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(71) Applicant: SABIC GLOBAL TECHNOLOGIES B.V.
[NL/NL]; Plasticslaan 1, 4612 PX Bergen op Zoom (NL).

(72) Inventors: PATEL, Haresh; P.O. Box 11669, Jubail,
31961 (SA). KADIR, Suprayudi S.; P.O. Box 11669,
Jubail, 31961 (SA).

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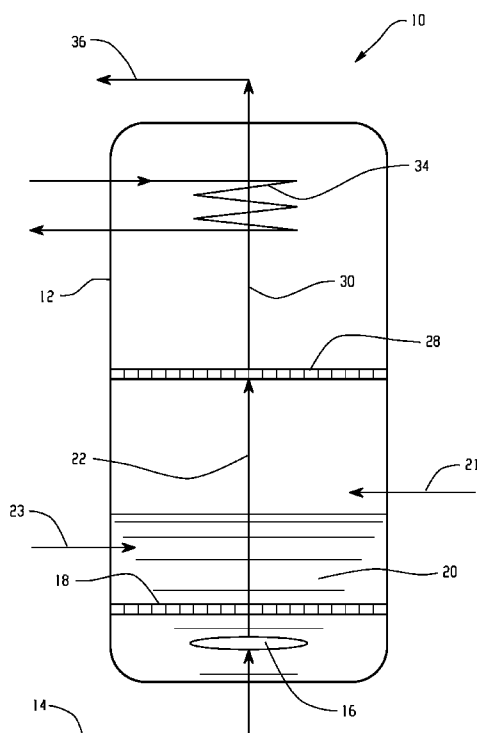
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[Continued on next page]

(54) Title: METHOD OF PROCESSING LINEAR ALPHA OLEFINS



(57) Abstract: A method of processing linear alpha olefins comprises: passing a feed stream comprising gaseous linear alpha olefins through a reactor; passing the feed stream through a liquid within the reactor to produce a reaction stream, wherein the reaction stream comprises linear alpha olefins, polymer droplets, and linear alpha olefin droplets; and passing the reaction stream through a filter to produce a gaseous product stream that exits the reactor, wherein the gaseous product stream is free of droplets having a diameter of greater than 40 micrometers.



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METHOD OF PROCESSING LINEAR ALPHA OLEFINS

BACKGROUND

[0001] A major portion of the petrochemical industry is concerned with the production and use of linear alpha olefins. For example, C4-C8 linear alpha olefins can be used as comonomer in the production of polyethylene. C14 can be converted to chloroparaffins or used as an on-land drilling fluid. C16-C18 linear alpha olefins can be used as the hydrophobic material in oil-soluble surfactants. Therefore, the production of linear alpha olefins remains an important goal of the petrochemical industry.

[0002] Linear alpha olefins can be produced by the oligomerization of ethylene. Conventional methods of production often result in the formation of polymer droplets and linear alpha olefin droplets within the oligomerization reactor. The droplets foul the reactor and significantly reduce its function. The droplets also clog and disrupt downstream equipment such as piping and heat exchangers. As a result, frequent cleaning, maintenance, and shutdown periods are required. These cleaning requirements negatively affect the efficiency of the linear alpha olefin production process and are costly to perform.

[0003] Bubble column reactors are widely known. A bubble column reactor is, for example, utilized for the oligomerization of ethylene to form linear alpha-olefins (LAO). Such a bubble column reactor comprises a column reactor which is divided by a sparger plate into an upper reaction compartment and a bottom compartment. Via the bottom compartment a gaseous feed of monomer(s) is introduced into the column reactor and passes through the sparger plate and into the homogenous solution comprising monomer(s), solvent and catalyst in the upper compartment to then form linear alpha-olefins. From the top of the upper reaction compartment gaseous products and the like are removed. Further, a line is provided to remove a liquid mixture comprising solvent, catalyst, dissolved monomer(s) and linear alpha-olefins.

[0004] In conventional bubble column reactors there is a problem that weeping of the sparger plate may occur which may lead to a filling of the bottom compartment. This may often have the disadvantages that potential mechanical damage may occur, the gas distribution above the sparger plate may be disturbed and plugging of the bottom compartment and outlet lines due to reactive material below the sparger plate may take place.

[0005] Thus, there is a need for a method that can effectively and efficiently produce linear alpha olefins without reactor fouling and downstream equipment disruption caused by droplet formation.

SUMMARY

[0006] Disclosed, in various embodiments, are methods of processing linear alpha olefins.

[0007] A method of processing linear alpha olefins comprises: passing a feed stream comprising gaseous linear alpha olefins through a reactor; passing the feed stream through a liquid within the reactor to produce a reaction stream, wherein the reaction stream comprises linear alpha olefins, polymer droplets, and linear alpha olefin droplets; and passing the reaction stream through a filter to produce a gaseous product stream that exits the reactor, wherein the gaseous product stream is free of droplets having a diameter of greater than 40 micrometers.

