Patent claims

1. An evaporator (1) adapted for a counter-current flow of at least one liquid and one vapor therein, comprising:

a first inlet (21) for a first liquid feed stream (30),

a first outlet (41) for a first liquid output stream (50),

a second outlet (42) for a first vapor stream (60),

an evaporator sub-unit (70) comprising an evaporating means (71) for evaporation of a liquid to produce a vapor,

an internal sub-unit (90) having a surface (92) embodied such that a contact is provided between a vapor and a liquid and a mass transfer is provided between the vapor and the liquid,

a heat exchanger sub-unit (100) comprising a heat exchanging means (102) embodied such that a heat exchange is provided between a liquid stream (300), preferably the feed stream (30) or a cooling or heating stream, and a liquid or vapor contained within the evaporator (1),

and a condenser sub-unit (110) comprising a condensing means (112) for condensing the vapor to a condensate,

characterized in that the first inlet (21), the first outlet (41), second outlet (42), the evaporator sub-unit (70), the internal sub-unit (90), the heat exchanger sub-unit (100), and the condenser sub-unit (110) are all in fluid and/or vapor communication with one another and are contained within one common vessel (12),

wherein the internal sub-unit (90) is located substantially above the evaporator sub-unit (70), the heat exchanger sub-unit (100) is located substantially above the evaporator sub-unit (70), preferably substantially above the internal sub-unit (90), and the condenser sub-unit (110) is located substantially above the heat exchanger sub-unit (100) and the internal sub-unit (90),

and wherein the first inlet (21) is located in a lower portion (13) of the vessel (12), preferably substantially above the evaporator sub-unit (70), the first outlet (41) is located substantially below the evaporator sub-unit (70), and the second outlet (42) is located substantially above the evaporator sub-unit (70) and the first inlet (21).

2. The evaporator (1) of claim 1, wherein the evaporator sub-unit (70) is a falling film evaporator sub-unit (72) comprising one or more heated surfaces (80), wherein the surfaces (80) are preferably those of tubes, channels, or plates.

3. The evaporator (1) of either claim 1 or 2, wherein the heat exchanger sub-unit (100) is a feed preheater sub-unit (105) for preheating the feed stream (30) and the internal sub-unit (90) is a mist eliminator sub-unit (94) for eliminating a mist.

4. The evaporator (1) of any one of claims 1 to 3, wherein the evaporator (1) additionally comprises a first collector (150), preferably having a jacket (152) for providing thermal isolation, located in an upper portion (14) of the vessel (12) and substantially below the heat exchanger sub-unit (100), and substantially above the evaporator sub-unit (70), and embodied such that a condensate is collected and the collected condensate is partially or fully withdrawn from or refluxed within the common vessel (12).

5. The evaporator (1) of any one of claims 1 to 4, wherein the evaporator (1) additionally comprises a boot (120), wherein the boot (120) is contained within the common vessel (12) and is located in the lower portion (13) and substantially below the evaporator sub-unit (70).

6. The evaporator (1) of any one of claims 1 to 5, wherein a means other than piping (1200') is used for leading the liquid and/or the vapor between any of the sub-units (70), (90), (100), and (110).

7. The evaporator (1) of any one of claims 1 to 6, wherein moving parts are absent within the common vessel (12).

8. The evaporator (1) of any one of claims 2 to 7, wherein the one or more heated surfaces (80) are substantially vertical.

9. The evaporator (1) of any one of claims 1 to 8, wherein the evaporator (1) additionally comprises one or more static sections (130), wherein the one or more sections (130) are located substantially above the evaporator sub-unit (70) and substantially below the condenser sub-unit (110), and wherein the sections (130) each comprise a packing

and/or trays.

10. The evaporator (1) of any one of claims 1 to 9, wherein the evaporator (1) additionally comprises a second collector (154) for collecting a liquid, preferably from the condenser sub-unit (110), or the one or more static sections (130), and/or a distributor (160) for distributing a liquid, preferably to the evaporator sub-unit (70) or to the static section (130).

