We claim:

1. A process for purifying a crude ethanol product, the process comprising the steps of:

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

separating at least a portion of the crude ethanol product in a first column into a first distillate comprising ethanol, water and ethyl acetate, and a first residue comprising acetic acid;

separating at least a portion of the first distillate in a second column into a second distillate comprising ethyl acetate and a second residue comprising ethanol and water, wherein the second column is an extractive distillation column;

feeding an extraction agent to the second column; and

separating at least a portion of the second residue in a third column into a third distillate comprising ethanol and a third residue comprising water.

2. The process of claim 1, wherein the extraction agent comprises water.

3. The process as in any one of claims 1 and 2, wherein the extraction agent comprises at least a portion of the third residue.

4. The process as in one of claims 1-3, wherein the molar ratio of water in the extraction agent to ethanol in the portion of first distillate is at least 0.5:1.

5. A process for purifying a crude ethanol product, the process comprising the steps of:

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

separating at least a portion of the crude ethanol product in a first column into a first distillate comprising ethanol, water and ethyl acetate, and a first residue comprising acetic acid;

separating at least a portion of the first distillate in a second column into a second distillate comprising ethyl acetate and a second residue comprising ethanol and water; and

separating at least a portion of the second residue in a third column into a third distillate comprising ethanol and a third residue comprising water; wherein at least a portion of the third residue is directly or indirectly returned to the second column.

6. The process of claim 5, wherein the molar ratio of water in the third residue to ethanol in the portion of first distillate is at least 0.5:1.

7. The process as in one of claims 1-6, wherein the third residue comprises water in an amount of from 75 to 100 wt.% and ethyl acetate in an amount of from 0.01 to 1 wt%.

8. The process as in one of claims 1-7, wherein the acetic acid feed stream comprises one or more of the compounds selected from the group consisting of acetic acid, acetic anhydride, acetaldehyde, ethyl acetate, and mixtures thereof.

9. The process as in one of claims 1-8, further comprising the steps of:

separating the at least a portion of the crude ethanol product in a flasher into a vapor stream and a liquid stream,

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

directing at least a portion of the liquid stream to the first column.

10. The process as in one of claims 1-9, wherein the crude ethanol product comprises ethanol in an amount of from 5 to 70 wt.%., water in an amount of from 5 to 35 wt.%., acetic acid in an amount of from 0 to 90 wt.%, and ethyl acetate in an amount of from 0 to 20 wt.%.

11. The process as in one of claims 1-10, wherein the weight ratio of ethanol in the second residue to ethanol in the second distillate is at least 3:1.

12. The process as in one of claims 1-11, further comprising the step of:

separating at least a portion of the second distillate in a fourth column into a fourth distillate comprising acetaldehyde and a fourth residue comprising ethyl acetate, wherein at least a portion of the fourth distillate is directly or indirectly returned to the reactor.

13. The process as in one of claims 1-12, wherein the catalyst comprises a combination of metals selected from the group consisting of platinum/tin, platinum/ruthenium, platinum/rhenium, palladium/ruthenium, palladium/rhenium, cobalt/palladium, cobalt/platinum, cobalt/chromium, cobalt/ruthenium, silver/palladium, copper/palladium, nickel/palladium, gold/palladium, ruthenium/rhenium, and ruthenium/iron.

14. A process for purifying a crude ethanol product comprising ethanol, water, acetic acid, acetaldehyde and ethyl acetate, the process comprising the steps of:

separating the crude ethanol product in a first column into a first distillate comprising ethanol, water and ethyl acetate, and a first residue comprising acetic acid;

separating the first distillate in a second column into a second distillate comprising ethyl acetate and a second residue comprising ethanol and water;

separating the second residue in a third column into a third distillate comprising ethanol and a third residue comprising water; and

directing at least a portion of the third residue to the second column.

15. The process of claim 14, wherein the crude ethanol product comprises ethanol in an amount of from 5 to 70 wt.%., water in an amount of from 5 to 35 wt.%., acetic acid in an amount of from 0 to 90 wt.%, and ethyl acetate in an amount of from 0 to 20 wt.%.

