (23.4 g, 156 mmol) in acetonitrile (400 mL) was heated at 120°C overnight. The mixture was cooled to room temperature and 2*N* aqueous Na₂CO₃ (400 mL) and DCM (400 mL) were added. The organic layer was separated, washed with water, dried over anhydrous sodium sulfate and concentrated. The residue was purified by flash column chromatography on silica gel (DCM/MeOH = 200:1) to afford compound **13** (12.1 g, 64% yield) as a light yellow solid.

4-Chloro-*N*-(2-methyl-5-nitrophenyl)pyrimidin-2-amine (14)

A mixture of compound **13** (2 g, 8.13 mmol) and DMF (5 drops) in POCl₃ (40 mL) was heated under reflux for 2 h. The mixture was cooled to room temperature and most of POCl₃ was removed. The residue was poured into aqueous NaOH (100 mL) carefully and the resulting mixture was extracted with DCM (100 mL×2). The combined organic layers were washed with brine and water (100 mL), dried over anhydrous sodium sulfate and concentrated to afford compound **14** (2.0 g, 93% yield) as a yellow solid.

General procedure for compound 15

A mixture of compound **14** (1.0 eq), **X-Int** (1.0 eq), Pd(dppf)Cl₂ (cat.) and K₂CO₃ (3.0 eq) in 1,4-dioxane (20 mL) and water (20 mL) was heated under reflux for 12 h under N₂. The mixture was cooled to room temperature and diluted with ethyl acetate and water. The resulting mixture was filtered and the filtrate was separated. The aqueous phase was extracted with ethyl acetate. The combined organic phases were washed with brine, dried over anhydrous sodium sulfate and concentrated to dryness. The residue was purified by flash column chromatography on silica gel (DCM/MeOH = 200:1) to afford compound **15** as a yellow solid.

General procedure for compound 16

To a mixture of iron (1.0 eq), NH₄Cl (2.0 eq) and SiO₂ (cat) in ethanol/water (1:1) was heated at 55°C for 10 min. Then a suspension of compound **15** (2.0 eq) in THF was added. The reaction mixture was stirred under reflux for 1 h and cooled to room temperature. The mixture was poured into water and then extracted with ethyl acetate. The combined organic layers were washed with brine and water, dried over anhydrous sodium sulfate and concentrated to afford compound **16**.

Procedure for 806

A mixture of compound **16** (Het=3-methylisoxazol-5-yl, 150 mg, 0.42 mmol), compound **7a** (134 mg, 0.42 mmol) and HATU (159 mg, 0.42 mmol) in DMF (2 mL) was cooled to 0°C and DIPEA (217 mg, 1.68 mmol) was added. The reaction mixture was allowed to warm to room temperature and stirred for 15 min. Saturated aqueous sodium bicarbonate was added and the resulting mixture was extracted with ethyl acetate. The combined extracts were dried over anhydrous sodium sulfate and concentrated. The residue was purified by flash column chromatography on silica gel (Petroleum ether/ethyl acetate = 1:1 to ethyl acetate) to afford compound **Boc-806** (180 mg, 65.2% yield) as a solid.

HCl/EtOAc (2*N*, 1 mL) was added to a solution of **Boc-806** (97 mg, 0.147 mmol) in EtOAc (1 mL) at 0°C with stirring. The reaction mixture was stirred for 1 h and the resulting precipitate was collected by filtration, washed with DCM and dried to afford compound **806** (HCl salt, 80 mg, 100% yield) as a yellow solid.

General procedure 806, 809, 8120, 8130, 8180, 8230 and 8240

A mixture of compound **16** (1.0 eq), compound **7b** (1.0 eq) and HATU (1.0 eq) in DMF (2 mL) was cooled to 0°C and DIPEA (4.0 eq) was added. The reaction mixture was allowed to warm to room temperature and stirred for 15 min. Saturated aqueous sodium bicarbonate was added and the resulting mixture was extracted with ethyl acetate. The combined extracts were dried over anhydrous sodium sulfate and concentrated. The residue was purified by flash column chromatography on silica gel (DCM/MeOH = 20:1) to afford final compound as a yellow solid.

Example 2: Inhibition of Abelson protein kinases c-Abl1, c-Abl2 and c-Kit and comparison to imatinib, the active ingredient in Gleevec®

Cpd	c-Abl1 (nM)	c-Abl2 (nM)	c-Kit (nM)
101	232.35	224.57	6.80
102	95.33	169.62	6.70
103	200.41	212.18	7.70
107	45.17	66.95	7.20
108	40.53	85.88	7.40
113	35.00	50.11	7.50
114	101.53	142.60	32.40
115	107.81	202.79	8.90
116	91.06	160.89	11.60
117	29.13	34.99	5.70
118	37.16	51.00	8.40
119	117.66	44.68	4.00
201	193.18	514.16	19.30
202	403.88	701.00	31.10
203	250.56	711.96	47.10
207	30.19	73.73	12.20
303	162.15	349.36	18.90
305	397.83	631.35	9.20
309	174.37	149.18	14.00
401	167.28	178.63	12.40
402	183.14	207.42	11.10
404	100.32	116.17	5.80
405	107.09	150.43	5.90
806	84	152	13
809	47	77	7.8

820	84	173	10
830	34	51	6.0
832	53	77	4.0
880	203	341	12
8120	476	783	27
8130	323	423	44
8170	128	182	11
8180	369	303	13
8190	97	91	9.7
8200	96	131	4.3
8230	>1000	>1000	37
8240	>1000	>1000	39
8250	71	216	15
8260	41	236	16
8270	53	100	4.9
8280	57	104	6.2
8290	51	137	5.7
8300	40	39	5.2
imatinib	828.3	1000	30.7

Kinase base buffer (50 mM HEPES, pH 7.5 0.0015% Brij-35; 10 mM MgCl₂ 2 mM DTT) and Stop buffer (100 mM HEPES, pH 7.5 0.015% Brij-35; 0.2% Coating Reagent (50 mM EDTA) are prepared. Test compound is diluted in 100% DMSO to 50-times the
 5 desired final inhibitor concentration (the Stock Solution) and serially diluted in half-log increments resulting in final concentrations 250 μ M to 75 μ M, 25 μ M, 7.5 μ M, 2.5 μ M, 0.75 μ M, 0.25 μ M, 75 nM, 25 nM, 7.5 nM in DMSO. 10 μ l of each compound is placed in a 96-well plate as the intermediate plate. 90 μ l of Kinase Buffer is added to each well to prepare the intermediate plate. Mix the compounds in intermediate plate for 10 min on
 10 shaker. For the assay of enzyme inhibitions, 5 μ l of each well from the intermediate plate is

transferred to a 384-well plate in duplicates, 10 . Then 10 µl of 2.5x enzyme solution is added to each well of the 384-well assay plate and incubated for 10 min. Then enzyme substrate is added as 10 µl of 2.5x FAM-labeled peptide + ATP solution to each well of the 384-well assay plate. The reaction is allowed to proceed at 28 °C and quenched with the addition of 25 µl of stop buffer. The release of fluorescent FAM is quantitated as Percent inhibition = (max-conversion)/(max-min)*100. “max” stands for DMSO control; “min” stands for low control. Data are fit in XLFit excel add-in version 4.3.1 to obtain IC50 values. Equation used is: $Y = \text{Bottom} + (\text{Top} - \text{Bottom}) / (1 + (\text{IC}_{50}/X)^{\text{HillSlope}})$.

Example 3: Inhibition profile of a 500 nM solution of test compounds against 14 protein kinases

Kinase base buffer (50 mM HEPES, pH 7.5 0.0015% Brij-35; 10 mM MgCl₂ 2 mM DTT) and Stop buffer (100 mM HEPES, pH 7.5 0.015% Brij-35; 0.2% Coating Reagent (50 mM EDTA) are prepared. Test compound is diluted in 100% DMSO to 50-times the desired final inhibitor concentration (the Stock Solution) in DMSO. 10 µl of each compound is placed in a 96-well plate as the intermediate plate. 90 µl of Kinase Buffer is added to each well to prepare the intermediate plate. Mix the compounds in intermediate plate for 10 min on shaker. For the assay of enzyme inhibitions, 5 µl of each well from the intermediate plate is transferred to a 384-well plate in duplicates, 10 . Then 10 µl of 2.5x enzyme solution is added to each well of the 384-well assay plate and incubated for 10 min. Then enzyme substrate is added as 10 µl of 2.5x FAM-labeled peptide + ATP solution to each well of the 384-well assay plate. The reaction is allowed to proceed at 28 °C and quenched with the addition of 25 µl of stop buffer. The release of fluorescent FAM is quantitated as Percent inhibition = (max-conversion)/(max-min)*100. “max” stands for DMSO control; “min” stands for low control. Convert conversion values to inhibition values. Percent inhibition = (max-conversion)/(max-min)*100. “max” stands for DMSO control; “min” stands for low control.

