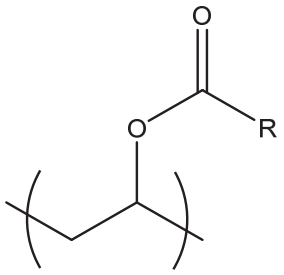
A number of solutions to this problem have been proposed and various additives which can be used to ameliorate the negative interaction have been described, for example, see EP1932899, US8021444, US8153567, US8628590, US8628591, US8734542, US20100154294, US20100180492 and US20100236139.

However due to the significant variability of fuels, the solutions that have been proposed do not always solve the problem and thus there is a continuing need for alternative solutions to this problem.

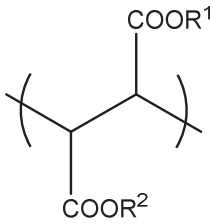
Summary of Disclosure

In one aspect, there is provided a method of improving the low temperature properties of a middle distillate fuel composition comprising (a) a nitrogen-containing dispersant; and (b) one or more low temperature property enhancers which are not fumarate vinyl ester copolymers and which are selected from (x) wax antisettling additives; (y) middle distillate flow improvers and mixtures thereof; by influencing the antagonistic interaction between component (a) and component (b), the method comprising adding to the fuel an additive (c) which is a copolymer comprising units of formula (A):



(A)

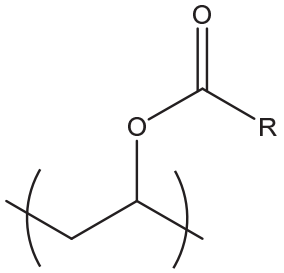
and units of formula (B):



(B)

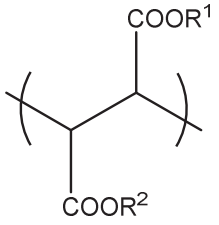
wherein R is an alkyl group and each of R^1 and R^2 is an alkyl group; wherein additive (c) is prepared by copolymerising vinyl ester monomers and fumaric acid monomers and then esterifying the acid residues or by copolymerising vinyl ester monomers and dialkyl fumarate monomers.

In another aspect, there is provided the use of (c) a copolymer comprising units of formula (A):



(A)

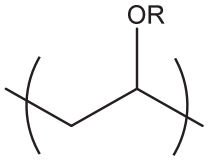
and units of formula (B):



(B)

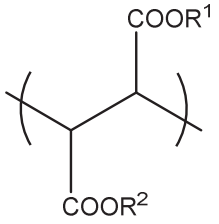
wherein R is an alkyl group and each of R^1 and R^2 is an alkyl group; to improve the low temperature properties of a middle distillate fuel composition comprising (a) a nitrogen-containing dispersant; and (b) one or more low temperature property enhancers which are not fumarate vinyl ester copolymers and which are selected from (x) wax antisettling additives; (y) middle distillate flow improvers and mixtures thereof; by influencing the antagonistic interaction between component (a) and component (b); and wherein additive (c) is prepared by copolymerising vinyl ester monomers and fumaric acid monomers and then esterifying the acid residues or by copolymerising vinyl ester monomers and dialkyl fumarate monomers.

In another aspect, there is provided a use of an additive (c) which is a copolymer comprising units of formula (A):



(A)

and units of formula (B):



(B)

wherein R is an alkyl group and each of R^1 and R^2 is an alkyl group; to ameliorate an antagonistic interaction in a middle distillate fuel composition between (a) a nitrogen-containing dispersant; and (b) one or more low temperature property enhancers which are not fumarate vinyl ester copolymers and which are selected from (x) wax antisettling additives; (y) middle distillate flow improvers and mixtures thereof; wherein additive (c) is prepared by copolymerising vinyl ester monomers and fumaric acid monomers and then esterifying the acid residues or by copolymerising vinyl ester monomers and dialkyl fumarate monomers.

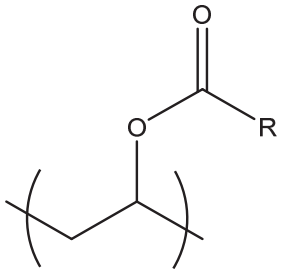
Detailed Description

According to a first aspect of the present invention there is provided a method of improving the low temperature properties of a middle distillate fuel composition comprising:

(a) a nitrogen-containing dispersant; and

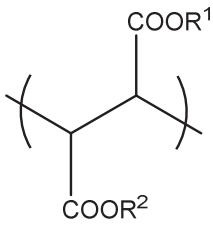
(b) one or more low temperature property enhancers which are not fumarate vinyl ester copolymers and which are selected from: (x) wax antisettling additives; (y) middle distillate flow improvers; and mixtures thereof;

the method comprising adding to the fuel an additive (c) which is a copolymer comprising units of formula (A):



(A)

and units of formula (B):



(B)

wherein R is an alkyl group and each of R^1 and R^2 is an alkyl group.

