catalytic.

[38] It is an object of the present invention to provide a polyisobutylene composition and process for forming the polyisobutylene composition which avoids the use of washing water and produces no wastes.

[39] It is another object of the present invention to provide a polyisobutylene composition and process for forming the polyisobutylene composition which is a green process.

[40] It is still another object of the present invention to provide a polyisobutylene composition and process for forming polyisobutylene composition which avoids the need for recycling.

[41] It is still another object of the present invention to provide a polyisobutylene composition and process for forming the polyisobutylene composition which produces high yields of high puirty product.

[42] It is a further object of the present invention to provide a polyisobutylene composition and process for forming the polyisobutylene composition which is simple and highly effective.

[43] It is still a further object of the present invention to provide a polyisobutylene composition and process for forming the polyisobutylene composition which involves a significantly reduced capital investment, low operating costs and low catalyst costs.

[44] It is still a further object of the present invention to provide a polyisobutylene composition and process for forming the polyisobutylene composition that provides the ability to make anhydride succinics, succinimide, mannich, and split-tail surfactants.

[45] These and other objects and advantages of the present invention will become apparent from a reading of the attached specification and appended claims.

BRIEF SUMMARY ~~OF THE INVENTION~~

[45a] In a first aspect of the present disclosure, there is provided a polyisobutylene composition comprising polyisobutylene molecules, wherein a first portion of the polyisobutylene molecules has alpha vinylidene molecules and a second portion of the polyisobutylene molecules has beta vinylidene molecules and a third portion of the polyisobutylene molecules has internal vinylidene molecules, wherein the first portion has less than 75% of the polyisobutylene molecules of the composition, wherein a total of first portion and the second portion is less than 90% of the polyisobutylene molecules of the composition, and wherein the third portion is more than 3% of the polyisobutylene molecules of the composition, wherein said second portion is less than 10% of the polyisobutylene molecules of the composition.

[45b] In a second aspect of the present disclosure, there is provided a polyisobutylene composition comprising polyisobutylene molecules, wherein a first portion of the polyisobutylene molecules has alpha vinylidene molecules and a second portion of the polyisobutylene molecules has beta vinylidene molecules and a third portion of the polyisobutylene molecules has internal vinylidene molecules, wherein the first portion has less than 75% of the polyisobutylene molecules of the composition, wherein a total of first portion and the second portion is less than 90% of the polyisobutylene molecules of the composition, and wherein the third portion is more than 3% of the polyisobutylene molecules of the composition, wherein said polyisobutylene composition has a fourth portion that has tetra-substituted isomers, said fourth portion is less than 5% of the total composition.

[45c] In a third aspect of the present disclosure, there is provided a polymerization process for preparing a polyisobutylene polymer composition comprising:

providing a liquid feedstock containing isobutylene;

forming a solid catalyst that is a reaction product of a boron trifluoride/alcohol catalyst complex that is supported on an alumina substrate;

positioning said solid catalyst complex in a reactor;

flowing said liquid feedstock through said solid catalyst in said reactor such that said isobutylene is catalyzed by said solid catalyst; and

discharging said polyisobutylene polymer composition from said reactor, the discharged polyisobutylene polymer composition having polyisobutylene molecules in which a first portion of the polyisobutylene molecules has alpha vinylidene molecules and a second portion of the polyisobutylene molecules has beta vinylidene molecules and the third portion of the polyisobutylene molecules has internal vinylidene molecules, wherein in the first portion is less than 75% of the polyisobutylene molecules of the composition.

[46] The present disclosure relates to ~~invention is~~ a polyisobutylene composition that comprises polyisobutylene molecules wherein a first portion of the polyisobutylene molecules has alpha vinylidene molecules, a second portion of the polyisobutylene molecules has beta vinylidene molecules, and a third portion of the polyisobutylene molecules has internal vinylidene molecules. The first portion is less than 75% of the polyisobutylene molecules of the composition. A total of the first portion and the second portion is less than 90% of the polyisobutylene molecules of the composition. The third portion is more than 3% of the polyisobutylene molecules of the composition.

