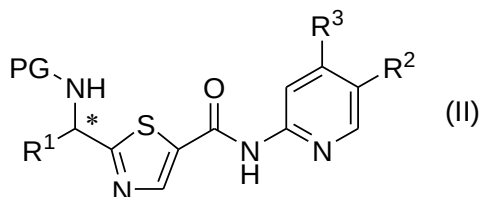


CLAIMS

1. A method of producing an optically active form of a compound represented by the following formula (II):



5 wherein

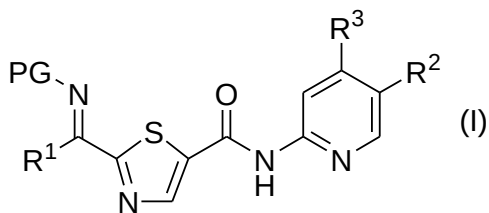
R¹ is a C₁₋₆ alkyl group;

R² is a hydrogen atom or a halogen atom;

R³ is a hydrogen atom or an optionally halogenated C₁₋₆ alkyl group;

10 PG is a protecting group; and

the carbon atom marked with * is an asymmetric carbon atom, or a salt thereof, which comprises subjecting a compound represented by the following formula (I):



15 wherein each symbol is as defined above,

or a salt thereof, to an asymmetric reduction reaction, wherein the asymmetric reduction reaction is a reduction reaction in the presence of an iridium complex and a reducing agent,

20 wherein the iridium complex is selected from [IrCl(L)]₂, [IrBr(L)]₂, [IrI(L)]₂, [IrCp*(L)]₂, [Ir(cod)(L)]OTf, [Ir(cod)(L)]BF₄, [Ir(cod)(L)]B{3,5-(CF₃)₂C₆H₃}₄, [Ir(cod)(L)]ClO₄, [Ir(cod)(L)]PF₆, [Ir(cod)(L)]SbF₆, [Ir(cod)(L)]BPh₄, [Ir(nbd)(L)]B{3,5-(CF₃)₂C₆H₃}₄, [Ir(nbd)(L)]OTf, [Ir(nbd)(L)]BF₄,
25 [Ir(nbd)(L)]ClO₄, [Ir(nbd)(L)]PF₆, [Ir(nbd)(L)]SbF₆, [Ir(nbd)(L)]BPh₄, [Ir(nbd)(L)]B{3,5-(CF₃)₂C₆H₃}₄, or [Ir(π-allyl)(L)((C,O)-substituted-benzoate)],

wherein L is a ligand selected from:

(3,5-dioxa-4-phosphacyclohepta[2,1-a;3,4-a']dinaphthalen-4-yl)dimethylamine (MonoPhos);

(3,5-dioxa-4-phosphacyclohepta[2,1-a;3,4-a']dinaphthalen-4-yl)benzyl (methyl) amine;

5 (3,5-dioxa-4-phosphacyclohepta[2,1-a;3,4-a']dinaphthalen-4-yl)-(1-phenylethyl) amine;

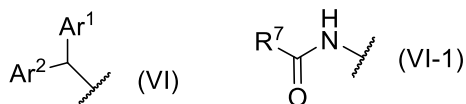
(3,5-dioxa-4-phosphacyclohepta[2,1-a;3,4-a']dinaphthalen-4-yl)bis(1-phenylethyl) amine;

10 (3,5-dioxa-4-phosphacyclohepta[2,1-a;3,4-a']dinaphthalen-4-yl)-2,5-diphenylpyrrolidine;

(3,5-dioxa-4-phosphacyclohepta[2,1-a;3,4-a']dinaphthalen-4-yl)morpholine (Morfphos); or

(3,5-dioxa-4-phosphacyclohepta[2,1-a;3,4-a']dinaphthalen-4-yl)piperidine (PipPhos),

15 wherein the PG is represented by the following formula (VI) or (VI-1):

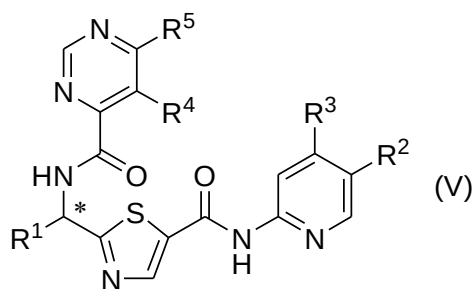


wherein

20 Ar¹ is a hydrogen atom or C₆₋₁₄ aryl group optionally substituted by C₁₋₆ alkoxy;

Ar² is a C₆₋₁₄ aryl group optionally substituted by C₁₋₆ alkoxy; and R⁷ is C₆₋₁₄ aryl group optionally substituted by C₁₋₆ alkoxy or a C₁₋₆ alkoxy group.