11. A process to separate at least two components,

wherein to an evaporator (1) of any one of claims 1 to 10, a first liquid feed stream (30) comprising the at least two components is fed by means of the first inlet (21),

the feed stream (30) passes into the evaporator sub-unit (70), in which a vapor stream (32) is formed from the feed stream (30) by means of heat and mass transfer in an evaporating means (71), preferably in contact with heated surfaces (80),

wherein the vapor stream (32) exits in a substantially upward direction from the sub-unit (70), and wherein the remaining non-vaporized feed stream (31) exits in a substantially downward direction from the sub-unit (70) and is subsequently removed as a first liquid output stream (50) comprising a first component of the at least two components by means of the first outlet (41),

the vapor stream (32), optionally containing a mist, passes into the internal subunit (90), in which the mist, if present, is removed from the vapor stream (32), and the mist is, optionally collected, withdrawn from

the evaporator (1) and/or returned by means of gravity to the evaporator sub-unit (70),

the vapor stream (32) passes into the heat exchanger sub-unit (100), in which a heat transfer occurs in a heat exchanging means (102) between the vapor stream (32) and a liquid stream (300), preferably the feed stream (30) or a cooling or heating stream, wherein, if the liquid stream is the feed stream (30) the heat transfer occurs prior to the feed stream (30) passing into the vessel (12) through the first inlet (21),

wherein a first portion of the vapor stream (32') is condensed within the condenser sub-unit (110) in a condensing means (112) to form a first condensed stream (36) which is partially or fully withdrawn from the evaporator (1) and/or returned by means of gravity to the evaporator sub-unit (70) and a second non-condensed portion of the vapor stream (32'') is removed as a first vapor stream (60) comprising a second component of the at least two components by means of the second outlet (42).

12. The process of claim 11, wherein the feed stream (30) and the first liquid output stream (50) comprise a compound having a thermal degradation temperature of from 10 to 300, preferably from 20 to 275, most preferably 30 to 250 °C, and preferably one having a viscosity at the operating temperature of less than or equal to 20, preferably 10, most preferably 2 millipascal-second.

13. The process of either one of claims 11 or 12, wherein the feed stream (30) and the first vapor stream (60) comprise a solvent.

14. The process of any one of claims 11 to 13, wherein the pressure within the evaporator sub-unit (70) is less than 10, preferably 5, more preferably 2, most preferably 1 mbar.

15. Use of the evaporator (1) of any one of claims 1 to 10 in the purification and/or concentration of a compound having a thermal degradation temperature of from 10 to 300, preferably from 20 to 275, most preferably 30 to 250 °C, and preferably one having a viscosity at the operating temperature of less than or equal to 20, preferably 10, most preferably 2 millipascal-second, and/or in the removal of a solvent, or in the separation of a compound having a boiling point under atmospheric pressure at a temperature above its thermal decomposition temperature.

Claims

1. An evaporator (1) adapted for a counter-current flow of at least one liquid and one vapor therein, comprising:

   a first inlet (21) for a first liquid feed stream (30),

   a first outlet (41) for a first liquid output stream (50),

   a second outlet (42) for a first vapor stream (60),

   an evaporator sub-unit (70) comprising an evaporating means (71) for evaporation of a liquid to produce a vapor,

   an internal sub-unit (90) having a surface (92) embodied such that a contact is provided between a vapor and a liquid and a mass transfer is provided between the vapor and the liquid,

   a heat exchanger sub-unit (100) comprising a heat exchanging means (102) embodied such that a heat exchange is provided between a liquid stream (300), preferably the feed stream (30) or a cooling or heating stream, and a liquid or vapor contained within the evaporator (1),

   and a condenser sub-unit (110) comprising a condensing means (112) for condensing the vapor to a condensate,

   characterized in that the first inlet (21), the first outlet (41), second outlet (42), the evaporator sub-unit (70), the internal sub-unit (90), the heat exchanger sub-unit (100), and the condenser sub-unit (110) are all in fluid and/or vapor communication with one another and are contained within one common vessel (12),

   wherein the internal sub-unit (90) is located above the evaporator sub-unit (70), the heat exchanger sub-unit (100) is located above the evaporator sub-unit (70), preferably above the internal sub-unit (90), and the condenser subunit (110) is located above the heat exchanger sub-unit (100) and the internal sub-unit (90),

   wherein the first inlet (21) is located in a lower portion (13) of the vessel (12), preferably above the evaporator sub-unit (70), the first outlet (41) is located below the evaporator sub-unit (70), and the second outlet (42) is located above the evaporator sub-unit (70) and the first inlet (21),

   and wherein the evaporator (1) additionally comprises a first collector (150), preferably having a jacket (152) for providing thermal isolation, located in an upper portion (14) of the vessel (12) and below the heat exchanger sub-unit (100), and above the evaporator

sub-unit (70), and embodied such that a condensate is collected and the collected condensate is partially or fully withdrawn from or refluxed within the common vessel (12).

