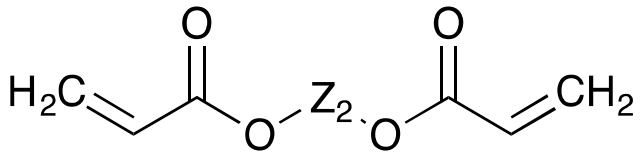
(i) a four-branching monomer having four reaction sites that can react with acrylate or amine groups;

(ii) a diacrylate component, typically of formula (I)



(I)

wherein Z2 is a linear or branched carbon chain of 1 to 30 carbon atoms, a linear or branched heteroatom-containing carbon chains of 1 to 30 atoms, a carbocycle containing 3 to 30 carbon atoms, or a heterocycle containing 3 to 30 atoms;

wherein Z2 is unsubstituted or substituted with at least one of a halogen, a hydroxyl, an amino group, a sulfonyl group, a sulphonamide group, a thiol, a C1-C6 alkyl, a C1-C6 alkoxy, a C1-C6 ether, a C1-C6 thioether, a C1-C6 sulfone, a C1-C6 sulfoxide, a C1-C6 primary amide, a C1-C6 secondary amide, a halo C1-C5 alkyl, a carboxyl group, a cyano group, a nitro group, a nitroso group, -OC(0)NR'R', -N(R')C(0)NR'R, -N(R')C(0)0-C1-C6 alkyl, C3-C6 cycloalkyl, C3-C6 heterocyclyl, C2-C5 heteroaryl and C6-C10 aryl; wherein each R' is independently selected, from the group consisting of hydrogen and C1-C6 alkyl;

(iii) a first amine component typically comprising 3 to 20 atoms,
wherein said amine component typically is unsubstituted or substituted with at least one of a halogen, a hydroxyl, an amino group, a sulfonyl group, a sulphonamide group, a thiol, a C1-C6 alkyl, a C1-C6 alkoxy, a C1-C6 ether, a C1-C6 thioether, a C1-C6 sulfone, a C1-C6 sulfoxide, a C1~C6 primary amide, a C1-C6 secondary amide, a halo C1-C6 alkyl, a carboxyl group, a cyano group, a nitro group, a nitroso group, -OC(0)NR'R', -N(R')C(0)NR'R, -N(R')C(0)0-C1-C6 alkyl, C3-C6 cycloalkyl, C3-C6 heterocyclyl, C2-C5 heteroaryl and C6-C10 aryl; wherein each R' is independently selected, from the group consisting of hydrogen and C1-C6 alkyl; and

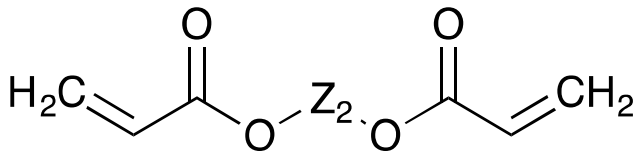
(iv) a second amine component typically comprising 3 to 20 atoms,
wherein said amine component typically is unsubstituted or substituted with at least one of a halogen, a hydroxyl, an amino group, a sulfonyl group, a sulphonamide group, a thiol, a C1-C6 alkyl, a C1-C6 alkoxy, a C1-C6 ether, a C1-C6 thioether, a C1-C6 sulfone, a C1-C6 sulfoxide, a C1~C6 primary amide, a C1-C6 secondary amide, a halo C1-C6 alkyl, a

carboxyl group, a cyano group, a nitro group, a nitroso group, -OC(0)NR'R', -N(R')C(0)NR'R, -N(R')C(0)0-C1-C6 alkyl, C3-C6 cycloalkyl, C3-C6 heterocyclyl, C2-C5 heteroaryl and C6-C10 aryl; wherein each R' is independently selected, from the group consisting of hydrogen and C1-C6 alkyl.