16. The process as in any one of claims 14 and 15, wherein the molar ratio of water in the third residue to ethanol in the portion of first distillate is at least 0.5:1.

17. The process as in one of claims 14-16, wherein the second residue comprises ethanol in an amount from 10 to 75 wt.% ethanol and from 30 to 90 wt.% water.

18. The process as in one of claims 14-17, wherein the weight ratio of ethanol in the second residue to ethanol in the second distillate is at least 3:1.

19. The process as in one of claims 14-18, wherein the second column is an extractive distillation column.

20. The process as in one of claims 14-19, wherein the third residue comprises water in an amount of from 75 to 100 wt.% and ethyl acetate in an amount of from 0.01 to 1 wt%.

21. The process as in one of claims 14-20, the process further comprising the steps of:

separating at least a portion of the second distillate in a fourth column into a fourth distillate comprising acetaldehyde and a fourth residue comprising ethyl acetate, and

directing at least a portion of the fourth distillate to a hydrogenation reactor.

We claim:

1. A process for purifying a crude ethanol product, the process comprising the steps of: hydrogenating an acetic acid feed stream in a reactor in the presence of a catalyst to form a crude ethanol product; separating at least a portion of the crude ethanol product in a first column into a first distillate comprising ethanol, water and ethyl acetate, and a first residue comprising acetic acid; separating at least a portion of the first distillate in a second column into a second distillate comprising ethyl acetate and a second residue comprising ethanol and water, wherein the second column is an extractive distillation column; feeding an extraction agent to the second column; and separating at least a portion of the second residue in a third column into a third distillate comprising ethanol and a third residue comprising water, 0.001 to 0.5 wt. % ethanol, 0.001 to 0.5 wt. % ethyl acetate, and 0.001 to 0.5 wt. % acetic acid; wherein the extraction agent comprises at least a portion of the third residue.

2. The process of claim 1, wherein the molar ratio of water in the extraction agent to ethanol in the portion of first distillate is at least 0.5:1.

3. The process of claim 1, wherein the acetic acid feed stream comprises one or more of the compounds selected from the group consisting of acetic acid, acetic anhydride, acetaldehyde, ethyl acetate, and mixtures thereof.

4. The process of claim 1, further comprising the steps of: separating the at least a portion of the crude ethanol product in a flasher into a vapor stream and a liquid stream, returning at least a portion of the vapor stream to the reactor; and directing at least a portion of the liquid stream to the first column.

5. The process of claim 1, wherein the crude ethanol product comprises ethanol in an amount of from 5 to 70 wt. %, water in an amount of from 5 to 35 wt. %, acetic acid in an amount of from 0 to 90 wt. %, and ethyl acetate in an amount of from 0 to 20 wt. %.

6. The process of claim 1, wherein the weight ratio of ethanol in the second residue to ethanol in the second distillate is at least 3:1.

7. The process of claim 1, further comprising the step of: separating at least a portion of the second distillate in a fourth column into a fourth distillate comprising acetaldehyde and a fourth residue comprising ethyl acetate, wherein at least a portion of the fourth distillate is directly or indirectly returned to the reactor.

8. The process of claim 1, wherein the catalyst comprises a combination of metals selected from the group consisting of platinum/tin, platinum/ruthenium, platinum/rhenium, palladium/ruthenium, palladium/rhenium, cobalt/palladium, cobalt/platinum, cobalt/chromium,

cobalt/ruthenium, silver/palladium, copper/palladium, nickel/palladium, gold/palladium, ruthenium/rhenium, and ruthenium/iron.

9. A process for purifying a crude ethanol product, the process comprising the steps of: hydrogenating an acetic acid feed stream in a reactor in the presence of a catalyst to form a crude ethanol product; separating at least a portion of the crude ethanol product in a first column into a first distillate comprising ethanol, water and ethyl acetate, and a first residue comprising acetic acid; separating at least a portion of the first distillate in a second column into a second distillate comprising ethyl acetate and a second residue comprising ethanol and water; and separating at least a portion of the second residue in a third column into a third distillate comprising ethanol and a third residue comprising water, from 0.001 to 0.5 wt. % ethanol, 0.001 to 0.5 wt. % ethyl acetate, and 0.001 to 0.5 wt. % acetic acid; wherein at least a portion of the third residue is directly or indirectly returned to the second column.

