

CLAIMS

The invention claimed is:

1. A method comprising:
 - reacting the feed stream 112 comprising acetic acid, ethylene, oxygen, carbon dioxide, alkanes, and water in a reactor 116 to produce a crude vinyl acetate stream 118 comprising vinyl acetate, acetic acid, water, ethylene, carbon dioxide, and alkanes;
 - cooling the crude vinyl acetate stream 118 in a heat exchanger 120;
 - separating the crude vinyl acetate stream 118 into a tail gas stream 130, a flash gas stream 144, and a vinyl acetate stream 146, wherein the tail gas stream 130 comprises ethylene, carbon dioxide, alkanes, and oxygen, wherein the flash gas stream 144 comprises ethylene, carbon dioxide, alkanes, and oxygen, and wherein the vinyl acetate stream 146 comprises vinyl acetate, water, and acetic acid;
 - heating the tail gas stream 130 in the heat exchanger 120;
 - removing at least a portion of the carbon dioxide from the flash gas stream 144 to produce a CO₂ removal overheads stream 158;
 - mixing vaporized acetic acid with the tail gas stream 130 after heating and the CO₂ removal overheads stream 158 in a vaporizer 106 to produce a vaporized stream 108;
 - adding oxygen to the vaporized stream 108 to produce the feed stream 112;
 - measuring and/or determining conditions according (a), (b), and/or (c):
 - (a) a pressure of the feed stream 112 and/or the reactor 116, a temperature of the feed stream 112 and/or the reactor 116, and a concentration of at least one component in the feed stream 112 and/or the reactor 116;
 - (b) a pressure of the tail gas stream 130 after heating, a temperature of the tail gas stream 130 after heating, and a concentration of at least one component in the tail gas stream 130 after heating;
 - (c) a pressure of the CO₂ removal overheads stream 158, a temperature of the CO₂ removal overheads stream 158, and a concentration of at least one component in the CO₂ removal overheads stream 158; and
 - wherein (a) has associated therewith a first minimum approach to flammability limit (AFL_{min}) and a first flammability limit (FL) formula based on the conditions of (a), wherein (b)

has associated therewith a second minimum AFL_{min} and a second FL formula based on the conditions of (b), wherein (c) has associated therewith a third minimum AFL_{min} and a third FL formula based on the conditions of (c), wherein one or more of the first FL formula, second FL formula, and the third second FL formula include at least one interaction term;

measuring and/or determining an oxygen content ($[O_2]$) of a stream selected from the group consisting of: the feed stream 112, the tail gas stream 130 after heating, the CO_2 removal overheads stream 158, and any combination thereof; and

initiating a shutdown procedure or a remedial step when $AFL_{min} > FL - [O_2]$ is true for one or more of (a), (b), or (c).

2. The method of any preceding claim, wherein the first AFL_{min} is different than the second AFL_{min} and/or the first AFL_{min} is different than the third AFL_{min} and/or the second AFL_{min} is different than the third AFL_{min} .

3. The method of any preceding claim, wherein the first FL formula is different than the second FL formula and/or the first FL formula is different than the third FL formula and/or the second FL formula is different than the third FL formula.

4. The method of any preceding claim, wherein the at least one interaction term is selected from the group consisting of: a component-component interaction term, a temperature-component interaction term, a pressure-component interaction term, a pressure-temperature interaction term, and any combination thereof.

5. The method of any preceding claim, wherein the first FL formula, the second FL formula, and/or the third FL formula include one or more terms selected from the group consisting of a constant, temperature, pressure, a concentration of a component in the corresponding composition.

6. The method of any preceding claim, wherein the first FL formula and/or the second FL formula and/or the third FL formula includes at least two component-component interaction terms.

7. The method of any preceding claim, wherein the first FL formula and/or the second FL formula and/or the third FL formula includes at least one pressure-component term, at least one temperature-component interaction term, a pressure-temperature interaction term, and at least two component-component interaction terms.
8. The method of any preceding claim, wherein the at least one interaction term is 3 to 15 interaction terms.
9. The method of any preceding claim further comprising:
combining a portion of the tail gas slip stream 130 with the flash gas stream 144 before removing at least a portion of the carbon dioxide from the flash gas stream 144.
10. The method of any preceding claim, wherein separating the crude vinyl acetate stream 118 comprises:
separating the crude vinyl acetate stream 118 in a separator 122 into an overheads stream 124 and a first bottoms stream 126;
separating the overheads stream 124 in a scrubber 128 into the tail gas stream 130 and a second bottoms stream 132;
combining the first and second bottoms streams 126, 132; and
separating the combined first and second bottoms streams 126, 132 in a crude tank 142 into the flash gas stream 144 and the vinyl acetate stream 146.
11. The method of any preceding claim further comprising:
purifying the vinyl acetate stream 146 into a purified vinyl acetate product stream 150.
12. The method of one of claims 1-10 further comprising:
purifying the vinyl acetate stream 146 into a purified vinyl acetate product stream 150 and one or more additional streams; and
recycling at least one of the additional streams back to the vaporizer 106, the tail gas stream 130, and/or the flash gas stream 144.