Table 1

Cpd	YES	PDG FRa	LCK	SRC	ABL	FLT3	KIT	PDG FRb	FGR	LYNA	ARG/ AbI2	FES	FYN	JNK2
101	100	42	88	18	73	36	87	99	55	89	74	43	52	25
102	99	39	91	19	83	32	99	99	67	88	75	42	55	26
103	101	42	91	25	71	28	92	98	60	91	71	38	54	17
107	101	59	95	28	91	51	99	101	82	93	87	28	69	1.7
108	100	56	94	34	91	73	100	101	80	93	88	67	66	36
113	100	61	94	37	92	25	98	101	85	95	91	26	75	18
114	100	34	77	18	84	20	99	99	81	91	78	17	72	18
115	100	53	90	29	83	22	96	99	78	93	76	20	67	17
116	100	48	94	29	87	8.4	93	101	83	93	76	19	67	5.9
117	99	74	97	55	94	13	95	99	90	97	91	24	86	14
118	99	66	95	35	92	61	93	101	84	96	88	38	77	14
119	99	67	98	53	83	90	95	100	86	97	90	47	82	42
201	99	45	91	18	72	30	91	98	67	87	55	49	53	6.1
202	100	46	87	16	64	19	85	98	64	87	50	27	47	19
203	100	29	88	17	72	31	77	95	59	82	54	21	43	17
207	100	54	95	30	94	19	88	99	79	92	85	31	72	19

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303	100	33	87	13	79	25	87	100	58	86	62	31	45	4.7
305	100	16	80	10	62	20	98	100	47	80	50	47	25	4.4
309	101	25	84	13	77	13	96	99	59	87	79	31	44	24
401	100	40	88	18	76	24	98	99	67	90	81	19	50	23
402	100	29	86	19	72	31	96	100	65	89	75	23	48	21
404	100	47	91	21	82	24	97	100	75	90	83	32	56	34
405	101	33	90	16	80	29	95	100	68	90	80	33	52	28

Table 2

Cpd	Ab12	Ab11	PDGFRa	PDGFRb	JNK1	JNK2	SRC	LCK	CKIT	FES	YES	FYN	LYNA	FLT3	FGR
810	59	65	99	98	25	48	20	83	85	23	44	71	93	26	57
820	76	85	99	98	12	29	23	88	87	32	56	73	91	61	64
830	87	92	100	99	23	52	38	93	92	22	63	81	97	44	77
831	60	48	100	97	15	17	12	82	82	23	25	57	87	38	34
832	81	88	100	100	24	16	28	93	91	24	66	79	106	58	80
840	30	38	99	92	24	56	15	50	73	35	25	64	77	69	24
870	60	60	100	97	17	37	17	70	82	39	23	58	83	73	38
880	61	71	100	100	28	48	15	70	87	35	33	64	80	62	46
8150	54	42	99	97	31	42	14	77	83	26	26	62	90	68	34
8170	73	78	100	98	32	40	25	88	86	67	49	70	93	79	68
8190	81	82	100	99	41	58	28	92	86	51	52	74	96	72	71
8200	75	78	98	97	41	54	22	92	85	52	50	65	100	68	63
8220	54	44	99	97	56	50	22	90	83	57	40	75	93	75	47
8250	68	87	100	98	15	8	20	87	80	37	45	74	85	68	63
8260	67	85	100	101	21	15	22	83	79	16	41	71	88	62	60
8270	80	91	99	98	41	36	33	91	88	60	60	83	104	78	81
8280	80	90	100	99	23	14	28	82	89	32	53	76	98	54	78
8290	75	86	100	100	33	23	26	87	88	36	55	76	98	63	75
8300	89	92	99	98	35	30	45	97	88	19	63	90	108	61	81

Example 4: Pharmacokinetic Parameters of Certain Compounds of the Invention

Various pharmacokinetic parameters of the compounds described herein were measured in Sprague-Dawley rats. The results of are presented in Table 3.

Table 3

Compound:	207	832	809	8270	830	imatinib
C _{max} (ng/mL)	225.3±83.8	415.8±84.5	170.5	210±31	465±115	241
t _{max} (h)	5.3±1.2	4.0±0	4	5.3	4	4
t _{1/2} (h)	3.1±ND	2.6±0	2.2	3.3	3.6	≈3
AUC _{last} (h*ng/mL)	1647±1084	3178.3±930	1065	1760±268	3715±1090	2726
CL (L/h/kg)	2±0.34	1.3±0.74	2.7	2.6±0.41	1.3±0.33	0.57
V _d (L/kg)	6.5±0.96	3.6±1.8	7.2	7.8±0.70	6.3±1.1	1.1
Bioavailability	32%±21%	33%±10%	24%	46%±7%	47%±14%	≈53%
Caco-2 permeability ratio influx:efflux	0.44	0,63	0.58	2.2	0.52	0.67
Human liver microsome t _{1/2} (min)	17.51	24.46	21.86	20.87	19.56	34.82
Serum protein binding	85.9%	ND	85.7%	ND	ND	>98%
Fold-improvement in brain penetration	2.7	5.3	4.5	2.5	ND	1

Example 5: Mouse MPTP Neurotoxicity model

Certain compounds of the present invention were evaluated using the MPTP neurotoxicity model. MPTP causes oxidative stress, which in turn causes c-Abl1 and/or c-Abl2 phosphorylation in the SNpc of mice treated with MPTP. MPTP administration according to this model produces a reliable, irreversible loss of DA neurons 7 days after the last injection, similar to that observed in PD. MPTP causes greater loss of DA neurons in SNpc and degeneration of DA nerve terminals in the caudate putamen. Many of the cell

death signaling events observed in PD postmortem tissue are present in the MPTP model including oxidative stress, nitrosative stress, c-Abl activation, Parkin inactivation and PARIS and AIMP2 elevation and PARP activation. The ATK inhibitors imatinib and nilotinib provide neuroprotection in the acute MPTP-induced model of PD. Because the model is relatively rapid, this model was used to assess dosing for future studies, and as a preliminary measure of efficacy.

The study design is depicted in Figure 1. Compounds 207, 832, 8270, and 809 were tested. Wild type mice (n=5 per group) were divided into 4 treatment groups as follows: saline, MPTP, Drug and MPTP+Drug. Saline and MPTP groups were pre-treated with drug vehicle (unbuffered water) (20 animals total). Drug and MPTP+Drug groups received the test compounds for 6 days administered by oral gavage daily. On the seventh day, the saline and Drug groups received four intra-peritoneal (i.p.) injections of saline at 2 h intervals. The MPTP and MPTP+Drug groups received four intraperitoneal (i.p.) injections of MPTP·HCl (20 mg/kg free base) at 2 hr intervals. After the MPTP injection day, mice were treated for an additional 6 days with saline or an ATK inhibitor of the present invention. Mice in the saline and MPTP only groups received saline vehicle while the Drug and MPTP+Drug groups received an additional week of drug treatment. On the 14th day, mice were given a pole test, then sacrificed. Brain samples were processed for analysis of biogenic amine concentrations, including dopamine (DA), by high-performance liquid chromatography with electrochemical detection (HPLC-ECD). Loss of DA and its metabolites in the striatum is a consistently reliable indication of loss of DA neurons in the SNpc.

None of the tested compounds caused significant bodyweight loss (Fig. 2). In the pole test (Fig. 3), the control animals had a latency of about 5 seconds, while the MPTP animals took about 30. Animals treated with 207, 832, and 809 recovered to a near-normal latency time. The result for 8270 was not statistically significant.

Dopamine secretion measurements test whether dopamine-secreting cells are being protected from degradation by ATK inhibition. Compounds 207, 832, 8270, and 809 all protected dopamine-secreting neurons from degeneration, although not equally (Fig. 4).

The levels of metabolites of dopamine in the test animals were measured. All four tested compounds protected loss of 3,4-Dihydroxyphenylacetic acid (DOPAC) and 3-methoxytyramine (3MT) to differing extents (Fig. 5). The dopamine turnover ratio was also measured. Some of the tested compounds recovered the turnover ratio observed in the control animals, others did not show a statistically significant result (Fig. 6)

The phosphorylation level of c-Abl in the ventral midbrain was measured in the group that received Compound 809. Compound 809 provided full recovery of the c-Abl phosphorylation levels observed in the control group (Fig. 7 (left).)

Example 6: Functional Rescue Study in Mutated Alpha-Synuclein Model

Functional rescue by exemplary compounds of the present disclosure is demonstrated using a mutated alpha-synuclein model of Parkinson's Disease. The A53T mutant of alpha-synuclein is a clinically identified mutation that leads to hyper aggregation of alpha-synuclein in mice, and recapitulates the symptoms of Parkinson's disease such as dopaminergic neuron loss.

A53T synuclein mice are treated with a compound of the present disclosure (for example compound 809). Mice so treated fail to display the characteristics of dopaminergic neuron loss. This effect is believed to be due to the compound blocking formation of the toxic form of A53T-alpha-synuclein by inhibiting c-Abl.

Example 7: Functional Rescue Study in Alpha-Synuclein Fibril Model

Injection of pre-formed alpha-synuclein fibrils is known to induce Parkinson's-like disease in mice. Mice that have been injected with pre-formed alpha-synuclein fibrils are treated with a compound of the present disclosure (for example compound 809). Mice so treated fail to exhibit Parkinson's like disease because. This effect is believed to be due to the compound blocking the formation of toxic pre-formed-fibril alpha synuclein by inhibiting c-Abl.

