We claim:

1. A process for producing ethanol comprising the steps of:

hydrogenating acetic acid from an acetic acid feed stream in a reactor in the presence of a catalyst to form a crude ethanol product comprising ethanol;

separating at least a portion of the crude ethanol product to yield a vapor stream and a liquid stream, wherein the vapor stream comprises unreacted hydrogen and at least one by-product gas, and wherein the liquid stream comprises ethanol;

purging less than 15% of the vapor stream in a first purge stream;

returning at least a portion of the vapor stream directly or indirectly to the reactor; and

recovering ethanol from the liquid stream.

2. The process of claim 1, further comprising purging less than 1% of the vapor stream in the first purge stream.

3. The process of claim 1, further comprising purging less than 0.01% of the vapor stream in the first purge stream.

4. The process of claim 1, wherein the at least one by-product gas is selected from a group consisting of methane, ethane, carbon monoxide, carbon dioxide, nitrogen and mixtures thereof.

5. The process of claim 1, wherein the at least one by-product gas comprises methane, and wherein the vapor comprises the methane in an amount from 0.01 to 3 mol.%.

6. The process of claim 1, wherein the at least one by-product gas comprises carbon monoxide, and wherein the vapor stream comprises the carbon monoxide in an amount from 0.01 to 2 mol.%.

7. The process of claim 1, wherein the liquid stream further comprises at least one dissolved by-product gas.

8. The process of claim 7, wherein the liquid stream comprises the at least one dissolved by-product gas in an amount from 0.001 to 0.1 wt.%.

9. The process of claim 7, further comprising purging at least a portion of the dissolved by-product gas from the liquid stream to form a second purge stream.

10. The process of claim 9, wherein the second purge stream comprises said at least one by-product gases in an amount greater than 60 mol.%.

11. The process of claim 1, wherein the vapor stream comprises said unreacted hydrogen in an amount between 90 to 100 mol.%.

12. The process of claim 1, wherein the concentration of at least one of the at least one by-product gas is substantially constant at steady state.

13. A process for producing ethanol comprising the steps of:

hydrogenating acetic acid from an acetic acid feed stream in a reactor in the presence of a catalyst to form a crude ethanol product comprising ethanol;

separating at least a portion of the crude ethanol product to yield a vapor stream and a liquid stream, wherein the vapor stream comprises unreacted hydrogen and carbon monoxide in an amount from 0.01 to 2 mol.%, and wherein the liquid stream comprises ethanol;

returning at least a portion of the vapor stream directly or indirectly to the reactor; and

recovering ethanol from the liquid stream.

14. The process of claim 13, wherein the vapor stream further comprises methane in an amount from 0.01 to 3 mol.%.

15. The process of claim 13, wherein the vapor stream further comprises ethane in an amount from 0.01 to 3 mol.%.

16. The process of claim 13, wherein the vapor stream further comprises carbon dioxide in an amount from 0.01 to 3 mol.%.

17. The process of claim 1, wherein the acetic acid is formed from methanol and carbon monoxide, wherein each of the methanol, the carbon monoxide, and hydrogen for the hydrogenating step is derived from syngas, and wherein the syngas is derived from a carbon source selected from the group consisting of natural gas, oil, petroleum, coal, biomass, and combinations thereof.

18. A process for producing ethanol comprising the steps of:

hydrogenating acetic acid from an acetic acid feed stream and a hydrogen feed stream in a reactor system in the presence of a catalyst to form a crude ethanol product comprising ethanol;

separating at least a portion of the crude ethanol product to yield a vapor stream and a liquid stream, wherein the vapor stream comprises unreacted hydrogen, and wherein the liquid stream comprises ethanol;

returning at least a portion of the vapor stream directly or indirectly to the reactor;

measuring a pressure of the vapor stream or a pressure of the at least a portion of the vapor stream;

controlling pressure in the reactor system by regulating the feed of fresh hydrogen to the reactor in response to the measured pressure; and

recovering ethanol from the liquid stream.

