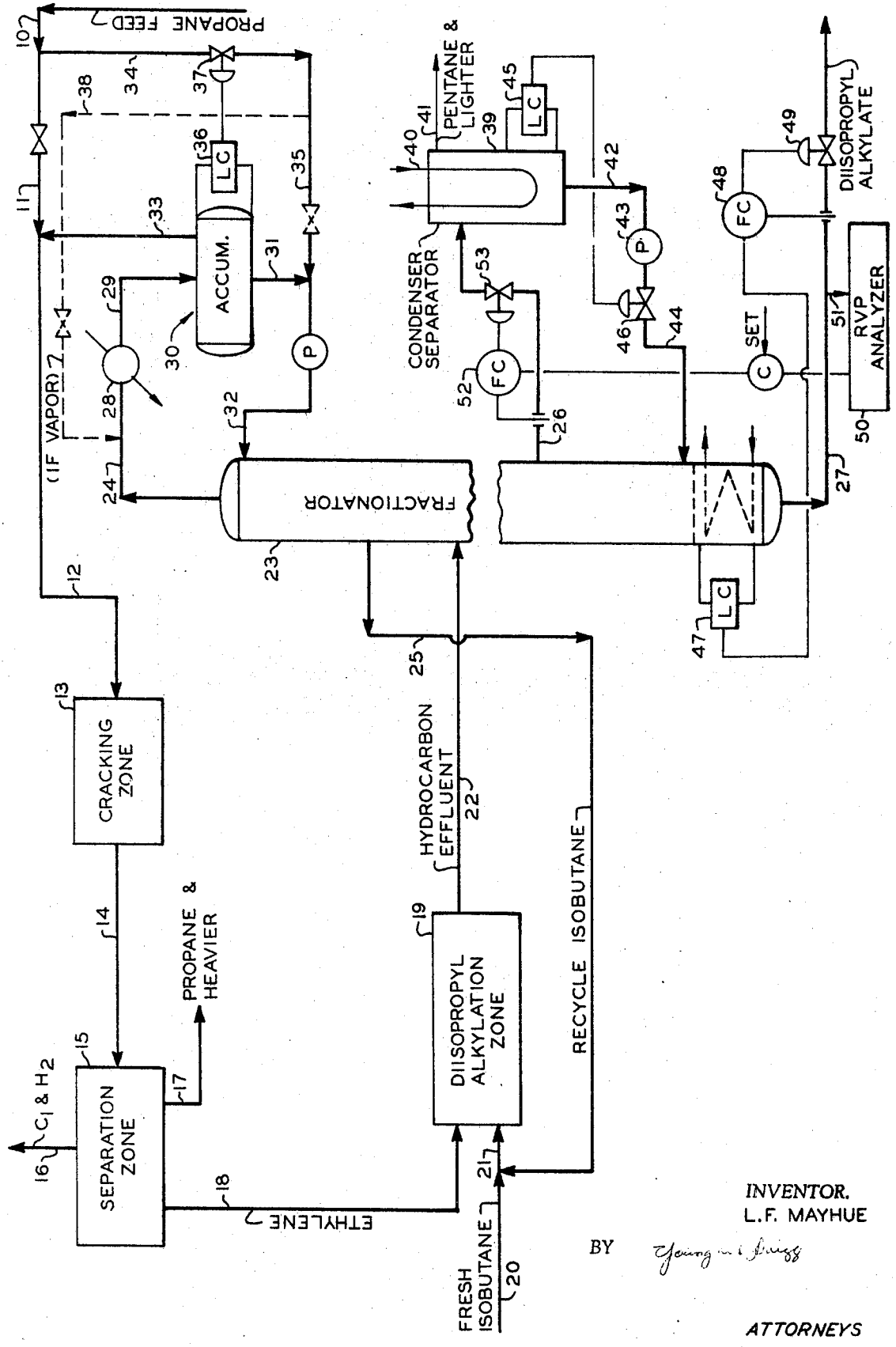
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VAPOR PRESSURE CONTROL IN A FRACTIONATOR OF AN ALKYLATION PROCESS