INCORPORATION BY REFERENCE

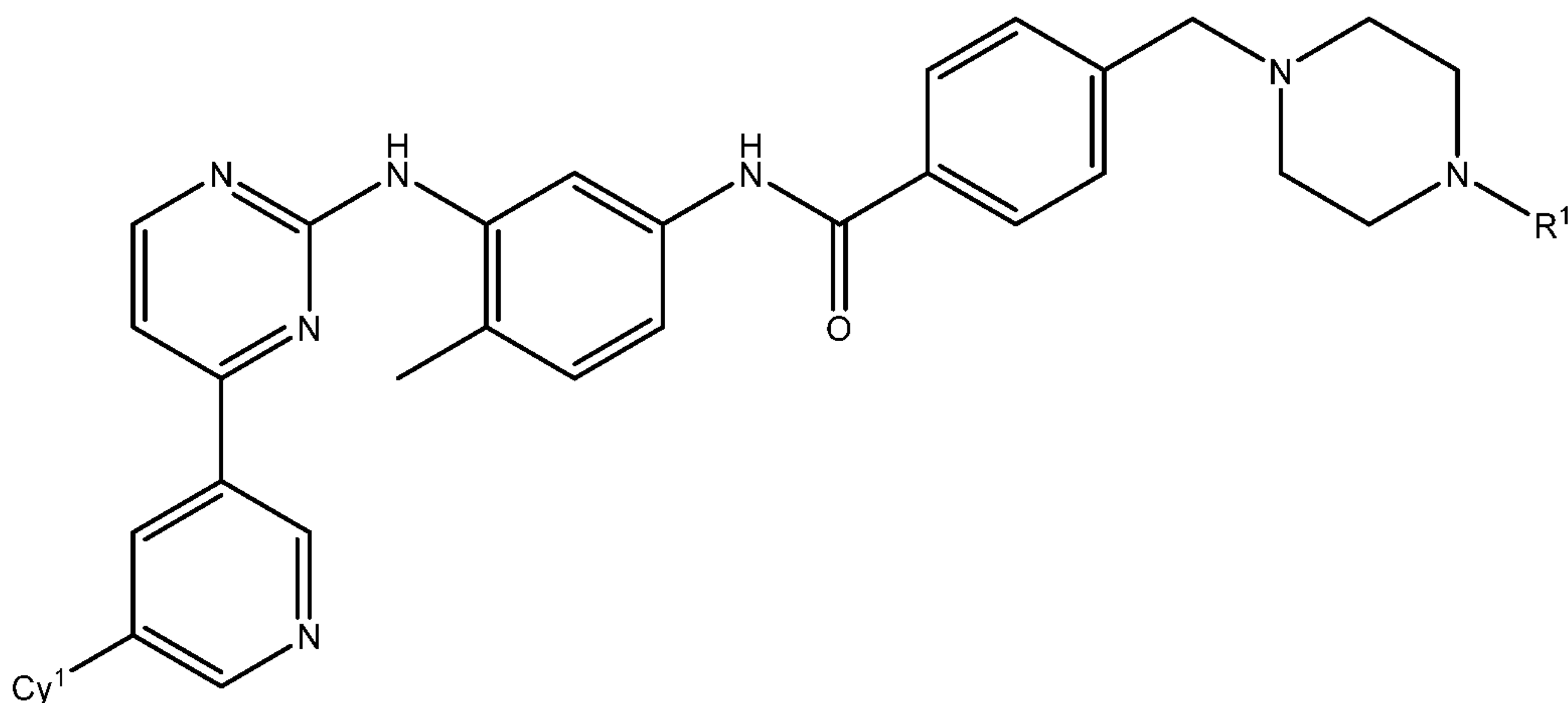
Each of the patents, published patent applications, and non-patent references cited herein are hereby incorporated by reference in their entirety.

EQUIVALENTS

Those skilled in the art will recognize, or be able to ascertain using no more than routine experimentation, many equivalents to the specific embodiments of the invention described herein. Such equivalents are intended to be encompassed by the following claims.

WE CLAIM

1. A method of treating or preventing Parkinson's Disease, comprising administering to a subject an effective amount of an ATK inhibitor, wherein the ATK inhibitor is a compound having a structure of Formula (I) or a pharmaceutically acceptable salt thereof:



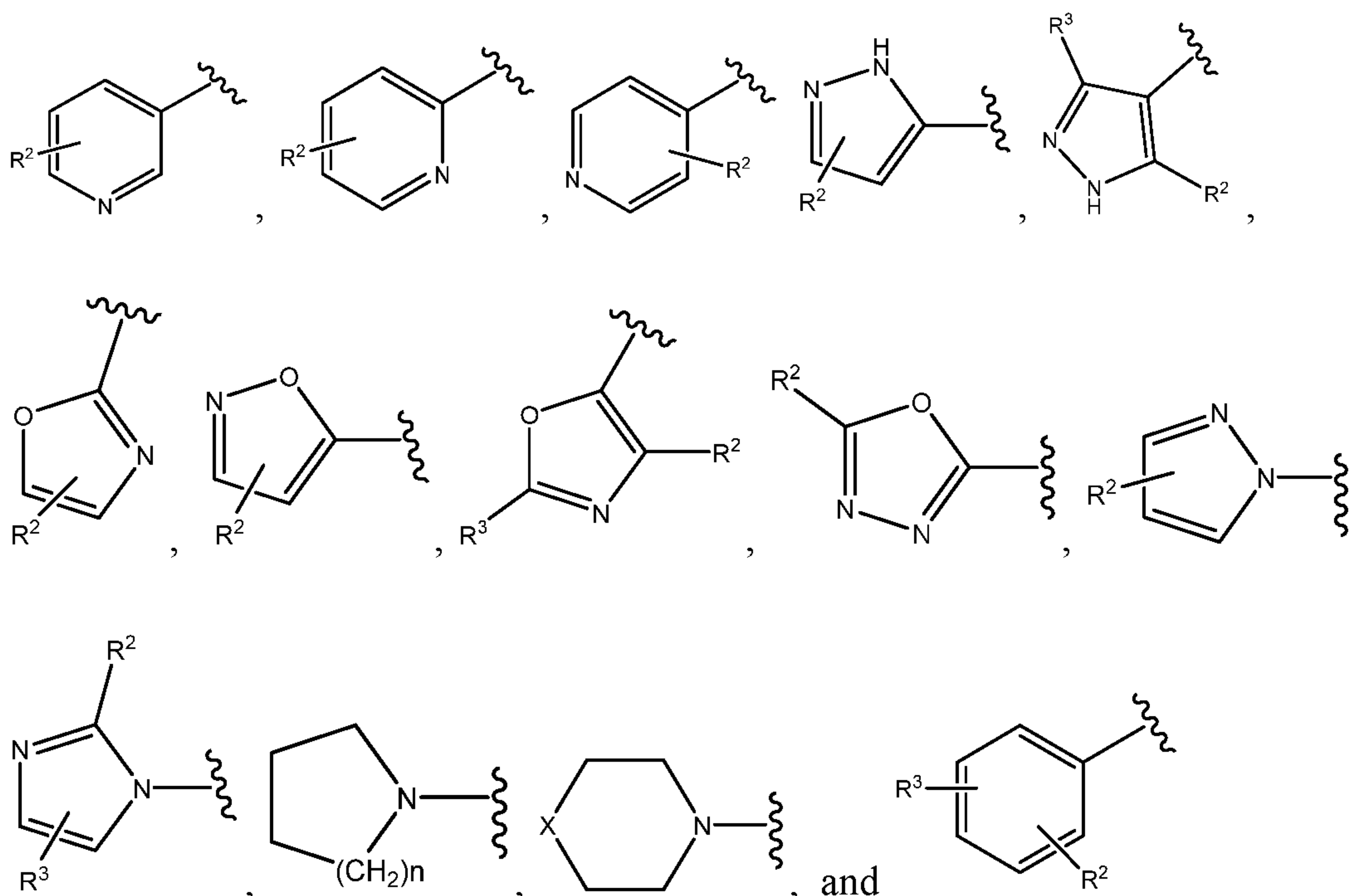
Formula (I)

wherein, independently for each occurrence,

R¹ is selected from hydrogen or lower alkyl, which may optionally be deuterated; and

Cy¹ is selected from substituted or unsubstituted aryl, substituted or unsubstituted heteroaryl, and substituted or unsubstituted heterocyclyl.

2. The method of claim 1, wherein Cy¹ is selected from:



wherein, independently for each occurrence,

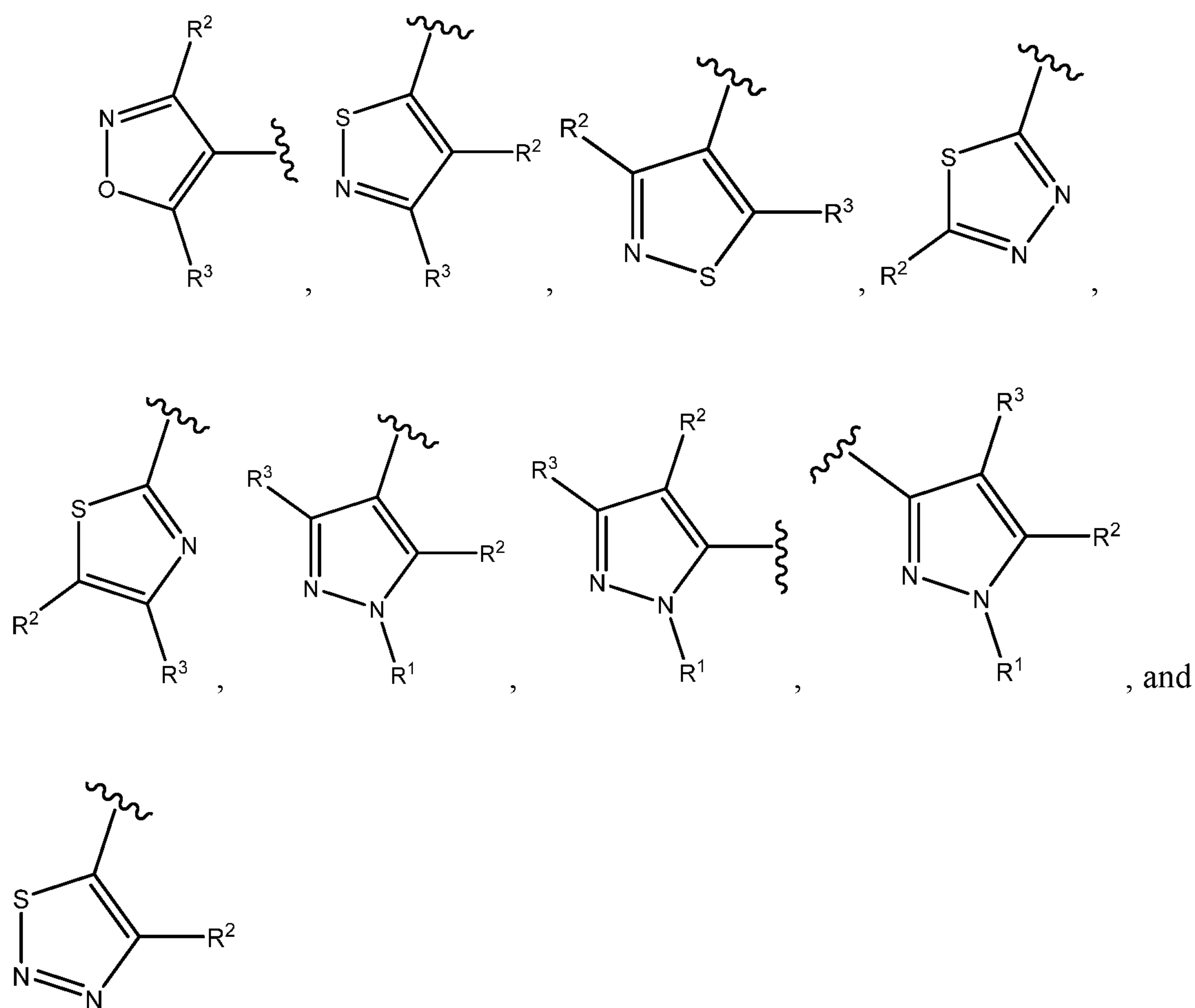
R^2 and R^3 are selected from hydrogen, alkyl, amino, monoalkylamino, dialkylamino, cycloalkyl, halo, cyano, alkoxy, $-C(O)OH$, and $-C(O)N(R^4)(R^4)$;

n is 1, 2, 3 or 4;

X is $C(R^4)_2$, S, O, or NR^4 ;

R^4 is selected from hydrogen and substituted or unsubstituted alkyl, aralkyl, cycloalkyl, heterocyclyl, aryl, heteroaryl, heteroaralkyl, cycloalkylalkyl, or heterocyclylalkyl.

