à vide [Vacuum pumps], B4030, 10/11/1983). Generally a distinction is made between "volumetric" pumps which generate the vacuum by using liquid seals (oils, organic products or water), such as for example vane pumps and liquid ring pumps, and "drive" pumps, in which it is the flow of a fluid that creates the vacuum (ejector pumps, steam jet pumps, etc.). The systems most commonly used involve water or steam jet ejectors or liquid ring pumps, mainly water ring pumps.

These systems are not suitable for reducing the operating pressure of the finishing column of a solvent-free (meth)acrylic acid purification process, such as that described in document EP 2 066 613.

Such systems, for example described in document US 6,677,482 or US 7,288,169, use steam and generate a large amount of aqueous effluents containing acrylic acid and organic impurities, which cannot be economically recycled to the purification loop formed by the dehydration column and the finishing column. Indeed, it has been observed that the recycling of too large an amount of water at the dehydration column leads to sizeable losses of acrylic acid at the top of this column, unless an oversized column is used but this leads to an expensive investment. These aqueous effluents therefore need to be sent to a water treatment plant or directly to a thermal oxidizer, thus giving rise on the one hand to a loss of high quality product and on the other hand to an environmentally harmful discharge. The effluents from these vacuum systems, rich in noncondensable compounds which are incinerated or sent directly to the atmosphere, release in the first case oxidation products and in the second case organic compounds that are environmental pollutants.

Therefore, there remains a need to eliminate and/or reduce the generation of aqueous discharges in a solvent-free recovery/purification process enabling the finishing column to operate under vacuum.

The inventors have now discovered that the use of a dry vacuum pump linked to the operation of the finishing column in a solvent-free acrylic acid recovery/purification process makes it possible to meet this need, with the economic and environmental advantages that result therefrom.

It has become apparent to the inventors that this invention could be applied to acrylic acid produced from sources other than propylene, to methacrylic acid and also to these acids derived from renewable raw materials, which are capable of posing the same purification problems.

SUMMARY

The present disclosure relates firstly to a process for recovering (meth)acrylic acid without using azeotropic solvent, starting from a gaseous reaction mixture

comprising (meth)acrylic acid obtained by gas-phase oxidation of a precursor of the (meth)acrylic acid, comprising at least the following steps:

i) the gaseous reaction mixture is subjected to dehydration without using azeotropic solvent in a first column, referred to as dehydration column, resulting in an overhead stream, at least a portion of which is condensed and sent back to the dehydration column in the form of reflux, and in a bottom stream;

ii) the dehydration column bottom stream is subjected, at least in part, to a distillation at a pressure below atmospheric pressure in a second column, referred to as finishing column, resulting in an overhead stream and in a bottom stream containing heavy compounds;

iii) a (meth)acrylic acid stream is recovered by drawing off as a sidestream from the finishing column, and/or as bottoms from the finishing column;

said process being characterized in that the overhead stream from the finishing column is subjected, at least in part, to a dry vacuum pump condensation system, forming a condensate that is sent back to the dehydration column, and a final gaseous effluent.

In an aspect, there is provided a process for recovering (meth)acrylic acid without using azeotropic solvent, starting from a gaseous reaction mixture comprising (meth)acrylic acid obtained by gas-phase oxidation of a precursor of the (meth)acrylic acid, comprising at least the following steps:

i) subjecting the gaseous reaction mixture to dehydration without using azeotropic solvent in a dehydration column, resulting in a dehydration column overhead stream, at least a portion of which is condensed and sent back to the dehydration column in the form of reflux, and in a dehydration column bottom stream;

ii) subjecting the dehydration column bottom stream, at least in part, to a distillation at a pressure below atmospheric pressure in a finishing column, resulting in a finishing column overhead stream and in a finishing column bottom stream containing heavy compounds;

iii) recovering a (meth)acrylic acid stream by drawing off as a sidestream from the finishing column, and/or as bottoms from the finishing column;

subjecting the finishing column overhead gaseous stream, at least in part, to a dry vacuum pump condensation system such that the finishing column operates under vacuum, thereby eliminating or reducing generation of aqueous discharge and forming a condensate comprising light compounds that is recycled back to the dehydration column, and a final gaseous effluent.

In another aspect, there is provided the process for producing (meth)acrylic acid comprising at least the following steps:

A) subjecting at least one (meth)acrylic acid precursor to gas-phase oxidation to form a gaseous reaction mixture comprising (meth)acrylic acid;

B) cooling the gaseous reaction mixture;

C) subjecting the cooled gaseous reaction mixture to the process for recovering (meth)acrylic acid as defined above.