In another aspect, there is provided a method of forming a polymer comprising a step of reacting together:

(i) a four-branching monomer;

(ii) a diacrylate component, typically of formula (I)



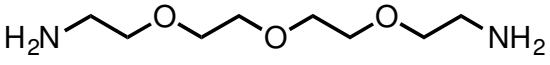
(I)

wherein Z2 is a linear or branched carbon chain of 1 to 30 carbon atoms, a linear or branched heteroatom-containing carbon chains of 1 to 30 atoms, a carbocycle containing 3 to 30 carbon atoms, or a heterocycle containing 3 to 30 atoms;

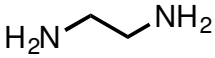
wherein Z2 is unsubstituted or substituted with at least one of a halogen, a hydroxyl, an amino group, a sulfonyl group, a sulphonamide group, a thiol, a C1-C6 alkyl, a C1-C6 alkoxy, a C1-C6 ether, a C1-C6 thioether, a C1-C6 sulfone, a C1-C6 sulfoxide, a C1-C6 primary amide, a C1-C6 secondary amide, a halo C1-C5 alkyl, a carboxyl group, a cyano group, a nitro group, a nitroso group, -OC(0)NR'R', -N(R')C(0)NR'R, -N(R')C(0)0-C1-C6 alkyl, C3-C6 cycloalkyl, C3-C6 heterocyclyl, C2-C5 heteroaryl and C6-C10 aryl; wherein each R' is independently selected, from the group consisting of hydrogen and C1-C6 alkyl

(iii) a first amine component typically comprising 3 to 20 atoms,

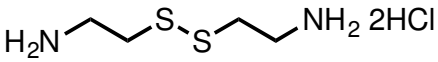
wherein said amine component typically is unsubstituted or substituted with at least one of a halogen, a hydroxyl, an amino group, a sulfonyl group, a sulphonamide group, a thiol, a C1-C6 alkyl, a C1-C6 alkoxy, a C1-C6 ether, a C1-C6 thioether, a C1-C6 sulfone, a C1-C6 sulfoxide, a C1~C6 primary amide, a C1-C6 secondary amide, a halo C1-C6 alkyl, a carboxyl group, a cyano group, a nitro group, a nitroso group, -OC(0)NR'R', -N(R')C(0)NR'R, -N(R')C(0)0-C1-C6 alkyl, C3-C6 cycloalkyl, C3-C6 heterocyclyl, C2-C5 heteroaryl and C6-C10 aryl; wherein each R' is independently selected, from the group consisting of hydrogen and C1-C6 alkyl; and



DATA,122, Mw=192.26



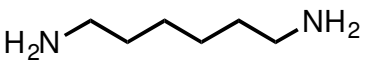
EDA,102, Mw=60



Cystamine, Mw=225.20

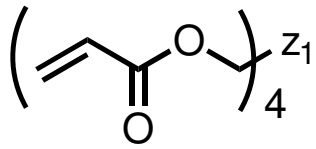


DA,103, Mw=74.13



HMDA,106, Mw=116.21

In one embodiment, the tetraacrylate component is a 4-arm PEG acrylate or has a formula (II),



(II)

in which Z1 is a scaffold consisting of:

a linear or branched carbon chain of 1 to 30 carbon atoms, a linear or branched heteroatom-containing carbon chains of 1 to 30 atoms, a carbocycle containing 3 to 30 carbon atoms, or a heterocycle containing 3 to 30 atoms;

wherein Z1 is unsubstituted or substituted with at least one of a halogen, a hydroxyl, an amino group, a sulfonyl group, a sulphonamide group, a thiol, a C1-C6 alkyl, a C1-C6 alkoxy, a C1-C6 ether, a C1-C6 thioether, a C1-C6 sulfone, a C1-C6 sulfoxide, a C1-C6 primary amide, a C1-C6 secondary amide, a halo C1-C6 alkyl, a carboxyl group, a cyano group, a nitro group, a nitroso group, -OC(0)NR'R', -N(R')C(0)NR'R, -N(R')C(0)0-C1-C6 alkyl, C3-C6 cycloalkyl, C3-C6 heterocyclyl, C2-C5 heteroaryl and C6-C10 aryl; wherein each R' is independently selected, from the group consisting of hydrogen and C1-C6 alkyl;

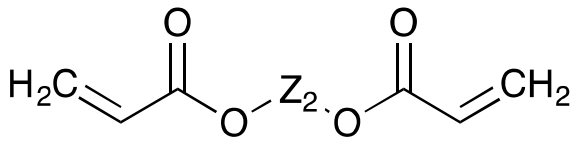
In one embodiment, the tetraacrylate component is selected from:

CLAIMS:

1. A hyperbranched polymer made by reacting together:

(i) a four-branching monomer;

(ii) a diacrylate component of formula (I)



(I)

wherein Z2 is a linear or branched carbon chain of 1 to 30 carbon atoms, a linear or branched heteroatom-containing carbon chains of 1 to 30 atoms, a carbocycle containing 3 to 30 carbon atoms, or a heterocycle containing 3 to 30 atoms;
wherein Z2 is unsubstituted or substituted with at least one of a halogen, a hydroxyl, an amino group, a sulfonyl group, a sulphonamide group, a thiol, a C1-C6 alkyl, a C1-C6 alkoxy, a C1-C6 ether, a C1-C6 thioether, a C1-C6 sulfone, a C1-C6 sulfoxide, a C1-C6 primary amide, a C1-C6 secondary amide, a halo C1-C5 alkyl, a carboxyl group, a cyano group, a nitro group, a nitroso group, -OC(0)NR'R', -N(R')C(0)NR'R, -N(R')C(0)0-C1-C6 alkyl, C3-C6 cycloalkyl, C3-C6 heterocyclyl, C2-C5 heteroaryl and C6-C10 aryl; wherein each R' is independently selected, from the group consisting of hydrogen and C1-C6 alkyl;

(iii) a first amine component comprising 3 to 20 atoms,
wherein said amine component is unsubstituted or substituted with at least one of a halogen, a hydroxyl, an amino group, a sulfonyl group, a sulphonamide group, a thiol, a C1-C6 alkyl, a C1-C6 alkoxy, a C1-C6 ether, a C1-C6 thioether, a C1-C6 sulfone, a C1-C6 sulfoxide, a C1~C6 primary amide, a C1-C6 secondary amide, a halo C1-C6 alkyl, a carboxyl group, a cyano group, a nitro group, a nitroso group, -OC(0)NR'R', -N(R')C(0)NR'R, -N(R')C(0)0-C1-C6 alkyl, C3-C6 cycloalkyl, C3-C6 heterocyclyl, C2-C5 heteroaryl and C6-C10 aryl; wherein each R' is independently selected, from the group consisting of hydrogen and C1-C6 alkyl; and

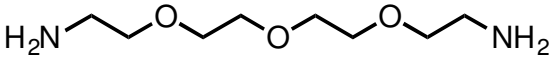
(iv) a second amine component comprising 3 to 20 atoms,
wherein said amine component is unsubstituted or substituted with at least one of a halogen, a hydroxyl, an amino group, a sulfonyl group, a sulphonamide group, a thiol, a C1-C6 alkyl, a C1-C6 alkoxy, a C1-C6 ether, a C1-C6 thioether, a C1-C6 sulfone, a C1-C6 sulfoxide, a C1~C6 primary amide, a C1-C6 secondary amide, a halo C1-C6 alkyl, a carboxyl group, a cyano group, a nitro group, a nitroso group, -OC(0)NR'R', -N(R')C(0)NR'R, -N(R')C(0)0-C1-C6 alkyl, C3-C6 cycloalkyl, C3-C6 heterocyclyl, C2-C5 heteroaryl and C6-C10 aryl; wherein each R' is independently selected, from the group consisting of hydrogen and C1-C6 alkyl.

2. A hyperbranched polymer according to Claim 1, in which the diacrylate and first amine components are reacted together to form a first oligomer, the first oligomer and second amine component are reacted together to form a second oligomer, and the second oligomer and four branching monomer are reacted together to form the hyperbranched polymer.

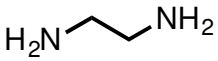
3. A hyperbranched polymer according to Claim 1, in which the four-branching monomer, diacrylate component, and first amine are reacted together in a Michael addition reaction to form a first polymer, and the first polymer and second amine component are reacted together in a Michael addition reaction to form the hyperbranched polymer.

4. A hyperbranched polymer according to any preceding Claim, in which the four-branching monomer is selected from a diamine component, a tetraacrylate component, a tetra acrylamide component, a tetrathiol component, a tetraepoxy component, and a tetra-substituted silane.