3. The method of claim 1, wherein Cy^1 is selected from:



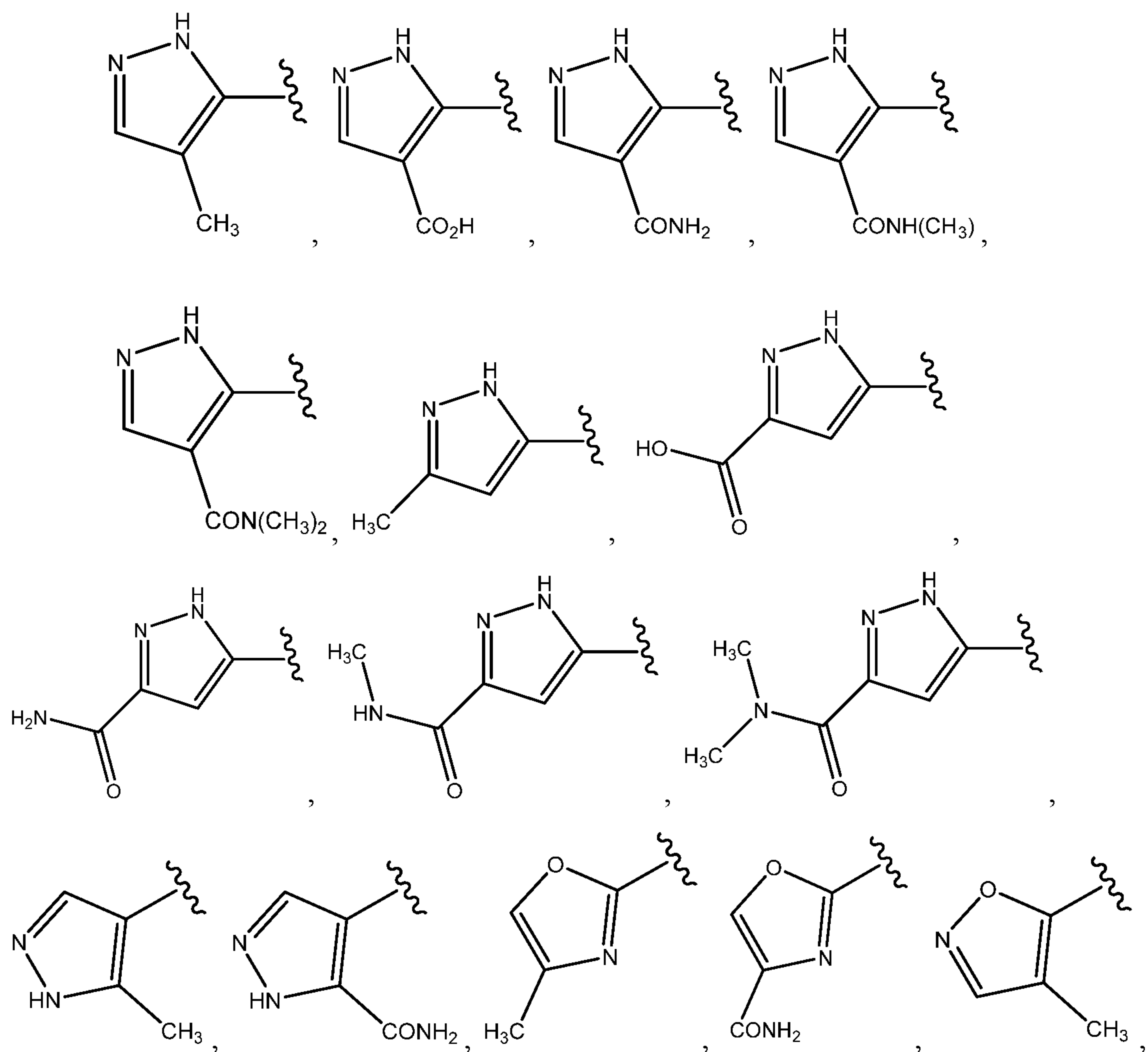
wherein, independently for each occurrence,

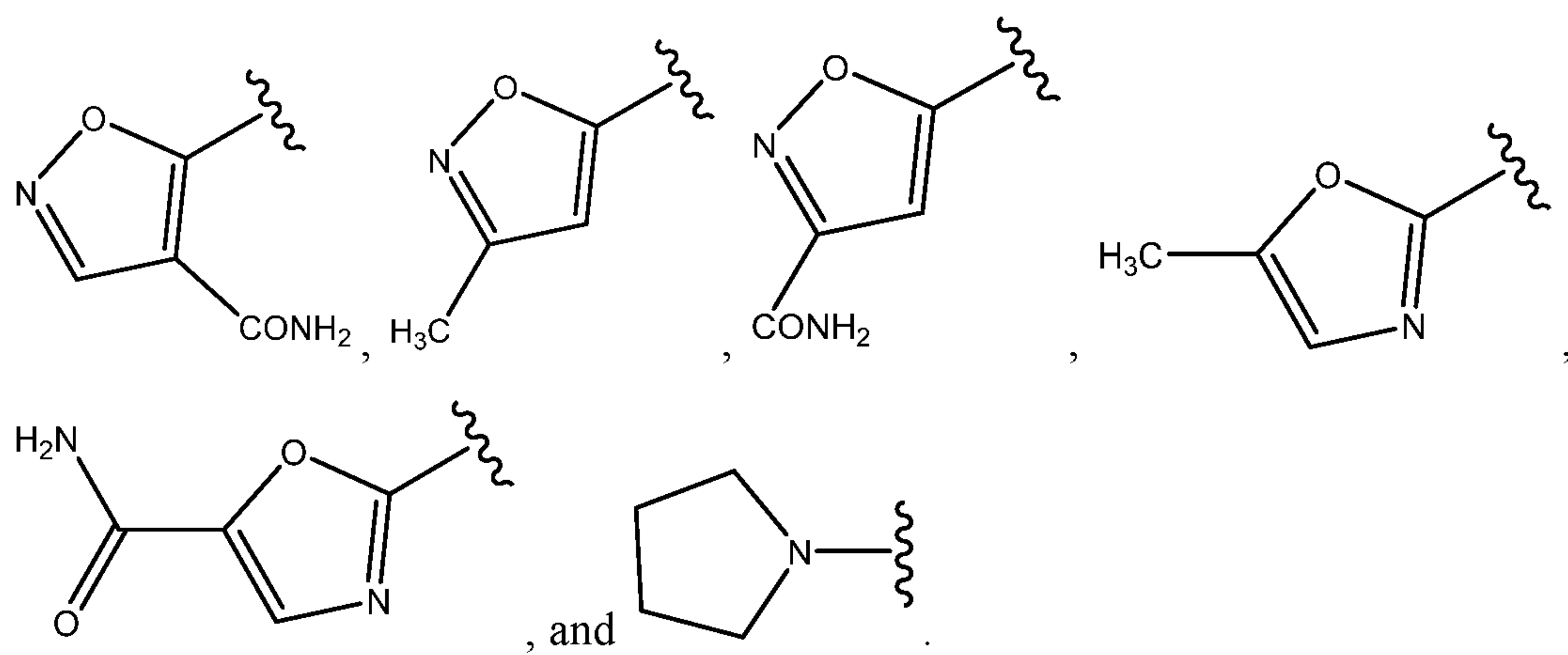
R^1 is selected from hydrogen or lower alkyl;

R^2 and R^3 are selected from hydrogen, alkyl, amino, monoalkylamino, dialkylamino, cycloalkyl, halo, cyano, alkoxy, $-C(O)OH$, and $-C(O)N(R^4)(R^4)$;

