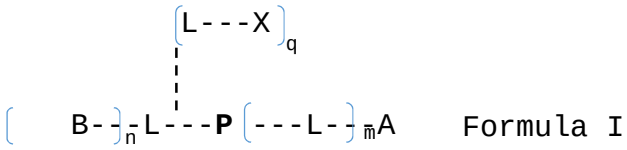
Claims

1. A hyperbranched polymer having the following formula I:



Formula I

wherein the line "---" represents a covalent bond, or a linkage group selected from: –NRC(O)O-, –C(O)OC(O)-NR-, -C(O)NR-, -NHC(O)NH-, wherein R is H, optionally substituted C_1-C_6 alkyl, C_1-C_6 heteroalkyl, carbocycle, aryl, or heteroaryl;

P is a hyperbranched polymer comprising y number of peripheral functional groups;

L is a linker moiety selected from optionally substituted, aliphatic, branched or cyclic alkyl, aryl, phenyl, or alkylene diphenyl;

A is a hydrophobic functional group;

B is a hydrophilic functional group comprising an alkoxy and further additionally comprising at least one or more of the following: amino, amide, ammonium, carboxyl, carboxylate, phosphoric acid groups, sulfonic acid groups, and combinations thereof; and

X is a cross-linkable functional group;

each of m, n and q are integers, wherein m, n and q are each greater than zero, and $m + n + q \leq y$; and wherein the following conditions are met:

$8 \leq y \leq 64$;

$0.01\ y \leq m \leq 0.6\ y$;

$0.1\ y \leq n \leq 0.5\ y$; and

$0.01 \leq q \leq 0.5\ y$.

2. The hyperbranched polymer of claim 1, wherein the following conditions are met:

$8 \leq y \leq 64$;

$0.01\ y \leq m \leq 0.4\ y$;

$0.2\ y \leq n \leq 0.4\ y$; and

$0.1 \leq q \leq 0.5\ y$.

3. The hyperbranched polymer of claim 1, wherein said hydrophilic functional group B is selected from polyethylene oxide, a primary amino group, a secondary amino group, a tertiary amino group, or a quaternary ammonium salt.

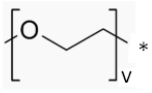
4. The hyperbranched polymer of claim 1, wherein said hydrophobic functional group A is an oleophobic group.

5. The hyperbranched polymer of claim 4, wherein said oleophobic group is a polysiloxane, fluoroalkyl, fluorinated heteroalkyl, or a fluorinated alkoxy.

6. The hyperbranched polymer of claim 5, wherein said hydrophobic functional group **A** is a fluorinated alkyl having the following **Formula III:**

$$CF_3(CF_2)_uCH_2CH_2O\text{-}*$$ Formula III

wherein *denotes an attachment point and u is an integer from 1 to 12.

7. The hyperbranched polymer of any one of claims 1 to 6, wherein said alkoxy functional group is represented by 
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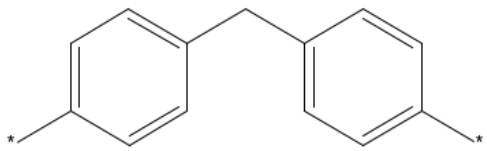
wherein ***** denotes the point of attachment; and v is an integer from 1 to 50.

8. The hyperbranched polymer of any one of claims 1 to 7, wherein L is selected from substituted or unsubstituted

aliphatic C_{1-10} alkyl, substituted cycloalkyl, methylbenzene, or diphenyl.

9. The hyperbranched polymer of claim 8, where L is selected from the group consisting of: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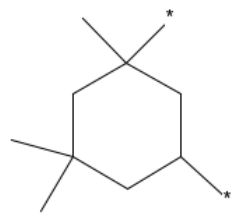
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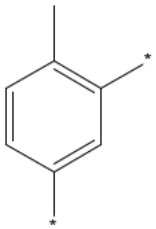
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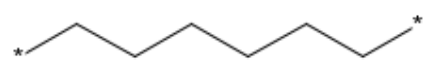
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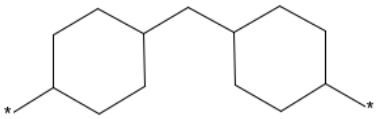


wherein * denotes an attachment point.

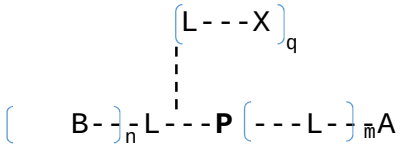
10. The hyperbranched polymer of claim 1, wherein hyperbranched polymer P is a dendritic polyester having y number of reactive peripheral hydroxyl groups.

