Claims

1. An alkylation reaction apparatus, which is characterized by comprising n reactors, wherein in said n reactors, there are m reactors; said m reactors include a first reactor; and each of said m reactors has three reaction zones as defined below; according to the flow direction order of alkylation reaction streams, said three reaction zones are an x reaction zone, a y reaction zone and a z reaction zone respectively; based on the mixing intensity, the mixing intensity of the y reaction zone>the mixing intensity of the x reaction zone>the mixing intensity of the z reaction zone, wherein $n \geq 1$ and $n \geq m$.

2. The apparatus of claim 1, wherein,

n is 2, 3, 4, 5, 6, 7, or 8;

preferably, n is 3, 4, 5, or 6;

more preferably, n is 3 or 4, m=2 or 3.

3. The apparatus according to any of the aforementioned claims, wherein the reactor provided with three reaction zones has the inner diameters Rx reaction zone for the x reaction zone, Ry reaction zone for the y reaction zone and Rz reaction zone for the z reaction zone respectively, wherein Rz reaction zone > Rx reaction zone > Ry reaction zone,

preferably, the ratio of the inner diameter of the z reaction zone to the inner diameter of the x reaction zone to the inner diameter of the y reaction zone is Rz reaction zone: Rx reaction zone: Ry reaction zone = (2-5):(1.1-1.8):1.

4. The apparatus according to any of the aforementioned claims, wherein internal flow disturbance component(s) is provided in the x reaction zone, the y reaction zone, and/or the z reaction zone;

preferably, the internal flow disturbance component is a static flow disturbance component or a dynamic flow disturbance component;

more preferably, the static flow disturbance component is selected from:

CompaX Mixer, SMI Mixer, KVM Mixer, SMV Mixer, SMX plus Mixer, SMXL Mixer, SMR Mixer, SMX Mixer, SMR Reactor, Contour Mixer, SMF Mixer, Polygard Mixer;

KM Mixer, KMX-V Mixer, HEV Mixer, UltraTab Mixer, WVM Mixer;

SV, SH, SK, SX, SL, Toray Hi-Type.

5. The apparatus according to any of the aforementioned claims, wherein said n reactors are connected in series and/or in parallel;

preferably, when n=3, m=3 or 2, the reactors are connected in series in an N-type manner; or

preferably, when n=4, m=4, or 3, or 2, the reactors are connected in series in an M-type manner.

6. An alkylation reaction system comprising an alkylation reaction unit, a compression refrigeration unit, a reaction effluent refining unit, and a product fractionation unit, characterized in that, the alkylation reaction unit comprises the alkylation reaction apparatus according to any of claims 1-5.

7. The reaction system according to claim 6, wherein,

the alkylation reaction apparatus is provided with a mixer for receiving a diluted alkylation reaction raw material, the diluted alkylation reaction raw material is obtained by mixing an alkylation reaction raw material with an isobutane refrigerant obtained from the compression refrigeration unit, a recycled isobutane obtained from the product fractionation unit and a recycled hydrocarbon obtained from the reaction effluent refining unit;

a reaction effluent is subjected to a preliminary separation of acid hydrocarbon phases in the reaction effluent refining unit, and a majority of the resulting hydrocarbon phase is used as the recycled hydrocarbon;

the product fractionation unit comprises at least one deisobutanizer, isobutane in the hydrocarbon phase of the reaction effluent is removed, and the recycled isobutane, normal butane and an alkylation product are respectively obtained from the top of the deisobutanizer, the middle upper part of the deisobutanizer and the bottom of the deisobutanizer.

8. The reaction system according to claim 6 or 7, wherein the reaction effluent refining unit comprises a self-vaporization separator and a preliminary acid-hydrocarbon separator,

a coalescing internal member is arranged at the upper part of the self-vaporization separator to provide a place for vaporizing butane and separating a reaction product from an acid phase, and an acid-hydrocarbon phase homogenizer is arranged at the lower part of the self-vaporization separator to ensure the stable operation of the apparatus;

the preliminary acid-hydrocarbon separator is used for performing the

primary separation of acid hydrocarbon phases, a majority of the separated hydrocarbon phase is recycled, and a minority of the hydrocarbon phase is optionally subjected to a further coalescence-deacidification separation in one or more customized precision coalescers.