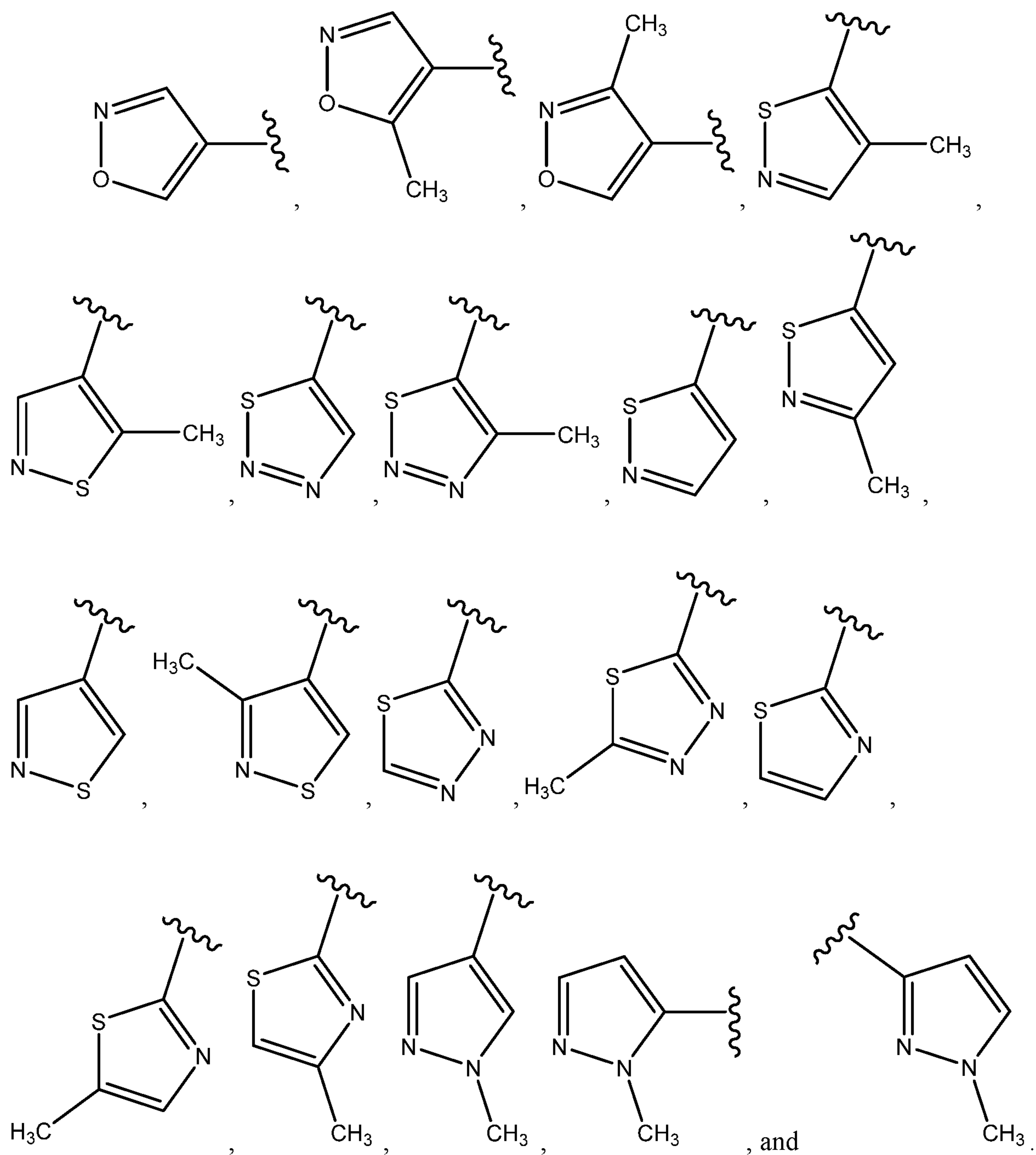
R^4 is selected from hydrogen and substituted or unsubstituted alkyl, aralkyl, cycloalkyl, heterocyclyl, aryl, heteroaryl, heteroaralkyl, cycloalkylalkyl, or heterocyclylalkyl.

4. The method of claim 1, wherein Cy¹ is not unsubstituted pyrid-4-yl or unsubstituted phenyl.
5. The method of claim 1, wherein Cy¹ is not substituted or unsubstituted pyrid-4-yl or substituted or unsubstituted phenyl.
6. The method of claim 1, wherein Cy¹ is 5-membered heteroaryl, aryl or heterocyclyl.
7. The method of claim 6, wherein Cy¹ is selected from:

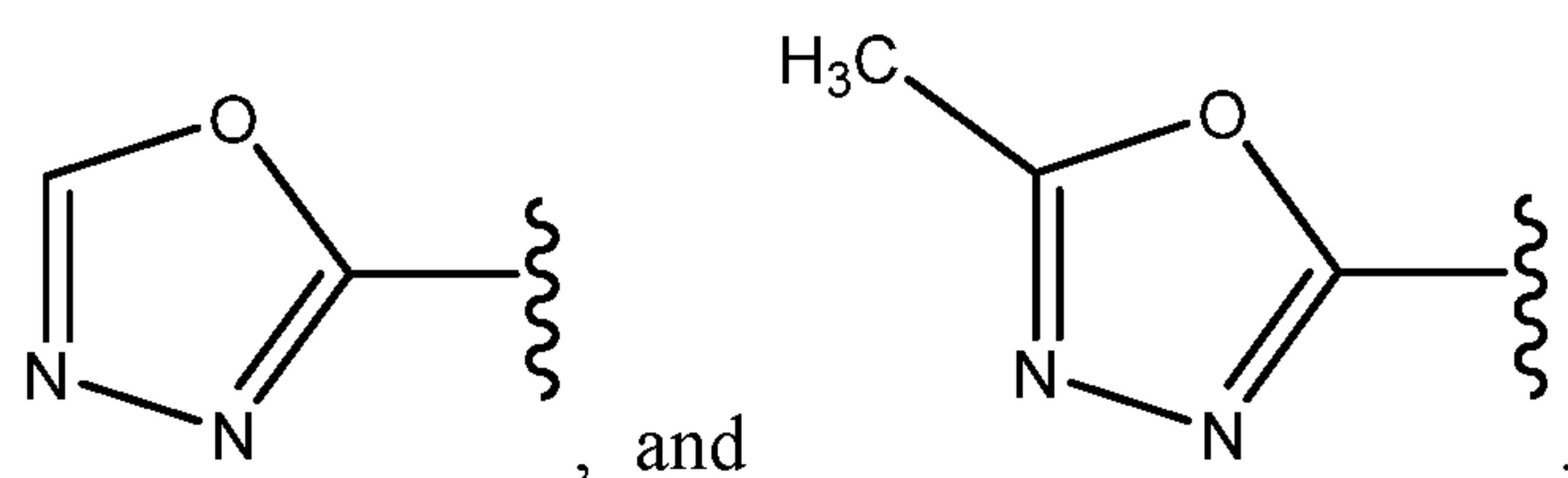




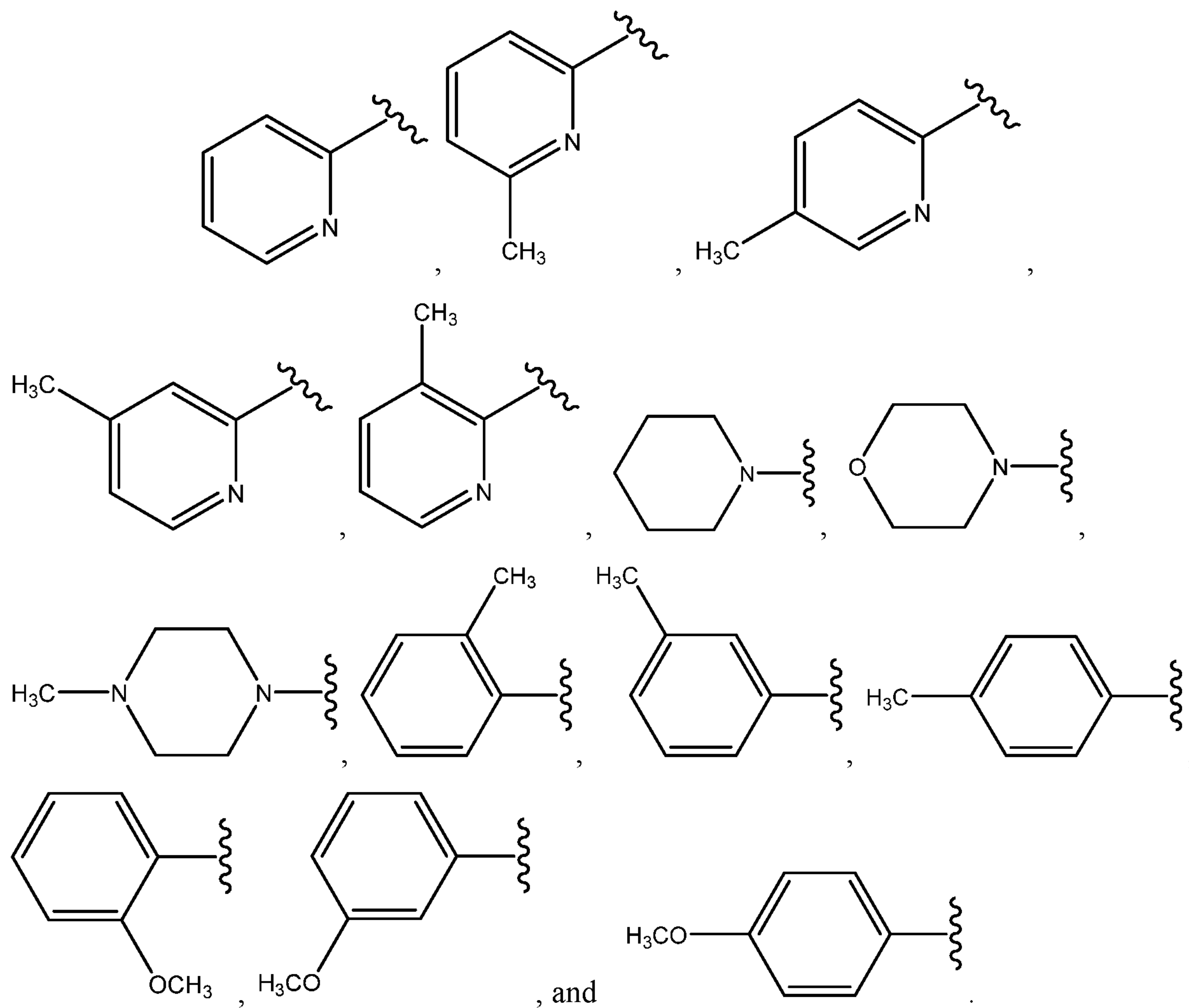
8. The method of claim 6, wherein Cy¹ is selected from:



