plant may corrode distillation columns and other equipment, especially if there is any water present. Accordingly it is important to avoid the introduction of water during ionic liquid catalyzed hydrocarbon conversion processes.

There is a need for a systematic startup procedure for ionic liquid catalyzed hydrocarbon conversion processes, including alkylation processes for alkylate gasoline manufacture, not only to optimize the process performance and efficiency, but also to increase plant reliability and prolong the useful life of the equipment.

SUMMARY OF THE ~~INVENTION~~DISCLOSURE

The present ~~invention~~disclosure provides startup procedures for greatly improving the performance of ionic liquid catalyzed hydrocarbon conversion processes. In an embodiment, a startup procedure of the present ~~invention~~disclosure also substantially decreases equipment maintenance and extends the life of the equipment used in systems for performing such ionic liquid catalyzed hydrocarbon conversion processes.

In one embodiment, there is provided a method for starting up a chloroaluminate ionic liquid catalyzed alkylation system, the method comprising:

a) purging air and free water from at least a portion of the system;

b) introducing at least one reactant into the at least a portion of the system;

c) via at least one feed dryer unit, re-circulating the at least one reactant through the at least a portion of the system until the at least one reactant exiting the at least a portion of the system has a water content at or below a threshold value of 10 ppm; and

d) after step c), introducing a chloroaluminate ionic liquid catalyst into a reactor of the system.

In one embodiment, there is provided a method for starting up a chloroaluminate ionic liquid catalyzed alkylation system, the method comprising:

a) purging air and free water from the system, wherein the system comprises a reactor, a distillation unit in fluid communication with the reactor, and a catalyst regeneration unit in fluid communication with the reactor;

b) introducing at least one reactant into the system;

c) via at least one feed dryer unit, re-circulating the at least one reactant through the system until the at least one reactant exiting the system has a water content at or below a threshold value of 10 ppm;

d) after the water content has attained the threshold value according to step c), introducing a catalyst promoter into the reactor; and

e) after step d), introducing a chloroaluminate ionic liquid catalyst into the reactor.

In one embodiment, there is provided a method for starting up a chloroaluminate ionic liquid catalyzed alkylation system, the method comprising:

a) purging air and free water from the system, wherein the system comprises a reactor, a distillation unit in fluid communication with the reactor, and a catalyst regeneration unit in fluid communication with the reactor;

b) recycling a dried feed through the system, via a feed dryer unit, until the residual water content of the feed is at or below a threshold value of 10 ppm;

c) after the water content has attained the threshold value according to step b), introducing at least one reactant into the reactor;

d) after initiation of step c), introducing a catalyst promoter into the reactor;

e) after initiation of step d), introducing a chloroaluminate ionic liquid catalyst into the reactor;

f) contacting the at least one reactant with the ionic liquid catalyst in the reactor to form at least one hydrocarbon product;

g) separating the ionic liquid catalyst from a hydrocarbon phase containing the at least one hydrocarbon product;

h) feeding at least a portion of the hydrocarbon phase to the distillation unit;

i) adjusting distillation conditions of the distillation unit to provide the at least one hydrocarbon product under steady state distillation conditions; and

j) adjusting the catalyst regeneration unit to provide steady state catalytic activity of the reactor.

According to one aspect of the present ~~invention~~disclosure there is provided a method for operating an ionic liquid catalyzed hydrocarbon conversion system, the method comprising purging air and free water from at least a portion of the system; introducing at least one reactant into the at least a portion of the system; via at least one feed dryer unit, re-circulating the at least one reactant through the at least a portion of the system until the at least one reactant exiting the at least a portion of the system has a water content at or below a threshold value; and after the re-circulating step, introducing an ionic liquid catalyst into a reactor of the system.

In an embodiment, the present ~~invention~~disclosure also provides a method for operating an ionic liquid catalyzed hydrocarbon conversion system, the method comprising purging air and free water from the system, wherein the system comprises a reactor, a distillation unit in fluid communication with the reactor, and a catalyst regeneration unit in fluid communication with the reactor; introducing at least one reactant into the system; via at least one feed dryer unit, re-circulating the at least one reactant through the system until the at least one reactant exiting the system has a water content at or below a threshold value; after the water content

has attained the threshold value, introducing a catalyst promoter into the reactor; and after introducing the catalyst promoter, introducing an ionic liquid catalyst into the reactor.

