CLAIMS

What is claimed is:

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

passing a feed stream comprising C4 hydrocarbons including butadiene, isobutylene, 1-butene, 2-butene, or a combination thereof through a hydrogenation unit comprising multiple reactors in series producing a hydrogenated stream;

passing the hydrogenated stream through a distillation unit producing a first stream and a second stream;

producing an isobutylene stream by passing the first stream through a molecular sieve unit;

passing the isobutylene stream to a hydration unit as a feedstock for the fuel additive; and

forming the fuel additive in the hydration unit.

2. The method of Claim 1, wherein the feed stream comprises propylene, ethyl acetylene, vinyl acetylene, propadiene, 1,3-butadiene, 1,2-butadiene, isobutylene, cis-2-butene, trans-2-butene, 1-butene, isobutane, n-butane, propene, or a combination thereof.

3. The method of any of the preceding claims, wherein the first stream comprises isobutane and isobutylene.

4. The method of any of the preceding claims, wherein the second stream comprises 1-butene and 2-butene.

5. The method of any of the preceding claims, wherein greater than or equal to 85% by weight, preferably, greater than or equal to 90% by weight, more preferably, greater than or equal to 95% by weight of the butadiene present in the feed stream is converted to 1-butene and/or 2-butene within the hydrogenation unit.

6. The method of any of the preceding claims, further comprising passing a water stream through the hydration unit.

7. The method of any of the preceding claims, further comprising adding tertiary butyl catechol and/or hydrogen to the feed stream prior to passing through the hydrogenation unit.

8. The method of any of the preceding claims, further comprising withdrawing an isobutylene product from the isobutylene stream, wherein the isobutylene product has a purity of greater than or equal to 90%, preferably, greater than or equal to 95%, more preferably, greater than or equal to 99%.

9. The method of any of the preceding claims, further comprising withdrawing an n-butane stream from the distillation unit and recycling the n-butane stream back to the feed stream.

10. The method of any of the preceding claims, further comprising withdrawing an isobutane stream from the molecular sieve unit and recycling the isobutane stream back to the feed stream.

11. The method of Claim 10, further comprising passing the isobutane stream through a propylene unit and withdrawing a propylene product from the propylene unit.

12. The method of any of the preceding claims, further comprising withdrawing a 2-butene stream from the distillation unit, passing the 2-butene stream through a second hydrogenation unit producing a 1-butene stream, and recycling the 1-butene stream back to the distillation unit.

13. The method of Claim 12, further comprising passing at least a portion of the 1-butene stream through a separation unit and through the hydration unit.

14. The method of any of the preceding claims, wherein the hydration unit comprises an oscillating baffle reactor, a fixed bed reactor, a membrane integrated reactor, an isothermal multi-tubular reactor, or a combination thereof.

15. The method of any of the preceding claims, wherein greater than or equal to 0.01% of the butene present in the second stream is converted to butanol within the hydration unit.

16. The method of any of the preceding claims, further comprising withdrawing a fuel additive product from the hydration unit, wherein the fuel additive product comprises 2-butanol, tert-butyl alcohol, di-isobutene, or a combination thereof.

17. The method of Claim 16, further comprising determining the fuel additive product comprises greater than or equal to 0.01% trimethylpentane.

18. The method of Claim 16, further comprising determining an octane number of the fuel additive product is greater than or equal to 85 according to the Anti-Knock Index.

19. The method of Claim 16, further comprising determining a Reid vapor pressure of the fuel additive product is less than or equal to less than or equal to 75 kiloPascals, preferably, less than or equal to 65 kiloPascals, preferably, less than or equal to 60, preferably less than or equal to 55 kiloPascals.

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

producing hydrogenated products by passing a feed stream comprising C4 hydrocarbons including butadiene, isobutylene, 1-butene, 2-butene through a hydrogenation unit comprising multiple reactors in series, wherein greater than or equal to 90% of any butadiene present in the feed stream is converted to 1-butene and/or 2-butene within the hydrogenation unit;

passing the hydrogenated products through a distillation unit producing a first stream comprising isobutylene and isobutane and a second stream comprising n-butane, 1-butene, and 2-butene;

producing an isobutylene stream having greater than or equal to 90% purity by passing the first stream through a molecular sieve unit having a pore size of 3 to 10;

passing the isobutylene to a hydration reactor as a feedstock;

withdrawing a 2-butene stream from the distillation unit, passing the 2-butene stream through a second hydrogenation unit producing a 1-butene stream, and passing the 1-butene stream to the hydration reactor as a feedstock; and

withdrawing a fuel additive product from the hydration reactor, wherein the fuel additive product comprises greater than or equal to 0.5% by weight trimethylpentane.

21.The method of any of the preceding claims, wherein the method does not include an MTBE unit or a butadiene unit.