13. The method of any preceding claim further comprising:
adding ethylene and/or methane to the tail gas stream 130 upstream of the heat exchanger 120.
14. The method of any preceding claim further comprising:
removing at least a portion of the carbon dioxide from the tail gas stream 130 upstream of the heat exchanger 120.
15. The method of any preceding claim further comprising:
adding ethylene and/or acetic acid to the vaporizer 106.
16. The method of any preceding claim further comprising:
conveying a portion of the flash gas stream 144 to an ethylene recovery process 166 having a vent stream 168;
measuring conditions of a pressure of the vent stream 168, a temperature of the vent stream 168, and a concentration of at least one component in the vent stream 168, wherein the conditions have associated therewith a fourth minimum approach to flammability limit (AFL_{min}) and a fourth flammability limit (FL) formula that includes at least one interaction term;
measuring an oxygen content ($[O_2]$) in the vent stream 168; and
changing an operating condition of the ethylene recovery process 166 when $AFL_{min} > FL - [O_2]$ is true for the vent stream 168 to return the ethylene recovery process 166 to $AFL_{min} \leq FL - [O_2]$.
17. The method of claim 16, wherein the fourth AFL_{min} is different than the first AFL_{min} and/or second AFL_{min} and/or the third AFL_{min} .
18. The method of one of claims 16-17, wherein the fourth FL formula is different than the first FL formula and/or the second FL formula and/or the third FL formula.

19. The method of one of claims 16-18, wherein the at least one interaction term for the fourth FL formula is selected from the group consisting of: a component-component interaction term, a temperature-component interaction term, a pressure-component interaction term, a pressure-temperature interaction term, and any combination thereof.
20. The method of one of claims 16-19, wherein the first FL formula, the second FL formula, and/or the third FL formula include one or more terms selected from the group consisting of a constant, temperature, pressure, a concentration of a component in the corresponding composition.
21. The method of one of claims 16-20, wherein the fourth FL formula includes at least two component-component interaction terms.
22. The method of one of claims 16-21, wherein the fourth FL formula includes at least one pressure-component term, at least one temperature-component interaction term, a pressure-temperature interaction term, and at least two component-component interaction terms.
23. The method of one of claims 16-22, wherein the at least one interaction term for the fourth FL formula is 3 to 15 interaction terms.
24. A method comprising:
reacting the feed stream 112 comprising acetic acid, ethylene, oxygen, carbon dioxide, alkanes, and water in a reactor 116 to produce a crude vinyl acetate stream 118 comprising vinyl acetate, acetic acid, water, ethylene, carbon dioxide, and alkanes;
cooling the crude vinyl acetate stream 118 in a heat exchanger 120;
separating the crude vinyl acetate stream 118 into a tail gas stream 130, a flash gas stream 144, and a vinyl acetate stream 146;
conveying a portion of the flash gas stream 144 to an ethylene recovery process 166 having a vent stream 168;
measuring conditions of a pressure of the vent stream 168, a temperature of the vent stream 168, and a concentration of at least one component in the vent stream 168, wherein the

conditions have associated therewith a minimum approach to flammability limit (AFL_{min}) and a flammability limit (FL) formula that includes at least one interaction term;

measuring an oxygen content ($[O_2]$) in the vent stream 168; and

changing an operating condition of the ethylene recovery process 166 when $AFL_{min} > FL - [O_2]$ is true for the vent stream 168 to return the ethylene recovery process 166 to $AFL_{min} \leq FL - [O_2]$.

25. The method of claim 24, wherein the at least one interaction term is selected from the group consisting of: a component-component interaction term, a temperature-component interaction term, a pressure-component interaction term, a pressure-temperature interaction term, and any combination thereof.

26. The method of one of claims 24-25, wherein the FL formula includes at least two component-component interaction terms.

27. The method of one of claims 24-26, wherein the FL formula includes at least one pressure-component term, at least one temperature-component interaction term, a pressure-temperature interaction term, and at least two component-component interaction terms.

28. The method of one of claims 24-27, wherein the at least one interaction term is 3 to 15 interaction terms.