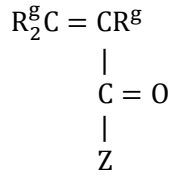
Claims

1. A fouling control coating composition comprising:
(i) a functional polysiloxane,
(ii) a functionalised acrylate-based polymer, and
(iii) a non-curable polymeric or oligomeric fluid that is liquid at 25 °C and atmospheric pressure,
where the functional polysiloxane and the functionalised acrylate-based polymer each comprise a silane moiety of formula $-Si(R^b)_{3-a}(OR^a)_a$, in which
each R^a is independently selected from H, and C_{1-12} alkyl, phenyl, and phenyl with one or more C_{1-6} alkyl substituents, each R^a group optionally comprising one or more substituents selected from halide, OR^t and NR^t_2
each R^b is independently selected from H and R^c,
each R^c is independently selected from C_{1-20} aliphatic hydrocarbyl groups, C_{6-12} aryl groups, and C_{6-12} aryl groups having one or more C_{1-6} alkyl groups, each R^c optionally comprising one or more substituents selected from from halide, $-OR^t$, $-NR^t_2$, -NCO, $-C(O)R^t$, $-C(O)OR^t$, $-OC(O)R^t$, $-C(O)NR^t_2$, $-OC(O)NR^t_2$, $-NR^tC(O)NR^t_2$, $-OC(O)OR^t$, $-([CR^t_2]_jE-)_pR^t$, $-E-([CR^t_2]_jE-)_pR^t$ and $-(CR^t_2)_j[O(CR^t_2)_k]_m[CR^t(O)CR^t_2]$, where $[CR^t(O)CR^t_2]$ represents an epoxy moiety;
each R^t is independently selected from H, C_{1-6} alkyl and C_{1-6} haloalkyl;
each E is independently selected from -O- and $-NR^t$-;
a is an integer in the range of from 1 to 3;
j is in the range of from 1 to 6;
k is in the range of from 2 to 3;
m is in the range of from 0 to 3; and
p is in the range of from 1 to 20.

2. The fouling control coating composition as claimed in claim 1, in which the functionalised acrylate-based polymer comprises one or more acrylate-based monomer units derived from monomers represented by the Formula (3):



Formula (3)

where:

Z is selected from -OR^h and -NR^h_2;

each R^g is selected from H, $C_{1\text{-}20}$ aliphatic hydrocarbyl, $C_{6\text{-}12}$ aryl, $C_{6\text{-}12}$ aryl with one or more $C_{1\text{-}6}$ aliphatic hydrocarbyl substituents; and

each R^h is independently selected from H and $C_{1\text{-}20}$ alkyl; where each R^g and R^h optionally comprise one or more substituents selected from halide, -OR^t, -NR^t_2, -NCO, -$C(O)R^t$, -$C(O)OR^t$, -$OC(O)R^t$, -$C(O)NR^t_2$, -$OC(O)NR^t_2$, -$NR^tC(O)NR^t_2$, -$OC(O)OR^t$, -$([CR^t_2]_jE\text{-})_pR^t$, -E-$([CR^t_2]_jE\text{-})_pR^t$, -$(CR^t_2)_j[O(CR^t_2)_k]_m[CR^t(O)CR^t_2]$ and silyl moieties as defined in claim 1;

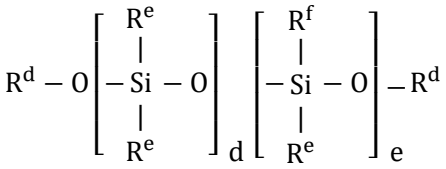
where R^t, j, k, m and p are as defined in claim 1.

3. The fouling control composition as claimed in claim 2, in which the functionalised acrylate-based polymer comprises one or more monomer units derived from monomers of Formula (3), in which Z is selected from OR^h, and R^h is selected from $C_{1\text{-}12}$ alkyl substituted with a silane moiety as defined in claim 1.

4. The fouling control coating composition as claimed in any one of claims 1 to 3, in which the functionalised acrylate-based polymer comprises one or more styrene comonomers of formula $R^j_2C{=}CR^kR^j$, where each R^j is selected from H, halide and $C_{1\text{-}6}$ alkyl, and R^k is selected from phenyl, phenyl with one or more $C_{1\text{-}6}$ alkyl groups, where each R^j and R^k is optionally substituted with halide, OR^t and NR^t_2 where R^t is as defined in claim 1.

5. The fouling control coating composition as claimed in any one of claims 1 to 4, in which acrylate-based monomer units make up 10 % or more of the functionalised acrylate-based polymer on a molar basis.