9. The method of claim 6, wherein Cy¹ is selected from:



10. The method of claim 1, wherein Cy¹ is selected from:



11. The method of claim 1, wherein R¹ is -CH₃, -CDH₂, -CD₂H, or -CD₃.

MPTP Mouse Model: Study Design

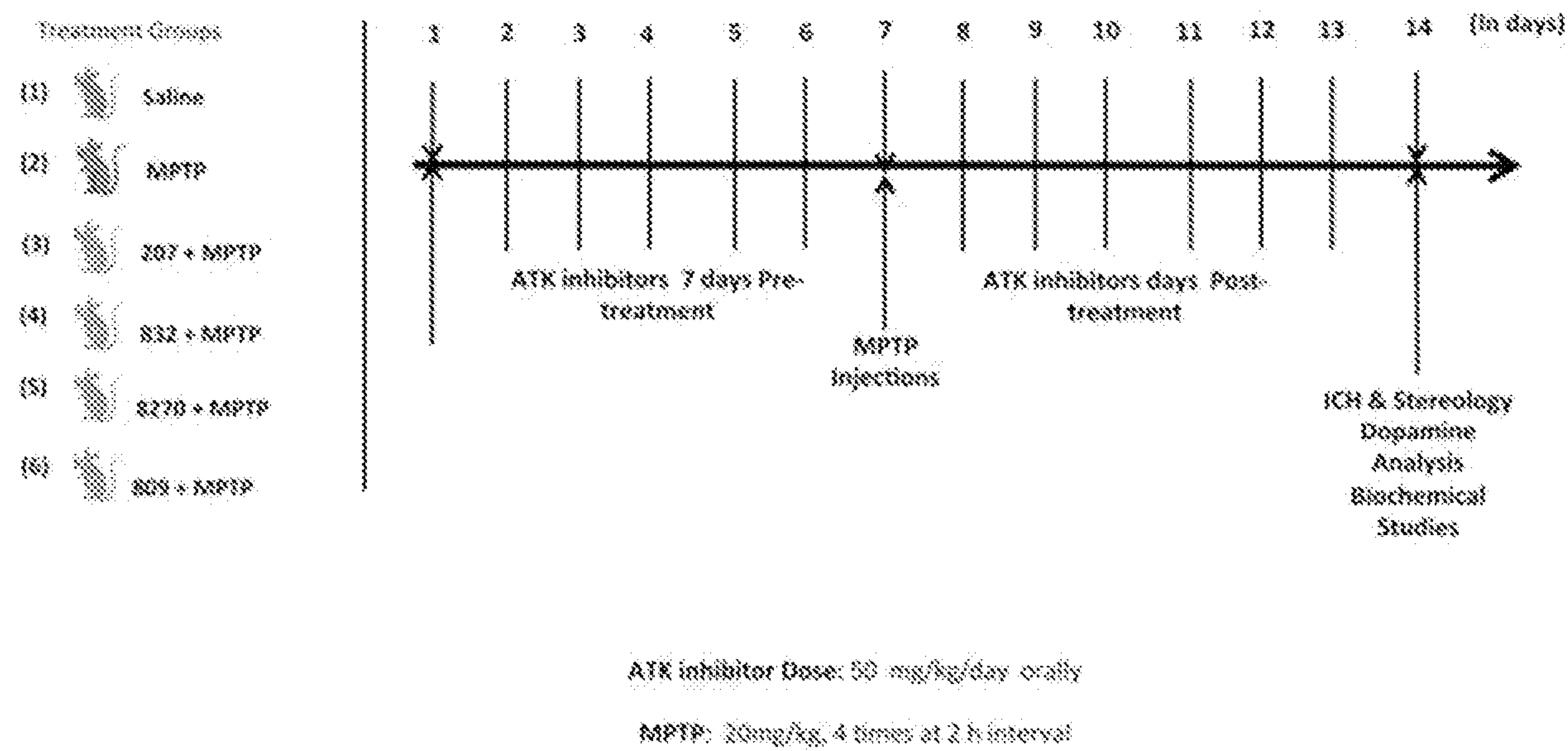
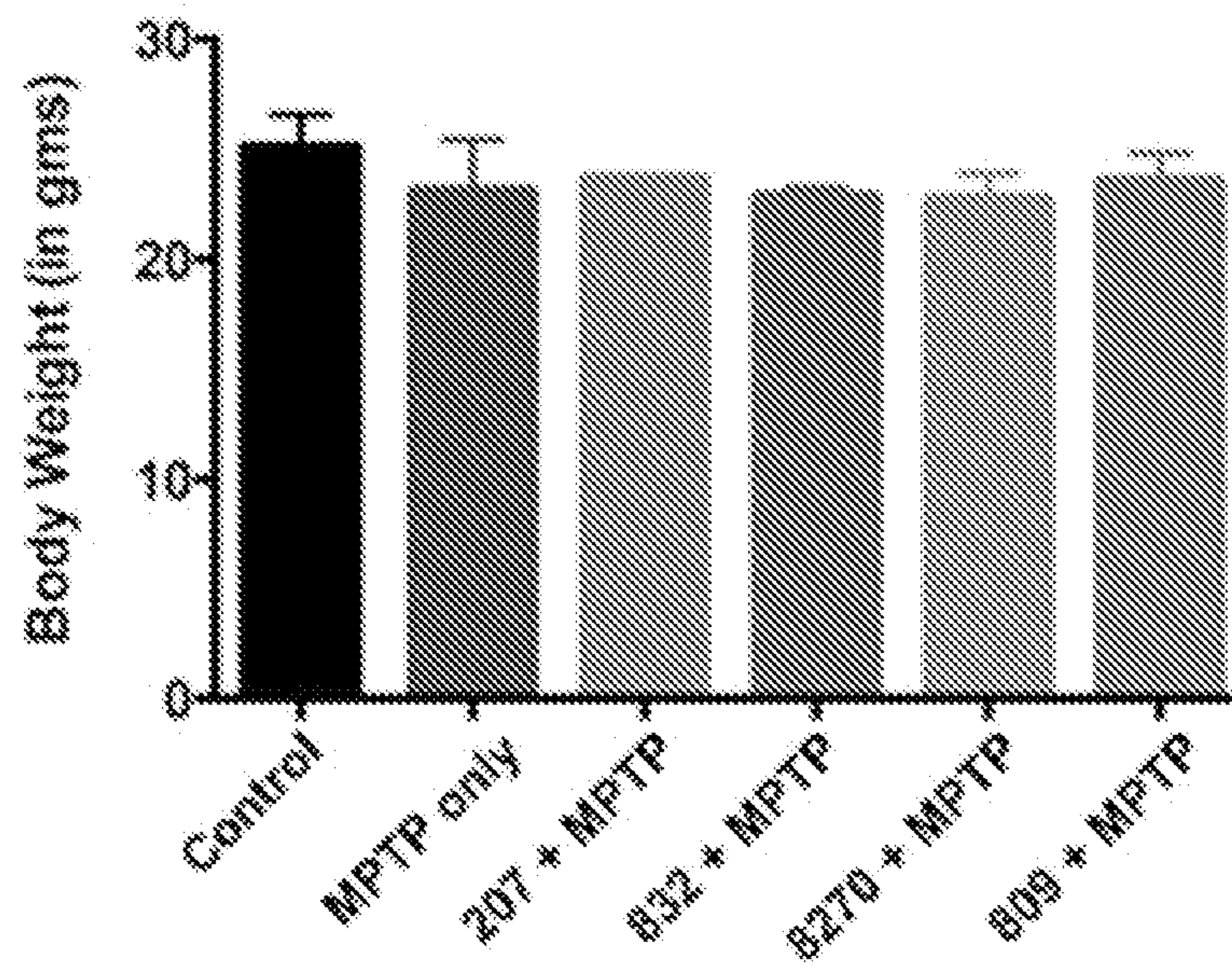
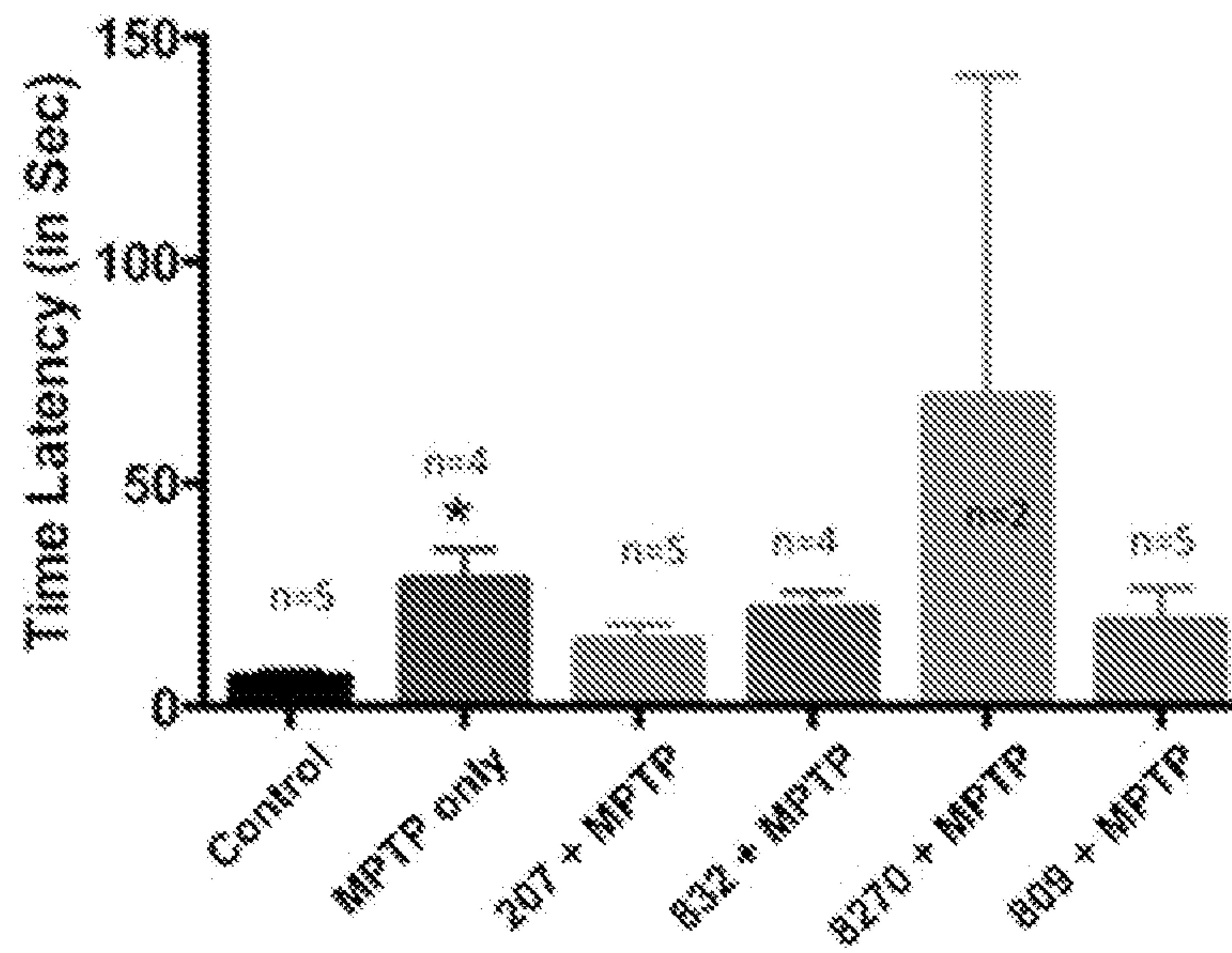
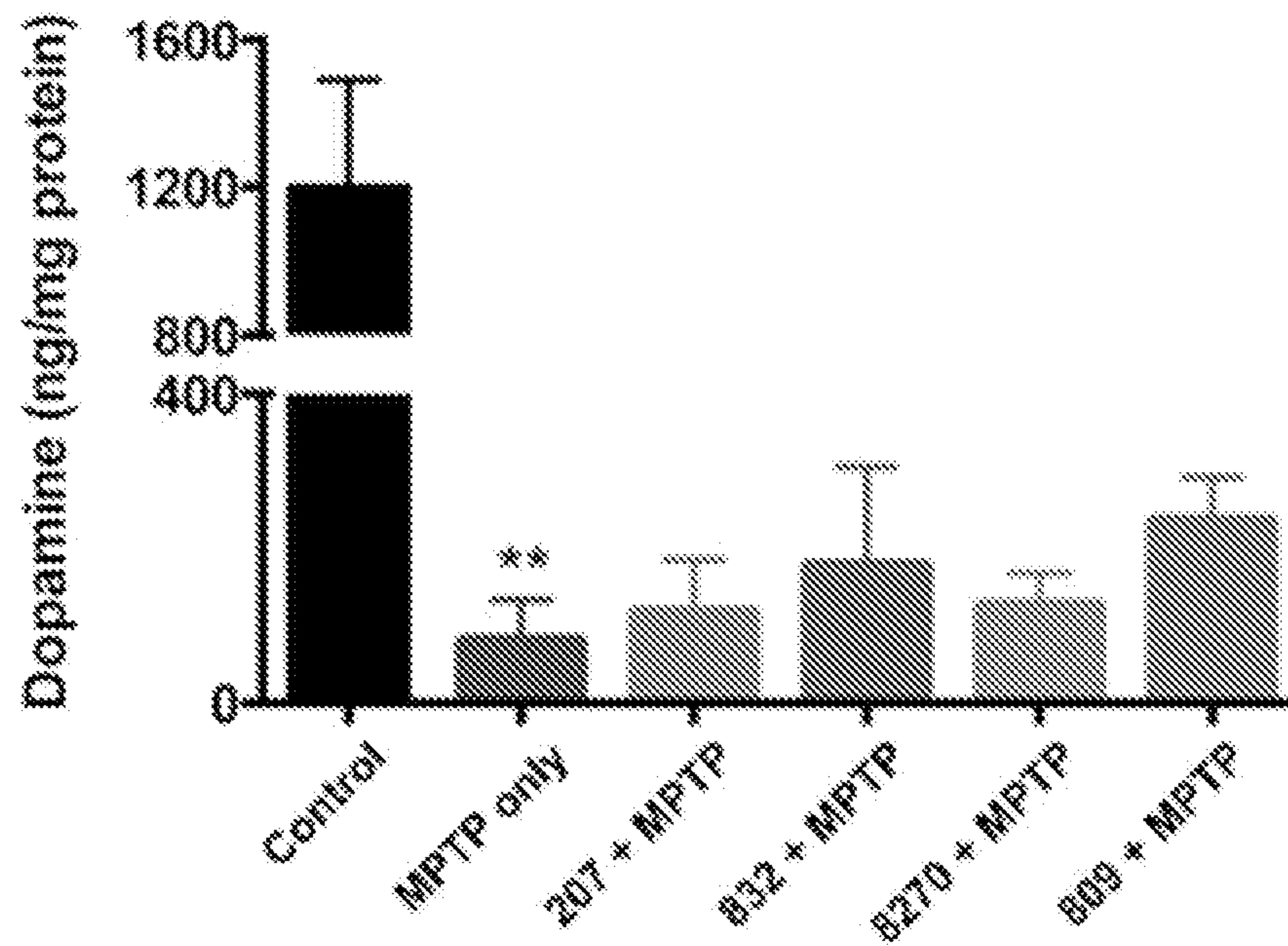


