the degasser and about 193°C at the bottom of the degasser. In contrast, the degasser in the conventional design may be operated at an overhead pressure of only 0.7 kg/cm^2 gage, and at much lower temperatures: about 105°C at the top of the degasser and about 149°C at the bottom of the degasser. Additionally, solvent heat recovery schemes are different between the two designs to achieve respective process efficiencies at the disparate pressures.

SUMMARY OF THE CLAIMED EMBODIMENTS

[0010] It has now been found that butadiene extraction processes may be designed for flexible operations, with or without a compressor, while adding little additional capital investment cost. The ability to run at both high and low pressures provides added process flexibility.

[0011] In one aspect, embodiments disclosed herein relate to a system for recovering 1,3-butadiene from a C_4 fraction in both a high pressure mode or a low pressure mode. The system may include, among other components: a feed vaporization system for at least partially vaporizing a hydrocarbon feed containing butanes, butenes, 1,2-butadiene, 1,3-butadiene, C_4 acetylenes, C_3 acetylenes, and C_{5+} hydrocarbons; an extractive distillation system for contacting the vaporized hydrocarbon fraction with a solvent to selectively dissolve a portion of the hydrocarbon fraction forming (a) an enriched solvent fraction comprising the 1,3-butadiene, the 1,2-butadiene, C_4 acetylenes, C_3 acetylenes, C_{5+} hydrocarbons, and a first portion of the butanes and the butenes and (b) a vapor fraction comprising a second portion of the butanes and the butenes; a rectifier and afterwasher for at least partially degassing the enriched solvent and recovering a first vapor fraction comprising the first portion of the butanes and butenes, a second vapor fraction comprising the C_3 and C_4 acetylenes, 1,3-butadiene, 1,2-butadiene, and C_{5+} hydrocarbons, and a bottoms fraction comprising partially degassed solvent; a degasser and cooling column for further degassing the solvent and recovering a liquid fraction comprising degassed solvent, a third vapor fraction comprising at least one of C4 acetylenes and 1,2-butadiene, and a fraction comprising C4 acetylenes; a compressor for compressing the third vapor fraction when operating in the low pressure mode. The system for recovering 1,3-butadiene is configured to operate ~~alternatively~~ alternately (a) with the degasser in a high pressure mode, or (b) with the degasser in a low pressure mode.

[0012] In another aspect, embodiments disclosed herein relate to a system for recovering 1,3-butadiene from a C_4 fraction alternately in ~~both~~ a high pressure mode or a low pressure mode. The system ~~may~~ includes: a feed vaporization system for at least partially vaporizing a hydrocarbon feed containing butanes, butenes, 1,2-butadiene, 1,3-butadiene, C_4 acetylenes, C_3 acetylenes, and C_{5+} hydrocarbons; an extractive distillation system for contacting the vaporized hydrocarbon fraction with a solvent to selectively dissolve a portion of the hydrocarbon fraction forming (a) an enriched solvent fraction comprising the 1,3-butadiene, the 1,2-butadiene, C_4 acetylenes, C_3 acetylenes, C_{5+} hydrocarbons, and a first portion of the butanes and the butenes and (b) a vapor fraction comprising a second portion of the butanes and the butenes; a rectifier and afterwasher for at least partially degassing the enriched solvent and recovering a first vapor fraction comprising the first portion of the butanes and butenes, a second vapor fraction comprising the C_3 and C_4 acetylenes, 1,3-butadiene, 1,2-butadiene, and C_{5+} hydrocarbons, and a bottoms fraction comprising partially degassed solvent; a degasser and cooling column for further degassing the solvent and recovering a liquid fraction comprising degassed solvent, a third vapor fraction comprising at least one of C4 acetylenes and 1,2-butadiene, and a fraction comprising C4 acetylenes; a compressor for compressing the third vapor fraction when operating in the low pressure mode; and a heat exchanger for indirectly heating the partially degassed solvent with the liquid fraction comprising degassed solvent when operating in the ~~low~~ high pressure mode.