[47] More specifically, with the polyisobutylene composition of the present ~~invention~~disclosure, a sum of the first portion and the second portion and the third portion is less than 90% of the polyisobutylene molecules of the composition. The second portion is, preferably, less than 10% of the polyisobutylene molecules of the composition. The first portion is preferably between 20% and 75% of the polyisobutylene molecules of the composition. The polyisobutylene composition can have a fourth portion that has tetra-substituted isomers. This fourth portion is less than 5% of the total composition. The polyisobutylene composition will have a molecular weight of between 250 and 5,000 Daltons.

[48] The present ~~invention~~disclosure ~~is~~ also relates to a polymerization process for preparing a polyisobutylene polymer composition. This polymerization process comprises the steps of: (1) providing a liquid feedstock containing isobutylene; (2) forming a solid catalyst that is a reaction product of a boron trifluoride/alcohol catalyst complex that is supported on an alumina substrate; (3) positioning the solid catalyst complex in a reactor; (4) flowing the liquid feedstock through the solid catalyst in the reactor such that the isobutylene is catalyzed by the solid catalyst; and (5) discharging the polyisobutylene polymer composition from the reactor. The discharged polyisobutylene polymer composition will have polyisobutylene molecules in which a first portion of the polyisobutylene molecules has alpha vinylidene molecules and a second portion of the polyisobutylene molecules has beta vinylidene molecules and the third portion of the polyisobutylene molecules has internal vinylidene molecules. The first portion is less than 75% of the polyisobutylene molecules of the composition.

[49] In the process of the present ~~invention~~disclosure, the polyisobutylene polymer composition can be distilled after the step of discharging. The step of distilling serves to separate oligomers from the polyisobutylene polymer composition. In particular, the step of distilling includes passing the polyisobutylene polymer composition to a first distillation column, feeding the polyisobutylene polymer composition under pressure in the first distillation column so as to separate isobutane and isobutylene from the polyisobutylene polymer composition, and discharging the polyisobutylene polymer composition from the first distillation column. The step of distilling further includes passing the discharged polyisobutylene polymer composition from the first distillation column to a second distillation column, feeding the polyisobutylene polymer in the second distillation column at

atmospheric pressure so as to separate C8 oligomers from the polyisobutylene polymer composition, and discharging the polyisobutylene polymer composition from the second distillation column. The step of distilling further includes passing the discharged polyisobutylene composition from the second distillation column to a third distillation column, feeding the polyisobutylene polymer composition in the third distillation column under vacuum conditions so as to separate C12 and higher oligomers from the polyisobutylene polymer composition, and discharging the polyisobutylene polymer composition from the third distillation column.

[50] The boron trifluoride/alcohol catalyst complex has between 10 to 30% by weight of the solid catalyst. A ratio of the alcohol to the boron trifluoride in the catalyst complex ranges from 0.5 mole of alcohol per mole of boron trifluoride to about two moles of alcohol per mole of boron trifluoride.

[51] In the present ~~invention~~disclosure, the reactor is a fixed bed reactor. The fixed bed reactor has a plurality of tubes extending therethrough. The solid catalyst is received in the plurality of tubes. The process of the present ~~invention~~disclosure includes flowing a heat exchange fluid around an exterior of the plurality of tubes so as to control a temperature of the reaction between the liquid feedstock and the isobutylene in an interior of the plurality of tubes.

[52] The discharged polyisobutylene polymer complex can be passed through a filter in which the filter has alumina therein. As such, any residual boron can be removed from the polyisobutylene. The discharged polyisobutylene polymer composition has the third portion of greater than 3% of polyisobutylene molecules of the composition. A total of the first portion and the second portion being less than 90% of the polyisobutylene molecules of the composition. The discharged polyisobutylene polymer composition has a molecular weight of between 250 and 5,000 Daltons.

