

RENEWABLE FEEDSTOCK FOULING CONTROL WITH A SYNERGISTIC DISPERSANT & ANTIOXIDANT TREATMENT

FIELD

[0001] The disclosed technology relates to products and methods for reducing fouling in renewable fuel production processes. In particular, the disclosed technology relates to products and methods for reducing fouling in renewable fuel production processes, that include a combination of dispersants and antioxidants.

BACKGROUND

[0002] The significance of heat exchanger fouling in renewable fuel production is substantial. It exceeds mere operational disruptions, notably affecting the industry by increasing operational costs, diminishing efficiency, reducing unit run lengths, and posing potential risks to personnel and the environment. Effectively addressing and mitigating these challenges are crucial to cultivating safe, cost-effective, and environmentally conscious production methods.

[0003] Different solutions for countering these fouling issues are needed.

SUMMARY

[0004] The disclosed technology provides for reducing fouling in renewable fuel production processes, using products including a combination of dispersants and antioxidants.

[0005] Various aspects of the disclosure relate to a product for reducing fouling in renewable fuel production processes comprising a first composition comprising an effective amount of one or more dispersants, and a second composition comprising an effective amount of one or more antioxidants, wherein the product is configured to be applied to one or more locations of the renewable fuel production process as a synergistic combination of the first composition and the second composition.

[0006] Various aspects of the disclosure additionally relate to a product for reducing fouling in renewable fuel production processes comprising a synergistic combination of a first composition comprising an effective amount of one or more dispersants, and a second composition comprising an effective amount of one or more antioxidants; wherein the first composition is configured to be applied at a first location of the renewable fuel production

process and the second composition is configured to be applied at a second location of the renewable fuel production process.

[0007] Various aspects of the disclosure additionally relate to a method of reducing fouling in renewable fuel production processes comprising adding a synergistic combination of one or more dispersants, and one or more antioxidants to one or more locations of a renewable fuel production process.

[0008] Various aspects of the disclosure further relate to a method of reducing fouling in renewable fuel production processes comprising: adding a synergistic combination of a first composition comprising an effective amount of one or more dispersants, and a second composition comprising an effective amount of one or more antioxidants; wherein the first composition is added to a first location of a renewable fuel production process and the second composition is added to a second location of the renewable fuel production process, thereby synergistically reducing fouling in the renewable fuel production process

BRIEF DESCRIPTION OF THE FIGURES

[0009] Those of skill in the art will understand that the figures, described below, are for illustrative purposes only. The figures are not intended to limit the scope of the present teachings in any way.

[0010] FIG. 1 illustrates the fouling reduction in an example feedstock treated with an embodiment of the composition of the disclosure that includes a mixture of a dispersant and an antioxidant, when compared to untreated example feedstock, and example feedstock treated with the dispersant or the antioxidant used alone.

DETAILED DESCRIPTION

[0011] Approximating language, as used herein throughout the specification and claims, may be applied to modify any quantitative representation that could permissibly vary without resulting in a change in the basic function to which it is related. Accordingly, a value modified by a term or terms, such as “about”, is not limited to the precise value specified. In at least some instances, the approximating language may correspond to the precision of an instrument for measuring the value. Range limitations may be combined and/or interchanged, and such ranges are identified and include all the sub-ranges stated herein unless context or language indicates otherwise. Other than in the operating examples or where otherwise indicated, all numbers or expressions referring to quantities of ingredients, reaction conditions

and the like, used in the specification and the claims, are to be understood as modified in all instances by the term “about”.

[0012] “Optional” or “optionally” means that the subsequently described event or circumstance may or may not occur, or that the subsequently identified material may or may not be present, and that the description includes instances where the event or circumstance occurs or where the material is present, and instances where the event or circumstance does not occur or the material is not present.

[0013] As used herein, the terms “comprises”, “comprising”, “includes”, “including”, “has”, “having”, or any other variation thereof, are intended to cover a non-exclusive inclusion. For example, a process, method, article or apparatus that comprises a list of elements is not necessarily limited to only those elements, but may include other elements not expressly listed or inherent to such process, method, article, or apparatus.

[0014] The singular forms “a”, “an”, and “the” include plural referents unless the context clearly dictates otherwise.