Figure 1

MPTP Mouse Model: Body Weight on 14th Day**Figure 2**

MPTP Mouse Model: Pole Test**Figure 3**

MPTP Mouse Model: Dopamine Levels**Figure 4**

MPTP Mouse Model: Metabolite Levels

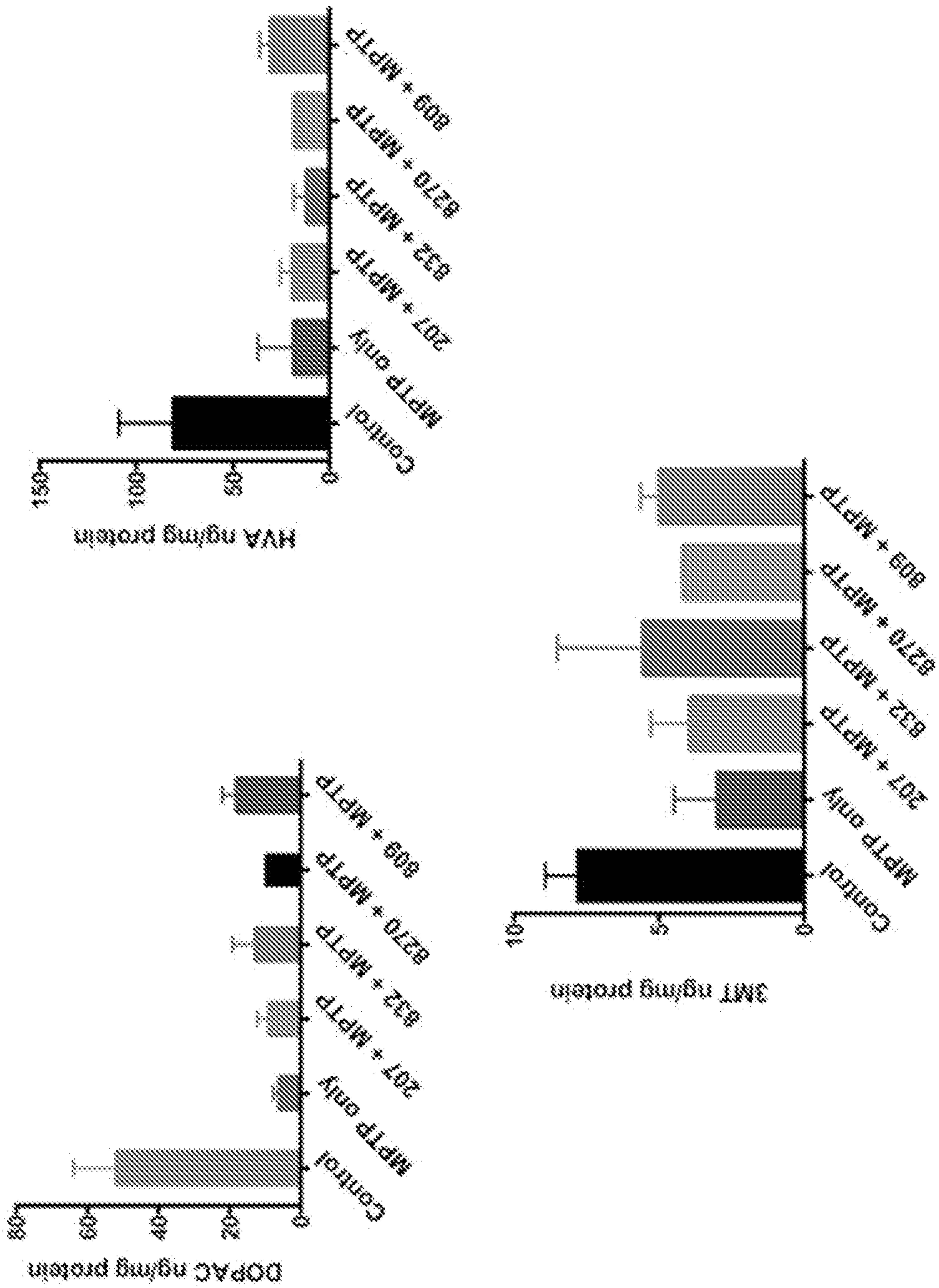
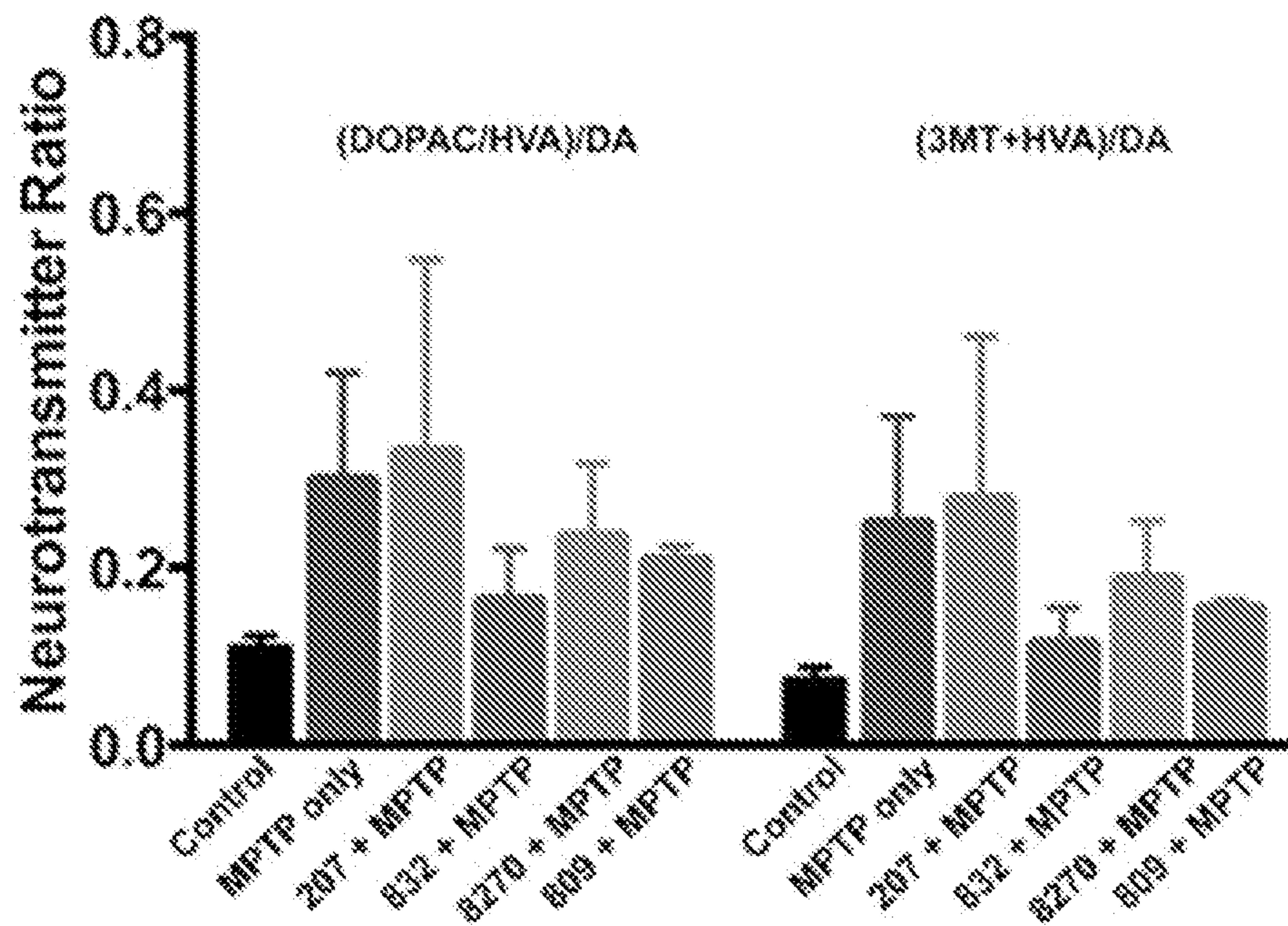