In another embodiment, the present ~~invention~~disclosure provides a method for operating an ionic liquid catalyzed hydrocarbon conversion system, the method comprising purging air and free water from the system, wherein the system comprises a reactor, a distillation unit in fluid communication with the reactor, and a catalyst regeneration unit in fluid communication with the reactor; recycling a dried feed through the system, via a feed dryer unit, until the residual water content of the feed is at or below a threshold value; after the water content has attained the threshold value, introducing at least one reactant into the reactor; and after initiation of the step for introducing reactant(s), introducing a catalyst promoter into the reactor. After initiation of the step for introducing the catalyst promoter, the method further comprises: introducing an ionic liquid catalyst into the reactor; contacting the at least one reactant with the ionic liquid catalyst in the reactor to form at least one hydrocarbon product; separating the ionic liquid catalyst from a hydrocarbon phase containing the at least one hydrocarbon product; feeding at least a portion of the hydrocarbon phase to the distillation unit; adjusting the distillation conditions of the distillation unit to provide the at least one hydrocarbon product under steady state distillation conditions; and adjusting the catalyst regeneration unit to provide steady state catalytic activity of the reactor.

WHAT IS CLAIMED IS:

1. A method for operating an ionic liquid catalyzed hydrocarbon conversion system, the method comprising:

a) purging air and free water from at least a portion of the system;

b) introducing at least one reactant into the at least a portion of the system;

c) via at least one feed dryer unit, re-circulating the at least one reactant through the at least a portion of the system until the at least one reactant exiting the at least a portion of the system has a water content at or below a threshold value; and

d) after step c), introducing an ionic liquid catalyst into a reactor of the system.

2. The method of claim 1, wherein:

the system comprises a separation unit in fluid communication with the reactor, a distillation unit in fluid communication with the separation unit, and a catalyst regeneration unit in fluid communication with the separation unit and with the reactor, and

the at least a portion of the system is selected from the group consisting of the reactor, the separation unit, the distillation unit, the catalyst regeneration unit, and combinations thereof.

3. The method of claim 1, wherein step a) comprises purging the at least a portion of the system with dry nitrogen gas or dry isobutane.

4. The method of claim 1, wherein:

step a) comprises purging the at least a portion of the system with dry nitrogen gas,

the at least one reactant comprises isobutane; and

step b) comprises purging the at least a portion of the system with dry isobutane.

5. The method of claim 1, wherein step c) comprises:

e) feeding the at least one reactant from the at least a portion of the system through the at least one feed dryer unit, whereby water is removed from the at least one reactant, and

f) returning the at least one reactant from the at least one feed dryer unit to the at least a portion of the system.

6. The method of claim 1, further comprising:

g) after initiation of step b) and prior to initiation of step d), introducing a catalyst promoter into the reactor.

7. The method of claim 6, wherein the catalyst promoter comprises anhydrous HCl or an alkyl halide.

8. The method of claim 1, wherein:

the at least one reactant comprises a first reactant and a second reactant,

the at least one feed dryer unit comprises a first feed dryer unit and a second feed dryer unit, and the method further comprises:

h) drying the first reactant via the first feed dryer unit; and

i) drying the second reactant via the second feed dryer unit, wherein the first reactant comprises a C_4 to C_{10} isoparaffin and the second reactant comprises a C_2 to C_{10} olefin.

9. The method of claim 8, wherein:

step b) comprises introducing the first reactant and the second reactant into the reactor,

the first reactant is introduced into the reactor before step d), and

the second reactant is introduced into the reactor after step d).

10. The method of claim 1, wherein the threshold value is about 10 ppm.

11. The method of claim 2, wherein:

the at least one reactant comprises a C_4 to C_{10} isoparaffin, and the method further comprises:

j) after the water content has attained the threshold value according to step c), recycling the C_4 to C_{10} isoparaffin from the distillation unit directly to the reactor.

12. The method of claim 8, further comprising:

k) contacting the first and second reactants with the ionic liquid catalyst under alkylating conditions to form an alkylate product;

l) separating the ionic liquid catalyst from a hydrocarbon phase containing the alkylate product; and

m) feeding at least a portion of the hydrocarbon phase to the distillation unit.

13. The method of claim 12, further comprising:

n) adjusting distillation conditions of the distillation unit to provide the alkylate product under steady state distillation conditions.