[0015] The disclosed technology provides for products and methods for reducing fouling in renewable fuel production processes comprising one or more dispersants and one or more antioxidants.

[0016] The compositions and methods disclosed herein have been found to be effective in mitigating fouling issues within the context of renewable fuel processing, such as heat exchanger fouling. It was found that, when employed together, the combination of one or more dispersants and one or more antioxidants yielded superior and/or synergistic results when compared to using each component independently. The dual functionality not only addresses fouling challenges more comprehensively, but also amplifies the overall benefits. Without being bound by theory, it is believed that the dispersant prevents the accumulation and agglomeration of undesirable substances, while the antioxidant concurrently inhibits oxidative processes. This integrated approach provides a heightened level of fouling prevention, offering increased benefits and efficiency compared to the individual use of dispersant or antioxidant alone.

[0017] As used herein, the term “dispersant” refers to a component capable of enhancing the dispersibility of undesirable substances generated during processing of renewable feedstocks.

[0018] As used herein, the term “antioxidant” refers to a component that is capable of inhibiting the oxidation of other components that lead to formation of fouling residues.

[0019] As used herein, the term “synergistic combination” refers to a combination of the one or more dispersants and one or more antioxidants of the disclosure, which provides superior fouling reduction to each of the additives individually.

[0020] In various aspects of the disclosed technology, products for reducing fouling in renewable fuel production processes are disclosed. In various aspects, the product may include a first composition comprising an effective amount of one or more dispersants and a second composition comprising an effective amount of one or more antioxidants.

[0021] In various aspects, the product may be configured to be applied to one or more locations of a renewable fuel production process as a synergistic combination of the first composition and the second composition. In other aspects, the first composition of the product may be configured to be applied at a first location of the renewable fuel production process and the second composition may be configured to be applied at a second location of the renewable fuel production process.

[0022] In various aspects, the one or more locations of the renewable fuel production process may include a renewable feedstock, an intermediate stream, or any other location that is susceptible to fouling in the renewable fuel production process.

[0023] In various aspects, suitable dispersants may include any component capable of enhancing the dispersibility of undesirable substances generated during processing of renewable feedstocks. In various aspects, suitable dispersants may include alkenyl succinic acids or anhydride; alkenyl succinic acid or anhydride reaction products with polyamines; alkenyl succinic acid reaction products with polyhydric alcohols; alkenyl thiophosphonic acid reaction products with polyhydric alcohols; alkenyl phosphonate; alkenyl esters; metal salts of alkylphenol sulfide; metal salts of alkyl sulfonate; metal salts of aryl sulfonate; metal salts of alkyl salicylate; reaction products of fatty acids and polyamine; reaction products of fatty acids, formaldehyde and polyamine; reaction products of fatty acid and hydroxylated amine; reaction products of alkylphenol, formaldehyde and polyamine; reaction products of alkene, maleic anhydride and polyamines; reaction products of maleic anhydride, alkenyl hydrocarbons, polyamines, and aryl anhydride; reaction products of aryl anhydride, alkenyl hydrocarbons, and polyamines; and combinations thereof.

[0024] In various aspects, the dispersant may be present in an amount of between about 1 ppm to about 5000 ppm, or about 1, 10, 50, 100, 200, 300, 400, 500, 600, 700, 800, 900, 1000, 1100, 1200, 1300, 1400, 1500, 1600, 1700, 1800, 1900, 2000, 2100, 2200, 2300, 2400, 2500, 2600, 2700, 2800, 2900, 3000, 3100, 3200, 3300, 3400, 3500, 3600, 3700, 3800, 3900,

4000, 4100, 4200, 4300, 4400, 4500, 4600, 4700, 4800, 4900, or 5000 ppm, or about 1 ppm to about 1000 ppm or about 1 ppm to about 500 ppm, or about 10 ppm to about 100 ppm or about 100 ppm to about 1000 ppm or about 1 ppm to about 100 ppm or about 100 ppm to about 500 ppm, or any amount between any of these values.

[0025] In various aspects, suitable antioxidants may include any component that is effective in preventing oxidation and polymerization that lead to the formation of fouling residues. Suitable antioxidants include alkyl phenylenediamines, alkyl phenols, cyclohexylamines, alkyl hydroxylamines, hydroquinones, alkyl hydroquinones, alkyl hydroquinolines and polymers, tocopherols, pyrogallols, alkyl hydroxyanisole, alkyl gallates, alkyl diphenylamines, gallic acid, caffeic acid, and combinations thereof. In some aspects, suitable antioxidants may include hydroxylamine derivatives.