19. The process of claim 18, maintaining a substantially constant pressure in the reactor system.

20. The process of claim 18, wherein at least 85 % of the gases separated from the crude ethanol product are returned to the reactor via vapor stream.

21. The process of claim 18, wherein the fed of fresh hydrogen is controlled to maintain a molar ratio of total hydrogen to acetic acid of at least 2:1 in the reactor.

22. A process for producing ethanol comprising the steps of:

hydrogenating acetic acid from an acetic acid feed stream in a reactor in the presence of a catalyst to form a crude ethanol product comprising ethanol;

separating the crude ethanol product to yield a vapor stream and a liquid stream, wherein the vapor stream comprises unreacted hydrogen and at least one by-product gas, and wherein the liquid stream comprises ethanol;

withdrawing a slip stream from the vapor stream;

purging a portion of the slip stream when the concentration of one of the at least one by-product gases is greater than 5 mol.%; and

recovering ethanol from the liquid stream.

23. The process of claim 22, further comprising monitoring the concentration of the at least one by-product gas.

24. The process of claim 22, further comprising maintaining a constant pressure in the reactor by regulating feed of fresh hydrogen to the reactor in response to the purged stream.

25. The process of claim 22, wherein the at least one by-product gas is selected from the group consisting of methane, ethane, carbon monoxide, carbon dioxide, nitrogen and mixtures thereof.

26. The process of claim 22, wherein the at least one by-product gas is carbon monoxide and wherein the slip stream is purged when the concentration of carbon monoxide is greater than 0.5 mol.%.

27. A process for producing ethanol comprising the steps of:

hydrogenating acetic acid from an acetic acid feed stream in a reactor in the presence of a catalyst to form a crude ethanol product comprising ethanol;

separating at least a portion of the crude ethanol product to yield a vapor stream and a liquid stream, wherein the vapor stream comprises unreacted hydrogen and at least one by-

product gas, and wherein the liquid stream comprises ethanol and at least one dissolved by-product gas;

purging the at least one dissolved by-product gas from the liquid stream; and

recovering ethanol from the liquid stream.

28. The process of claim 27, further comprising returning the vapor stream directly or indirectly to the reactor.

29. The process of claim 27, wherein the vapor stream is not purged.

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Marked Up Version of Amendments

1-17. (Cancelled)

18. (Amended) A process for producing ethanol comprising the steps of:

hydrogenating acetic acid from an acetic acid feed stream and a hydrogen feed stream in a reactor system at a pressure from 50 kPa to 2300 kPa in the presence of a catalyst to form a crude ethanol product comprising ethanol;

separating at least a portion of the crude ethanol product to yield a vapor stream and a liquid stream, wherein the vapor stream comprises unreacted hydrogen, and wherein the liquid stream comprises ethanol;

returning at least a portion of the vapor stream directly or indirectly to the reactor;

measuring a pressure of the vapor stream or a pressure of the at least a portion of the vapor stream;

controlling pressure in the reactor system by regulating the feed of fresh hydrogen to the reactor in response to the measured pressure; and

recovering ethanol from the liquid stream.

19. (Amended) The process of claim 18, maintaining a ~~substantially~~ constant pressure in the reactor system that varies by less than 5%, preferably by less than 3%, or more preferably by less than 1%.

20. The process of claim 18, wherein at least 85 % of the gases separated from the crude ethanol product are returned to the reactor via vapor stream.

21. The process of claim 18, wherein the fed of fresh hydrogen is controlled to maintain a molar ratio of total hydrogen to acetic acid of at least 2:1 in the reactor.

22-29. (Cancelled)

30. (New) The process of claim 18, wherein the vapor stream further comprises at least one by-product gas.

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31. (New) The process of claim 18, further comprises purging less than 15% of the vapor stream in a first purge stream.

32. (New) The process of claim 18, further comprising purging less than 1% of the vapor stream in the first purge stream.

