CLAIMS

What is claimed is:

1. A method of producing a fuel additive, comprising:

passing a feed stream comprising C4 hydrocarbons through a butadiene extraction unit producing a first process stream and an extracted butadiene product stream, wherein the C4 hydrocarbons of the feed stream comprises butadiene and isobutylene;

passing the first process stream and methanol through a methyl tertiary butyl ether unit producing a second process stream and a methyl tertiary butyl ether product, wherein methanol and isobutylene are present in the methyl tertiary butyl ether unit in a molar ratio of one mole of isobutylene to 0.05 moles to 10 moles of methanol;

withdrawing the methyl tertiary butyl ether product from the methyl tertiary butyl ether unit;

passing the second process stream through a hydration unit producing the fuel additive and a recycle stream, wherein a temperature within the hydration unit is 30ºC to 250ºC and a pressure within the hydration unit is 500 kiloPascals to 20,000 kiloPascals;

withdrawing a fuel additive product from the hydration unit, wherein the fuel additive product comprises at least one of 2-butanol, tert-butyl alcohol, or a C4 dimer;

passing the recycle stream through a recycle hydrogenation unit, wherein ~~at least a portion~~ greater than or equal to 0.001% by weight of butene present in the recycle stream is converted to butane within the recycle hydrogenation unit; and

recycling the hydrogenated recycle stream from the recycle hydrogenation unit to a steam cracker unit and/or to the feed stream;

wherein the first process stream withdrawn from the butadiene extraction unit comprises less than or equal to 5% butadiene by weight.

2. The method of Claim 1, wherein a source of the feed stream comprises a product of an olefin cracking process and/or an olefin production process.

3. The method of any of the preceding claims, wherein the feed stream comprises at least one of propane, propylene, ethyl acetylene, vinyl acetylene, 1,3-butadiene, 1,2-butadiene, isobutylene, cis-2-butene, trans-2-butene, 1-butene, isobutane, or n-butane.

4. The method of any of the preceding claims, wherein the butadiene extraction unit comprises a butadiene extractive distillation column, followed by, solvent degassing, solvent regeneration and/or solvent recovery.

~~5. The method of any of the preceding claims, wherein the butadiene extraction unit comprises a butadiene extractive distillation column; and~~

~~wherein the extracted butadiene product stream has a purity of greater than or equal to 90%.~~

5. The method of any of the preceding claims, wherein the temperature within the butadiene extraction unit is less or equal to 150ºC and the pressure within the butadiene extraction unit is 700 kPa.

6. The method of any of the preceding claims, comprising contacting the first process stream with a catalyst within the methyl tertiary butyl ether unit, wherein the catalyst comprises an acid-type ion-exchange resin; and

wherein the second process stream exiting the methyl tertiary butyl ether unit comprises less than or equal to 5% isobutylene by weight.

7. The method of any of the preceding claims, wherein a temperature within the methyl tertiary butyl ether unit is 15ºC to 150ºC and a pressure within the methyl tertiary butyl ether unit is 500 kiloPascals to 2800 kiloPascals.

8. The method of any of the preceding claims, wherein methanol and isobutylene are present in the methyl tertiary butyl ether unit in a molar ratio of one mole of isobutylene to ~~0.05~~0.1 moles to ~~10~~ 5 moles of methanol.

~~9. The method of any of the preceding claims, wherein greater than or equal to 75% by weight of any isobutylene present in the first process stream is converted to methyl tertiary butyl ether within the methyl tertiary butyl ether unit.~~

~~10~~9. The method of Claim 1, ~~comprising withdrawing the methyl tertiary butyl ether product from the methyl tertiary butyl ether unit;~~

wherein the purity of the methyl tertiary butyl ether product is greater than or equal to 95%.

~~11~~10. The method of any of the preceding claims, wherein the second process stream comprises less than or equal to 3.0% butadiene by weight prior to passing through the hydration unit.

~~12~~11. The method of any of the preceding claims, comprising contacting the second process stream with a catalyst within the hydration unit, wherein the catalyst comprises at least one of phosphoric acid, hypophosphorous acid, ion-exchange resin, sulfur, polystyrene, polymer, or niobium oxide.

~~13. The method of any of the preceding claims, wherein a temperature within the hydration unit is 30ºC to 250ºC and a pressure within the hydration unit is 500 kiloPascals to 20,000 kiloPascals.~~

~~14. The method of any of the preceding claims, wherein greater than or equal to 90% by weight of any butene present in the second process stream is converted to butanol within the hydration unit.~~

~~15. The method of any of the preceding claims, comprising withdrawing a fuel additive product from the hydration unit.~~

~~16. The method of Claim 15, wherein the fuel additive product comprises at least one of 2-butanol, tert-butyl alcohol, or a C4 dimer;~~

~~wherein the fuel additive product comprises 1 to 50 weight % of the at least one of 2-butanol, tert-butyl alcohol, or C4 dimer; and~~

~~wherein the fuel additive product comprises 1 to 25 weight % of trimethylpentane.~~

~~17~~12. The method of any of the preceding claims~~Claim 15 or Claim 16~~, wherein an octane number of the fuel additive product is greater than 85 in accordance with the Anti-Knock Index.

~~18~~13. The method of ~~any of~~ Claim~~s 15-17~~12, wherein a Reid vapor pressure of the fuel additive product is less than or equal to 15 kiloPascals.

~~19. The method of any of the preceding claims, wherein greater than or equal to 90 % by weight of any butene present in the recycle stream is converted to butane within the recycle hydrogenation unit.~~

20. The method of Claim 1, comprising:

prior to passing the feed stream through the butadiene extraction unit, passing the feed stream comprising C4 hydrocarbons through a catalytic cracking unit;

withdrawing the extracted butadiene product stream from the butadiene extraction unit;

withdrawing the methyl tertiary butyl ether product from the methyl tertiary butyl ether unit, wherein greater than or equal to 75% by weight of any isobutylene present in the first process stream is converted to methyl tertiary butyl ether within the methyl tertiary butyl ether unit;

withdrawing the fuel additive from the hydration unit, wherein the fuel additive comprises at least one of 2-butanol, tert-butyl alcohol, or a C4 dimer;

and

recycling the hydrogenated recycle stream from the recycle hydrogenation unit to the catalytic cracking unit;

wherein the butadiene extraction unit comprises extractive distillation, solvent degassing, solvent regeneration, and/or solvent recovery, and wherein the extracted butadiene product stream has a purity of greater than or equal to 90%;

wherein methanol and isobutylene are present in the methyl tertiary butyl ether unit in a molar ratio of one mole of isobutylene to 0.1 moles to 5 moles of methanol;

wherein a temperature within the hydration unit is 30ºC to 250ºC, a pressure within the hydration unit is 500 kiloPascals to 20,000 kiloPascals, and wherein 90% by weight of any butenes present in the second process stream is converted to butanol within the hydration unit;

wherein greater than or equal to 90% by weight of any butene present in the recycle stream is converted to butane within the recycle hydrogenation unit.