[0006]

[Patent Document 1] JP-A-60-251109

[Patent Document 2] Japanese Patent No. 2987713

[Non-Patent Document 1] Fluorine Chemistry Vol. 1 (1950)

DISCLOSURE OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

[0007]

In light of the problems, the invention has been made. An object thereof is to provide a phosphorus pentafluoride producing process wherein phosphorus pentafluoride is separated/extracted from a pentavalent phosphorus compound or a solution thereof, or a composition obtained by allowing the pentavalent phosphorus compound or the solution thereof to react with hydrogen fluoride, thereby producing phosphorus pentafluoride; and a phosphate hexafluoride producing process wherein the resultant phosphorus pentafluoride is used as raw material to produce a phosphate hexafluoride high in purity.

SUMMARY

In an aspect, there is provided a process for producing phosphorus pentafluoride, comprising:

bringing a carrier gas into contact with either of the following one:

a pentavalent phosphorus compound,

a solution thereof,

or a solution in which a composition obtained by allowing the pentavalent phosphorus compound or the solution thereof to react with hydrogen fluoride is dissolved;

thereby extracting a phosphorus pentafluoride into the carrier gas,

wherein the pentavalent phosphorus compound contains a compound which is phosphorus pentaoxide (P_2O_5), orthophosphoric acid (H_3PO_4), polyphosphoric acid, metaphosphoric acid, pyrophosphoric acid, triphosphoric acid, isodiphosphate, phosphonic acid, phosphinic acid, phosphenic acid, diphosphonic acid, cyanophosphoric acid, cyanophosphonic acid, diethyldithiophosphinic acid, chlorophenylphosphonic acid, trimethyl phosphate, o-methyl phenylselenophosphinate, pyrophosphonic acid, a phosphorus oxyhalide, phosphorus pentasulfide (P_2S_5), phosphorus thiofluoride (PSF_3), trichlorophosphinesulfide ($PSCl_3$), phosphonitrile fluoride (PNF_2), phosphonitrile chloride ($PNCl_2$), phosphorus pentabromide, or phosphorus pentaiodide, or any combination thereof.

In another aspect, there is provided a process for producing a phosphate hexafluoride, comprising:

producing phosphorus pentafluoride through a process as defined above; and

reacting the phosphorus pentafluoride with a fluoride in accordance with the following chemical reaction formula, thereby producing the phosphate hexafluoride:

$nPF_5+MFn \rightarrow M(PF_6)n$

wherein M represents Li, Na, K, Rb, Cs, NH_4 or Ag when n is 1, represents Ca, Mg, Ba, Zn, Cu or Pb when n is 2, and represents Al or Fe when n is 3.

MEANS FOR SOLVING THE PROBLEMS

[0008]

In order to solve the conventional problems, the inventors have investigated processes for producing phosphorus pentafluoride and a phosphate hexafluoride. As a result, the

CLAIMS

1. A process for producing phosphorus pentafluoride, wherein

a carrier gas is brought into contact with either of the following one:

a pentavalent phosphorus compound,

a solution thereof,

or a solution in which a composition obtained by allowing the pentavalent phosphorus compound or the solution thereof to react with hydrogen fluoride is dissolved,

thereby a phosphorus pentafluoride is extracted into the career gas.

2. The process for producing phosphorus pentafluoride according to claim 1, wherein the solution, in which the composition is dissolved, is heated, thereby evaporating phosphorus pentafluoride gas together with hydrogen fluoride gas to separate phosphorus pentafluoride.

3. The process for producing phosphorus pentafluoride according to claim 1, wherein the solution, in which the composition is dissolved, is bubbled with the carrier gas.

4. The process for producing phosphorus pentafluoride

according to claim 1, wherein the water content in the carrier gas is 1% or less by weight.

5. The process for producing phosphorus pentafluoride according to claim 1, wherein the temperature when the carrier gas is brought into contact with the solution, in which the composition is dissolved, is from -50 to 100°C.

6. The process for producing phosphorus pentafluoride according to claim 1, wherein the carrier gas is inert to the solution, in which the composition is dissolved.

7. The process for producing phosphorus pentafluoride according to claim 1, wherein the phosphorus atom content in the solution, in which the composition is dissolved, is from 0.01 to 25% by weight.

8. The process for producing phosphorus pentafluoride according to claim 1, wherein hydrogen fluoride gas is used as the carrier gas.

9. The process for producing phosphorus pentafluoride according to claim 1, wherein

the carrier gas is brought into contact with anhydrous hydrogen fluoride,

thereby phosphorus oxyfluoride extracted in the carrier gas reacts with anhydrous hydrogen fluoride in accordance with the following chemical reaction formula,

and generates phosphorus pentafluoride:

$$POF_3 + 2HF \rightarrow PF_5 + H_2O$$

10. The process for producing phosphorus pentafluoride according to claim 1, wherein the pentavalent phosphorus compound is a compound obtained by oxidizing a zerovalent or trivalent phosphorus compound.

11. A process for producing a phosphate hexafluoride, wherein phosphorus pentafluoride obtained by the process for producing phosphorus pentafluoride according to claim 1 is allowed to react with a fluoride in accordance with the following chemical reaction formula, thereby producing the phosphate hexafluoride:

$$nPF_5 + MFn \rightarrow M(PF_6)n$$

wherein M represents any one selected from the group consisting of Li, Na, K, Rb, Cs, NH_4 and Ag when n is 1, represents any one selected from the group consisting of Ca, Mg, Ba, Zn, Cu and Pb when n is 2, and represents any one selected from the group consisting of Al and Fe when n is 3.