33. (New) The process of claim 18, further comprising purging less than 0.01% of the vapor stream in the first purge stream.

34. (New) The process of claim 30, wherein the at least one by-product gas is selected from a group consisting of methane, ethane, carbon monoxide, carbon dioxide, nitrogen and mixtures thereof.

35. (New) The process of claim 30, wherein the at least one by-product gas comprises methane, and wherein the vapor comprises the methane in an amount from 0.01 to 3 mol.%.

36. (New) The process of claim 30, wherein the at least one by-product gas comprises carbon monoxide, and wherein the vapor stream comprises the carbon monoxide in an amount from 0.01 to 2 mol.%.

37. (New) The process of claim 18, wherein the liquid stream further comprises at least one dissolved by-product gas.

38. (New) The process of claim 37, wherein the liquid stream comprises the at least one dissolved by-product gas in an amount from 0.001 to 0.1 wt.%.

39. (New) The process of claim 18, wherein the vapor stream comprises said unreacted hydrogen in an amount between 90 to 100 mol.%.

40. (New) The process of claim 18, wherein the concentration of at least one of the at least one by-product gas is substantially constant at steady state.

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41. (New) The process of claim 18, wherein the vapor stream further comprises ethane in an amount from 0.01 to 3 mol.%.

42. (New) The process of claim 18, wherein the acetic acid is formed from methanol and carbon monoxide, wherein each of the methanol, the carbon monoxide, and hydrogen for the hydrogenating step is derived from syngas, and wherein the syngas is derived from a carbon source selected from the group consisting of natural gas, oil, petroleum, coal, biomass, and combinations thereof.

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We claim:

1. A process for producing ethanol comprising the steps of: hydrogenating acetic acid from an acetic acid feed stream in a reactor in the presence of a catalyst to form a crude ethanol product comprising ethanol; separating at least a portion of the crude ethanol product to yield a vapor stream and a liquid stream, wherein the vapor stream comprises unreacted hydrogen and at least one by-product gas, and wherein the liquid stream comprises ethanol and at least one dissolved by-product gas; purging less than 15% of the vapor stream in a first purge stream; purging at least a portion of at least one dissolved by-product gas from the liquid stream to form a second purge stream; returning at least a portion of the vapor stream directly or indirectly to the reactor; and recovering ethanol from the liquid stream.

2. The process of claim 1, further comprising purging less than 1% of the vapor stream in the first purge stream.

3. The process of claim 1, further comprising purging less than 0.01% of the vapor stream in the first purge stream.

4. The process of claim 1, wherein the at least one by-product gas is selected from a group consisting of methane, ethane, carbon monoxide, carbon dioxide, nitrogen and mixtures thereof.

5. The process of claim 1, wherein the at least one by-product gas comprises methane, and wherein the vapor comprises the methane in an amount from 0.01 to 3 mol. %.

6. The process of claim 1, wherein the at least one by-product gas comprises carbon monoxide, and wherein the vapor stream comprises the carbon monoxide in an amount from 0.01 to 2 mol. %.

7. The process of claim 1, wherein the liquid stream comprises the at least one dissolved by-product gas in an amount from 0.001 to 0.1 wt. %.

8. The process of claim 1, wherein the second purge stream comprises said at least one by-product gases in an amount greater than 60 mol. %.

9. The process of claim 1, wherein the vapor stream comprises said unreacted hydrogen in an amount between 90 to 100 mol. %.

10. The process of claim 1, wherein the concentration of at least one of the at least one by-product gas is substantially constant at steady state.

11. A process for producing ethanol comprising the steps of: hydrogenating acetic acid from an acetic acid feed stream in a reactor in the presence of a catalyst to form a crude ethanol product comprising ethanol; separating at least a portion of the crude ethanol product to yield a vapor stream and a liquid stream, wherein the vapor stream comprises unreacted hydrogen and carbon monoxide in an amount from 0.01 to 2 mol. %, and wherein the liquid stream comprises ethanol and at least one dissolved by-product gas; purging at least a portion of at least one dissolved by-product gas from the liquid stream to form a second purge stream; returning at least a portion of the vapor stream directly or indirectly to the reactor; and recovering ethanol from the liquid stream.