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VAPOR PRESSURE CONTROL IN A FRACTIONATOR OF AN ALKYLATION PROCESS

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ABSTRACT OF THE DISCLOSURE

A light hydrocarbon is used to control the vapor pressure of the overhead removed from a fractionator and a vapor side stream is removed from below the fractionator feed point in order to control the vapor pressure of the bottoms. The fractionator can be combined with a cracking-alkylation process wherein propane is cracked to produce ethylene, and the ethylene is reacted with isobutane to produce alkylate, and a portion of the propane feed to the cracking is used to control the vapor pressure of the fractionator overhead.

BACKGROUND OF THE INVENTION

This invention relates to the conversion and separation of hydrocarbons. In accordance with one aspect, this invention relates to a fractionation process for the separation of alkylate effluents wherein the vapor pressure of the overhead removed from the fractionation is controlled by the addition of a light hydrocarbon and the vapor pressure of the bottoms alkylate removed from the fractionator is controlled by removal of a vapor side stream below the fractionation feed point. In accordance with a further aspect, this invention relates to a combination thermal cracking and alkylation process wherein the alkylate effluent is fractionated and a portion of the thermal cracking feed is used to control the vapor pressure of the overhead from the fractionator. In accordance with a further aspect, the rate of introduction of light hydrocarbon into the upper portion of the fractionation column is controlled responsive to the liquid level of an accumulation zone and the rate of withdrawal of the vapor side stream is controlled responsive to the vapor pressure of the bottoms alkylate stream.

In the manufacture of alkylate, normal butane is ordinarily included in the fresh isoparaffin feed as a contaminant or the butane can be contained in mixed olefin feed which is obtained from normal butane cracking. The normal butane will go through the alkylation reaction substantially unchanged and appears in the alkylate product still as a contaminating component. Ordinarily, the normal butane present will be in large enough quantities to raise the vapor pressure of the alkylate above a desirable level, ordinarily 7½ to 8 p.s.i.

In accordance with the process of the invention, in order to eliminate separate alkylate debutanizing facilities, a vapor side stream composed primarily of normal butane and heavier components is withdrawn from the fractionator following alkylation from a lower portion of the fractionation column. The normal butane vapor as well as any isopentane and heavier hydrocarbons contained in the vapor side stream are separated from the heavier side stream components. The heavier components separated will be ordinarily returned to the column as a liquid into a lower portion of the fractionation column. The normal butane and part of the isopentane are withdrawn as a vapor side draw product.

Operation of a DIP alkylation unit with high purity ethylene feed results in an excessive amount of isobutane being lost in the depropanizer overhead product of the

fractionation step unless a low temperature condensing unit is used on the overhead vapor stream. The refrigeration facilities increase the overall construction and operating costs of the fractionator installation significantly.

In order to obviate the necessity of a low temperature condenser and the attendant cost, in accordance with the invention the DIP alkylation system fractionator incorporates a secondary feed stream, preferably comprising propane, which is introduced near the top of the fractionation column. This propane will flash overhead from the column and leave the column as overhead product, thereby adjusting the dew point temperature of the overhead product upward while maintaining the same column pressure, and thus enable the use of a water cooled overhead vapor condenser.

Accordingly, an object of this invention is to provide an improved fractionation operation for the separation of alkylate.

A further object of this invention is to provide a combined economical process for cracking light hydrocarbons, alkylating olefin effluent obtained from the cracking and separating alkylate effluent.

A still further object of this invention is to provide a control system for regulating the vapor pressure of the overhead from a fractionating column and vapor pressure of the bottoms product removed from the same column.

Other aspects, objects and the several advantages of this invention will be apparent to those skilled in the art upon reading the specification, the drawing and the appended claims.

SUMMARY OF THE INVENTION

In accordance with the invention, in a fractionation column separating the alkylate stream, the process comprising introducing a light paraffinic hydrocarbon such as propane into the top of the factionating column to lower the vapor pressure, i.e., raise the dew point, of the overhead being removed from the column.