25 2. A method of producing an optically active form of a compound represented by the following formula (V):



wherein

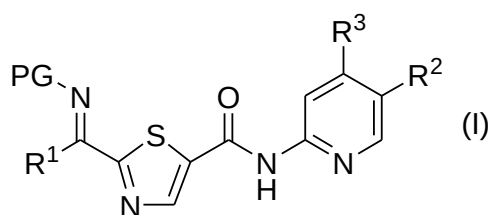
R¹ is a C₁₋₆ alkyl group;

R² is a hydrogen atom or a halogen atom;

5 R³ is a hydrogen atom or an optionally halogenated C₁₋₆ alkyl group;

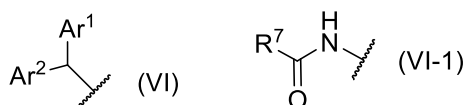
R⁴ and R⁵ are each independently a hydrogen atom, a halogen atom, a cyano group, a nitro group, an optionally substituted hydrocarbon group, an optionally substituted heterocyclic group,
 10 an acyl group, an optionally substituted amino group, an optionally substituted carbamoyl group, an optionally substituted thiocarbamoyl group, an optionally substituted sulfamoyl group, an optionally substituted hydroxy group, an optionally substituted sulfanyl (SH) group, or an optionally substituted silyl group; and

15 the carbon atom marked with * is an asymmetric carbon atom, or a salt thereof, wherein the method comprises a step of subjecting a compound represented by the following formula (I);



20 wherein

PG is a protecting group, that is represented by the following formula (VI) or (VI-1)



wherein

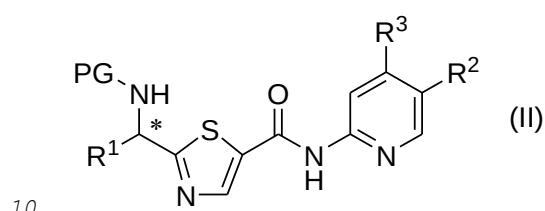
Ar¹ is a hydrogen atom or C₆₋₁₄ aryl group optionally substituted by C₁₋₆ alkoxy;

Ar² is a C₆₋₁₄ aryl group optionally substituted by C₁₋₆ alkoxy; and R⁷ is C₆₋₁₄ aryl group optionally substituted by

5 C₁₋₆ alkoxy or a C₁₋₆ alkoxy group,

and the other symbols are as defined above,

or a salt thereof, to an asymmetric reduction reaction to obtain an optically active form of a compound represented by the following formula (II);



wherein each symbol is as defined above,

or a salt thereof,

wherein the asymmetric reduction reaction is a reduction reaction in presence of an iridium complex and a reducing agent,

15 wherein the iridium complex is selected from [IrCl(L)]₂, [IrBr(L)]₂, [IrI(L)]₂, [IrCp*(L)]₂, [Ir(cod)(L)]OTf, [Ir(cod)(L)]BF₄, [Ir(cod)(L)]B{3,5-(CF₃)₂C₆H₃}₄, [Ir(cod)(L)]ClO₄, [Ir(cod)(L)]PF₆, [Ir(cod)(L)]SbF₆, [Ir(cod)(L)]BPh₄, [Ir(nbd)(L)]B{3,5-(CF₃)₂C₆H₃}₄, [Ir(nbd)(L)]OTf, [Ir(nbd)(L)]BF₄,
 20 [Ir(nbd)(L)]ClO₄, [Ir(nbd)(L)]PF₆, [Ir(nbd)(L)]SbF₆, [Ir(nbd)(L)]BPh₄, [Ir(nbd)(L)]B{3,5-(CF₃)₂C₆H₃}₄, or [Ir(π-allyl)(L)((C,O)-substituted-benzoate)],

wherein L is a ligand selected from:

(3,5-dioxa-4-phosphacyclohepta[2,1-a;3,4-a']dinaphthalen-4-yl)dimethylamine (MonoPhos);

25

(3,5-dioxa-4-phosphacyclohepta[2,1-a;3,4-a']dinaphthalen-4-yl)benzyl(methyl)amine;

3,5-dioxa-4-phosphacyclohepta[2,1-a;3,4-a']dinaphthalen-4-yl)-(1-phenylethyl)amine;

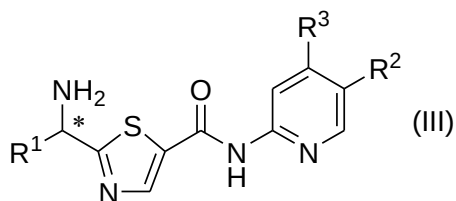
(3,5-dioxa-4-phosphacyclohepta[2,1-a;3,4-a']dinaphthalen-4-yl)bis(1-phenylethyl)amine;

3,5-dioxa-4-phosphacyclohepta[2,1-a;3,4-a']dinaphthalen-4-yl)-2,5-diphenylpyrrolidine;

5 3,5-dioxa-4-phosphacyclohepta[2,1-a;3,4-a']dinaphthalen-4-yl)morpholine (MorfpHos); or

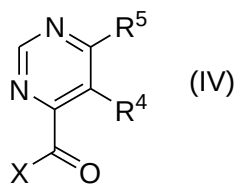
(3,5-dioxa-4-phosphacyclohepta[2,1-a;3,4-a']dinaphthalen-4-yl)piperidine (PipPhos),

wherein the method further comprises a step of subjecting
10 the optically active form of the compound represented by formula (II) to a deprotection reaction, and a step of reacting the obtained optically active form of a compound represented by the following formula (III);



15 wherein each symbol is as defined above,

or a salt thereof, with a compound represented by the following formula (IV);



wherein

20 X is a leaving group; and

R⁴ and R⁵ are each independently a hydrogen atom, a halogen atom, a cyano group, a nitro group, an optionally substituted hydrocarbon group, an optionally substituted heterocyclic group, an acyl group, an optionally substituted amino group, an
25 optionally substituted carbamoyl group, an optionally substituted thiocarbamoyl group, an optionally substituted sulfamoyl group, an optionally substituted hydroxy group, an

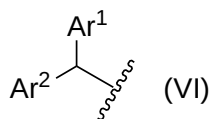
optionally substituted sulfanyl (SH) group, or an optionally substituted silyl group, or a salt thereof.