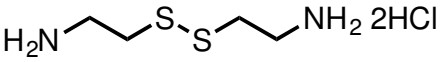
5. A hyperbranched polymer according to Claim 4, in which the four-branching monomer is selected from the group consisting of:



DATA,122, Mw=192.26



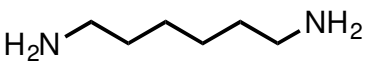
EDA,102, Mw=60



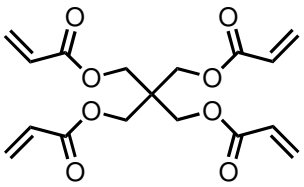
Cystamine, Mw=225.20



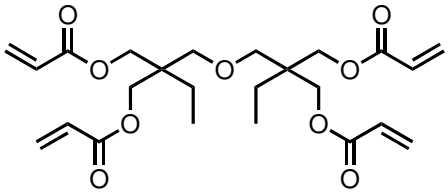
DA,103, Mw=74.13



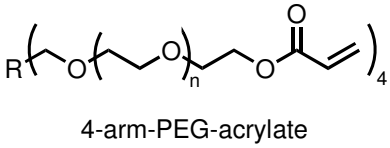
HMDA,106, Mw=116.21



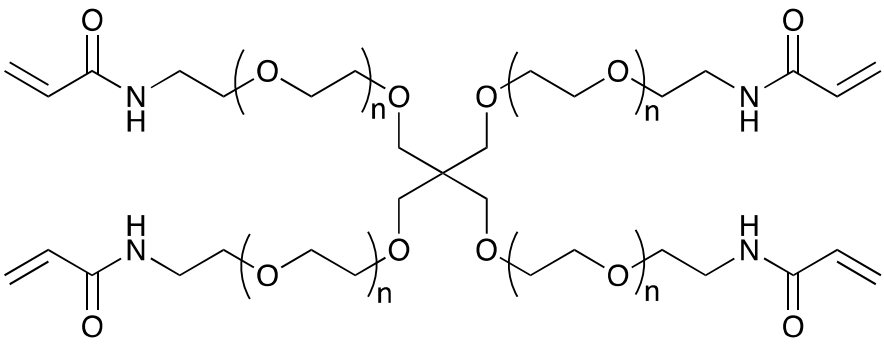
PTTA, Mw=352.34



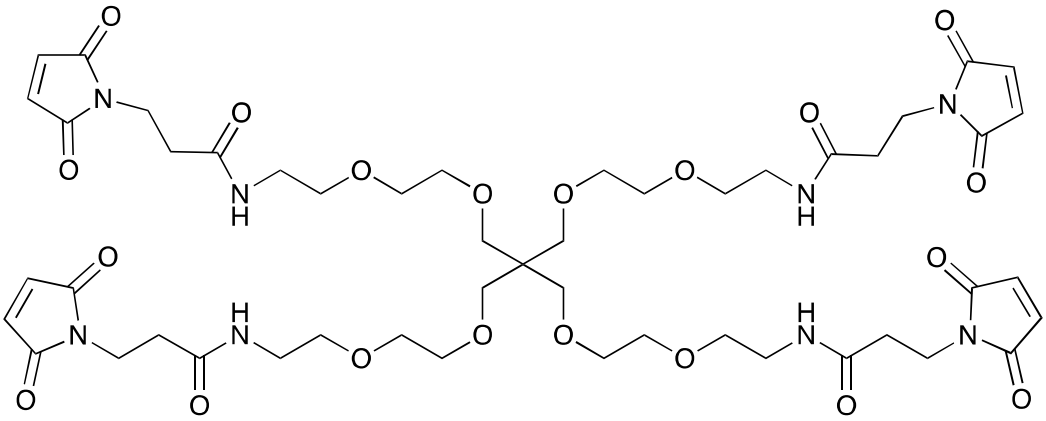
DTTA, Mw=466

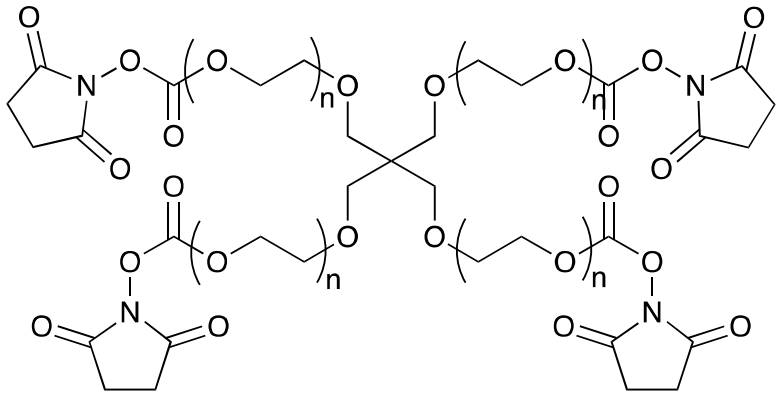


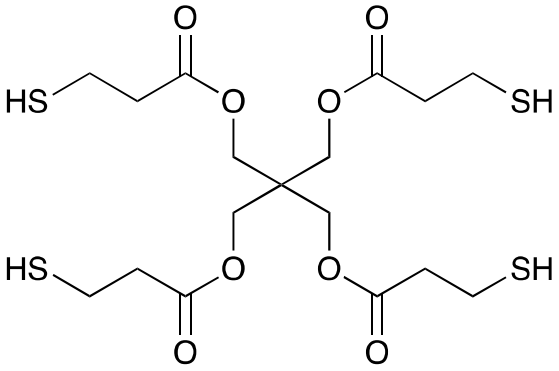
4-arm-PEG-acrylate

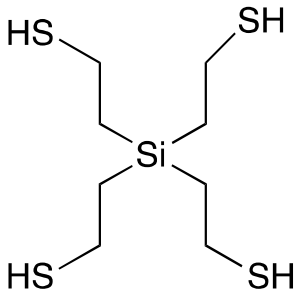


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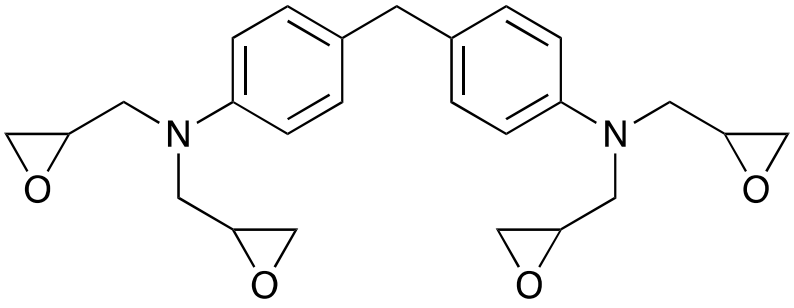