[0026] In various aspects, the antioxidant may be present in an amount of between about 1 ppm to about 5000 ppm, or about 1, 10, 50, 100, 200, 300, 400, 500, 600, 700, 800, 900, 1000, 1100, 1200, 1300, 1400, 1500, 1600, 1700, 1800, 1900, 2000, 2100, 2200, 2300, 2400, 2500, 2600, 2700, 2800, 2900, 3000, 3100, 3200, 3300, 3400, 3500, 3600, 3700, 3800, 3900, 4000, 4100, 4200, 4300, 4400, 4500, 4600, 4700, 4800, 4900, or 5000 ppm, or about 1 ppm to about 1000 ppm or about 1 ppm to about 500 ppm, or about 10 ppm to about 100 ppm or about 100 ppm to about 1000 ppm or about 1 ppm to about 100 ppm or about 100 ppm to about 500 ppm, or any amount between any of these values.

[0027] In various aspects, the products of the disclosed technology may be used in a method of reducing fouling in renewable fuel production processes. In various aspects, the method may include adding a synergistic combination of one or more dispersants and one or more antioxidants to one or more locations of a renewable fuel production process. In other aspects, the method may include adding a synergistic combination of a first composition comprising an effective amount of one or more dispersants, and a second composition comprising an effective amount of one or more antioxidants; wherein the first composition is added to a first location of a renewable fuel production process and the second composition is added to a second location of the renewable fuel production process.

[0028] In various aspects, the one or more locations of the renewable fuel production process may include a renewable feedstock, an intermediate stream, or any other location that is susceptible to fouling in the renewable fuel production process.

[0029] In various aspects of the method, suitable dispersants may include any component capable of enhancing the dispersibility of undesirable substances generated during

processing of renewable feedstocks. In various aspects, suitable dispersants may include alkenyl succinic acids or anhydride; alkenyl succinic acid or anhydride reaction products with polyamines; alkenyl succinic acid reaction products with polyhydric alcohols; alkenyl thiophosphonic acid reaction products with polyhydric alcohols; alkenyl phosphonate; alkenyl esters; metal salts of alkylphenol sulfide; metal salts of alkyl sulfonate; metal salts of aryl sulfonate; metal salts of alkyl salicylate; reaction products of fatty acids and polyamine; reaction products of fatty acids, formaldehyde and polyamine; reaction products of fatty acid and hydroxylated amine; reaction products of alkylphenol, formaldehyde and polyamine; reaction products of alkene, maleic anhydride and polyamines; reaction products of maleic anhydride, alkenyl hydrocarbons, polyamines, and aryl anhydride; reaction products of aryl anhydride, alkenyl hydrocarbons, and polyamines; and combinations thereof.

[0030] In various aspects of the method, the dispersant may be added in an amount of between about 1 ppm to about 5000 ppm, or about 1, 10, 50, 100, 200, 300, 400, 500, 600, 700, 800, 900, 1000, 1100, 1200, 1300, 1400, 1500, 1600, 1700, 1800, 1900, 2000, 2100, 2200, 2300, 2400, 2500, 2600, 2700, 2800, 2900, 3000, 3100, 3200, 3300, 3400, 3500, 3600, 3700, 3800, 3900, 4000, 4100, 4200, 4300, 4400, 4500, 4600, 4700, 4800, 4900, or 5000 ppm, or about 1 ppm to about 1000 ppm or about 1 ppm to about 500 ppm, or about 10 ppm to about 100 ppm or about 100 ppm to about 1000 ppm or about 1 ppm to about 100 ppm or about 100 ppm to about 500 ppm, or any amount between any of these values.

[0031] In various aspects, suitable antioxidants may include any component that is effective in preventing oxidation and polymerization that lead to the formation of fouling residues. Suitable antioxidants may include alkyl phenylenediamines, alkyl phenols, cyclohexylamines, alkyl hydroxyl amines, hydroquinones, alkyl hydroquinones, alkyl hydroquinolines and polymers, tocopherols, pyrogallols, alkyl hydroxyanisole, alkyl gallates, alkyl diphenylamines, gallic acid, caffeic acid, and combinations thereof. In some aspects, suitable antioxidants may include hydroxylamine derivatives.