[0008] A method of processing linear alpha olefins comprises: passing a feed stream comprising gaseous linear alpha olefins through a bubble column reactor; passing the feed stream through a liquid within the bubble column reactor, wherein an oligomerization reaction occurs producing a reaction stream; wherein the liquid comprises linear alpha olefins with greater than or equal to 4 carbon atoms and wherein the reaction stream comprises linear alpha olefins, polymer droplets, and linear alpha olefin droplets; passing the reaction stream through a vane type mist eliminator to produce a gaseous product stream, wherein the gaseous product stream is free of droplets having a diameter of greater than 40 micrometers; passing the gaseous product stream through a condenser within the bubble column reactor; and withdrawing the gaseous product stream from the bubble column reactor.

[0009] These and other features and characteristics are more particularly described below.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] The following is a brief description of the drawings wherein like elements are numbered alike and which are presented for the purposes of illustrating the exemplary embodiments disclosed herein and not for the purposes of limiting the same.

[0011] FIG. 1 is a simplified schematic diagram of a linear alpha olefin processing method in accordance with the present disclosure.

DETAILED DESCRIPTION

[0012] The method disclosed herein can provide a linear alpha olefin processing method that can effectively and efficiently produce linear alpha olefins without reactor fouling and downstream equipment disruption caused by droplet formation. For example, the method disclosed herein can produce a gaseous product stream that is free of polymer droplets and linear

alpha olefin droplets having a size (e.g., diameter) of greater than or equal to 20 micrometers, for example, greater than or equal to 30 micrometers, for example, greater than or equal to 40 micrometers, for example, greater than or equal to 50 micrometers. The method disclosed herein can retain polymer droplets and linear alpha olefin droplets within an oligomerization reactor. The method disclosed herein can prevent the fouling of a reactor used to produce linear alpha olefins. For example, the method disclosed herein can prevent the fouling of a condenser within the reactor caused by polymer droplets and linear alpha olefin droplets. For example, the method disclosed herein can reduce reactor fouling by greater than 50%. The method described herein can also prevent the clogging and disruption of downstream equipment such as piping and heat exchangers caused by the escape of droplets from the reactor. As a result, the method disclosed herein the frequent cleaning, maintenance, and shutdown periods that are required by other methods can be reduced. The method disclosed herein can also provide a linear alpha olefin processing method that is more cost efficient and wherein reactor runtimes are significantly longer than in other methods.

[0013] The method disclosed herein for processing linear alpha olefins can include passing a feed stream comprising gaseous linear alpha olefins through a bubble column reactor. The feed stream can then be passed through a liquid within the bubble column reactor, wherein an oligomerization reaction can occur thereby producing a reaction stream. For example, the liquid can comprise linear alpha olefins with greater than or equal to 4 carbon atoms. The reaction stream can comprise linear alpha olefins, polymer droplets, and linear alpha olefin droplets. The reaction stream can then be passed through a vane type mist eliminator to produce a gaseous product stream. The gaseous product stream can be free of both polymer droplets and linear alpha olefin droplets having a size (e.g., diameter) of greater than or equal to 20 micrometers, for example, greater than or equal to 30 micrometers, for example, greater than or equal to 40 micrometers, for example, greater than or equal to 50 micrometers. The method disclosed herein can also include passing the gaseous product stream through a condenser within the bubble column reactor. The gaseous product stream can then be withdrawn from the bubble column reactor. The gaseous product stream can also be passed through additional downstream processing units subsequent to withdrawal from the bubble column reactor. For example, the additional downstream processing units can include a condenser, a heat exchanger, a reactor, or a combination comprising at least one of the foregoing.

[0014] The method disclosed herein for processing linear alpha olefins can include a feed stream. For example, the feed stream can comprise hydrocarbons, linear alpha olefins, or a combination comprising at least one of the foregoing. For example, the feed stream can comprise

ethylene, ethane, methane, 1-butene, 1-hexene, 1-octene, or a combination comprising at least one of the foregoing. The feed stream can be in a gaseous phase. For example, the feed stream can comprise gaseous ethylene.

[0015] The method described herein for processing linear alpha olefins can include passing a feed stream through a reactor. For example, the reactor can be a bubble column reactor. For example, the reactor can be a bubble column reactor for oligomerization. The reactor can comprise steel, other metals, polymers, ceramics, or a combination comprising at least one of the foregoing. A temperature within the reactor can be greater than or equal to 50°C. For example, a temperature within the reactor can be 50°C to 100°C. A pressure within the reactor can be greater than or equal to 2000 kiloPascals. For example, a pressure within the reactor can be 2000 kiloPascals to 3500 kiloPascals.