[53] The process of the present ~~invention~~disclosure is based on a novel solid catalyst as used as a fixed bed reactor system. The solid catalyst is in the form of beads or other convenient geometric shapes and sizes. The solid catalyst is packed into a tubular reactor forming a stationary, completely-contained bed. The isobutylene monomer is fed to the reactor at a controlled rate and passes over the solid catalyst allowing the polymerization reaction to occur. A separate circulation loop is employed to provide heat transfer. Isobutylene polymerization is highly exothermic so as to generate between 350 BTU/lb. of isobutylene. The circulation loop provides sufficient reaction temperature control ensuring that isothermal conditions are maintained over the reaction bed. This is critical to

controlling molecular weight distribution. The residence time over the catalyst is regulated to provide the desired isobutylene conversion.

[54] When the polymer reaction mixture exits the reactor, the polymerization and isomerization reaction has stopped and the crude reaction mixture contains no catalyst residues. As such, no subsequent washing steps are necessary. The reaction mixture is fed directly from the final distillation steps. Since the catalyst is contained solely within the reactor, catalyst injection and handling systems are not required.

[55] Current technology used to produce polyisobutylene has both human and environmental risks. The present ~~invention~~disclosure eliminates waste. The present ~~invention~~disclosure recycles the material so as to minimize human exposure to hazardous materials, reduce catalyst use, and decrease plant capital, energy, and operation cost. The present ~~invention~~disclosure produces no wash water or other waste. There is no human exposure to boron trifluoride gas or boron trifluoride complexes. The very high feed-to-catalyst ratio requires only one to two percent of the catalyst currently used. The cost for building a facility is greatly decreased. Additionally, the energy and operation cost associated with the production of the polyisobutylene in the process of the present ~~invention~~disclosure produces significant annual savings.

[56] This foregoing Section is intended to describe, with particularity, the preferred embodiment of the present ~~invention~~disclosure. It is understood that modifications to this preferred embodiment can be made within the scope of the present ~~invention~~disclosure without departing from the true spirit of the ~~invention~~disclosure. As such, this Section should not be construed as limiting of the scope of the present ~~invention~~disclosure. The present ~~invention~~disclosure should only be limited by the following claims and their legal equivalents.

BRIEF DESCRIPTION OF THE DRAWINGS

[57] FIGURE 1 is an illustration of the typically polymerization mechanism associated with the formation of polyisobutylene from isobutylene.

[58] FIGURE 2 is a flow diagram showing the process of the polymerization process of the present invention.

[59] FIGURE 3 is a detailed view showing the fixed bed reactor associated with the polymerization process of the present invention.

CLAIMS

I claim:

1. A polyisobutylene composition comprising polyisobutylene molecules, wherein a first portion of the polyisobutylene molecules has alpha vinylidene molecules and a second portion of the polyisobutylene molecules has beta vinylidene molecules and a third portion of the polyisobutylene molecules has internal vinylidene molecules, wherein the first portion has less than 75% of the polyisobutylene molecules of the composition, wherein a total of first portion and the second portion is less than 90% of the polyisobutylene molecules of the composition, and wherein the third portion is more than 3% of the polyisobutylene molecules of the composition, wherein said second portion is less than 10% of the polyisobutylene molecules of the composition.

~~2. The polyisobutylene composition of Claim 1, wherein a sum of the first portion and the second portion and the third portion is less than 90% of the polyisobutylene molecules of the composition.~~

~~3. The polyisobutylene composition of Claim 1, wherein the second portion is less than 10% of the polyisobutylene molecules of the composition.~~

2. The polyisobutylene composition of Claim 1, wherein the first portion is between 20% and 75% of the polyisobutylene molecules of the composition.

3. A polyisobutylene composition comprising polyisobutylene molecules, wherein a first portion of the polyisobutylene molecules has alpha vinylidene molecules and a second portion of the polyisobutylene molecules has beta vinylidene molecules and a third portion of the polyisobutylene molecules has internal vinylidene molecules, wherein the first portion has less than 75% of the polyisobutylene molecules of the composition, wherein a total of first portion and the second portion is less than 90% of the polyisobutylene molecules of the composition, and wherein the third portion is more than 3% of the polyisobutylene molecules of the composition~~The polyisobutylene composition of Claim 1~~, wherein said polyisobutylene composition has a fourth portion that has tetra-substituted isomers, said fourth portion is less than 5% of the total composition.