11. The hyperbranched polymer of any preceding claim, wherein cross-linkable functional group X is selected from isocyanate, blocked isocyanate, epoxy, acrylate and silane, or mixtures thereof.

12. A method of forming a hyperbranched polymer for use in a coating composition, the method comprising the steps of:

a) providing precursor compounds comprising at least one terminal cross-linkable group and at least two additional functional group selected from a hydrophobic functional group, a hydrophilic functional group, or a cross-linkable group;

b) forming a covalent bond between the terminal cross-linkable group of said precursor compound with a peripheral reactive group of a polymer to thereby form a polymer having the following formula I:



Formula I

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P is a hyperbranched polymer comprising y number of peripheral functional groups;

L is a linker moiety selected from optionally substituted, aliphatic, branched or cyclic alkyl, aryl, phenyl, or alkylene diphenyl;

A is a hydrophobic functional group;

B is a hydrophilic functional group comprising an alkoxy and further additionally comprising one or more of the following: amino, amide, ammonium, carboxyl, carboxylate phosphoric acid groups, sulfonic acid groups, and combinations thereof; and

X is a cross-linkable functional group;

each of m, n and q are integers, wherein m, q and n are each greater than zero, and $m + n + q \leq y$; and further wherein the following conditions are met:

$8 \leq y \leq 64$;

$0.01\ y \leq m \leq 0.6\ y$;

$0.1\ y \leq n \leq 0.5\ y$; and

$0.01 \leq q \leq 0.5\ y$.

13. The method of claim 12, wherein said cross-linkable group X is selected from the group consisting of: isocyanate, blocked isocyanate, epoxy, acrylate and silane, and mixtures thereof.

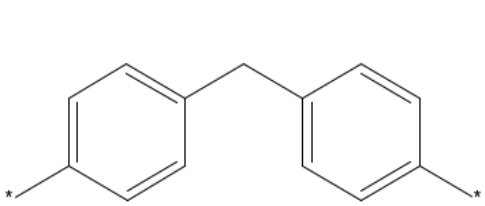
14. The method of claim 12, wherein said forming step (b) is undertaken at stoichiometric conditions to form said polymer of formula (I) where m is between 0.1 y to 0.4 y.

15. The method of claim 12, wherein said forming step (b) is undertaken at stoichiometric conditions to form said polymer of formula (I) wherein n is between 0.2 y to 0.4 y.

16. The method of claim 12, wherein said forming step (b) is undertaken at stoichiometric conditions to form said polymer of formula (I) wherein q is between 0.2y to 0.4y.

17. The method of any one of claims 12 to 16, where L is selected from the group consisting of: substituted or unsubstituted aliphatic $C_{1\text{-}10}$ alkyl, substituted cycloalkyl, methylbenzene, or diphenyl.

18. The method of claim 17, wherein L is selected from the group consisting of: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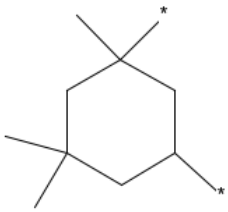
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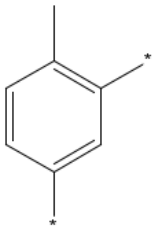
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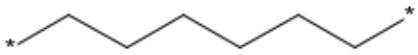
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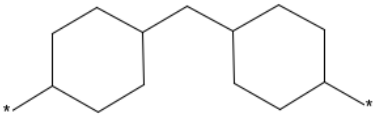
and

wherein * denotes an attachment point.

19. The method of any one of claims 12 to 18, wherein providing step (a) comprises reacting a compound comprising at least two cross-linkable terminal groups with a fluorinated alcohol and an alkoxyalcohol.

20. The method of claim 19, wherein providing step (a) comprises reacting said compound comprising at least two cross-linkable terminal groups with:

a fluorinated alcohol;

a polyethylene oxide;

and one or more additional compounds selected from the group consisting of: epoxide alcohol, aminoalkoxysilane, alkyl acrylate, cyclic amide, heterocycloalkyl and mixtures thereof.

21. The method of claim 20, wherein forming step (a) comprises reacting said compound comprising at least two cross-linkable functional group with:

fluorinated alcohol;

polyethylene oxide; aminoalkoxysilane; and epoxide alcohol.

22. The method of any one of claims 12 to 21, wherein prior to step (b), the method further comprising a step (a1) of reacting said polymer P with caprolactam or ε-caprolactone to form a chain extended polymer P1 having y number of peripheral groups.

23. A coating composition comprising a hyperbranched polymer P according to any one of claims 1 to 11.

24. The coating composition of claim 23, further comprising one or more of the following:

b) nanoparticles having a particle size of between 5 to 2000 nm;

c) at least one photoinitiator compound; and

d) cross-linking catalyst.