CLAIMS

[Claim 1] A method for producing a carbonyl halide, the method comprising the step of:

irradiating a light to a mixed gas comprising methane, a halogen molecule gas and oxygen,

wherein a peak wavelength of the light is included in 180 nm or more and 500 nm or less.

[Claim 2] The method according to claim 1, wherein the carbonyl halide is carbonyl chloride, and the halogen molecule gas is a chlorine gas.

[Claim 3] The method according to claim 1, wherein the light has a peak wavelength of 360 nm or more and 500 nm or less.

[Claim 4] The method according to claim 1, wherein the light is irradiated to the mixed gas at an atmospheric temperature.

[Claim 5] The method according to claim 1, wherein the shortest distance between a light source to irradiate the light and the mixed gas is 1 m or less.

[Claim 6] The method according to claim 1, further comprising the step of producing a sodium halide aqueous solution by neutralizing a hydrogen halide with a basic sodium salt, wherein the hydrogen halide is produced as a side product by irradiating the light to the mixed gas.

[Claim 7] The method according to claim 1, further comprising

the step of electrolyzing the sodium halide aqueous solution to produce the halogen molecule and sodium hydroxide.

[Claim 8] A method for producing a carbonate compound, the method comprising the steps of:

producing a carbonyl halide by the method according to any one of claims 1 to 7, and

reacting an alcohol compound and the carbonyl halide.

[Claim 9] A method for producing a halogenated formate ester compound, the method comprising the steps of:

producing a carbonyl halide by the method according to any one of claims 1 to 7, and

reacting an alcohol compound and the carbonyl halide.

[Claim 10] A method for producing an isocyanate compound, the method comprising the steps of:

producing a carbonyl halide by the method according to any one of claims 1 to 7, and

reacting a primary amine compound and the carbonyl halide.

[Claim 11] A method for producing a carbamoyl halide compound, the method comprising the steps of:

producing a carbonyl halide by the method according to any one of claims 1 to 7, and

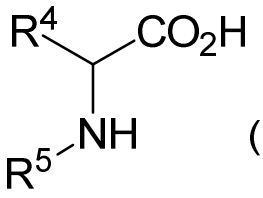
reacting a secondary amine compound and the carbonyl halide.

[Claim 12] A method for producing an amino acid-N-carboxylic anhydride, the method comprising the steps of:

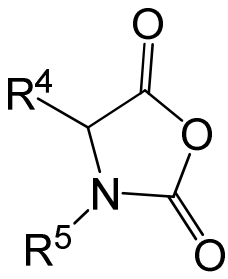
producing a carbonyl halide by the method according to any one of claims 1 to 7, and

reacting an amino acid compound represented by the following formula (VII) and the carbonyl halide,

wherein the amino acid-N-carboxylic anhydride is represented by the following formula (VIII):



(VII)



(VIII)

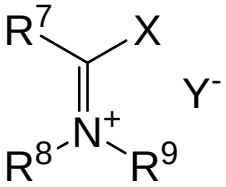
wherein

R^4 is an amino acid side chain group wherein a reactive group is protected,

R^5 is H or P^1-[-NH-CHR^6-C(=O)-]$_l$- wherein R^6 is an amino acid side chain group wherein a reactive group is protected, P^1 is a protective group of the amino group, l is an integer of 1 or more, and when l is an integer of 2 or more, a plurality of R^6 may be the same as or different from each other.

[Claim 13] A method for producing a Vilsmeier reagent,

wherein the Vilsmeier reagent is a salt represented by the following formula (X):



(X)

wherein

R^7 is a hydrogen atom, a C_{1-6} alkyl group or an optionally substituted C_{6-12} aromatic hydrocarbon group,

R^8 and R^9 are independently a C_{1-6} alkyl group or an

optionally substituted C_{6-12} aromatic hydrocarbon group, or R^8 and R^9 may form a 4 or more and 7 or less-membered ring structure together with each other,

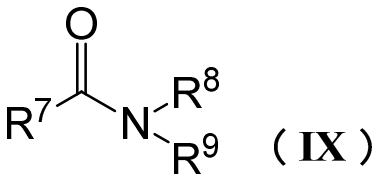
X is a halogeno group selected from the group consisting of chloro, bromo and iodo,

Y^- is a counter anion,

the method comprising the steps of:

producing a carbonyl halide by the method according to any one of claims 1 to 7, and

reacting the carbonyl halide and an amide compound represented by the following formula (IX):



(IX)

wherein R^7 to R^9 have the same meanings as the above.

[Claim 14] A method for producing a urea compound, the method comprising the steps of:

producing a carbonyl halide by the method according to any one of claims 1 to 7, and

reacting a primary amine compound or a secondary amine compound and the carbonyl halide.