9. The reaction system according to any of claims 6-8, which further comprises an alkylation reaction raw material pretreatment unit, in which the alkylation reaction raw material is subjected to the operation of removing butadiene, light hydrocarbons, oxygen-containing compounds and water.

10. A liquid acid catalyzed alkylation reaction process, characterized in that the alkylation reaction of isobutane with a C3-C5 alkene fraction, preferably isobutane with a C4 alkene, is carried out in n reactors, the inlet temperature of a first reactor is-10°C to 20°C, preferably-3 to 10°C;

in said n reactors, there are m reactors; said m reactors include the first reactor; and each of said m reactors has three reaction zones, namely, an x reaction zone, a y reaction zone and a z reaction zone;

a diluted alkylation reaction raw material is distributed to said m reactors, preferably, the diluted alkylation reaction raw material is equally distributed to said m reactors, or is distributed to said m reactors in a gradually decreasing manner in the order of the reaction streams in the reactors;

in m reactors provided with three reaction zones, the alkylation reaction stream firstly flows into the x reaction zone and then successively flows through the y reaction zone and the z reaction zone, and based on the mixing intensity, the mixing intensity of the y reaction zone>the mixing intensity of the x reaction zone>the mixing intensity of the z reaction zone, wherein $n \geq 1$ and $n \geq m$;

the reaction stream has a residence time in the x reaction zone of 0.01-10 seconds, a residence time in the y reaction zone of 0.01-10 seconds, and a residence time in the z reaction zone of 0.1-15 minutes.

11. The reaction process according to claim 10, wherein the diluted alkylation reaction raw material consists of a recycled isobutane, an isobutane refrigerant, an optionally pretreated alkylation reaction raw material, and a recycled hydrocarbon, and the molar ratio of alkane to alkene of the diluted alkylation reaction raw material is 10-300:1, preferably 30-150:1, and more preferably 40-100: 1.

12. The reaction process according to claim 10 or 11, which further comprises,

a reaction effluent obtained from the outlet of the nth reactor is depressurized to 0.005-0.18MPa by a coalescing internal member in the self-vaporization separator, so that a part of the C4 alkanes in the reaction effluent is vaporized and the reaction heat is taken away;

gas phase components are separated, and the separated gas phase components are compressed and refrigerated to obtain an isobutane refrigerant, the remaining acid-hydrocarbon mixture is separated into two phases of acid and hydrocarbon in the lower part of the self-vaporization separator, and the separated acid phase is recycled back to the x reaction zone of the first reactor, a majority of the separated hydrocarbon phase is sent to a raw material mixer, and a minority of the separated hydrocarbon phase is sent to an optional precision coalescer to further remove small acid droplets and acid esters in the hydrocarbon phase;

in a deisobutanizer, isobutane in the hydrocarbon phase of the reaction effluent is removed, and the recycled isobutane, normal butane and an alkylation product are respectively obtained from the top of the deisobutanizer, the middle upper part of the deisobutanizer and the bottom of the deisobutanizer.

13. The process according to any of claims 10-12, wherein in the x-reaction zone and in the y-reaction zone, the pressure drop is 0.05-0.5 MPa, preferably 0.1-0.3 MPa, and in the z-reaction zone, the pressure drop is 0.001-0.1 MPa, preferably 0.002-0.05 MPa.

14. The process according to any of claims 10-13, wherein the liquid acid is a concentrated sulfuric acid or a mixed acid mainly comprising a concentrated sulfuric acid,

optionally, the liquid acid further comprises an auxiliary agent, wherein the addition amount of the auxiliary agent is zero or 0.001-0.1% by weight of the alkene feed;

preferably, the auxiliary agent is sulfurous acid lower carbon ester or sulfuric acid lower carbon ester,

more preferably, the auxiliary agent is one or more of ethyl sulfate, propyl sulfite, butyl sulfate and hexyl sulfate,

most preferably, the auxiliary agent is a mixture of butyl sulfate and hexyl sulfate in a mass ratio of 1: (0.5-2).