6. The fouling control composition as claimed in any one of claims 1 to 5, in which the functional polysiloxane is represented by the formula:



where;

each R^d is independently selected form H and R^e;

each R^e is independently selected from C_{1-6} alkyl, phenyl and phenyl with one or more C_{1-6} substituents;

each R^f is independently selected from C_{6-10} aryl, C_{6-20} aliphatic hydrocarbyl and C_{6-10} aryl having one or more C_{1-6} aliphatic hydrocarbyl substituents;

where each R^d, R^e and R^f optionally comprise one or more substituents selected from halide, $-OR^t$, $-NR^t_2$, -NCO, $-C(O)R^t$, $-C(O)OR^t$, $-OC(O)R^t$, $-C(O)NR^t_2$, $-OC(O)NR^t_2$, $-NR^tC(O)NR^t_2$, $-OC(O)OR^t$, $-([CR^t_2]_jE-)_pR^t$, $-E-([CR^t_2]_jE-)_pR^t$ and $-(CR^t_2)_j[O(CR^t_2)_k]_m[CR^t(O)CR^t_2]$;

R^t, E, j, k, m and p are as defined in claim 1;

R^f is different from all R^d and R^e groups;

d is in the range of from 1 to 100;

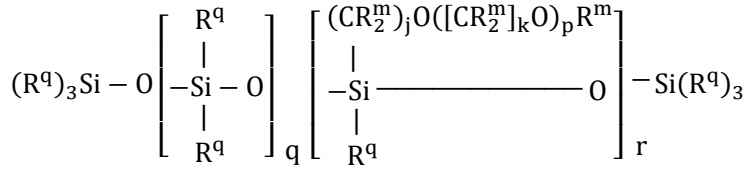
e is in the range of from 0 to 99; and

the sum of d + e is in the range of from 5 to 100.

7. The fouling control composition as claimed in claim 6, in which all R^d and R^e are C_{1-6} alkyl, and R^f is phenyl or C_{1-6} alkyl-substituted phenyl.

8. The fouling control composition as claimed in any one of claims 1 to 7, in which the non-curable oligomeric or polymeric fluid is selected from non-functional polysiloxanes, non-functional polyethers, non-functional perfluoropolyethers and non-functional halogenated hydrocarbon polymers.

9. The fouling control composition as claimed in claim 8, in which the non-curable oligomeric or polymeric fluid is a non-functional polysiloxane is selected from those of formula:



where

each R^m is independently selected from H, C_{1-4} alkyl and C_{1-4} haloalkyl

each R^q is independently selected from C_{1-20} alkyl, phenyl and phenyl having one or more C_{1-6} alkyl substituents, each R^q optionally comprising one or more substituents selected from $-OR^t$, $-NR^t_2$, $-C(O)R^t$, $-([CR^t_2]_jE-)_pR^t$, $-E-([CR^t_2]_jE-)_pR$;

R^t, E, j and p are as defined in claim 1.

q and r are relative molar ratios of the individual siloxane units in the non-functional polysiloxane, where the ratio of q : r is selected from the following ranges: from 0.1 : 1 to 100 : 1, from 1 : 1 to 70 : 1, and from 2 : 1 to 35 : 1.

10. A fouling control coating composition as claimed in any one of claims 1 to 9, in which one or more of the following apply:

(i) the functional polysiloxane, non-curable polymeric or oligomeric fluid and the functionalised acrylate-based polymer comprise no halide substituents and no halide-containing substituents;

(ii) the functionalised acrylate-based polymer comprises one or more styrene comonomers, where each R^j is selected from H and methyl, and R^k is phenyl or C_{1-4} alkyl-substituted phenyl;

(iii) at least one silane moiety on the functionalised acrylate-based polymer is on group Z of an acrylate-based monomer unit of Formula (3) as defined in claim 2;

(iv) at least one silane moiety on the functional polysiloxane is at a terminal position;

(v) the functionalised acrylate-based polymer comprises at least 20 mol% monomer units derived from acrylate-based monomers;

(i) the coating composition further comprises one or more cross-linking agents at a

concentration of 0.1 to 30 wt%;
(ii) the coating composition comprises one or more additional curable resins at a concentration of 20 wt% or less;
(iii) the coating composition has a solids content of 50wt% or more, or 70wt% or more;
(iv) the coating composition comprises no more than 15 wt% marine biocide;
(v) the coating composition comprises no more than 5 wt% water;
(vi) the total content of functional polysiloxane in the coating composition is in the range of from 3 to 50 wt%;
(vii) the total content of functionalised acrylate-based polymer(s) in the coating composition is in the range of from 5 to 70 wt%;
(viii) the total content of non-curable oligomeric or polymeric fluid(s) in the coating composition is in the range of from 2 to 40 wt%.

11. A method for controlling aquatic biofouling on a man-made object, comprising applying to the surface of a man-made structure a fouling control coating composition as claimed in any one of claims 1 to 10.

12. The method as claimed in claim 11, in which the fouling control coating composition has dried and/or cured.

13. A substrate or article comprising a coating of the fouling control coating composition as claimed in any one of claims 1 to 10.

14. The substrate or article of claim 13, in which the fouling control coating composition has been dried and/or cured.

15. The use of a fouling control coating as claimed in any one of claims 1 to 10 for controlling aquatic biofouling of a man-made structure.