[0016] The method disclosed herein for processing linear alpha olefins can include passing a feed stream through a gas distributor and a sparger plate within a reactor. The gas can disperse the feed stream evenly throughout the reactor. For example, the gas can evenly disperse a gaseous ethylene feed stream throughout a bubble column reactor. The reactor can comprise steel, other metals, polymers, ceramics, or a combination comprising at least one of the foregoing.

[0017] The method disclosed herein for processing linear alpha olefins can include passing a feed stream through a liquid within a reactor. For example, a gaseous feed stream can rise up through the liquid. The liquid can comprise linear alpha olefins. For example, the liquid can comprise linear alpha olefins with greater than or equal to 4 carbon atoms. The liquid can comprise a solvent. For example, the solvent can comprise toluene. The solvent can be introduced to the reactor through a solvent injection stream located in the reactor. The liquid can comprise a catalyst. For example, the liquid can comprise an oligomerization catalyst. For example, the liquid can comprise a zirconium catalyst, an aluminum catalyst, or a combination comprising at least one of the foregoing.

[0018] The method disclosed herein can include an oligomerization reaction that occurs within a liquid. For example, the oligomerization of ethylene can occur within the liquid. The oligomerization reaction can produce a reaction stream that rises up out of the liquid within the reactor. The reaction stream can comprise droplets produced by the oligomerization reaction. For example, the reaction stream can comprise polymer droplets, linear alpha olefin droplets, or a combination comprising at least one of the foregoing. For example, the reaction stream can comprise polyethylene droplets, linear alpha olefin droplets with greater than or equal to 18

carbon atoms, or a combination comprising at least one of the foregoing with droplet size of 1 micrometer to 100 micrometer.

[0019] The method disclosed herein for processing linear alpha olefins can include passing the reaction stream through a filter. For example, the filter can be a vane type mist eliminator. The filter can comprise stainless steel, nickel-based alloys, titanium, aluminum, copper, polypropylene, fluoroplastics, glass fibers, or a combination comprising at least one of the foregoing. The filter can comprise a grid arrangement, a knitted arrangement, or a combination comprising at least one of the foregoing. The filter can remove all droplets with more than 40 micrometer & substantially remove lower size droplets from the stream and retain them within the reactor. The filter can produce a gaseous product stream. The gaseous product stream can comprise linear alpha olefins. For example, the gaseous product stream can comprise linear alpha olefins with greater than or equal to 4 carbon atoms. For example, the gaseous product stream can comprise linear alpha olefins with 14 to 18 carbon atoms. The gaseous product stream can comprise hydrocarbons. For example, the gaseous product stream can comprise ethylene, methane, ethane, or a combination comprising at least one of the foregoing. The gaseous product stream can be free of droplets. For example, the gaseous product stream can comprise less than 1% droplets having a size of more than 40 micrometers. The gaseous stream can comprise of 0% droplets having a size of more than 40 micrometers.

[0020] The method disclosed herein for processing linear alpha olefins can include passing a gaseous product stream through additional downstream processing units subsequent to withdrawal from a reactor. For example, the additional downstream processing units can include a condenser, a heat exchanger, a reactor, or a combination comprising at least one of the foregoing. A gaseous product comprising linear alpha olefins can be used in a variety of applications subsequent to withdrawal from the reactor. For example, C4-C8 linear alpha olefins can be used as comonomer in the production of polyethylene. C14 can be converted to chloroparaffins or used as an on-land drilling fluid. C14 drilling fluid is significantly more biodegradable, less irritating to skin, and less toxic than traditional diesel or kerosene drilling fluid. C16-C18 linear alpha olefins can be used as the hydrophobic material in oil-soluble surfactants. For example, the method disclosed herein can include converting a product from the reactor to chloroparaffin, using a product from the reactor as drilling fluid, or a combination comprising at least one of the foregoing.

[0021] 1-Hexene is commonly manufactured by two general routes: (i) full-range processes via the oligomerization of ethylene and (ii) on-purpose technology. A minor route to 1-hexene, used commercially on smaller scales, is the dehydration of hexanol. Prior to the 1970s,

1-hexene was also manufactured by the thermal cracking of waxes. Linear internal hexenes were manufactured by chlorination/dehydrochlorination of linear paraffins.

[0022] "Ethylene oligomerization" combines ethylene molecules to produce linear alpha-olefins of various chain lengths with an even number of carbon atoms. This approach results in a distribution of alpha-olefins. Oligomerization of ethylene can produce 21 percent 1-hexene.

