# SELECTIVE OLEFIN EXTRACTION

## FIELD OF THE DISCLOSURE

**[0001]** Embodiments disclosed herein relate generally to improved selective olefin extraction processes wherein condensed degasser overhead is phase separated with total aqueous phase reflux, make-up water separately refluxed, plus improved heat integration.

## BACKGROUND

**[0002]** Butenes and butanes are products in high industrial demand and are usually obtained by working up cuts comprising $C_4$-hydrocarbons from steam or naphtha crackers. In the available raw material sources, the different isomers of the butenes and butanes and also butadiene are typically present in varying proportions. Butadiene may either be converted to n-butenes by hydrogenation or removed from these mixtures by extractive distillation. For further workup of the butenes and butanes, it is frequently necessary to separate them from each other. As a consequence of the very close proximity of their boiling points, it is generally not possible to achieve the purities required by simple distillation. As such, it is necessary to resort to other separating processes, including extractive distillation using polar solvents, such as disclosed in US20060096849.

**[0003]** Unfortunately, use of polar extractants, such as a mixture of N-methylpyrrolidone (NMP) and water, may result in undesirably high concentrations of water in the butene product, if not handled properly. Additionally, use of such mixtures adds the potential for formation of separate hydrocarbon and aqueous phases on trays or packing in a tower, which may reduce the separation efficiency of the tower.

## SUMMARY OF THE CLAIMED EMBODIMENTS

**[0004]** In one aspect, embodiments disclosed herein relate to a process for separating butenes and butanes by extractive distillation using a polar solvent. The process ~~may~~ includes: contacting a hydrocarbon mixture comprising butanes and butenes with a lean solvent mixture comprising water and one or more polar solvents in an extractive distillation column to form an enriched solvent fraction comprising the butenes and

solvent(s); recovering an overheads fraction comprising butanes from the extractive distillation column; recovering the enriched solvent fraction as a bottoms fraction from the extractive distillation column; feeding the bottoms fraction to a stripper ~~comprising~~ above a stripping section and below a wash section of the stripper to separate the butenes from the enriched solvent ~~mixture~~fraction; recovering the lean solvent mixture as a bottoms fraction from the stripper; recovering a stripper overheads fraction comprising butenes and water from the stripper; condensing the stripper overheads fraction to form a condensed water fraction and a product butenes fraction; feeding water as a reflux to a top of the stripper wash section; feeding at least a portion of the condensed water fraction intermediate the top and bottom of the stripper wash section as a second reflux.

**[0005]** In another aspect, embodiments disclosed herein relate to a system for separating butenes and butanes by extractive distillation using a polar solvent. The system ~~may~~ includes: an extractive distillation column for contacting a hydrocarbon mixture comprising butanes and butenes with a lean solvent mixture comprising water and one or more polar solvents to recover an enriched solvent fraction comprising the butenes and solvent(s) as a bottoms fraction and to recover an overheads fraction comprising the butanes; a stripper comprising a lower stripping section and an upper wash section to separate the bottoms fraction and recover an overheads fraction comprising butenes and water and a bottoms fraction comprising the lean solvent mixture; a flow conduit for feeding the bottoms fraction to the stripper at a location above the stripping section and below the wash section; a stripper overheads system for condensing the stripper overheads fraction to form a condensed water fraction and a product butenes fraction; a flow conduit for feeding water as a reflux to a top of the stripper wash section; a flow conduit for feeding at least a portion of the condensed water fraction intermediate the top and bottom of the stripper wash section as a second reflux.

**[0006]** Other aspects and advantages will be apparent from the following description and the appended claims.

## BRIEF DESCRIPTION OF DRAWINGS

**[0007]** Figure 1 is a simplified flow diagram of a process for separating butenes from butane according to embodiments disclosed herein.

**[0008]** Figure 2 is a simplified flow diagram of a process for separating butenes from butane according to embodiments disclosed herein.

# CLAIMS

What is claimed:

1. A process for separating butenes and butanes by extractive distillation using a polar solvent, the process comprising:

contacting a hydrocarbon mixture comprising butanes and butenes with a lean solvent mixture comprising water and one or more polar solvents in an extractive distillation column to form an enriched solvent fraction comprising the butenes and solvent(s);

recovering an overheads fraction comprising butanes from the extractive distillation column;

recovering the enriched solvent fraction as a bottoms fraction from the extractive distillation column;

feeding the bottoms fraction to a stripper ~~comprising~~ above a stripping section and below a wash section of the stripper to separate the butenes from the ~~solvent mixture~~enriched solvent fraction;

recovering the lean solvent mixture as a bottoms fraction from the stripper;

recovering a stripper overheads fraction comprising butenes and water from the stripper;

condensing the stripper overheads fraction to form a condensed water fraction and a product butenes fraction;

feeding water as a reflux to a top of the stripper wash section;

feeding at least a portion of the condensed water fraction intermediate the top and bottom of the stripper wash section as a second reflux.

2. The process of claim 1, wherein the hydrocarbon mixture is a vapor fraction comprising butanes and butenes recovered from a butadiene recovery process for recovering butadiene from a mixture comprising butadiene, butanes, and butenes.

3. The process of claim 1, further comprising vaporizing the hydrocarbon mixture in a feed vaporization system prior to the contacting.

