Claims

1. A method for selective hydrogenation of butadiene extraction tail gas, characterized in that, the selective hydrogenation method comprises:

(1) an alkyne-containing tail gas from a butadiene extraction unit is fed into a raw material tank;

(2) a C4 raw material in the raw material tank is pressurized by a feed pump to a pressure required for reaction, then merged with a circulated C4 stream from a first-stage reactor outlet buffer tank and fed into a first-stage mixer, wherein it is mixed with hydrogen gas, and fed into a first-stage reactor to undergo a first-stage hydrogenation reaction, and a first-stage reaction stream obtained by the reaction is fed into the first-stage reactor outlet buffer tank;

the hydrogen gas required for the reaction in the first-stage reactor is fed through a first feeding mode or a second feeding mode:

the first feeding mode comprises: all the hydrogen gas required for the reaction is fed through the first-stage reactor outlet buffer tank, and then fed into the first-stage reactor through a first route at an outlet of the first-stage reactor outlet buffer tank;

the second feeding mode comprises: a part of the hydrogen gas required for the reaction is fed through the first-stage reactor outlet buffer tank, and then fed into the first-stage reactor through the first route at an outlet of the first-stage reactor outlet buffer tank; and the other part of the hydrogen gas is fed through the first-stage mixer, and then fed into the first-stage reactor;

(3) there is no gas-phase discharge from the first-stage reactor outlet buffer tank, and a liquid-phase product is divided into at least two streams, wherein the first stream is returned to the first-stage reactor as the circulated C4 stream, and the second stream is used as a feed to a stabilization tower or subjected to further hydrotreatment prior to being fed into the stabilization tower;

(4) a C4 hydrogenation product is recovered after separation in the stabilization tower.

2. The method for selective hydrogenation of butadiene extraction tail gas according to claim 1, wherein, in step (1), the alkyne-containing tail gas is diluted with a side-draw diluent C4 stream from the stabilization tower.

3. The method for selective hydrogenation of butadiene extraction tail gas according to claim 1, wherein, in step (1), the alkyne-containing tail gas is diluted with a diluent C4 stream from the first-stage reactor outlet buffer tank.

4. The method for selective hydrogenation of butadiene extraction tail gas according to any one of claims 1-3, wherein, in step (2), in the second feeding mode, the mass ratio of the part of the hydrogen gas required for the reaction to the hydrogen gas required for the first-stage hydrogenation reaction is not less than 0.3, and the hydrogen gas required for the first-stage hydrogenation reaction is the sum of the part of the hydrogen gas required for the reaction and the other part of the hydrogen gas.

5. The method for selective hydrogenation of butadiene extraction tail gas according to any one of claims 1-4, wherein, in step (3), the further hydrotreatment of the second stream prior to being fed into the stabilization tower comprises: the second stream is used as a feed to a second-stage reactor and fed into a second-stage reactor through a second-stage feed cooler and a second-stage mixer to carry out a second-stage hydrogenation reaction, and then a second-stage reaction stream obtained by the reaction in the second-stage reactor passes through a second-stage reactor outlet buffer tank and enters the stabilization tower.

6. The method for selective hydrogenation of butadiene extraction tail gas according to claim 5, wherein, in step (3), the hydrogen gas required for the reaction in the second-stage reactor is fed through a third feeding mode or a fourth feeding mode;

the third feeding mode comprises: all the hydrogen gas required for the reaction is fed through the first-stage reactor outlet buffer tank, and then fed into the second-stage reactor through a second route at the outlet of the first-stage reactor outlet buffer tank;

the fourth feeding mode comprises: a part of the hydrogen gas required for the reaction is fed through the first-stage reactor outlet buffer tank, and then fed into the second-stage reactor through the second route at the outlet of the first-stage reactor outlet buffer tank; and the other part of the hydrogen gas is fed through the second-stage mixer, and then fed into the second-stage reactor.

7. The method for selective hydrogenation of butadiene extraction tail gas according to claim 6, wherein, in step (3), in the fourth feeding mode, the mass ratio of the part of the hydrogen gas required for the reaction to the hydrogen gas required for the second-stage hydrogenation reaction is not less than 0.3, and the hydrogen gas required for the second-stage hydrogenation reaction is the sum of the part of the hydrogen gas required for the reaction and the other part of the hydrogen gas.