12. The process for producing a phosphate hexafluoride

according to claim 11, wherein for the reaction between the phosphorus pentafluoride and the fluoride, at least the following steps are conducted:

a first step of dissolving phosphorus pentafluoride gas in an organic solvent,

a second step of adding, to the organic solvent, the fluoride, the amount of which is an amount stoichiometrically equivalent to the phosphorus pentafluoride, or a stoichiometric amount less than the stoichiometrically equivalent amount, thereby generating a solution of the phosphate hexafluoride, and

a third step of cycling the solution of the phosphate hexafluoride into the first step, thereby dissolving phosphorus pentafluoride gas in the solution of the phosphate hexafluoride instead of the organic solvent.

13. The process for producing a phosphate hexafluoride according to claim 12, wherein the organic solvent is at least either one of a nonaqueous organic solvent or a nonaqueous ionic liquid.

14. The process for producing a phosphate hexafluoride according to claim 12, wherein the organic solvent is a solvent having a water concentration of 100 ppm or less by weight.

15. The process for producing a phosphate hexafluoride according to claim 12, wherein the first and third steps are conducted, using an absorption tower.

16. An electrolytic solution, comprising a phosphate hexafluoride obtained by the process for producing the phosphate hexafluoride according to claim 1.

17. An electricity accumulating element, comprising the electrolytic solution according to claim 16.

CLAIMS

1. A process for producing phosphorus pentafluoride, comprising:

bringing a carrier gas into contact with either of the following one:

a pentavalent phosphorus compound,

a solution thereof,

or a solution in which a composition obtained by allowing the pentavalent phosphorus compound or the solution thereof to react with hydrogen fluoride is dissolved;

thereby extracting a phosphorus pentafluoride into the carrier gas,

wherein the pentavalent phosphorus compound contains a compound which is phosphorus pentaoxide (P_2O_5), orthophosphoric acid (H_3PO_4), polyphosphoric acid, metaphosphoric acid, pyrophosphoric acid, triphosphoric acid, isodiphosphate, phosphonic acid, phosphinic acid, phosphenic acid, diphosphonic acid, cyanophosphoric acid, cyanophosphonic acid, diethyldithiophosphinic acid, chlorophenylphosphonic acid, trimethyl phosphate, o-methyl phenylselenophosphinate, pyrophosphonic acid, a phosphorus oxyhalide, phosphorus pentasulfide (P_2S_5), phosphorus thiofluoride (PSF_3), trichlorophosphinesulfide ($PSCl_3$), phosphonitrile fluoride (PNF_2), phosphonitrile chloride ($PNCl_2$), phosphorus pentabromide, or phosphorus pentaiodide, or any combination thereof.

2. The process according to claim 1, wherein the solution, in which the composition is dissolved, is heated, thereby evaporating phosphorus pentafluoride gas together with hydrogen fluoride gas to separate phosphorus pentafluoride.

3. The process according to claim 1 or 2, wherein the solution, in which the composition is dissolved, is bubbled with the carrier gas.

4. The process according to any one of claims 1 to 3, wherein the water content in the carrier gas is 1 % or less by weight.

5. The process according to any one of claims 1 to 4, wherein the temperature when the carrier gas is brought into contact with the solution, in which the composition is dissolved, is from -50 to 100°C.

6. The process according to any one of claims 1 to 5, wherein the carrier gas is inert to the solution, in which the composition is dissolved.

7. The process according to any one of claims 1 to 6, wherein the phosphorus atom content in the solution, in which the composition is dissolved, is from 0.01 to 25 % by weight.

8. The process according to any one of claims 1 to 7, wherein hydrogen fluoride gas is used as the carrier gas.

9. The process according to any one of claims 1 to 8, wherein the carrier gas is brought into contact with anhydrous hydrogen fluoride,

wherein phosphorus oxyfluoride extracted in the carrier gas reacts with anhydrous hydrogen fluoride in accordance with the following chemical formula,

and generates phosphorus pentafluoride:

$POF_3+2HF \rightarrow PF_5+H_2O$.

10. The process according to any one of claims 1 to 9, wherein the pentavalent phosphorus compound is a compound obtained by oxidizing a zerovalent or trivalent phosphorus compound.

11. A process for producing a phosphate hexafluoride, comprising:

producing phosphorus pentafluoride through a process as defined in any one of claims 1 to 10; and

reacting the phosphorus pentafluoride with a fluoride in accordance with the following chemical reaction formula, thereby producing the phosphate hexafluoride:

$nPF_5+MFn \rightarrow M(PF_6)n$

wherein M represents Li, Na, K, Rb, Cs, NH_4 or Ag when n is 1, represents Ca, Mg, Ba, Zn, Cu or Pb when n is 2, and represents Al or Fe when n is 3.

12. The process according to claim 11, wherein for the reaction between the phosphorus pentafluoride and the fluoride, at least

the following steps are conducted:

a first step of dissolving phosphorus pentafluoride gas in an organic solvent,

a second step of adding, to the organic solvent, the fluoride, the amount of which is an amount stoichiometrically equivalent to the phosphorus pentafluoride, or a stoichiometric amount less than the stoichiometrically equivalent amount, thereby generating a solution of the phosphate hexafluoride, and

a third step of cycling the solution of the phosphate hexafluoride into the first step, thereby dissolving phosphorus pentafluoride gas in the solution of the phosphate hexafluoride instead of the organic solvent.

13. The process according to claim 12, wherein the organic solvent is a nonaqueous organic solvent or a nonaqueous ionic liquid, or a combination thereof.

14. The process according to claim 12 or 13, wherein the organic solvent is a solvent having a water concentration of 100 ppm or less by weight.

15. The process according to any one of claims 12 to 14, wherein the first and third steps are conducted, using an absorption tower.