~~4. The process of any one of claims 1-3, wherein the bottoms fraction is fed to the stripper above the stripping section and below the wash section.~~

~~5.~~4. The process of any one of claims 1-43, wherein the condensed water fraction used as the second reflux is a single liquid phase.

~~6.~~5. The process of any one of claims 1-~~5~~4, wherein the condensing the stripper overheads fraction comprises condensing the stripper overheads fraction in a two-stage condensation process comprising:

partially condensing the stripper overheads fraction to condense and recover the water as the condensed water fraction and to recover a vapor fraction comprising the butenes;

condensing the vapor fraction comprising the butenes to form the product butene fraction.

~~7.~~6. The process of any one of claims 1-~~6~~5, wherein the stripper overheads fraction comprises less than 10 ppm solvent, by weight.

~~8.~~7. The process of any one of claims 1-~~6~~5, wherein the stripper overheads fraction comprises 5 ppm or less solvent, by weight.

~~9.~~8. The process of any one of claims 1-~~8~~7, wherein the product butene fraction comprises less than 1 ppm solvent, by weight.

~~10.~~9. The process of any one of claims 1-~~9~~8, further comprising:

withdrawing a liquid side draw from the stripper;

at least partially vaporizing the liquid side draw by indirect heat exchange in a first heat exchanger with the lean solvent mixture recovered as a bottoms fraction from the stripper;

returning the at least partially vaporized side draw to the stripper.

~~11.~~10. The process of claim ~~10~~9, further comprising:

recovering a partially cooled lean solvent mixture from the first heat exchanger;

contacting at least one of (a) the enriched solvent fraction as a bottoms fraction from the extractive distillation column and (b) one or more liquid side draws from the extractive distillation column via indirect heat exchange in a second heat exchanger with the partially cooled lean solvent mixture.

~~12.~~11. The process of claim ~~10~~9 or claim ~~11~~10, appropriately, wherein at least one of the first heat exchanger and the second heat exchanger is a once-thru vaporization type exchanger.

~~13.~~12. The process of any one of claims ~~10~~9-~~12~~11, appropriately, further comprising contacting a partially cooled lean solvent mixture recovered from at least one of the first heat exchanger and the second heat exchanger via indirect heat exchange with the hydrocarbon mixture to at least partially vaporize the hydrocarbon mixture prior to the contacting.

~~14.~~13. A system for separating butenes and butanes by extractive distillation using a polar solvent, the system comprising:

an extractive distillation column for contacting a hydrocarbon mixture comprising butanes and butenes with a lean solvent mixture comprising water and one or more polar solvents to recover an enriched solvent fraction comprising the butenes and solvent(s) as a bottoms fraction and to recover an overheads fraction comprising the butanes;

a stripper comprising a lower stripping section and an upper wash section to separate the bottoms fraction and recover an overheads fraction comprising butenes and water and a bottoms fraction comprising the lean solvent mixture;

a flow conduit for feeding the bottoms fraction to the stripper at a location above the stripping section and below the wash section;

a stripper overheads system for condensing the stripper overheads fraction to form a condensed water fraction and a product butenes fraction;

a flow conduit for feeding water as a reflux to a top of the stripper wash section;

a flow conduit for feeding at least a portion of the condensed water fraction intermediate the top and bottom of the stripper wash section as a second reflux.

~~15.~~14. The system of claim ~~14~~13, further comprising a feed vaporization system for vaporizing the hydrocarbon mixture upstream of the extractive distillation column.

~~16. The system of any one of claims 14-15, further comprising a flow conduit for feeding the bottoms fraction to the stripper at a location above the stripping section and below the wash section.~~

~~17.~~15. The system of any one of claims ~~14~~13-~~16~~14, wherein the stripper overheads system comprises a two-stage condensation system comprising:

a first condenser for partially condensing the stripper overheads fraction to condense and recover the water as the condensed water fraction and to recover a vapor fraction comprising the butenes;

a second condenser for condensing the vapor fraction comprising the butenes to form the product butene fraction.

~~18.~~16. The system of any one of claims ~~14~~13-~~17~~15, further comprising:

a flow conduit for withdrawing a liquid side draw from the stripper;

a first heat exchanger for at least partially vaporizing the liquid side draw by indirect heat exchange with the lean solvent mixture recovered as a bottoms fraction from the stripper;

a flow conduit for returning the at least partially vaporized side draw to the stripper.

~~19.~~17. The system of claim ~~18~~16, further comprising:

a flow conduit for recovering a partially cooled lean solvent mixture from the first heat exchanger;

one or more ~~second~~ additional heat exchangers for contacting at least one of (a) the enriched solvent fraction as a bottoms fraction from the extractive distillation column and (b) one or more liquid side draws from the extractive distillation column via indirect heat exchange with the partially cooled lean solvent mixture.

~~20.~~18. The system of claim ~~18~~16 or claim ~~19~~17, appropriately, wherein at least one of the first heat exchanger and the one or more ~~second~~ additional heat exchangers is a once-thru vaporization type exchanger.

~~21.~~19. The system of any one of claims ~~18~~16-~~20~~18, appropriately, further comprising a ~~third~~ heat exchanger for contacting a partially cooled lean solvent mixture recovered from at least one of the first heat exchanger and the ~~second~~one or more additional heat exchangers via indirect heat exchange with the hydrocarbon mixture to at least partially vaporize the hydrocarbon mixture.