8. The method for selective hydrogenation of butadiene extraction tail gas according to any one of claims 1-7, wherein, in step (1), the raw material tank has an operating pressure of 0.1-1.0 MPaG.

9. The method for selective hydrogenation of butadiene extraction tail gas according to any one of claims 1-8, wherein, in step (2), the C4 raw material in the raw material tank is pressurized to 1.0-4.0MPaG by the feed pump, and the mass flow ratio of the circulated C4 stream to the raw material is 5-30:1;
the first-stage reactor has an inlet temperature of 5-60°C, and a liquid space velocity of 1-50h^{-1};
the first-stage reactor has a pressure that is controlled by a pressure-compensating hydrogen gas of the first-stage reactor outlet buffer tank, and the reaction pressure is 1.0-4.0MPaG.

10. The method for selective hydrogenation of butadiene extraction tail gas according to any one of claims 1-9, wherein, in step (4), the stabilization tower has an operating pressure of 0.4-1.2 MPaG, a theoretical plate number of 10-40, and a side-draw theoretical plate position at 5-35.

11. The method for selective hydrogenation of butadiene extraction tail gas according to any one of claims 1-10, wherein, in step (1), the alkyne-containing tail gas from the butadiene extraction unit is fed into the raw material tank without removing the impurities from the alkyne-containing tail gas.

12. The method for selective hydrogenation of butadiene extraction tail gas according to claim 11, wherein,
in step (3), there is no gas-phase discharge from the first-stage reactor outlet buffer tank, and the liquid-phase product is divided into two streams, wherein the first stream is returned to the first-stage reactor as the circulated C4 stream, and the second stream is used as a feed to the stabilization tower;

in step (4), the first-stage reaction stream obtained from the reaction in the first-stage reactor is fed into the stabilization tower through the first-stage reactor outlet buffer tank, and separated by the stabilization tower to recover a C4 hydrogenation product.

13. The method for selective hydrogenation of butadiene extraction tail gas according to claim 12, wherein,
in step (1), the alkyne-containing tail gas is diluted with a side-draw diluent C4 stream from the stabilization tower.

14. The method for selective hydrogenation of butadiene extraction tail gas according to claim 12 or 13, wherein,

in step (1), the raw material tank has an operating pressure of 0.5-1.0MPaG;

in step (2), the diluted C4 raw material is pressurized by the feed pump to 1.0-4.0MPaG, and the mass flow ratio of the circulated C4 stream to the diluted C4 raw material is 5-30:1;

the first-stage reactor has an inlet temperature of 5-60°C, and a liquid space velocity of 1-40 h^{-1}; the first-stage reactor has a pressure that is controlled by the pressure-compensating hydrogen gas of the first-stage reactor outlet buffer tank, and the reaction pressure is 1.0-4.0MPaG;

in step (4), the stabilization tower has an operating pressure of 0.4-1.0 MPaG, a theoretical plate number of 10-40, and a side-draw theoretical plate position at 5-35.

15. The method for selective hydrogenation of butadiene extraction tail gas according to claim 11, wherein,

in step (1), the alkyne-containing tail gas is fed into the raw material tank, and the alkyne-containing tail gas in the raw material tank is diluted with the diluent C4 stream from the first-stage reactor outlet buffer tank;

in step (3), the first-stage reactor outlet buffer tank has no gas-phase discharge, and the liquid-phase product is divided into three streams, wherein the first stream is returned to the first-stage reactor as the circulated C4 stream, the second stream is used as a feed to the second-stage reactor and fed into the second-stage reactor through the second-stage feed cooler and the second-stage mixer to carry out the second-stage hydrogenation reaction, and the third stream is fed into the raw material tank as the diluent C4 stream to dilute the alkyne-containing tail gas;

the hydrogen gas required for the reaction of the second-stage reactor is fed through a third feeding mode or a fourth feeding mode:

the third feeding mode comprises: all the hydrogen gas required for the reaction is fed through the first-stage reactor outlet buffer tank, and then fed into the second-stage reactor through the second route at the outlet of the first-stage reactor outlet buffer tank;

the fourth feeding mode comprises: a part of the hydrogen gas required for the reaction is fed through the first-stage reactor outlet buffer tank, and then fed into the second-stage reactor through the second route at the outlet of the first-stage reactor outlet buffer tank; and the other part of the hydrogen gas is fed through the second-stage mixer, and then fed into the second-stage reactor;

in step (4), the second-stage reaction stream obtained by the reaction in the second-stage reactor is fed into the stabilization tower through the second-stage reactor outlet buffer tank, and separated by the stabilization tower to recover a C4 olefin product as a side-draw.