12. The process of claim 11, wherein the vapor stream further comprises methane in an amount from 0.01 to 3 mol. %.

13. The process of claim 11, wherein the vapor stream further comprises ethane in an amount from

0.01 to 3 mol. %.

14. The process of claim 11, wherein the vapor stream further comprises carbon dioxide in an amount from 0.01 to 3 mol. %.

15. The process of claim 1, wherein the acetic acid is formed from methanol and carbon monoxide, wherein each of the methanol, the carbon monoxide, and hydrogen for the hydrogenating step is derived from syngas, and wherein the syngas is derived from a carbon source selected from the group consisting of natural gas, oil, petroleum, coal, biomass, and combinations thereof.

16. A process for producing ethanol comprising the steps of: hydrogenating acetic acid from an acetic acid feed stream and a hydrogen feed stream in a reactor system in the presence of a catalyst to form a crude ethanol product comprising ethanol; separating at least a portion of the crude ethanol product to yield a vapor stream and a liquid stream, wherein the vapor stream comprises unreacted hydrogen, and wherein the liquid stream comprises ethanol; returning at least a portion of the vapor stream directly or indirectly to the reactor; measuring a pressure of the vapor stream or a pressure of the at least a portion of the vapor stream; controlling pressure in the reactor system by regulating the feed of fresh hydrogen to the reactor in response to the measured pressure; and recovering ethanol from the liquid stream.

17. The process of claim 16, maintaining a substantially constant pressure in the reactor system.

18. The process of claim 16, wherein at least 85% of the gases separated from the crude ethanol product are returned to the reactor via vapor stream.

19. The process of claim 16, wherein the feed of fresh hydrogen is controlled to maintain a molar ratio of total hydrogen to acetic acid of at least 2:1 in the reactor.

20. A process for producing ethanol comprising the steps of: hydrogenating acetic acid from an acetic acid feed stream in a reactor in the presence of a catalyst to form a crude ethanol product comprising ethanol; separating the crude ethanol product to yield a vapor stream and a liquid stream, wherein the vapor stream comprises unreacted hydrogen and at least one by-product gas, and wherein the liquid stream comprises ethanol; withdrawing a slip stream from the vapor stream; purging a portion of the slip stream when the concentration of one of the at least one by-product gases is greater than 5 mol. %; and recovering ethanol from the liquid stream.

21. The process of claim 20, further comprising monitoring the concentration of the at least one by-product gas.

22. The process of claim 20, further comprising maintaining a constant pressure in the reactor by regulating feed of fresh hydrogen to the reactor in response to the purged stream.

23. The process of claim 20, wherein the at least one by-product gas is selected from the group consisting of methane, ethane, carbon monoxide, carbon dioxide, nitrogen and mixtures thereof.

24. The process of claim 20, wherein the at least one by-product gas is carbon monoxide and wherein the slip stream is purged when the concentration of carbon monoxide is greater than 0.5 mol. %.

25. A process for producing ethanol comprising the steps of: hydrogenating acetic acid from an acetic acid feed stream in a reactor in the presence of a catalyst to form a crude ethanol product comprising ethanol; separating at least a portion of the crude ethanol product to yield a vapor stream and a liquid stream, wherein the vapor stream comprises unreacted hydrogen and at least one by-product gas,

and wherein the liquid stream comprises ethanol and at least one dissolved by-product gas; purging the at least one dissolved by-product gas from the liquid stream; and recovering ethanol from the liquid stream.

26. The process of claim 25, further comprising returning the vapor stream directly or indirectly to the reactor.

27. The process of claim 25, wherein the vapor stream is not purged.