[0023] Fischer-Tropsch synthesis to make fuels from synthesis gas derived from coal can recover 1-hexene from the aforementioned fuel streams, where the initial 1-hexene concentration cut can be 60% in a narrow distillation, with the remainder being vinylidenes, linear and branched internal olefins, linear and branched paraffins, alcohols, aldehydes, carboxylic acids, and aromatic compounds. The trimerization of ethylene by homogeneous catalysts has been demonstrated.

[0024] There are a wide range of applications for linear alpha olefins. The lower carbon numbers, 1-butene, 1-hexene and 1-octene can be used as comonomers in the production of polyethylene. High density polyethylene (HDPE) and linear low density polyethylene (LLDPE) can use approximately 2-4% and 8-10% of comonomers, respectively.

[0025] Another use of C₄-C₈ linear alpha olefins can be for production of linear aldehyde via oxo synthesis (hydroformylation) for later production of short-chain fatty acid, a carboxylic acid, by oxidation of an intermediate aldehyde, or linear alcohols for plasticizer application by hydrogenation of the aldehyde.

[0026] An application of 1-decene is in making polyalphaolefin synthetic lubricant basestock (PAO) and to make surfactants in a blend with higher linear alpha olefins.

[0027] C₁₀-C₁₄ linear alpha olefins can be used in making surfactants for aqueous detergent formulations. These carbon numbers can be reacted with benzene to make linear alkyl benzene (LAB), which can be further sulfonated to linear alkyl benzene sulfonate (LABS), a popular relatively low cost surfactant for household and industrial detergent applications.

[0028] Although some C₁₄ alpha olefin can be sold into aqueous detergent applications, C₁₄ has other applications such as being converted into chloroparaffins. A recent application of C₁₄ is as on-land drilling fluid basestock, replacing diesel or kerosene in that application. Although C₁₄ is more expensive than middle distillates, it has a significant advantage environmentally, being much more biodegradable and in handling the material, being much less irritating to skin and less toxic.

[0029] C₁₆ - C₁₈ linear olefins find their primary application as the hydrophobes in oil-soluble surfactants and as lubricating fluids themselves. C₁₆ - C₁₈ alpha or internal olefins are used as synthetic drilling fluid base for high value, primarily off-shore synthetic drilling fluids.

The preferred materials for the synthetic drilling fluid application are linear internal olefins, which are primarily made by isomerizing linear alpha-olefins to an internal position. The higher internal olefins appear to form a more lubricious layer at the metal surface and are recognized as a better lubricant. Another application for C₁₆ - C₁₈ olefins is in paper sizing. Linear alpha olefins are, once again, isomerized into linear internal olefins and are then reacted with maleic anhydride to make an alkyl succinic anhydride (ASA), a popular paper sizing chemical.

[0030] C₂₀ - C₃₀ linear alpha olefins production capacity can be 5-10% of the total production of a linear alpha olefin plant. These are used in a number of reactive and non-reactive applications, including as feedstocks to make heavy linear alkyl benzene (LAB) and low molecular weight polymers used to enhance properties of waxes.

[0031] The use of 1-hexene can be as a comonomer in production of polyethylene. High-density polyethylene (HDPE) and linear low-density polyethylene (LLDPE) use approximately 2–4% and 8–10% of comonomers, respectively.

[0032] Another use of 1-hexene is the production of the linear aldehyde heptanal via hydroformylation (oxo synthesis). Heptanal can be converted to the short-chain fatty acid heptanoic acid or the alcohol heptanol.

[0033] A more complete understanding of the components, processes, and apparatuses disclosed herein can be obtained by reference to the accompanying drawings. These figures (also referred to herein as “FIG.”) are merely schematic representations based on convenience and the ease of demonstrating the present disclosure, and are, therefore, not intended to indicate relative size and dimensions of the devices or components thereof and/or to define or limit the scope of the exemplary embodiments. Although specific terms are used in the following description for the sake of clarity, these terms are intended to refer only to the particular structure of the embodiments selected for illustration in the drawings, and are not intended to define or limit the scope of the disclosure. In the drawings and the following description below, it is to be understood that like numeric designations refer to components of like function.

[0034] Referring now to Figure 1, this schematic represents linear alpha olefin processing method 10 in accordance with the present disclosure. The method disclosed herein can include passing a feed stream 14 through a reactor 12. For example, the feed stream 14 can comprise gaseous ethylene and the reactor 12 can be a bubble column reactor. The feed stream 14 can then be passed through a gas distributor 16. The feed stream 14 can then be passed through a sparger plate 18. The gas distributor 16 and the sparger plate 18 can disperse the gaseous ethylene feed stream 14 evenly throughout the reactor 12.