Claims

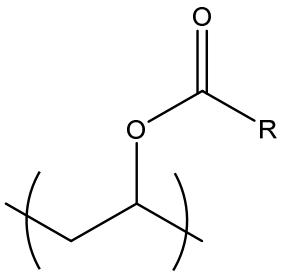
1. A method of improving the low temperature properties of a middle distillate fuel composition comprising:

(a) a nitrogen-containing dispersant; and

(b) one or more low temperature property enhancers which are not fumarate vinyl ester copolymers and which are selected from (x) wax antisettling additives; (y) middle distillate flow improvers and mixtures thereof;

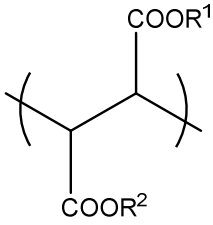
by influencing the antagonistic interaction between component (a) and component (b);

the method comprising adding to the fuel an additive (c) which is a copolymer comprising units of formula (A):



(A)

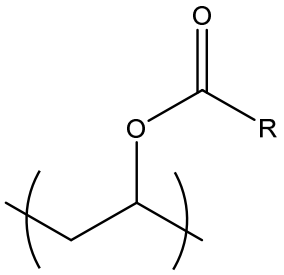
and units of formula (B):



(B)

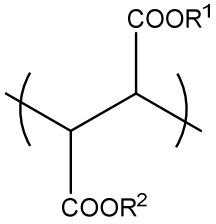
wherein R is an alkyl group and each of R^1 and R^2 is an alkyl group; wherein additive (c) is prepared by copolymerising vinyl ester monomers and fumaric acid monomers and then esterifying the acid residues or by copolymerising vinyl ester monomers and dialkyl fumarate monomers.

2. The use of (c) a copolymer comprising units of formula (A):



(A)

and units of formula (B):



(B)

wherein R is an alkyl group and each of R^1 and R^2 is an alkyl group;

to improve the low temperature properties of a middle distillate fuel composition comprising:

(a) a nitrogen-containing dispersant; and

(b) one or more low temperature property enhancers which are not fumarate vinyl ester copolymers and which are selected from (x) wax antisettling additives; (y) middle distillate flow improvers and mixtures thereof; by influencing the antagonistic interaction between component (a) and component (b); and wherein additive (c) is prepared by copolymerising vinyl ester monomers and fumaric acid monomers and then esterifying the acid residues or by copolymerising vinyl ester monomers and dialkyl fumarate monomers.

3. A method or use according to claim 1 or claim 2 wherein additive (c) is prepared by copolymerising vinyl ester monomers and dialkyl fumarate monomers.

4. A method or use according to any preceding claim wherein R is methyl.

5. A method or use according to any preceding claim wherein each of R^1 and R^2 is an alkyl group having less than 18 carbon atoms.

6. A method or use according to any preceding claim wherein component (a) is selected from

(i) a quaternary ammonium salt additive;

(ii) the product of a Mannich reaction between an aldehyde, an amine and an optionally substituted phenol;

(iii) the reaction product of a carboxylic acid-derived acylating agent and an amine;

(iv) the reaction product of a carboxylic acid-derived acylating agent and hydrazine;

(v) a salt formed by the reaction of a carboxylic acid with di-n-butylamine or tri-n-butylamine;

(vi) the reaction product of a hydrocarbyl-substituted dicarboxylic acid or anhydride and an amine compound or salt which product comprises at least one amino triazole group; and

(vii) a polyalkylene substituted amine.

7. A method or use according to any preceding claim wherein component (a) is selected from

(i) a quaternary ammonium salt additive;

(ii) the product of a Mannich reaction between an aldehyde, an amine and an optionally substituted phenol; and

(iii) the reaction product of a carboxylic acid-derived acylating agent and an amine.

8. A method or use according to any preceding claim wherein component (a) is selected from one or more of

- a quaternary ammonium salt additive formed by reacting methyl salicylate or dimethyl oxalate with the reaction product of a polyisobutylene-substituted succinic anhydride

having a PIB number average molecular weight of 700 to 1300 and dimethylaminopropylamine;

- the Mannich reaction product of dodecylphenol, formaldehyde and either ethylene diamine or tetraethylpentamine; and
- the reaction product of a polyisobutenyl substituted succinic acid/anhydride having a PIB molecular weight (Mn) of 500 to 1300 and a polyethylene polyamine having 1 to 9 amino groups and 1 to 8 ethylene groups.

9. A method or use according to any preceding claim wherein component (b) comprises at least one wax antisettling additive (x) and at least one middle distillate flow improver (y).

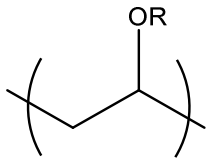
10. A method or use according to any preceding claim wherein component (b) comprises a wax antisettling additive (x) which is the reaction product of (I) a compound containing the segment $–NR^3R^4$ where R^3 represents a group containing from 4 to 44 carbon atoms and R^4 represents a hydrogen atom or a group R^3, and (II) a carboxylic acid having from 1 to 4 carboxylic acid groups or a reactive equivalent thereof.

11. A method or use according to any preceding claim wherein component (b) comprises a wax antisettling additive (x) which is the reaction product of di(hydrogenated) tallow amine (I) and phthalic acid or its acid anhydride (II).

12. A method or use according to any preceding claim wherein component (b) comprises a middle distillate flow improver (y) which is a copolymer of ethylene and an olefinically unsaturated compound.

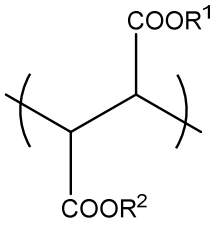
13. A method or use according to any preceding claim wherein component (b) comprises a middle distillate flow improver (y) which, in addition to ethylene, contains 1 to 23 mol %, of olefinically unsaturated compounds as co-monomers.

14. The use of an additive (c) which is a copolymer comprising units of formula (A):



(A)

and units of formula (B):



(B)

wherein R is an alkyl group and each of R^1 and R^2 is an alkyl group; to ameliorate an antagonistic interaction in a middle distillate fuel composition between (a) a nitrogen-containing dispersant; and (b) one or more low temperature property enhancers which are not fumarate vinyl ester copolymers and which are selected from (x) wax antisettling additives; (y) middle distillate flow improvers and mixtures thereof; wherein additive (c) is prepared by copolymerising vinyl ester monomers and fumaric acid monomers and then esterifying the acid residues or by copolymerising vinyl ester monomers and dialkyl fumarate monomers.