[0032] In various aspects, the antioxidant may be added in an amount of between about 1 ppm to about 5000 ppm, or about 1, 10, 50, 100, 200, 300, 400, 500, 600, 700, 800, 900, 1000, 1100, 1200, 1300, 1400, 1500, 1600, 1700, 1800, 1900, 2000, 2100, 2200, 2300, 2400, 2500, 2600, 2700, 2800, 2900, 3000, 3100, 3200, 3300, 3400, 3500, 3600, 3700, 3800, 3900, 4000, 4100, 4200, 4300, 4400, 4500, 4600, 4700, 4800, 4900, or 5000 ppm, or about 1 ppm to about 1000 ppm or about 1 ppm to about 500 ppm, or about 10 ppm to about 100 ppm or about

100 ppm to about 1000 ppm or about 1 ppm to about 100 ppm or about 100 ppm to about 500 ppm, or any amount between any of these values.

[0033] In various aspects, the methods of the disclosure may be used to reduce fouling in any device used during processing of renewable feedstocks. In some aspects, the methods may be used to reduce heat exchanger, pretreatment process or catalyst bed fouling in a renewable diesel production process.

EXAMPLES

[0034] The present technology will be further described in the following examples, which should be viewed as being illustrative and should not be construed to narrow the scope of the disclosed technology or limit the scope to any particular embodiments.

[0035] Example 1

[0036] Hot Liquid Process Simulator (HLPS) tests were conducted with an example renewable feedstock.

[0037] Materials and Parameters

[0038] Tube Material: 1018 Steel

[0039] Tube Temperature: 450 °C

[0040] Heat Ramp Up Time: 10 min

[0041] Cool Down Time: 5 min

[0042] Pump Rate: 4.40 %

[0043] Purge Time: 2 min

[0044] System Pressure: 600 PSI

[0045] Test Duration: 8.0 hr

[0046] Reservoir Heat: ON 100 °C

[0047] Line Heat: ON 100 °C

[0048] The example renewable feedstock was treated with 280 ppm of a polyisobutylene succinimide derivative (PIBSI 1) as a single additive, 280 ppm of diethyl hydroxylamine (DEHA) as a single additive, or a combination of 280 ppm of PIBSI 1 and 280 ppm of DEHA. As shown in FIG. 1, it was unexpectedly found that the combined use of PIBSI 1 and DEHA provided a synergistic fouling reduction in comparison to each additive used individually at the same ppm active dosage.

[0049] Example 2

[0050] The example renewable feedstock of Example 1 was treated with 280 ppm of PIBSI 1 as a single additive, 280 ppm of a different polyisobutylene succinimide derivative (PIBSI 2) as a single additive, 280 ppm of DEHA as a single additive, or a combination of 280 ppm of PIBSI 1 or PIBSI 2 and 280 ppm of DEHA. As shown in Table 1 below, it was found that the combined use of the PIBSI 1 or PIBSI 2 and the DEHA unexpectedly provided a synergistic fouling reduction in comparison to each additive used individually at the same ppm active dosage.

[0051] Table 1

Treatment	Fouling Reduction
PIBSI 1	36%
PIBSI 2	40%
DEHA	59%
PIBSI 1 + DEHA	66%
PIBSI 2 + DEHA	62%

[0052] While embodiments of the disclosed technology have been described, it should be understood that the present disclosure is not so limited and modifications may be made without departing from the disclosed technology. The scope of the disclosed technology is defined by the appended claims, and all devices, processes, and methods that come within the meaning of the claims, either literally or by equivalence, are intended to be embraced therein.