14. The method of claim 1, wherein:

the system includes a catalyst regeneration unit for regenerating the ionic liquid catalyst, and the method further comprises:

o) adjusting the catalyst regeneration unit to provide steady state catalytic activity of the reactor.

15. The method of claim 1, wherein the ionic liquid catalyst comprises a chloroaluminate.

16. The method of claim 1, wherein the ionic liquid catalyst comprises N-butylpyridinium heptachlorodialuminate.

17. A method for operating an ionic liquid catalyzed hydrocarbon conversion system, the method comprising:

a) purging air and free water from the system, wherein the system comprises a reactor, a distillation unit in fluid communication with the reactor, and a catalyst regeneration unit in fluid communication with the reactor;

b) introducing at least one reactant into the system;

c) via at least one feed dryer unit, re-circulating the at least one reactant through the system until the at least one reactant exiting the system has a water content at or below a threshold value;

d) after the water content has attained the threshold value according to step c), introducing a catalyst promoter into the reactor; and

e) after step d), introducing an ionic liquid catalyst into the reactor.

18. The method of claim 17, further comprising:

f) contacting the at least one reactant with the ionic liquid catalyst in the reactor to form at least one hydrocarbon product;

g) separating the ionic liquid catalyst from a hydrocarbon phase containing the at least one hydrocarbon product;

h) feeding at least a portion of the hydrocarbon phase to the distillation unit;

i) adjusting distillation conditions of the distillation unit to provide the at least one hydrocarbon product under steady state distillation conditions; and

j) adjusting the catalyst regeneration unit to provide steady state catalytic activity of the reactor.

19. A method for operating an ionic liquid catalyzed hydrocarbon conversion system, the method comprising:

a) purging air and free water from the system, wherein the system comprises a reactor, a distillation unit in fluid communication with the reactor, and a catalyst regeneration unit in fluid communication with the reactor;

b) recycling a dried feed through the system, via a feed dryer unit, until the residual water content of the feed is at or below a threshold value;

c) after the water content has attained the threshold value according to step b), introducing at least one reactant into the reactor;

d) after initiation of step c), introducing a catalyst promoter into the reactor;

e) after initiation of step d), introducing an ionic liquid catalyst into the reactor;

f) contacting the at least one reactant with the ionic liquid catalyst in the reactor to form at least one hydrocarbon product;

g) separating the ionic liquid catalyst from a hydrocarbon phase containing the at least one hydrocarbon product;

h) feeding at least a portion of the hydrocarbon phase to the distillation unit;

i) adjusting distillation conditions of the distillation unit to provide the at least one hydrocarbon product under steady state distillation conditions; and

j) adjusting the catalyst regeneration unit to provide steady state catalytic activity of the reactor.

20. The method of claim 19, wherein:

the dried feed comprises isobutane,

the catalyst promoter comprises *t*-butyl chloride or *n*-butyl chloride,

the ionic liquid catalyst comprises a chloroaluminate, and

the at least one hydrocarbon product comprises a C_5 to C_{16} alkylate.

CLAIMS:

1. A method for starting up a chloroaluminate ionic liquid catalyzed alkylation system, the method comprising:
a) purging air and free water from at least a portion of the system;
b) introducing at least one reactant into the at least a portion of the system;
c) via at least one feed dryer unit, re-circulating the at least one reactant through the at least a portion of the system until the at least one reactant exiting the at least a portion of the system has a water content at or below a threshold value of 10 ppm; and
d) after step c), introducing a chloroaluminate ionic liquid catalyst into a reactor of the system.

2. The method of claim 1, wherein: the system comprises a separation unit in fluid communication with the reactor, a distillation unit in fluid communication with the separation unit, and a catalyst regeneration unit in fluid communication with the separation unit and with the reactor, and the at least a portion of the system is selected from the group consisting of the reactor, the separation unit, the distillation unit, the catalyst regeneration unit, and combinations thereof.

3. The method of claim 1, wherein step a) comprises purging the at least a portion of the system with dry nitrogen gas or dry isobutane.

4. The method of claim 1, wherein: step a) comprises purging the at least a portion of the system with dry nitrogen gas and further comprises purging the at least a portion of the system with dry isobutane.

5. The method of claim 1, further comprising: e) after initiation of step b) and prior to initiation of step d), introducing a catalyst promoter into the reactor.