[0013] In another aspect, embodiments disclosed herein relate to a system for recovering 1,3-butadiene from a C_4 fraction in alternately a high pressure mode or a low pressure mode. The system ~~may~~ includes: a feed vaporization system for at least partially vaporizing a hydrocarbon feed containing butanes, butenes, 1,2-butadiene, 1,3-butadiene, C_4 acetylenes, C_3 acetylenes, and C_{5+} hydrocarbons; an extractive distillation system for contacting the vaporized hydrocarbon fraction with a solvent to selectively dissolve a portion of the hydrocarbon fraction forming (a) an enriched solvent fraction comprising the 1,3-butadiene, the 1,2-butadiene, C_4 acetylenes, C_3 acetylenes, C_{5+} hydrocarbons, and a first portion of the butanes and the butenes and (b) a vapor fraction comprising a second portion of the butanes and the butenes; a rectifier and afterwasher for at least partially

degassing the enriched solvent and recovering a first vapor fraction comprising the first portion of the butanes and butenes, a second vapor fraction comprising the C_3 and C_4 acetylenes, 1,3-butadiene, 1,2-butadiene, and C_{5+} hydrocarbons, and a bottoms fraction comprising partially degassed solvent; a degasser and cooling column for further degassing the solvent and recovering a liquid fraction comprising degassed solvent, a third vapor fraction comprising at least one of C4 acetylenes and 1,2-butadiene, and a fraction comprising C4 acetylenes; a compressor for compressing the third vapor fraction when operating in the low pressure mode. The system for recovering 1,3-butadiene is configured such that the cooling column is in operation during both the high pressure mode and the low pressure mode.

[0014] In another aspect, embodiments disclosed herein relate to a process for recovering 1,3-butadiene from a C_4 fraction, alternately, in a high pressure mode and a low pressure mode. The process may include: at least partially vaporizing a hydrocarbon feed containing butanes, butenes, 1,2-butadiene, 1,3-butadiene, C_4 acetylenes, C_3 acetylenes, and C_{5+} hydrocarbons in a feed vaporization system; selectively dissolving a portion of the hydrocarbon fraction in an extractive distillation system by contacting the vaporized hydrocarbon fraction with a solvent, forming (a) an enriched solvent fraction comprising the 1,3-butadiene, the 1,2-butadiene, C_4 acetylenes, C_3 acetylenes, C_{5+} hydrocarbons, and a first portion of the butanes and the butenes and (b) a vapor fraction comprising a second portion of the butanes and the butenes; at least partially degassing the enriched solvent in a rectifier and afterwasher and recovering a first vapor fraction comprising the first portion of the butanes and butenes, a second vapor fraction comprising the C_3 and C_4 acetylenes, 1,3-butadiene, 1,2-butadiene, and C_{5+} hydrocarbons, and a bottoms fraction comprising partially degassed solvent; further degassing the solvent in a degasser and a cooling column and recovering a liquid fraction comprising degassed solvent, a third vapor fraction comprising at least one of C4 acetylenes and 1,2-butadiene, and a fraction comprising C4 acetylenes; ~~alternatively~~ alternately (a) operating the degasser in a high pressure mode, and (b) operating the degasser in a low pressure mode; wherein operating the degasser in a low pressure mode further comprises compressing the third vapor fraction using a compressor.

[0015] Previous designs would have required many more changes to the processing scheme, resulting in either more investment cost or a less efficient process. By retaining much of the equipment used in the conventional process, and using this equipment when

operating in compressorless mode, butadiene extraction processes according to embodiments disclosed herein are flexible and do not require re-optimization of the solvent heat recovery system. With respect to additional capital expenses, only one additional heat exchanger is required, along with minor changes to controls and equipment design conditions to allow operation at both high and low pressures.

[0016] Other ~~aspects~~ embodiments and advantages will be apparent from the following description and the appended claims.

BRIEF DESCRIPTION OF DRAWINGS

[0017] Figure 1 is a simplified flow diagram of a process for butadiene recovery according to embodiments disclosed herein.

[0018] As noted, the flow diagrams in Figure 1 is simplified, and does not illustrate pumps, valves, control valves, filters, reboilers, condensers, and other equipment commonly associated with distillation columns and general petrochemical operations, and these would be understood to be present by one skilled in the art based on the Figures and the Detailed Description provided below.

DETAILED DESCRIPTION

[0019] Embodiments disclosed here relate to recovering butadiene from mixed C_4 hydrocarbon streams. More specifically, embodiments disclosed herein relate to an improved butadiene extraction process capable of operating at high or low pressure conditions, providing process flexibility.