Further in accordance with the invention, when carrying out the above fractionation a vapor side stream comprising butane and isopentane, and heavier, is removed from the fractionation column below the feed point in order to control the vapor pressure of the alkylate removed as bottoms.

In accordance with one embodiment of the invention, the overhead accumulator level controls the amount of light paraffinic feed, such as propane, charged to the fractionation column to lower the vapor pressure of the overhead being removed.

In accordance with another embodiment of the invention, a vapor pressure controller regulates the vapor side stream withdrawal rate responsive to the vapor pressure of the bottoms alkylate.

In accordance with a further embodiment of the invention, propane feed employed for a thermal cracking zone is used as the vapor pressure controlling agent introduced to the top of the fractionating column and the total make from the fractionator overhead is passed to a thermal cracking zone.

In accordance with a further embodiment, the effluent from the thermal cracking zone is separated to recover an ethylene stream which is contacted with isoparaffin, such as isobutane, in an alkylation zone to form DIP alkylate, which alkylate in turn is fractionated in accordance with the previous embodiments.

DESCRIPTION OF PREFERRED EMBODIMENTS

A better understanding of the invention will be obtained by reference to the accompanying drawing which diagrammatically illustrates the fractionation system of the inven-

tion in combination with a propane thermal cracking zone and a DIP alkylation process.

Referring now to the drawing, a propane feed to be thermally cracked is introduced into the process by way of line **10** and then passed by way of lines **11** and **12** to thermal cracking zone **13**. The cracking feed is comprised, principally, of propane but can contain, additionally ethane, isobutane and some normal butane. This feed stream is ordinarily preheated to a temperature of at least 200° F. before introduction into cracking zone **13**. Within cracking zone **13** the propane containing feed is subjected to a temperature of the order of 1425 to 1525° F. to effect cracking of the propane to ethylene and other light hydrocarbon products as well as hydrogen and some heavier materials. The cracking effluent is removed from zone **13** by way of line **14** and passed to separation zone **15**, which can comprise fractionation, solvent extraction, and other means to separate light hydrocarbon gases. Light gases including methane and hydrogen are removed from zone **15** by way of line **16**, and propane and heavier by way of line **17**. An ethylene stream is removed by way of line **18**, which is passed to alkylation zone **19**.

In alkylation zone **19**, fresh isobutane feed is introduced by way of lines **20** and **21** for alkylation with ethylene-rich stream previously introduced by way of line **18**. In alkylation zone **19**, the isobutane and the ethylene are contacted with a suitable catalyst, such as aluminum chloride or aluminum chloride complex, or other known catalyst, under alkylation conditions to produce a diisopropyl alkylate. The alkylate, together with catalyst, is separated to produce a hydrocarbon alkylate effluent removed from zone **19** by way of line **22**. The hydrocarbon alkylate effluent removed from zone **19** by way of line **22** is passed to fractionation zone **23**.

The alkylation conditions of temperature, pressure and ratio of reactants is well known, but these will ordinarily be: temperature, 120° F.; pressure, 400 p.s.i.a.; hydrocarbon to catalyst volume ratio, 1 to 1; isobutane to ethylene mol ratio, 10 to 1; and the catalyst is aluminum chloride complex, in a conventional diisopropyl alkylate manufacturing operation.

The hydrocarbon alkylate feed introduced into fractionation column **23** is separated into an overhead fraction removed by line **24**, an isobutane side stream withdrawal by way of line **25**, a butane and heavier vapor side stream by way of line **26**, and an alkylate bottoms stream by way of line **27**.

The overhead vapor stream removed by line **24** is passed through condenser **28**, line **29**, and then to accumulator **30**. Condensate is removed from accumulator **30** by way of line **31** and passed by way of line **32** as reflux to the top of column **23**. A vapor stream comprising ethane, ethylene, propane and a minor amount of heavier hydrocarbons is removed from accumulator **30** by way of line **33** and combined with the propane feed in lines **11** and **12**, being passed to thermal cracking zone **13**.