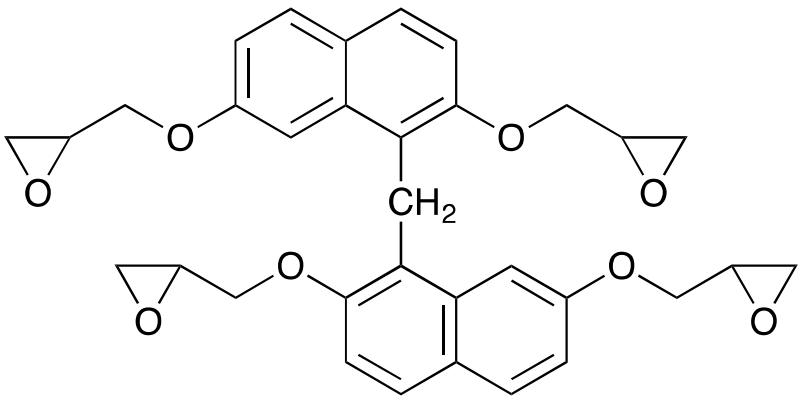


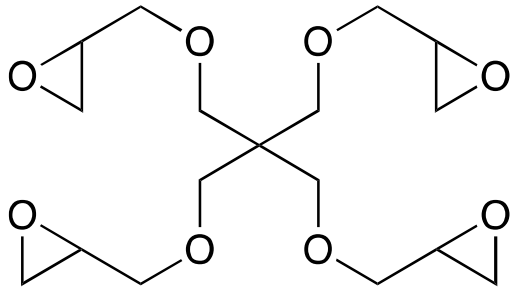


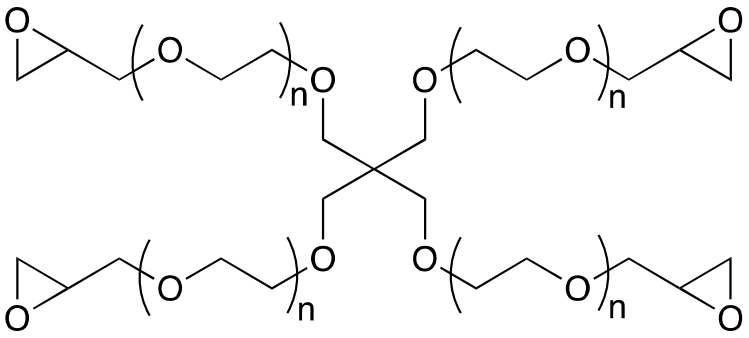


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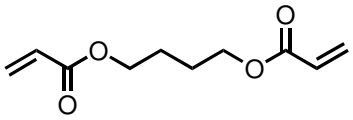




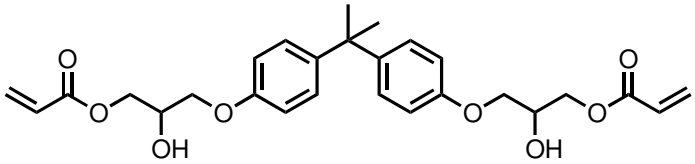


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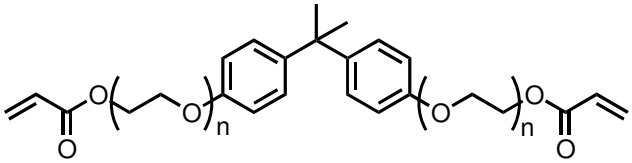
6. A hyperbranched polymer according to any preceding Claim, in which the diacrylate component of formula (I) is selected from