[0020] The C_4 fraction to be used as starting mixture in the present processes is a mixture of hydrocarbons having predominantly four carbon atoms per molecule. C_4 fractions are obtained, for example, in the preparation of ethylene and/or propylene by thermal or catalytic cracking of a petroleum fraction, such as liquefied petroleum gas, light naphtha or gas oil. C_4 fractions may also be obtained by the catalytic dehydrogenation (oxidative and/or non-oxidative dehydrogenation) of n-butane and/or n-butene. The resulting C_4 fractions generally include butanes, n-butene, isobutene, 1,3-butadiene and small amounts of C_3 and C_5 hydrocarbons, including methylacetylene, as well as butynes, in particular 1-butyne (ethylacetylene) and butenyne (vinylacetylene). The 1,3-butadiene content is generally from 5 to 80% by weight. For example, a cracker or a CATADIENE

CLAIMS

What is claimed:

1. A system for recovering 1,3-butadiene from a C_4 fraction in both a high pressure mode or a low pressure mode, comprising:

a feed vaporization system for at least partially vaporizing a hydrocarbon feed containing butanes, butenes, 1,2-butadiene, 1,3-butadiene, C_4 acetylenes, C_3 acetylenes, and C_{5+} hydrocarbons;

an extractive distillation system for contacting the vaporized hydrocarbon fraction with a solvent to selectively dissolve a portion of the hydrocarbon fraction forming (a) an enriched solvent fraction comprising the 1,3-butadiene, the 1,2-butadiene, C_4 acetylenes, C_3 acetylenes, C_{5+} hydrocarbons, and a first portion of the butanes and the butenes and (b) a vapor fraction comprising a second portion of the butanes and the butenes;

a rectifier and afterwasher for at least partially degassing the enriched solvent and recovering a first vapor fraction comprising the first portion of the butanes and butenes, a second vapor fraction comprising the C_3 and C_4 acetylenes, 1,3-butadiene, 1,2-butadiene, and C_{5+} hydrocarbons, and a bottoms fraction comprising partially degassed solvent;

a degasser and cooling column for further degassing the solvent and recovering a liquid fraction comprising degassed solvent, a third vapor fraction comprising at least one of C4 acetylenes and 1,2-butadiene, and a fraction comprising C4 acetylenes;

a compressor for compressing the third vapor fraction when operating in the low pressure mode;

wherein the system for recovering 1,3-butadiene is configured to operate ~~alternatively~~ alternately (a) with the degasser in a high pressure mode, or (b) with the degasser in a low pressure mode.

2. The system of claim 1, further comprising:

~~a compressor for compressing the third vapor fraction when operating in the low pressure mode; and~~

a heat exchanger for indirectly heating the partially degassed solvent with the liquid fraction comprising degassed solvent when operating in the ~~low~~ high pressure mode.

3. The system of claim 2, wherein valves and flow conduits associated with the heat exchanger and compressor are operable, respectively, such that (a) in low pressure mode, the liquid fraction comprising degassed solvent bypasses the heat exchanger and the third vapor fraction passes through the compressor, and (b) in high pressure mode, the liquid fraction comprising degassed solvent flows through the heat exchanger and the third vapor fraction bypasses the compressor.
4. The system of any one of claims 1-3, further comprising:
    a control system configured to operate the system for recovering 1,3-butadiene with or without the compressor.
5. The system of claim 4, wherein the control system is further configured to disable or enable operations of portions of the system for recovering 1,3-butadiene based on the selected mode of operation.
6. The system of claim 4, wherein the control system is further configured to transition between the modes of operation.
7. The system of any one of claims 1-6, wherein the system for recovering 1,3-butadiene is configured such that the cooling column is in operation during both the high pressure mode and the low pressure mode.
8. The system of any one of claims 1-7, wherein the cooling column, degasser and a degasser reboiler are designed for temperature and pressure conditions required for both modes of operation.
9. A system for recovering 1,3-butadiene from a C_4 fraction alternately in ~~both~~ a high pressure mode or a low pressure mode, comprising:
    a feed vaporization system for at least partially vaporizing a hydrocarbon feed containing butanes, butenes, 1,2-butadiene, 1,3-butadiene, C_4 acetylenes, C_3 acetylenes, and C_{5+} hydrocarbons;
    an extractive distillation system for contacting the vaporized hydrocarbon fraction with a solvent to selectively dissolve a portion of the hydrocarbon fraction forming (a) an enriched solvent fraction comprising the 1,3-butadiene, the 1,2-butadiene, C_4 acetylenes, C_3 acetylenes, C_{5+} hydrocarbons, and a first portion of

the butanes and the butenes and (b) a vapor fraction comprising a second portion of the butanes and the butenes;

a rectifier and afterwasher for at least partially degassing the enriched solvent and recovering a first vapor fraction comprising the first portion of the butanes and butenes, a second vapor fraction comprising the C_3 and C_4 acetylenes, 1,3-butadiene, 1,2-butadiene, and C_{5+} hydrocarbons, and a bottoms fraction comprising partially degassed solvent;

a degasser and cooling column for further degassing the solvent and recovering a liquid fraction comprising degassed solvent, a third vapor fraction comprising at least one of C4 acetylenes and 1,2-butadiene, and a fraction comprising C4 acetylenes;

a compressor for compressing the third vapor fraction when operating in the low pressure mode; and

a heat exchanger for indirectly heating the partially degassed solvent with the liquid fraction comprising degassed solvent when operating in the ~~low~~ high pressure mode.