CLAIMS

1. A product for reducing fouling in renewable fuel production processes comprising:

a first composition comprising an effective amount of one or more dispersants, and
a second composition comprising an effective amount of one or more antioxidants,
wherein the product is configured to be applied to one or more locations of the renewable fuel production process as a synergistic combination of the first composition and the second composition.
2. The product of claim 1, wherein the one or more dispersants is selected from alkenyl succinic acids or anhydride; alkenyl succinic acid or anhydride reaction products with polyamines; alkenyl succinic acid reaction products with polyhydric alcohols; alkenyl thiophosphonic acid reaction products with polyhydric alcohols; alkenyl phosphonate; alkenyl esters; metal salts of alkylphenol sulfide; metal salts of alkyl sulfonate; metal salts of aryl sulfonate; metal salts of alkyl salicylate; reaction products of fatty acids and polyamine; reaction products of fatty acids, formaldehyde and polyamine; reaction products of fatty acid and hydroxylated amine; reaction products of alkylphenol and formaldehyde; reaction products of alkylphenol, formaldehyde and polyamine; reaction products of alkene, maleic anhydride and polyamines; reaction products of maleic anhydride, alkenyl hydrocarbons, polyamines, and aryl anhydride; reaction products of aryl anhydride, alkenyl hydrocarbons, and polyamines; and combinations thereof.
3. The product of claim 1 or 2, wherein the one or more dispersants is selected from reaction products of alkene, maleic anhydride and polyamines.
4. The product of any one of claims 1-3, wherein the one or more antioxidants is selected from hydrocarbyl substituted phenylenediamines, hydrocarbyl substituted phenols, cyclohexylamines, hydrocarbyl substituted hydroxylamines, hydroquinone, hydrocarbyl substituted hydroquinone, hydrocarbyl substituted hydroquinolines and polymers, tocopherols, pyrogallols, hydrocarbyl substituted hydroxyanisole, hydrocarbyl substituted gallates, hydrocarbyl substituted diphenylamines, gallic acid, caffeic acid, and combinations thereof.

5. The product of claim 4, wherein the antioxidant is selected from diethyl hydroxylamine, hydroquinone, or combinations thereof.
6. A product for reducing fouling in renewable fuel production processes comprising a synergistic combination of:
a first composition comprising an effective amount of one or more dispersants, and
a second composition comprising an effective amount of one or more antioxidants;
wherein the first composition is configured to be applied at a first location of the renewable fuel production process and the second composition is configured to be applied at a second location of the renewable fuel production process.
7. The product of claim 6, wherein the one or more dispersants is selected from alkenyl succinic acids or anhydride; alkenyl succinic acid or anhydride reaction products with polyamines; alkenyl succinic acid reaction products with polyhydric alcohols; alkenyl thiophosphonic acid reaction products with polyhydric alcohols; alkenyl phosphonate; alkenyl esters; metal salts of alkylphenol sulfide; metal salts of alkyl sulfonate; metal salts of aryl sulfonate; metal salts of alkyl salicylate; reaction products of fatty acids and polyamine; reaction products of fatty acids, formaldehyde and polyamine; reaction products of fatty acid and hydroxylated amine; reaction products of alkylphenol and formaldehyde; reaction products of alkylphenol, formaldehyde and polyamine; reaction products of alkene, maleic anhydride and polyamines; reaction products of maleic anhydride, alkenyl hydrocarbons, polyamines, and aryl anhydride; reaction products of aryl anhydride, alkenyl hydrocarbons, and polyamines; and combinations thereof.
8. The product of claim 6 or 7, wherein the one or more dispersants is selected from reaction products of alkene, maleic anhydride and polyamines.
9. The product of any one of claims 6-8, wherein the one or more antioxidants is selected from the antioxidant is selected from hydrocarbyl substituted phenylenediamines, hydrocarbyl substituted phenols, cyclohexylamines, hydrocarbyl substituted hydroxylamines, hydroquinone, hydrocarbyl substituted hydroquinone, hydrocarbyl substituted hydroquinolines and polymers, tocopherols, pyrogallols, hydrocarbyl substituted hydroxyanisole, hydrocarbyl

substituted gallates, hydrocarbyl substituted diphenylamines, gallic acid, caffeic acid, and combinations thereof.

10. The product of claim 9, wherein the antioxidant is selected from diethyl hydroxylamine, hydroquinone, or combinations thereof.

11. A method of reducing fouling in renewable fuel production processes comprising:
adding a synergistic combination of one or more dispersants, and one or more antioxidants to one or more locations of a renewable fuel production process.