[0035] The method disclosed herein for processing linear alpha olefins can then include passing the feed stream 14 through a liquid 20. For example, gaseous ethylene can rise up through the liquid 20 within the reactor 12. The liquid 20 can comprise linear alpha olefins, toluene solvent, and a catalyst. For example, catalyst can enter the reactor 12 through the catalyst injection stream 23. Toluene solvent can enter the reactor 12 through solvent injection stream 21. A reaction can occur as the feed stream 14 passes through the liquid 20. For example, an oligomerization reaction can occur producing a reaction stream 22 that rises up out of the liquid 20. For example, the reaction stream can comprise polymer droplets and linear alpha olefin droplets.

[0036] The method disclosed herein for the processing of linear alpha olefins can then include passing the reaction stream 22 through a filter 28. For example, the filter 28 can be a vane type mist eliminator. The filter 28 can then produce a gaseous product stream 30. For example, the gaseous product stream 30 can be free of polymer droplets and linear alpha olefin droplets have a size of more than 40 micrometers in diameter. The stream 30 can contain a lower concentration of less than 40 micrometers diameter droplets compared to stream 28.

[0037] The method disclosed herein for the processing linear alpha olefins can then include passing the gaseous product stream 30 through a condenser 34 within the reactor 12. The gaseous product 30 can then be removed from the reactor 12 through the product removal stream 36. For example, the product removal stream 36 can comprise ethylene and linear alpha olefins. The product removal stream 36 can then be further processed by downstream units. For example, additional downstream processing units can include condensers, heat exchangers and reactors.

[0038] The following examples are merely illustrative of the linear alpha olefin processing method disclosed herein and are not intended to limit the scope hereof.

[0039] The processes disclosed herein include(s) at least the following embodiments:

[0040] Embodiment 1: A method of processing linear alpha olefins, comprising: passing a feed stream comprising gaseous linear alpha olefins through a reactor; passing the feed stream through a liquid within the reactor to produce a reaction stream, wherein the reaction stream comprises linear alpha olefins, polymer droplets, and linear alpha olefin droplets; and passing the reaction stream through a filter to produce a gaseous product stream that exits the reactor, wherein the gaseous product stream is free of droplets having a diameter of greater than 40 micrometers.

[0041] Embodiment 2: The method of Embodiment 1, wherein a diameter of the droplets within the agglomerate stream is greater than or equal to 1 micrometer.

[0042] Embodiment 3: The method of any of the preceding embodiments, wherein the feed stream comprises ethylene gas, ethane gas, methane gas, linear alpha olefins with greater than or equal to 4 carbon atoms, or a combination comprising at least one of the foregoing.

[0043] Embodiment 4: The method of any of the preceding embodiments, wherein the reactor is a bubble column reactor.

[0044] Embodiment 5: The method of any of the preceding embodiments, wherein the reactor is an oligomerization reactor.

[0045] Embodiment 6: The method of any of the preceding embodiments, wherein the liquid comprises linear alpha olefins with greater than or equal to 4 carbon atoms.

[0046] Embodiment 7: The method of any of the preceding embodiments, wherein the reaction stream comprises polyethylene droplets, linear alpha olefin droplets with greater than or equal to 4 carbon atoms, or a combination comprising at least one of the foregoing.

[0047] Embodiment 8: The method of any of the preceding embodiments, wherein the filter is a vane type mist eliminator.

[0048] Embodiment 9: The method of any of the preceding embodiments, further comprising passing the gaseous product stream through an additional downstream processing unit subsequent to exiting the reactor.

[0049] Embodiment 10: The method of Embodiment 9, wherein the additional downstream processing unit comprises a condenser, a heat exchanger, a reactor, or a combination comprising at least one of the foregoing.

[0050] Embodiment 11: The method of any of the preceding embodiments, further comprising passing the gaseous product stream through an internal condenser prior to exiting the reactor.

[0051] Embodiment 12: The method of any of the preceding Embodiments, wherein a temperature within the reactor is greater than or equal to 50°C and a pressure within the reactor is greater than or equal to 2000 kiloPascals.

[0052] Embodiment 13: The method of any of the preceding embodiments, wherein fouling of the reactor is reduced by greater than 50% as compared to a reactor operated by a different method.

[0053] Embodiment 14: A method of processing linear alpha olefins, comprising: passing a feed stream comprising gaseous linear alpha olefins through a bubble column reactor; passing the feed stream through a liquid within the bubble column reactor, wherein an oligomerization reaction occurs producing a reaction stream; wherein the liquid comprises linear alpha olefins with greater than or equal to 4 carbon atoms and wherein the reaction stream

comprises linear alpha olefins, polymer droplets, and linear alpha olefin droplets; passing the reaction stream through a vane type mist eliminator to produce a gaseous product stream, wherein the gaseous product stream is free of droplets; passing the gaseous product stream through a condenser within the bubble column reactor; and withdrawing the gaseous product stream from the bubble column reactor having a diameter of greater than 40 micrometers.