16. The method for selective hydrogenation of butadiene extraction tail gas according to claim 15, wherein,

in step (1), the raw material tank has an operating pressure of 0.5-1.0 MPaG, and the mass flow ratio of the diluent C4 stream to the alkyne-containing tail gas is 1-5:1;

in step (2), the diluted C4 raw material is pressurized by the feed pump to 1.0-4.0 MPaG, and the mass flow ratio of the circulated C4 stream to the diluted C4 raw material is 5-30:1;

in step (4), the stabilization tower has an operating pressure of 0.6-1.2MPaG, a theoretical plate number of 10-40, and a side-draw theoretical plate position at 5-35;

wherein, the first-stage reactor and the second-stage reactor each independently has an inlet temperature of 20-60°C, the first-stage reactor has a liquid space velocity of 10-50 h^{-1}, and the second-stage reactor has a liquid space velocity of 1-10 h^{-1}; the first-stage reactor and the second-stage reactor each independently has a pressures of 1.0-4.0MPaG that is controlled by the pressure-compensating hydrogen gas of each reactor outlet buffer tank.

17. The method for selective hydrogenation of butadiene extraction tail gas according to any one of claims 1-10, wherein, in step (1), the alkyne-containing tail gas is fed into a water-washing tower to remove the impurities entrained in the alkyne-containing tail gas, and then fed into the raw material tank.

18. The method for selective hydrogenation of butadiene extraction tail gas according to claim 17, wherein, in step (1), when the alkyne-containing tail gas is a gas-phase alkyne-containing tail gas, the alkyne-containing tail gas is fed into a blower suction tank, pressurized by a blower, condensed and liquefied by a liquefaction condenser, and then fed into a C4 collection tank, followed by pressurization by a booster pump, and being fed into the water-washing tower to remove the impurities entrained in the alkyne-containing tail gas, and then into the raw material tank.

19. The method for selective hydrogenation of butadiene extraction tail gas according to claim 18, wherein, in step (3), the first-stage reactor outlet buffer tank has no gas-phase discharge, and the liquid phase product is divided into two streams, wherein the first stream is returned to the first-stage reactor as the circulated C4 stream, and the second stream is used as a feed to the stabilization tower.

20. The method for selective hydrogenation of butadiene extraction tail gas according to claim 19, wherein, in step (1), the alkyne-containing tail gas is diluted with a side-draw diluent C4 stream from the stabilization tower.

21. The method for selective hydrogenation of butadiene extraction tail gas according to claim 19 or 20, wherein,

in step (1), the blower suction tank has an operating pressure of 0-20KPa; the condensed and liquefied gas in the liquefaction condenser has a temperature of 0-20°C, the liquefaction condenser has a pressure of 50-100KPa; the water-washing tower has an operating pressure of 0.5-1.0 MPaG, the mass ratio of the washing water in the washing tower to the C4 raw material is 1-5: 1, and the raw material tank has an operating pressure of 0.5-1.0MpaG;

in step (2), the C4 raw material is pressurized by the feed pump to 1.0-4.0MPaG; the first-stage reactor has an inlet temperature of 5-60°C, and a liquid space velocity of 10-50 h^{-1}; the first-stage reactor has a pressure that is controlled by the pressure-compensating hydrogen gas of the first-stage reactor outlet buffer tank, and the reaction pressure is 1.0-4.0 MPaG;

in step (4), the stabilization tower has an operating pressure of 0.4-1.0 MPaG, a theoretical plate number of 10-40, and a side-draw theoretical plate position at 5-35.