12. The method of claim 11, wherein the one or more dispersants is selected from alkenyl succinic acids or anhydride; alkenyl succinic acid or anhydride reaction products with polyamines; alkenyl succinic acid reaction products with polyhydric alcohols; alkenyl thiophosphonic acid reaction products with polyhydric alcohols; alkenyl phosphonate; alkenyl esters; metal salts of alkylphenol sulfide; metal salts of alkyl sulfonate; metal salts of aryl sulfonate; metal salts of alkyl salicylate; reaction products of fatty acids and polyamine; reaction products of fatty acids, formaldehyde and polyamine; reaction products of fatty acid and hydroxylated amine; reaction products of alkylphenol and formaldehyde; reaction products of alkylphenol, formaldehyde and polyamine; reaction products of alkene, maleic anhydride and polyamines; reaction products of maleic anhydride, alkenyl hydrocarbons, polyamines, and aryl anhydride; reaction products of aryl anhydride, alkenyl hydrocarbons, and polyamines; and combinations thereof.

13. The method of claim 11 or 12, wherein the one or more dispersants is selected from reaction products of alkene, maleic anhydride and polyamines.

14. The method of any one of claims 11-13, wherein the one or more antioxidants is selected from hydrocarbyl substituted phenylenediamines, hydrocarbyl substituted phenols, cyclohexylamines, hydrocarbyl substituted hydroxylamines, hydroquinone, hydrocarbyl substituted hydroquinone, hydrocarbyl substituted hydroquinolines and polymers, tocopherols, pyrogallols, hydrocarbyl substituted hydroxyanisole, hydrocarbyl substituted gallates, hydrocarbyl substituted diphenylamines, gallic acid, caffeic acid, and combinations thereof.

15. The method of claim 14, wherein the antioxidant is selected from diethyl hydroxylamine, hydroquinone, or combinations thereof.
16. The method of any one of claims 11-15, wherein the method is used to reduce heat exchanger, pretreatment process or catalyst bed fouling in a renewable diesel process.
17. A method of reducing fouling in renewable fuel production processes comprising:
adding a synergistic combination of a first composition comprising an effective amount of one or more dispersants, and a second composition comprising an effective amount of one or more antioxidants;
wherein the first composition is added to a first location of a renewable fuel production process and the second composition is added to a second location of the renewable fuel production process;
thereby synergistically reducing fouling in the renewable fuel production process.
18. The method of claim 17, wherein the one or more dispersants is selected from alkenyl succinic acids or anhydride; alkenyl succinic acid or anhydride reaction products with polyamines; alkenyl succinic acid reaction products with polyhydric alcohols; alkenyl thiophosphonic acid reaction products with polyhydric alcohols; alkenyl phosphonate; alkenyl esters; metal salts of alkylphenol sulfide; metal salts of alkyl sulfonate; metal salts of aryl sulfonate; metal salts of alkyl salicylate; reaction products of fatty acids and polyamine; reaction products of fatty acids, formaldehyde and polyamine; reaction products of fatty acid and hydroxylated amine; reaction products of alkylphenol and formaldehyde; reaction products of alkylphenol, formaldehyde and polyamine; reaction products of alkene, maleic anhydride and polyamines; reaction products of maleic anhydride, alkenyl hydrocarbons, polyamines, and aryl anhydride; reaction products of aryl anhydride, alkenyl hydrocarbons, and polyamines; and combinations thereof.
19. The method of claim 17 or 18, wherein the one or more dispersants is selected from reaction products of alkene, maleic anhydride and polyamines.
20. The method of any one of claims 17-19, wherein the one or more antioxidants is selected from hydrocarbyl substituted phenylenediamines, hydrocarbyl substituted phenols,

cyclohexylamines, hydrocarbyl substituted hydroxylamines, hydroquinone, hydrocarbyl substituted hydroquinone, hydrocarbyl substituted hydroquinolines and polymers, tocopherols, pyrogallols, hydrocarbyl substituted hydroxyanisole, hydrocarbyl substituted gallates, hydrocarbyl substituted diphenylamines, gallic acid, caffeic acid, and combinations thereof.

21. The method of claim 20, wherein the antioxidant is selected from diethyl hydroxylamine, hydroquinone, or combinations thereof.

22. The method of any one of claims 17-21, wherein the method is used to reduce heat exchanger, pretreatment process or catalyst bed fouling in a renewable diesel process.