6. The method of claim 5, wherein the catalyst promoter comprises anhydrous HCl or an alkyl halide.

7. The method of claim 1, wherein: the at least one reactant comprises a first reactant and a second reactant, the at least one feed dryer unit comprises a first feed dryer unit and a second feed dryer unit, and the method further comprises:
f) drying the first reactant via the first feed dryer unit; and
g) drying the second reactant via the second feed dryer unit, wherein the first reactant comprises a C_4 to C_{10} isoparaffin and the second reactant comprises a C_2 to C_{10} olefin.

8. The method of claim 7, wherein:
step b) comprises introducing the first reactant and the second reactant into the reactor,
the first reactant is introduced into the reactor before step d), and
the second reactant is introduced into the reactor after step d).

9. The method of claim 2, wherein: the at least one reactant comprises a C_4 to C_{10} isoparaffin, and the method further comprises:
h) after the water content has attained the threshold value according to step c), recycling the C_4 to C_{10} isoparaffin from the distillation unit directly to the reactor.

10. The method of claim 7, further comprising:
i) contacting the first and second reactants with the ionic liquid catalyst under alkylating conditions to form an alkylate product;
j) separating the ionic liquid catalyst from a hydrocarbon phase containing the alkylate product; and
k) feeding at least a portion of the hydrocarbon phase to the distillation unit.

11. The method of claim 10, further comprising: l) adjusting distillation conditions of the distillation unit to provide the alkylate product under steady state distillation conditions.

12. The method of claim 1, wherein:
the system includes a catalyst regeneration unit for regenerating the ionic liquid catalyst, and the method further comprises:
m) adjusting the catalyst regeneration unit to provide steady state catalytic activity of the reactor.

13. The method of claim 1, wherein the chloroaluminate ionic liquid catalyst comprises N-butylpyridinium heptachlorodialuminate.

14. A method for starting up a chloroaluminate ionic liquid catalyzed alkylation system, the method comprising:
a) purging air and free water from the system, wherein the system comprises a reactor, a distillation unit in fluid communication with the reactor, and a catalyst regeneration unit in fluid communication with the reactor;
b) introducing at least one reactant into the system;
c) via at least one feed dryer unit, re-circulating the at least one reactant through the system until the at least one reactant exiting the system has a water content at or below a threshold value of 10 ppm;
d) after the water content has attained the threshold value according to step c), introducing a catalyst promoter into the reactor; and
e) after step d), introducing a chloroaluminate ionic liquid catalyst into the reactor.

15. The method of claim 14, further comprising:
f) contacting the at least one reactant with the ionic liquid catalyst in the reactor to form at least one hydrocarbon product;
g) separating the ionic liquid catalyst from a hydrocarbon phase containing the at least one hydrocarbon product;
h) feeding at least a portion of the hydrocarbon phase to the distillation unit;
i) adjusting distillation conditions of the distillation unit to provide the at least one hydrocarbon product under steady state distillation conditions; and
j) adjusting the catalyst regeneration unit to provide steady state catalytic activity of the reactor.

16. A method for starting up a chloroaluminate ionic liquid catalyzed alkylation system, the method comprising:
a) purging air and free water from the system, wherein the system comprises a reactor, a distillation unit in fluid communication with the reactor, and a catalyst regeneration unit in fluid communication with the reactor;
b) recycling a dried feed through the system, via a feed dryer unit, until the residual water content of the feed is at or below a threshold value of 10 ppm;

c) after the water content has attained the threshold value according to step b), introducing at least one reactant into the reactor;

d) after initiation of step c), introducing a catalyst promoter into the reactor;

e) after initiation of step d), introducing a chloroaluminate ionic liquid catalyst into the reactor;

f) contacting the at least one reactant with the ionic liquid catalyst in the reactor to form at least one hydrocarbon product;

g) separating the ionic liquid catalyst from a hydrocarbon phase containing the at least one hydrocarbon product;

h) feeding at least a portion of the hydrocarbon phase to the distillation unit;

i) adjusting distillation conditions of the distillation unit to provide the at least one hydrocarbon product under steady state distillation conditions; and

j) adjusting the catalyst regeneration unit to provide steady state catalytic activity of the reactor.

17. The method of claim 16, wherein: the dried feed comprises isobutane, the catalyst promoter comprises t-butyl chloride or n-butyl chloride, and the at least one hydrocarbon product comprises a C_5 to C_{16} alkylate.