[0054] Embodiment 15: The method of Embodiment 14, further comprising passing the gaseous product stream through an additional downstream processing unit.

[0055] Embodiment 16: The method of Embodiment 15, wherein the additional downstream processing unit comprises a condenser, a heat exchanger, a reactor, or a combination comprising at least one of the foregoing.

[0056] Embodiment 17: The method of any of Embodiments 14-16, wherein a diameter of the droplets within the agglomerate stream is greater than or equal to 1 micrometers.

[0057] Embodiment 18: The method of any of Embodiments 14-17, wherein a temperature within the reactor is greater than or equal to 50°C and a pressure within the reactor is greater than or equal to 2000 kiloPascals.

[0058] Embodiment 19: A system, comprising: a reactor configured to process linear alpha olefins according to the method of any of Embodiments 1-18.

[0059] In general, the invention may alternately comprise, consist of, or consist essentially of, any appropriate components herein disclosed. The invention may additionally, or alternatively, be formulated so as to be devoid, or substantially free, of any components, materials, ingredients, adjuvants or species used in the prior art compositions or that are otherwise not necessary to the achievement of the function and/or objectives of the present invention. The endpoints of all ranges directed to the same component or property are inclusive and independently combinable (e.g., ranges of “less than or equal to 25 wt%, or 5 wt% to 20 wt%,” is inclusive of the endpoints and all intermediate values of the ranges of “5 wt% to 25 wt%,” etc.). Disclosure of a narrower range or more specific group in addition to a broader range is not a disclaimer of the broader range or larger group. “Combination” is inclusive of blends, mixtures, alloys, reaction products, and the like. Furthermore, the terms “first,” “second,” and the like, herein do not denote any order, quantity, or importance, but rather are used to denote one element from another. The terms “a” and “an” and “the” herein do not denote a limitation of quantity, and are to be construed to cover both the singular and the plural, unless otherwise indicated herein or clearly contradicted by context. “Or” means “and/or.” The suffix “(s)” as used herein is intended to include both the singular and the plural of the term that it modifies, thereby including one or more of that term (e.g., the film(s) includes one or more

films). Reference throughout the specification to “one embodiment”, “another embodiment”, “an embodiment”, and so forth, means that a particular element (e.g., feature, structure, and/or characteristic) described in connection with the embodiment is included in at least one embodiment described herein, and may or may not be present in other embodiments. In addition, it is to be understood that the described elements may be combined in any suitable manner in the various embodiments.

[0060] The modifier “about” used in connection with a quantity is inclusive of the stated value and has the meaning dictated by the context (e.g., includes the degree of error associated with measurement of the particular quantity). The notation “ $\pm 10\%$ ” means that the indicated measurement can be from an amount that is minus 10% to an amount that is plus 10% of the stated value. The terms “front”, “back”, “bottom”, and/or “top” are used herein, unless otherwise noted, merely for convenience of description, and are not limited to any one position or spatial orientation. “Optional” or “optionally” means that the subsequently described event or circumstance can or cannot occur, and that the description includes instances where the event occurs and instances where it does not. Unless defined otherwise, technical and scientific terms used herein have the same meaning as is commonly understood by one of skill in the art to which this invention belongs. A “combination” is inclusive of blends, mixtures, alloys, reaction products, and the like.

[0061] Unless otherwise indicated, each of the foregoing groups can be unsubstituted or substituted, provided that the substitution does not significantly adversely affect synthesis, stability, or use of the compound. The term “substituted” as used herein means that at least one hydrogen on the designated atom or group is replaced with another group, provided that the designated atom’s normal valence is not exceeded. When the substituent is oxo (i.e., =O), then two hydrogens on the atom are replaced. Combinations of substituents and/or variables are permissible provided that the substitutions do not significantly adversely affect synthesis or use of the compound. Exemplary groups that can be present on a “substituted” position include, but are not limited to, cyano; hydroxyl; nitro; azido; alkanoyl (such as a C₂₋₆ alkanoyl group such as acyl); carboxamido; C₁₋₆ or C₁₋₃ alkyl, cycloalkyl, alkenyl, and alkynyl (including groups having at least one unsaturated linkages and from 2 to 8, or 2 to 6 carbon atoms); C₁₋₆ or C₁₋₃ alkoxys; C₆₋₁₀ aryloxy such as phenoxy; C₁₋₆ alkylthio; C₁₋₆ or C₁₋₃ alkylsulfinyl; C₁₋₆ or C₁₋₃ alkylsulfonyl; aminodi(C₁₋₆ or C₁₋₃)alkyl; C₆₋₁₂ aryl having at least one aromatic rings (e.g., phenyl, biphenyl, naphthyl, or the like, each ring either substituted or unsubstituted aromatic); C₇₋₁₉ arylalkyl having 1 to 3 separate or fused rings and from 6 to 18 ring carbon atoms; or

arylalkoxy having 1 to 3 separate or fused rings and from 6 to 18 ring carbon atoms, with benzyloxy being an exemplary arylalkoxy.