In accordance with the invention, a portion of the propane feed in line **10** is passed by way of lines **34** and **35** and introduced into the condensate stream **31**, being removed from accumulator **30**. The condensate stream together with added propane is passed as reflux through line **32** to the top of column **23**. The amount of propane added is sufficient to lower the vapor pressure of the overhead stream being removed by way of line **24** in order to use water cooling on the overhead from the alkylate fractionator **23**. The rate of flow of propane introduced into the fractionator overhead by way of lines **34** and **35** is controlled responsive to liquid level controller **36** and valve **37**. The liquid level in accumulator **30** thus regulates the flow of propane added by way of line **34**. If the propane passed through line **34** is liquid, this can be passed, then, by way of lines **35** and **32** to the top of the column **23**. Alternatively, if the propane stream is vaporous, it is preferred that this stream be passed through valve line **38** for introduction into the overhead stream **24** prior to condenser **28**. Again, the rate of flow is controlled responsive to the liquid level in accumulator **30**. It should be realized that if the propane stream in line **34** is liquid, it need not be introduced into the top of column **23** together with the reflux in line **32**, but can be introduced separately near the top of the column.

Further in accordance with the invention, the butane and heavier vapor side stream removed by line **26** is passed to rectifying unit **39**, wherein the vapor stream is cooled by means of indirect heat exchange unit **40**, which contains a suitable heat exchange fluid. The vapor stream comprising pentane and lighter materials is removed from rectifier **39** by way of line **41** as product. A condensate stream comprising pentane and heavier liquid is removed from the bottom of rectifier **39** by way of line **42**, passed through pump **43**, and line **44**, for reintroduction into a lower portion of column **23**. The rate of passage of liquid in line **44** to column **23** is controlled by liquid level controller **45** and valve **46** responsive to the liquid level in the base of rectifier **39**.

As indicated previously, an alkylate stream is removed from the base of column **23** by way of line **27** as product. The rate of flow of alkylate removed from the base of column **23** is controlled by liquid level controller **47**, which, in turn, resets flow controller **48**, which controls the flow in line **27** by regulating the position of valve **49**.

The vapor pressure of the alkylate stream in line **27** is measured by Reid vapor pressure unit **50** by passing a side stream from conduit **27** by way of line **51**. The vapor pressure of the alkylate stream is in turn used to reset flow controller **52**, which regulates the position of valve **53** in line **26**. As the vapor pressure of the alkylate product stream varies, for example, if the alkylate vapor pressure rises, then more vapor flow is permitted in line **26**, and vice versa if the vapor pressure falls. Thus the withdrawal of the vapor side stream by way of line **26** is controlled responsive to the vapor pressure of the alkylate stream. A suitable vapor pressure unit **50** can comprise a Reid vapor pressure unit, described in Precision Scientific Development Company's bulletin "Reid Monitor," No. 758. The Reid vapor pressure range normally is in the range of from 2 to 19 pounds on the alkylate, preferably 5 to 15 pounds, and more specifically 7½ pounds.

EXAMPLE

Following are the conditions obtaining for a propane cracking system tied in with DIP alkylation and the fractionation process of the invention. The various units are indicated by numbers, as set forth in the drawings.

	Preferred range	Specific
Fractionator (23):		
Top temp., ° F	135–155	148
Top pressure, p.s.i.a	375–395	385
Bottom temp., ° F	400–440	421
Bottom pressure, p.s.i.a	380–400	390
Accumulator (30):		
Temp., ° F	105–125	115
Pressure, p.s.i.a	370–390	380
Condenser unit (39):		
Temp., ° F	115–175	125
Pressure, p.s.i.a	65–140	75

	Typical mol percent
Cracking Feed (10):	
Ethane	1.0
Propane	94.0
Isobutane	3.0
Normal butane	2.0
Total	100.0
Volume, barrels/hr	139
Alkylator hydrocarbon effluent (22): Volume, barrels/hr	1,141