10. The process of claim 9, wherein the acetic acid feed stream comprises one or more of the compounds selected from the group consisting of acetic acid, acetic anhydride, acetaldehyde, ethyl acetate, and mixtures thereof.

11. The process of claim 9, wherein the crude ethanol product comprises ethanol in an amount of from 5 to 70 wt. %, water in an amount of from 5 to 35 wt. %, acetic acid in an amount of from 0 to 90 wt. %, and ethyl acetate in an amount of from 0 to 20 wt. %.

12. The process of claim 9, wherein the molar ratio of water in the third residue to ethanol in the portion of first distillate is at least 0.5:1.

13. The process of claim 9, further comprising the steps of: separating the at least a portion of the crude ethanol product in a flasher into a vapor stream and a liquid stream, returning at least a portion of the vapor stream to the reactor; and directing at least a portion of the liquid stream to the first column.

14. The process of claim 9, wherein the second residue comprises ethanol in an amount from 10 to 75 wt. % of ethanol and from 30 to 90 wt. % of water.

15. The process of claim 9, wherein the weight ratio of ethanol in the second residue to ethanol in the second distillate is at least 3:1.

16. The process of claim 9, wherein the second column is an extractive distillation column.

17. The process of claim 9, the process further comprising the step of: separating at least a portion of the second distillate in a fourth column into a fourth distillate comprising acetaldehyde

and a fourth residue comprising ethyl acetate, wherein at least a portion of the fourth distillate is directly or indirectly returned to the reactor.

18. The process of claim 9, wherein the catalyst comprises a combination of metals selected from the group consisting of platinum/tin, platinum/ruthenium, platinum/rhenium, palladium/ruthenium, palladium/rhenium, cobalt/palladium, cobalt/platinum, cobalt/chromium, cobalt/ruthenium, silver/palladium, copper/palladium, nickel/palladium, gold/palladium, ruthenium/rhenium, and ruthenium/iron.

19. A process for purifying a crude ethanol product comprising ethanol, water, acetic acid, acetaldehyde and ethyl acetate, the process comprising the steps of: separating the crude ethanol product in a first column into a first distillate comprising ethanol, water and ethyl acetate, and a first residue comprising acetic acid; separating the first distillate in a second column into a second distillate comprising ethyl acetate and a second residue comprising ethanol and water, wherein the weight ratio of ethanol in the second residue to ethanol in the second distillate is at least 3:1; separating the second residue in a third column into a third distillate comprising ethanol and a third residue comprising water; and directing at least a portion of the third residue to the second column.

20. The process of claim 19, wherein the crude ethanol product comprises ethanol in an amount of from 5 to 70 wt. %, water in an amount of from 5 to 35 wt. %, acetic acid in an amount of from 0 to 90 wt. %, and ethyl acetate in an amount of from 0 to 20 wt. %.

21. The process of claim 19, wherein the molar ratio of water in the third residue to ethanol in the portion of first distillate is at least 0.5:1.

22. The process of claim 19, wherein the second residue comprises ethanol in an amount from 10 to 75 wt. % of ethanol and from 30 to 90 wt. % of water.

23. The process of claim 19, wherein the second column is an extractive distillation column.

24. The process of claim 19, wherein the third residue comprises water in an amount of from 75 to 100 wt. % and ethyl acetate in an amount of from 0.01 to 1 wt %.

25. The process of claim 19, the process further comprising the steps of: separating at least a portion of the second distillate in a fourth column into a fourth distillate comprising acetaldehyde and a fourth residue comprising ethyl acetate, and directing at least a portion of the fourth distillate to a hydrogenation reactor.

26. The process of claim 1, wherein the second distillate comprises from 0.01 to 5 wt. % ethanol.

27. The process of claim 9, wherein the second distillate comprises from 0.01 to 5 wt. % ethanol.

28. The process of claim 19, wherein the second distillate comprises from 0.01 to 5 wt. % ethanol.