[0062] All cited patents, patent applications, and other references are incorporated herein by reference in their entirety. However, if a term in the present application contradicts or conflicts with a term in the incorporated reference, the term from the present application takes precedence over the conflicting term from the incorporated reference

[0063] While particular embodiments have been described, alternatives, modifications, variations, improvements, and substantial equivalents that are or may be presently unforeseen may arise to applicants or others skilled in the art. Accordingly, the appended claims as filed and as they may be amended are intended to embrace all such alternatives, modifications variations, improvements, and substantial equivalents.

CLAIMS

What is claimed is:

1. A method of processing linear alpha olefins, comprising:
passing a feed stream comprising gaseous linear alpha olefins through a reactor;
passing the feed stream through a liquid within the reactor to produce a reaction stream,
wherein the reaction stream comprises linear alpha olefins, polymer droplets, and linear alpha olefin droplets; and
passing the reaction stream through a filter to produce a gaseous product stream that exits the reactor, wherein the gaseous product stream is free of droplets having a diameter of greater than 40 micrometers.
2. The method of Claim 1, wherein a diameter of the droplets within the reaction stream is greater than or equal to 1 micrometer.
3. The method of any of the preceding claims, wherein the feed stream comprises ethylene gas, ethane gas, methane gas, linear alpha olefins with greater than or equal to 4 carbon atoms, or a combination comprising at least one of the foregoing.
4. The method of any of the preceding claims, wherein the reactor is a bubble column reactor.
5. The method of any of the preceding claims, wherein the reactor is an oligomerization reactor.
6. The method of any of the preceding claims, wherein the liquid comprises linear alpha olefins with greater than or equal to 4 carbon atoms.
7. The method of any of the preceding claims, wherein the reaction stream comprises polyethylene droplets, linear alpha olefin droplets with greater than or equal to 4 carbon atoms, or a combination comprising at least one of the foregoing.
8. The method of any of the preceding claims, wherein the filter is a vane type mist eliminator.

9. The method of any of the preceding claims, further comprising passing the gaseous product stream through an additional downstream processing unit subsequent to exiting the reactor.

10. The method of Claim 9, wherein the additional downstream processing unit comprises a condenser, a heat exchanger, a reactor, or a combination comprising at least one of the foregoing.

11. The method of any of the preceding claims, further comprising passing the gaseous product stream through an internal condenser prior to exiting the reactor.

12. The method of any of the preceding claims, wherein a temperature within the reactor is greater than or equal to 50°C and a pressure within the reactor is greater than or equal to 2000 kiloPascals.

13. The method of any of the preceding claims, wherein fouling of the reactor is reduced by greater than 50% as compared to a reactor operated by a different method.

14. A method of processing linear alpha olefins, comprising:
passing a feed stream comprising gaseous linear alpha olefins through a bubble column reactor;

passing the feed stream through a liquid within the bubble column reactor, wherein an oligomerization reaction occurs producing a reaction stream;

wherein the liquid comprises linear alpha olefins with greater than or equal to 4 carbon atoms and wherein the reaction stream comprises linear alpha olefins, polymer droplets, and linear alpha olefin droplets;

passing the reaction stream through a vane type mist eliminator to produce a gaseous product stream, wherein the gaseous product stream is free of droplets having a diameter of greater than 40 micrometers;

passing the gaseous product stream through a condenser within the bubble column reactor; and

withdrawing the gaseous product stream from the bubble column reactor.