22. An apparatus for selective hydrogenation of butadiene extraction tail gas, which is used to carry out the method according to any one of claims 1-21, characterized in that the apparatus comprises: a raw material tank, a feed pump, a coalescer, a first-stage mixer, a first-stage reactor, a first-stage reactor outlet buffer tank, a circulated C4 cooler, a stabilization tower and a hydrogen gas feed pipeline;

the raw material tank, the feed pump, the coalescer, the first-stage mixer, the first-stage reactor and the first-stage reactor outlet buffer tank are connected in sequence;

an outlet pipeline of the first-stage reactor outlet buffer tank is divided into at least two routes, wherein the first route is connected with the circulated C4 cooler, the first-stage mixer and the first-stage reactor in sequence, and the second route is connected with the stabilization tower directly or indirectly;

the hydrogen gas feed pipeline comprises at least a first pipeline, wherein the first pipeline is connected with the first-stage reactor outlet buffer tank.

23. The apparatus for selective hydrogenation of butadiene extraction tail gas according to claim 22, wherein a diluent C4 port of the raw material tank is connected with an outlet of the stabilization tower.

24. The apparatus for selective hydrogenation of butadiene extraction tail gas according to claim 22, wherein the diluent C4 port of the raw material tank is connected with an outlet pipeline of the first-stage reactor outlet buffer tank.

25. The apparatus for selective hydrogenation of butadiene extraction tail gas according to any one of claims 22-24, wherein a top outlet of the stabilization tower is connected with a tower top condenser, a reflux tank and a reflux pump in sequence, and an outlet of the reflux pump is connected with an inlet of the stabilization tower.

26. The apparatus for selective hydrogenation of butadiene extraction tail gas according to any one of claims 22-25, further comprising a blower suction tank, a blower, a liquefaction condenser, a C4 collection tank, a booster pump and a water-washing tower, which are connected in sequence, and a C4 raw material outlet of the water-washing tower is connected with the raw material tank.

27. The apparatus for selective hydrogenation of butadiene extraction tail gas according to any one of claims 22-26, further comprising a second-stage feed cooler, a second-stage mixer, a second-stage reactor and a second-stage reactor outlet buffer tank, which are connected in sequence, and the second route of the outlet pipeline of the first-stage reactor outlet buffer tank is connected with the second-stage feed cooler, and the second-stage reactor outlet buffer tank is connected with the stabilization tower.

28. The apparatus for selective hydrogenation of butadiene extraction tail gas according to claim 22, wherein the hydrogen gas feed pipeline is divided into at least a first pipeline and a second pipeline, wherein the first pipeline is connected with the first-stage reactor outlet buffer tank, and the second pipeline is connected with the first-stage mixer.

29. The apparatus for selective hydrogenation of butadiene extraction tail gas according to any one of claims 22-25, wherein the outlet pipeline of the first-stage reactor outlet buffer tank is divided into two routes, wherein the first route is connected with the circulated C4 cooler, the first-stage mixer and the first-stage reactor in sequence, and the second route is directly connected with the stabilization tower.

30. The apparatus for selective hydrogenation of butadiene extraction tail gas according to any one of claims 27-28, wherein the outlet pipeline of the first-stage reactor outlet buffer tank is divided into three routes, wherein the first route is connected with the circulated C4 cooler, the first-stage mixer and the first-stage reactor in sequence, the second route is connected with the second-stage feed cooler, and the third route is connected with the diluent C4 port of the raw material tank;

the hydrogen gas feed pipeline is divided into at least a first pipeline, a second pipeline and a third pipeline, wherein the first pipeline is connected with the first-stage reactor outlet buffer tank, the second pipeline is connected with the first-stage mixer, and the third pipeline is connected with the second-stage mixer.

31. The apparatus for selective hydrogenation of butadiene extraction tail gas according to claim 26, wherein the outlet pipeline of the first-stage reactor outlet buffer tank is divided into two routes, wherein the first route is connected with the circulated cooler, the first-stage mixer and the first-stage reactor in sequence, and the second route is connected with the stabilization tower.

32. The apparatus for selective hydrogenation of butadiene extraction tail gas according to claim 31, wherein an outlet of the stabilization tower is connected with a diluent C4 port of the blower suction tank.

33. The apparatus for selective hydrogenation of butadiene extraction tail gas according to claim 31 or 32, wherein the water-washing tower is provided at top with a washing water inlet and a C4 raw material outlet, and provided at bottom with a liquefied C4 raw material inlet and a washing water outlet, and the booster pump is connected with the liquefied C4 raw material inlet.