10. A system for recovering 1,3-butadiene from a C_4 fraction in alternately a high pressure mode or a low pressure mode, comprising:

a feed vaporization system for at least partially vaporizing a hydrocarbon feed containing butanes, butenes, 1,2-butadiene, 1,3-butadiene, C_4 acetylenes, C_3 acetylenes, and C_{5+} hydrocarbons;

an extractive distillation system for contacting the vaporized hydrocarbon fraction with a solvent to selectively dissolve a portion of the hydrocarbon fraction forming (a) an enriched solvent fraction comprising the 1,3-butadiene, the 1,2-butadiene, C_4 acetylenes, C_3 acetylenes, C_{5+} hydrocarbons, and a first portion of the butanes and the butenes and (b) a vapor fraction comprising a second portion of the butanes and the butenes;

a rectifier and afterwasher for at least partially degassing the enriched solvent and recovering a first vapor fraction comprising the first portion of the butanes and butenes, a second vapor fraction comprising the C_3 and C_4 acetylenes, 1,3-

butadiene, 1,2-butadiene, and C_{5+} hydrocarbons, and a bottoms fraction comprising partially degassed solvent;

a degasser and cooling column for further degassing the solvent and recovering a liquid fraction comprising degassed solvent, a third vapor fraction comprising at least one of C4 acetylenes and 1,2-butadiene, and a fraction comprising C4 acetylenes;

a compressor for compressing the third vapor fraction when operating in the low pressure mode;

wherein the system for recovering 1,3-butadiene is configured such that the cooling column is in operation during both the high pressure mode and the low pressure mode.

11. A process for recovering 1,3-butadiene from a C_4 fraction, alternately, in a high pressure mode and a low pressure mode, comprising:

at least partially vaporizing a hydrocarbon feed containing butanes, butenes, 1,2-butadiene, 1,3-butadiene, C_4 acetylenes, C_3 acetylenes, and C_{5+} hydrocarbons in a feed vaporization system;

selectively dissolving a portion of the hydrocarbon fraction in an extractive distillation system by contacting the vaporized hydrocarbon fraction with a solvent, forming (a) an enriched solvent fraction comprising the 1,3-butadiene, the 1,2-butadiene, C_4 acetylenes, C_3 acetylenes, C_{5+} hydrocarbons, and a first portion of the butanes and the butenes and (b) a vapor fraction comprising a second portion of the butanes and the butenes;

at least partially degassing the enriched solvent in a rectifier and afterwasher and recovering a first vapor fraction comprising the first portion of the butanes and butenes, a second vapor fraction comprising the C_3 and C_4 acetylenes, 1,3-butadiene, 1,2-butadiene, and C_{5+} hydrocarbons, and a bottoms fraction comprising partially degassed solvent;

further degassing the solvent in a degasser and a cooling column and recovering a liquid fraction comprising degassed solvent, a third vapor fraction comprising at least one of C4 acetylenes and 1,2-butadiene, and a fraction comprisingC4 acetylenes;

~~alternatively~~ alternately (a) operating the degasser in a high pressure mode, and (b) operating the degasser in a low pressure mode;

wherein operating the degasser in a low pressure mode further comprises compressing the third vapor fraction using a compressor.

12. The process of claim ~~14~~11, further comprising transitioning between operating the degasser in a high pressure mode and operating the degasser in a low pressure mode.

13. The process of claim ~~14~~–11 or claim ~~15~~12, ~~wherein operating the degasser in a low pressure mode further comprises compressing the third vapor fraction using a compressor, and~~ wherein operating the degasser in a high pressure mode further comprises indirectly heating the partially degassed solvent with the liquid fraction comprising degassed solvent in a heat exchanger.

14. The process of claim ~~16~~13, further comprising operating valves and flow conduits associated with the heat exchanger and compressor, respectively, such that (a) in low pressure mode, the liquid fraction comprising degassed solvent bypasses the heat exchanger and the third vapor fraction passes through the compressor, and (b) in high pressure mode, the liquid fraction comprising degassed solvent flows through the heat exchanger and the third vapor fraction bypasses the compressor.

15. The process of claim ~~14~~11, wherein the process comprises operating the cooling column during both the high pressure mode and the low pressure mode.