Fractionator Overhead (without invention) (24)	Number mols/hr.
Ethylene	755
Propane	2,647
Isobutane (plus)	160
Total, pound mols/hr	3,562
Dew point, ° F., at 380 p.s.i.a	57

Fractionator Overhead (with invention) (24)	Number mols/hr.
Ethylene	755.3
Propane	2,675.0
Isobutane (plus)	161.5
Total, pound mols/hr	3,591.8
Dew Point, ° F., at 380 p.s.i.a	115

Recycle to cracking zone (33)	Typical mols/hr. Prior	With invention
Ethane, ethylene	26.35	26.65
Propane	7.25	35.25
Isobutane (plus)	0.05	1.55
Total, pound mols/hr	33.65	63.45

Mol ratio of added propane feed to fractionator total overhead (reflux plus make) ranges 0.005 to 0.030. This depends upon operating pressure in the condenser and the desired dew point. At 380 p.s.i.a., these give dew points of 105° F. to 150° F.

As can be readily seen from the data above, when operating in accordance with my invention, with the produced higher dew points (in the specific example, 115° F.), as compared with the prior art having low dew points (in the specific example, 57° F.), I am able to use inexpensive cooling water in the indirect exchanger-condenser **28**, while the prior art must necessarily employ expensive refrigeration therein.

I claim:

1. In the alkylation of isobutane with ethylene and the formation of a hydrocarbon effluent from said alkylation comprising unreacted ethylene, unreacted isobutane, butane, pentane and alkylate, the invention steps comprising:

(a) introducting said effluent, as feed, into an intermediate portion of a fractionation zone,

(b) removing a bottoms product stream comprising liquid alkylate substantially free of butane from said fractionation zone,

(c) introducing propane into an upper portion of said fractionation zone in an amount sufficient to lower the vapor pressure of the overhead vapor stream removed from said fractionation zone,

(d) removing said overhead vapor stream comprising ethylene, propane and isobutane, which overhead stream is cooled, condensed and passed to an accumulation zone,

(e) removing non-condensed ethylene and propane from said accumulation zone as overhead product,

(f) returning the isobutane condensate from said accumulation zone to an upper portion of said fractionation zone as reflux,

(g) withdrawing a first vapor side stream comprising said isobutane from said fractionation zone above the feed of step (a), but below said isobutane reflux of step (f), for recycle to the alkylation zone, and

(h) withdrawing a second vapor side stream comprising butane and heavier hydrocarbons below the feed of step (a) to control the vapor pressure of the alkylate being removed in step (b) and obviating the need for a separate debutanizer to process an otherwise butane-contaminated alkylate.

2. A pressure according to claim **1** wherein the amount of propane introduced in step (c) is controlled responsive to the level of liquid in said accumulation zone and is combined with the condensate passed as reflux to an upper portion of said fractionation zone.

3. A process according to claim **1** wherein said second vapor side stream in step (h) is cooled in a rectifying unit and a condensate stream comprising C_5 and heavier hydrocarbons removed from said rectifying unit is returned to the fractionation zone at a point below the second vapor stream withdrawal, and a third vapor side stream from the rectifying unit comprising pentane and a major portion of butane is withdrawn as product.

4. A process according to claim **1** wherein said propane removed in step (e) is a portion of a propane feed to be used in the production of ethylene in a thermal cracking zone, and further wherein said overhead product is charged as a portion of the feed to said thermal cracking zone.

5. A process according to claim **3** wherein the flow of condensate from the rectifying unit to the fractionation zone is controlled responsive to the level of liquid in the base of said rectifying unit, and the rate of flow of said second vapor side stream withdrawal is controlled responsive to the vapor pressure of the alkylate stream withdrawn in step (b), and the rate of withdrawal of alkylate in step (b) is controlled responsive to the liquid level in the bottom of said fractionation zone.

6. A process according to claim **4** wherein an ethylene stream is separated from said thermal cracking zone and said ethylene is passed to said alkylation zone wherein ethylene is contacted with isobutane and an aluminum chloride catalyst under alkylation conditions and said hydrocarbon effluent is seperated for step (a).

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