In another aspect, there is provided a system for recovering (meth)acrylic acid without using azeotropic solvent as defiened above, comprising at least:

a) one dehydration column;

b) one finishing column fluidically connected to the bottom of said dehydration column;

c) at least one dry vacuum pump condensation system, fluidically connected to the top of said finishing column;

d) optionally one dry vacuum pump condensation system fluidically connected laterally to said finishing column.

In the present invention, the term "(meth)acrylic" means "acrylic" or "methacrylic".

The term "azeotropic solvent" denotes any organic solvent exhibiting the property of forming an azeotropic mixture with water.

The term "light" describing the by-product compounds denotes the compounds for which the boiling point is lower than that of the (meth)acrylic acid and, analogously, the term "heavy" denotes the compounds for which the boiling point is greater than that of the (meth)acrylic acid.

The process according to the invention may additionally comprise other steps that aim to continue the purification of the (meth)acrylic acid stream recovered in step iii).

According to certain specific embodiments, the invention also exhibits one or preferably several of the advantageous characteristics listed below:

- the dry vacuum pump condensation system comprises at least one condenser and one dry vacuum pump (which may also be referred to as primary dry vacuum pump);

- the dry vacuum pump condensation system may optionally comprise, in addition to the primary dry vacuum pump, a liquid separator, one or more flame traps, one or more filters, sealing and insulating systems, a dry booster pump or a combination of dry

CLAIMS

1. A process for recovering (meth)acrylic acid without using azeotropic solvent, starting from a gaseous reaction mixture comprising (meth)acrylic acid obtained by gas-phase oxidation of a precursor of the (meth)acrylic acid, comprising at least the following steps:

i) subjecting the gaseous reaction mixture to dehydration without using azeotropic solvent in a dehydration column, resulting in a dehydration column overhead stream, at least a portion of which is condensed and sent back to the dehydration column in the form of reflux, and in a dehydration column bottom stream;

ii) subjecting the dehydration column bottom stream, at least in part, to a distillation at a pressure below atmospheric pressure in a finishing column, resulting in a finishing column overhead stream and in a finishing column bottom stream containing heavy compounds;

iii) recovering a (meth)acrylic acid stream by drawing off as a sidestream from the finishing column, and/or as bottoms from the finishing column;

subjecting the finishing column overhead gaseous stream, at least in part, to a dry vacuum pump condensation system such that the finishing column operates under vacuum, thereby eliminating or reducing generation of aqueous discharge and forming a condensate comprising light compounds that is recycled back to the dehydration column, and a final gaseous effluent.

2. The process according to claim 1, wherein the dry vacuum pump condensation system comprises at least one condenser and one dry vacuum pump.

3. The process according to claim 1, wherein the dry vacuum pump condensation system additionally comprises a liquid separator, or one or more flame traps, or one or more filters, or sealing and insulating systems, or a dry booster pump or a combination of dry booster pumps.

4. The process according to claim 1, wherein at least one portion of the (meth)acrylic acid stream drawn off as a sidestream is subjected to a dry vacuum pump condensation system, identical to or different from that used for the finishing column overhead stream from the finishing column.

5. The process according to claim 1, wherein the precursor of the (meth)acrylic acid is acrolein, obtained by oxidation of propylene or by oxydehydrogenation of propane.

6. The process according to claim 1, wherein the precursor of the (meth)acrylic acid is methacrolein, obtained by oxidation of isobutylene and/or of tert-butanol or from oxydehydrogenation of butane and/or isobutane.

7. The process according to claim 1, wherein the precursor of the (meth)acrylic acid comprises carbon of renewable origin.

8. The process according to claim 7, wherein the precursor of the (meth)acrylic acid is derived from glycerol, 3-hydroxypropionic acid or 2-hydroxypropanoic acid.

9. The process according to claim 1, further comprising the step of purifying the (meth)acrylic acid stream recovered in step iii).

10. The process for producing (meth)acrylic acid comprising at least the following steps:

A) subjecting at least one (meth)acrylic acid precursor to gas-phase oxidation to form a gaseous reaction mixture comprising (meth)acrylic acid;

B) cooling the gaseous reaction mixture;

C) subjecting the cooled gaseous reaction mixture to the process for recovering (meth)acrylic acid as recited in claim 1.

11. The process according to claim 10, wherein the (meth)acrylic acid is acrylic acid and the acrylic acid precursor is acrolein obtained by catalytic oxidation of propylene.

12. A system for recovering (meth)acrylic acid without using azeotropic solvent according to the process of claim 1, comprising at least:

a) one dehydration column;

b) one finishing column fluidically connected to the bottom of said dehydration column;

c) at least one dry vacuum pump condensation system, fluidically connected to the top of said finishing column;

d) optionally one dry vacuum pump condensation system fluidically connected laterally to said finishing column.