2. The evaporator (1) of claim 1, wherein the evaporator sub-unit (70) is a falling film evaporator sub-unit (72) comprising one or more heated surfaces (80), wherein the surfaces (80) are preferably those of tubes, channels, or plates.

3. The evaporator (1) of either claim 1 or 2, wherein the heat exchanger sub-unit (100) is a feed preheater sub-unit (105) for preheating the feed stream (30) and the internal sub-unit (90) is a mist eliminator sub-unit (94) for eliminating a mist.

4. The evaporator (1) of any one of claims 1 to 3, wherein the evaporator (1) additionally comprises a boot (120), wherein the boot (120) is contained within the common vessel (12) and is located in the lower portion (13) and below the evaporator sub-unit (70).

5. The evaporator (1) of any one of claims 1 to 4, wherein a means other than piping (1200') is used for leading the liquid and/or the vapor between any of the sub-units (70), (90), (100), and (110).

6. The evaporator (1) of any one of claims 1 to 5, wherein moving parts are absent within the common vessel (12).

7. The evaporator (1) of any one of claims 2 to 6, wherein the one or more heated surfaces (80) are vertical.

8. The evaporator (1) of any one of claims 1 to 7, wherein the evaporator (1) additionally comprises one or more static sections (130), wherein the one or more sections (130) are located above the evaporator subunit (70) and below the condenser sub-unit (110), and wherein the sections (130) each comprise a packing and/or trays.

9. The evaporator (1) of any one of claims 1 to 8, wherein the evaporator (1) additionally comprises a second collector (154) for collecting a liquid, preferably from the condenser sub-unit (110), or the one or more static sections (130), and/or a distributor (160) for distributing a liquid, preferably to the evaporator subunit (70) or to the static section (130).

10. A process to separate at least two components, wherein to an evaporator (1) of any one of claims 1 to 9, a first liquid feed stream (30) comprising the at least two components is fed by means of the first inlet (21),

the feed stream (30) passes into the evaporator subunit (70), in which a vapor stream (32) is formed from the feed stream (30) by means of heat and mass transfer in an evaporating means (71), preferably in contact with heated surfaces (80),

wherein the vapor stream (32) exits in a upward direction from the sub-unit (70), and wherein the remaining non-vaporized feed stream (31) exits in a downward direction from the sub-unit (70) and is subsequently removed as a first liquid output stream (50) comprising a first component of the at least two components by means of the first outlet (41),

the vapor stream (32), optionally containing a mist, passes into the internal subunit (90), in which the mist, if present, is removed from the vapor stream (32), and the mist is, optionally collected, withdrawn from the evaporator (1) and/or returned by means of gravity to the evaporator sub-unit (70),

the vapor stream (32) passes into the heat exchanger sub-unit (100), in which a heat transfer occurs in a heat exchanging means (102) between the vapor stream (32) and a liquid stream (300), preferably the feed stream (30) or a cooling or heating stream, wherein, if the liquid stream is the feed stream (30) the heat transfer occurs prior to the feed stream (30) passing into the vessel (12) through the first inlet (21),

wherein a first portion of the vapor stream (32') is condensed within the condenser sub-unit (110) in a condensing means (112) to form a first condensed stream (36) which is partially or fully withdrawn from the evaporator (1) and/or returned by means of gravity to the evaporator sub-unit (70) and a second non-condensed portion of the vapor stream (32") is removed as a first vapor stream (60) comprising a second component of the at least two components by means of the second outlet (42).

11. The process of claim 10, wherein the feed stream (30) and the first liquid output stream (50) comprise a compound having a thermal degradation temperature of from 10 to 300, preferably from 20 to 275, most preferably 30 to 250 °C, and preferably one having a viscosity at the operating temperature of less than or equal to 20, preferably 10, most preferably 2 millipascal-second.

12. The process of either one of claims 10 or 11, wherein the feed stream (30) and the first vapor stream (60) comprise a solvent.

13. The process of any one of claims 10 to 12, wherein the pressure within the evaporator sub-unit (70) is less than 10, preferably 5, more preferably 2, most preferably 1 mbar.

14. Use of the evaporator (1) of any one of claims 1 to 9 in the purification and/or concentration of a compound having a thermal degradation temperature of from 10 to 300, preferably from 20 to 275, most preferably 30 to 250 °C, and preferably one having

a viscosity at the operating temperature of less than or equal to 20, preferably 10, most preferably 2 millipascal-second, and/or in the removal of a solvent, or in the separation of a compound having a boiling point under atmospheric pressure at a temperature above its thermal decomposition temperature.