3. The method of claim 2, wherein the optically active
5 form of the compound represented by the formula (III) or a salt thereof is a salt of the optically active form of the compound represented by the formula (III) with mandelic acid.

4. The method of claim 2, wherein X is a hydroxy group.

10

5. The method of any one of claims 1-4, wherein PG is represented by the following formula (VI):



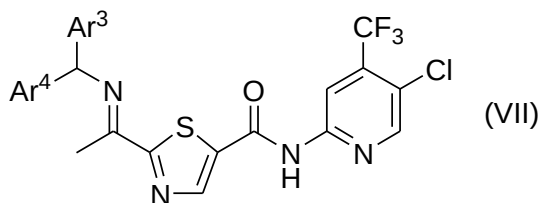
15 wherein

Ar¹ is a hydrogen atom or an optionally substituted C₆₋₁₄ aryl group; and

Ar² is an optionally substituted C₆₋₁₄ aryl group.

20 6. The method of claim 5, wherein Ar¹ and Ar² are each independently an optionally substituted phenyl group.

7. A compound represented by the following formula
(VII):

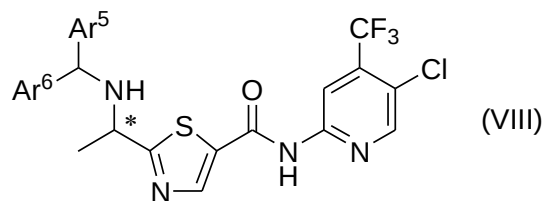


25

wherein Ar³ and Ar⁴ are each independently an optionally substituted C₆₋₁₄ aryl group,
or a salt thereof.

30 8. An optically active form of a compound represented by the

following formula (VIII):



wherein

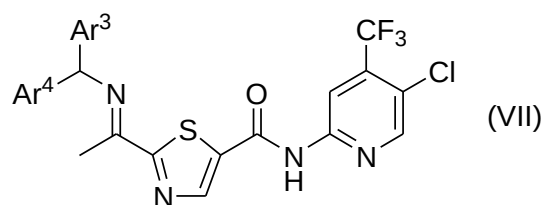
Ar⁵ and Ar⁶ are each independently an optionally substituted C₆-
 5 14 aryl group, and

the carbon atom marked with * is an asymmetric carbon atom,
 or a salt thereof.

10 9. The method of claim 1, wherein the asymmetric
 reduction reaction is an asymmetric hydrogenation reaction in
 the presence of [Ir(cod)₂]BARF and (S)-Monophos, wherein the
 reducing agent is hydrogen gas.

15 10. The method of claim 1, wherein R¹ is methyl, R² is
 Cl, and R³ is -CF₃.

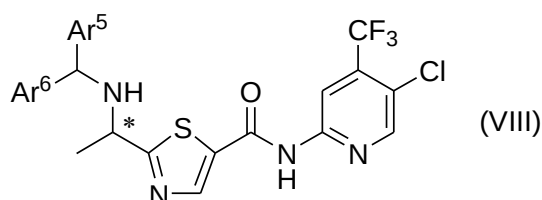
11. The method of claim 1, wherein the compound
 represented by Formula (I) is a compound represented by Formula
 20 (VII):



wherein

Ar³ and Ar⁴ are each independently a phenyl group optionally
 25 substituted C₁₋₆ alkoxy, and

the compound represented by the Formula (II) is a compound
 represented by Formula (VIII):



wherein

Ar⁵ and Ar⁶ are each independently a phenyl group optionally substituted C₁₋₆ alkoxy, and the carbon atom marked with * is an asymmetric carbon atom.

12. The method of claim 1, wherein the reducing agent is hydrogen gas.

10

13. The method of claim 2, wherein R⁴ is a hydrogen atom, a halogen atom, a cyano group, an optionally substituted hydrocarbon group, an acyl group, or a hydroxy group; and

R⁵ is hydrogen atom, an optionally substituted hydrocarbon group, an optionally substituted heterocyclic group, an acyl group, an optionally substituted amino group, an optionally substituted carbamoyl group, a hydroxy group, or a sulfanyl (SH) group.

14. The method of claim 2, wherein R⁴ is Cl and R⁵ is -NH₂.

15. The compound of claim 7, wherein Ar³ and Ar⁴ are each phenyl.

25

16. The compound of claim 8, wherein Ar⁵ and Ar⁶ are each phenyl.