4. The polyisobutylene composition of Claim 3, wherein said polyisobutylene

composition has a molecular weight of between 250 and 5000 Daltons.

57. A polymerization process for preparing a polyisobutylene polymer composition comprising:

providing a liquid feedstock containing isobutylene;

forming a solid catalyst that is a reaction product of a boron trifluoride/alcohol catalyst complex that is supported on an alumina substrate;

positioning said solid catalyst complex in a reactor;

flowing said liquid feedstock through said solid catalyst in said reactor such that said isobutylene is catalyzed by said solid catalyst; and

discharging said polyisobutylene polymer composition from said reactor, the

discharged polyisobutylene polymer composition having polyisobutylene molecules in which a first portion of the polyisobutylene molecules has alpha vinylidene molecules and a second portion of the polyisobutylene molecules has beta vinylidene molecules and the third portion of the polyisobutylene molecules has internal vinylidene molecules, wherein in the first portion is less than 75% of the polyisobutylene molecules of the composition.

68. The polymerization process of Claim 57, further comprising:

distilling the polyisobutylene polymer composition after the step of discharging, the step of distilling or separating oligomers from the polyisobutylene polymer composition.

79. The polymerization process of Claim 68, the step of distilling comprising:

passing the polyisobutylene polymer composition to a first distillation column;

feeding the polyisobutylene polymer composition under pressure in said first distillation column so as to separate isobutane and isobutylene from the polyisobutylene polymer composition; and

discharging the isobutane- and isobutylene-separated polyisobutylene polymer from the polyisobutylene polymer composition.

810. The polymerization process of Claim 79, the step of distilling further comprising:

passing the discharged polyisobutylene polymer composition from said first distillation column to a second distillation column;

feeding the polyisobutylene polymer composition in said second distillation column at atmospheric pressure so as to separate C8 oligomers from the polyisobutylene polymer composition; and

discharging the polyisobutylene polymer composition from the second distillation column.

911. The polymerization process of Claim 810, the step of distilling further comprising:

passing the discharged polyisobutylene polymer composition from said second distillation column to a third distillation column;

feeding the polyisobutylene polymer composition in said third distillation column under vacuum conditions so as to separate C12 and higher oligomers from the polyisobutylene polymer composition; and

discharging the polyisobutylene polymer composition from the third distillation column.

10~~12~~. The polymerization process of Claim 5~~7~~, said boron trifluoride/alcohol catalyst complex being between 10% to 30% by weight of the solid catalyst.

11~~13~~. The polymerization process of Claim 5~~7~~, wherein a ratio of the alcohol to the boron trifluoride in the catalyst complex ranges from 0.5 mole of alcohol per mole of boron trifluoride to about two moles of alcohol per mole of boron trifluoride.

12~~14~~. The polymerization process of Claim 5~~7~~, said reactor being a fixed bed reactor.

13~~15~~. The polymerization process of Claim 12~~14~~, said fixed bed reactor having a plurality of tubes extending therethrough, said solid catalyst received in said plurality of tubes, the polymerization process further comprising:

flowing a heat exchange fluid around an exterior of said plurality of tubes so as to control a temperature of the reaction between the liquid feedstock and the isobutylene in an interior of said plurality of tubes.

14~~16~~. The polymerization process of Claim 5~~7~~, further comprising:

passing the discharged polyisobutylene polymer composition through a filter, said filter having alumina therein.

15~~17~~. The polymerization process of Claim 5~~7~~, the polyisobutylene polymer composition having the third portion of greater than 3% of polyisobutylene molecules of the composition.

16~~18~~. The polymerization process of Claim 5~~7~~, a total of the first portion and the second portion being less than 90% of the polyisobutylene molecules of the composition.

17~~19~~. The polymerization process of Claim 5~~7~~, the discharged polyisobutylene polymer composition having a molecular weight of between 250 and 5000 Daltons.