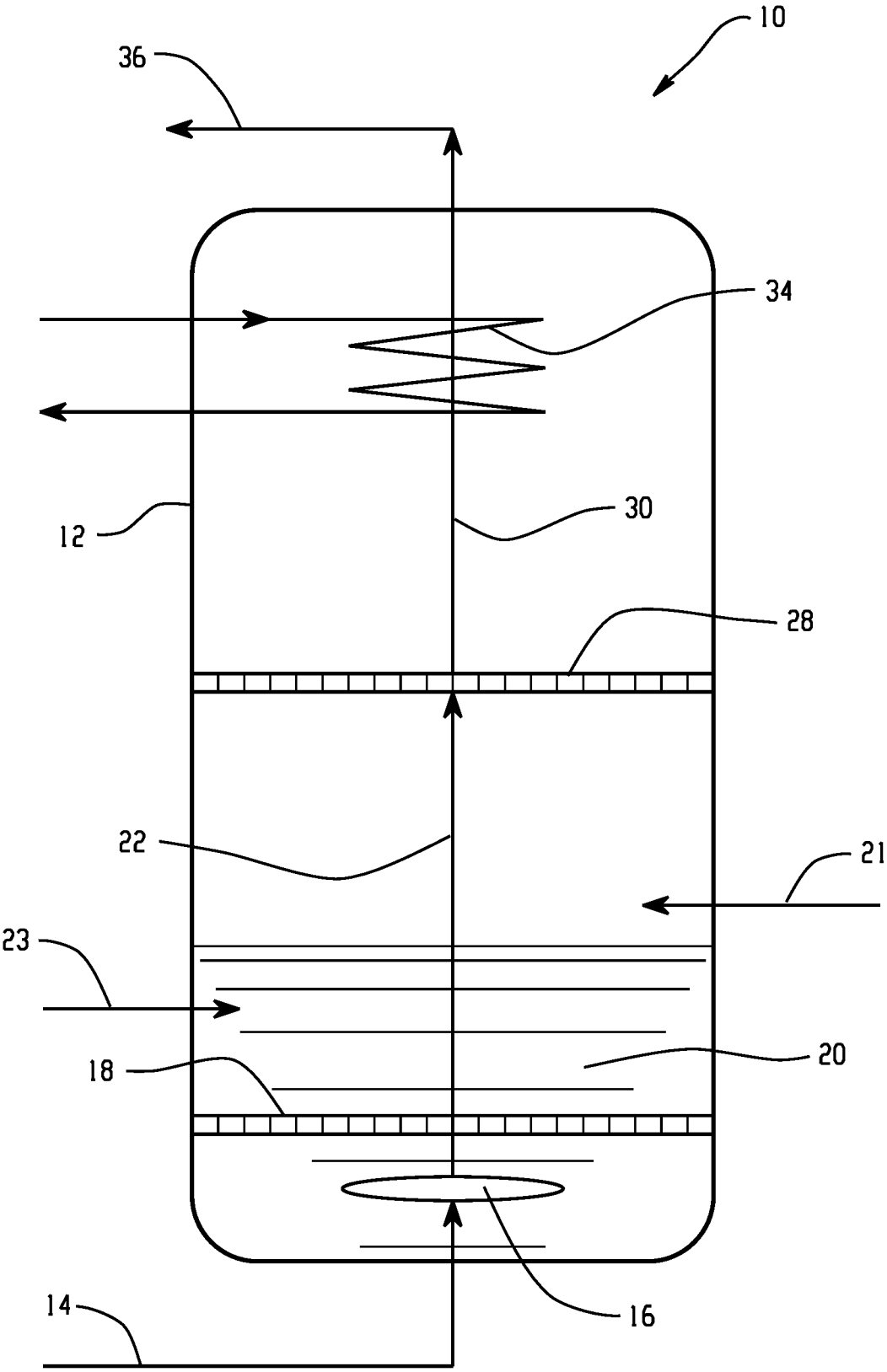
15. The method of Claim 14, further comprising passing the gaseous product stream through an additional downstream processing unit.

16. The method of Claim 15, wherein the additional downstream processing unit comprises a condenser, a heat exchanger, a reactor, or a combination comprising at least one of the foregoing.

17. The method of any of Claims 14-16, wherein a diameter of the droplets within the reaction stream is greater than or equal to 1 micrometers.

18. The method of any of Claims 14-17, wherein a temperature within the reactor is greater than or equal to 50°C and a pressure within the reactor is greater than or equal to 2000 kiloPascals.

19. A system, comprising: a reactor configured to process linear alpha olefins according to the method of any of Claims 1-18.



INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2016/057886

A. CLASSIFICATION OF SUBJECT MATTER

INV. C07C2/08 C07C11/02 C07C11/08 C07C11/107
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

C07C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data, CHEM ABS Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Y	US 2009/214405 A1 (R. SCHNEIDER, ET AL.) 27 August 2009 (2009-08-27) paragraph [0002] -----	1-19
Y	US 2007/137154 A1 (J. AGNELLO, ET AL.) 21 June 2007 (2007-06-21) paragraph [0007]; claim 1 -----	1-19
A	US 2013/102826 A1 (J.R. LATTNER, ET AL.) 25 April 2013 (2013-04-25) paragraph [0045]; claims 1, 5, 6 -----	1-19
A	EP 2 689 838 A1 (SAUDI BASIC INDUSTRIES, ET AL.) 29 January 2014 (2014-01-29) paragraph [0003]; claims 1, 2 ----- -/--	1-19



Further documents are listed in the continuation of Box C.



See patent family annex.

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

1 March 2017

Date of mailing of the international search report

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Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040,
Fax: (+31-70) 340-3016

Authorized officer

English, Russell

INTERNATIONAL SEARCH REPORT

International application No
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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

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