Figure 5

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MPTP Mouse Model: Dopamine Turnover Ratio**Figure 6**

MPTP Mouse Model: Compound 809 Summary

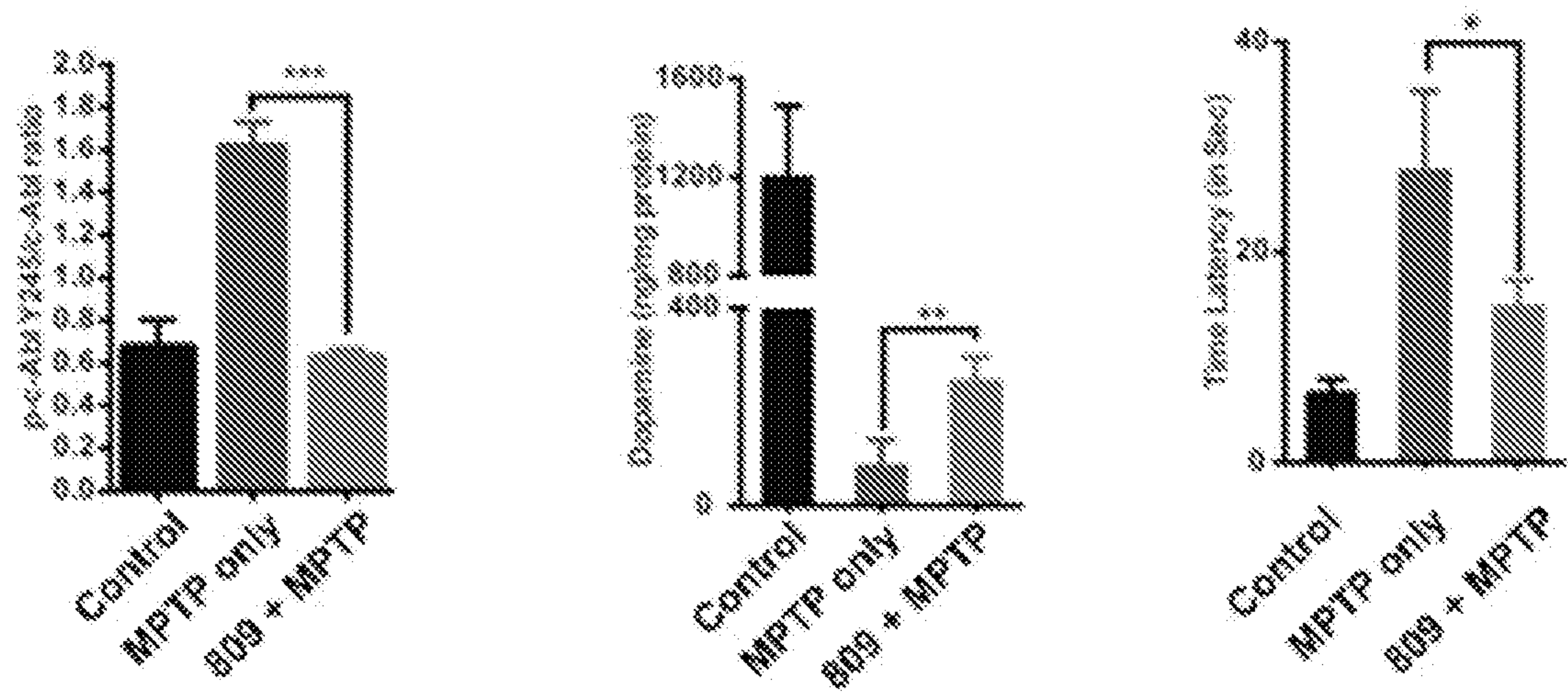


Figure 7

MPTP Mouse Model: Compound 809 Summary

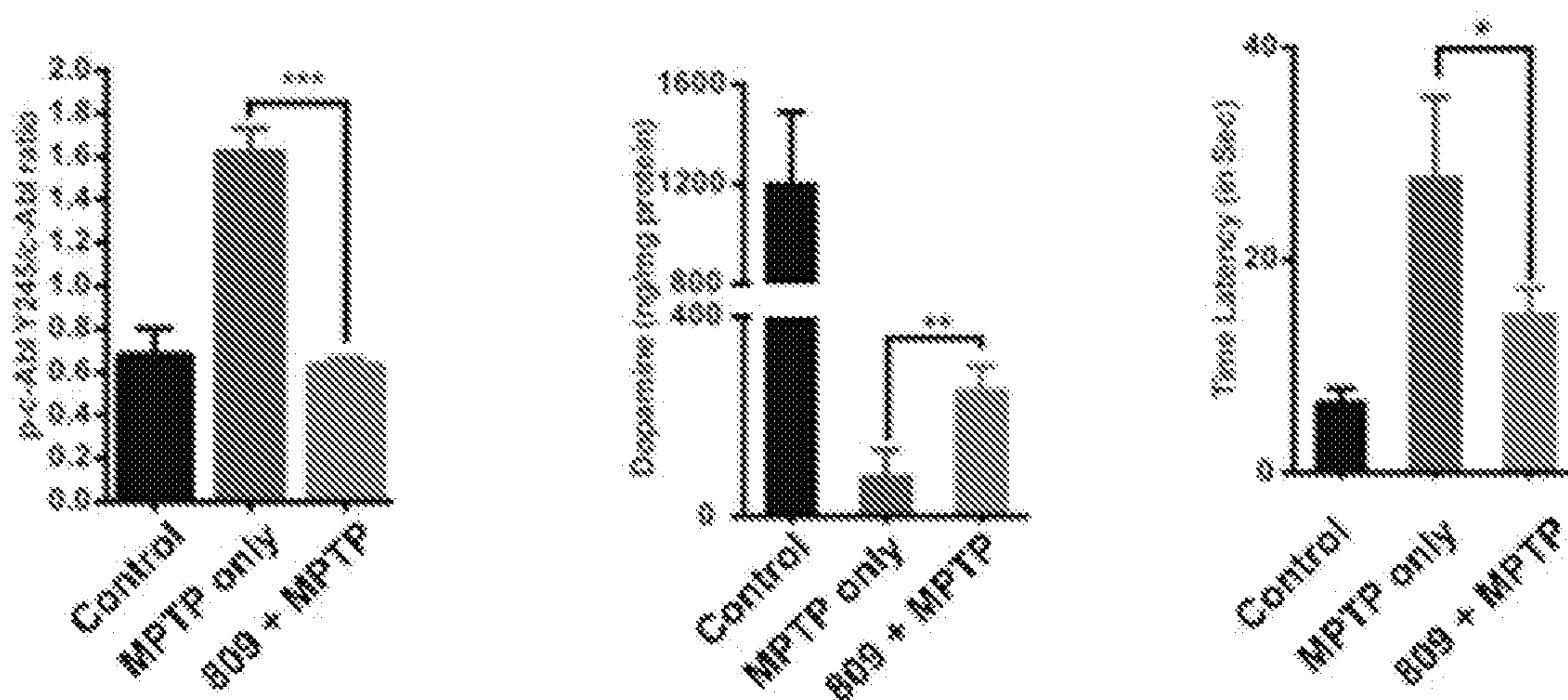


Figure 7