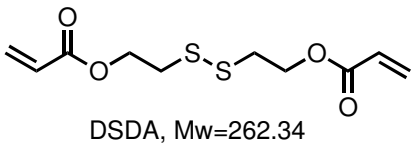
BDA, Mw=198.22



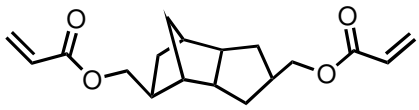
BPGDA, Mw=484.54



BPEDA, E/P=1.5, Mn=468



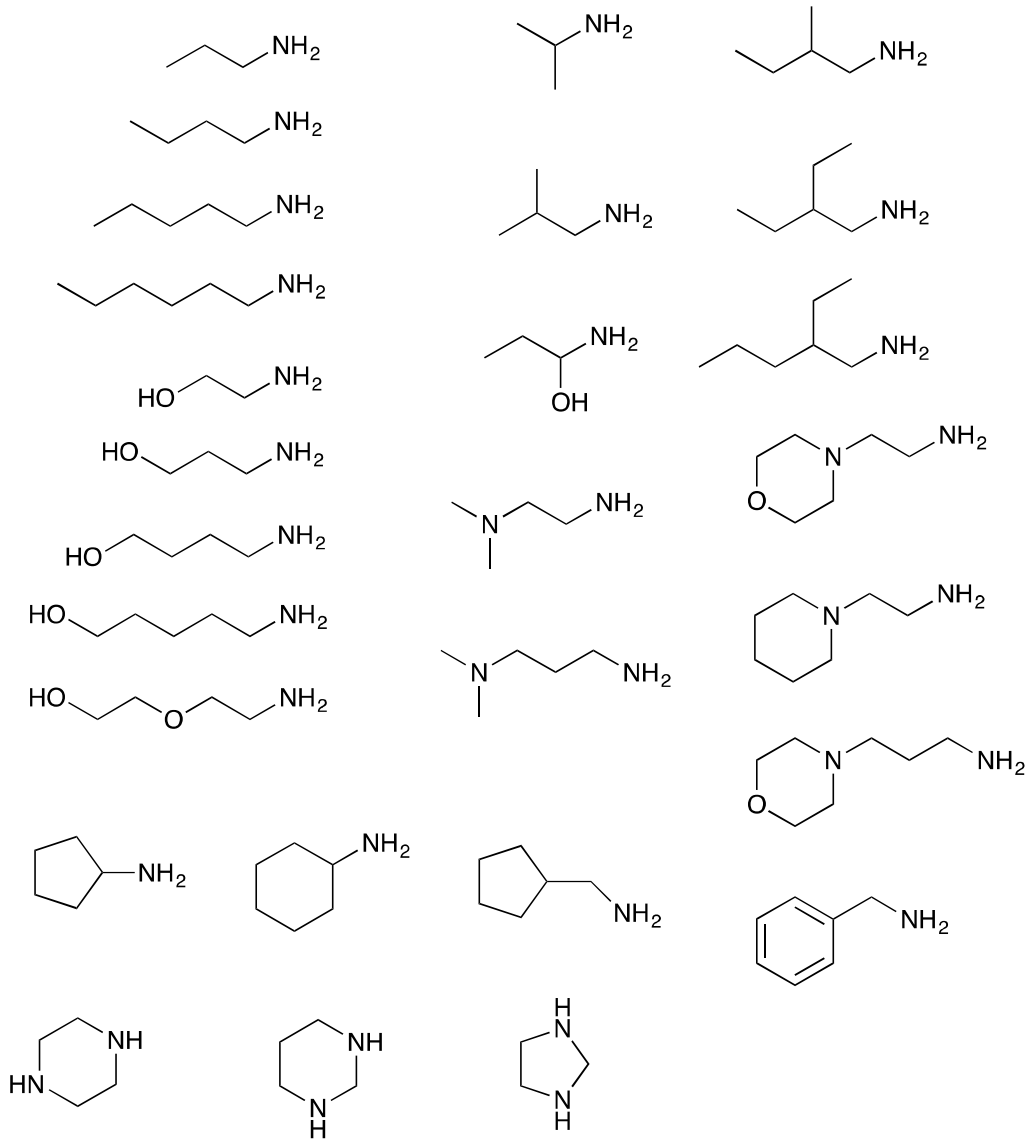
DSDA, Mw=262.34



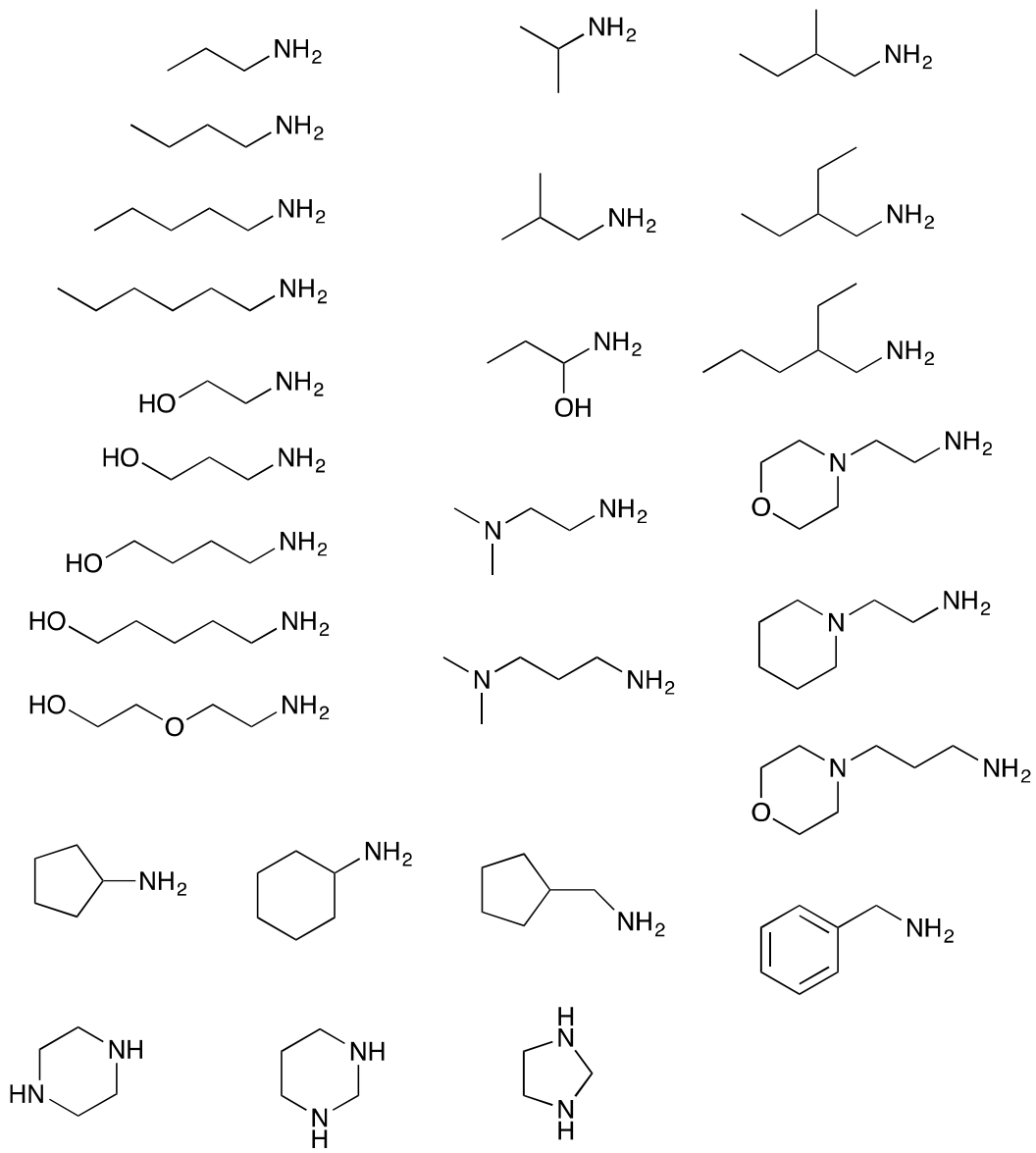
NPGDA, Mw=304.39

10

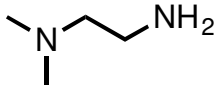
7. A hyperbranched polymer according to any preceding Claim, in which the first amine component is selected from:



8. A hyperbranched polymer according to any preceding Claim, in which the second amine component is a diamine component having a structure NH_2-L_4-NH_2 or is selected from:



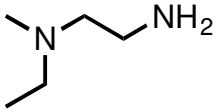
9. A hyperbranched polymer according to any preceding Claim, in which the second amine component is selected from:



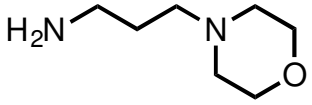
DMDA, Mw=88.15



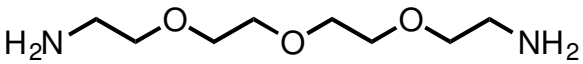
DA,103, Mw=74.13



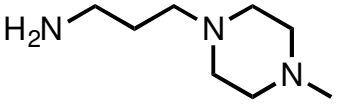
DAP, Mw=102.18



MPA, Mw=144.22



DATA,122, Mw=192.26



E7, Mw=157.26

10. A polyplex composition comprising a hyperbranched polymer of any preceding Claim and a nucleic acid component complexed together.

11. A polyplex composition according to Claim 10, in which the nucleic acid component is selected from a nucleic acid, a nucleic acid expression system, a plasmid, a nanoplasmid, a minicircle, and a ribonucleoprotein gene editing system.

12. A polyplex composition according to Claim 10 or 11, in which the nucleic acid component is a ribonucleoprotein gene editing system.

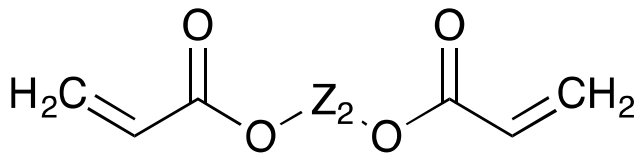
13. A polyplex composition according to any of Claims 10 to 12, in which the composition has a particle size of 100-500 nm.

14. A polyplex composition of any of Claims 10 to 13, for use as a medicament.

15. A method of forming a polymer comprising a step of reacting together:

(i) a four-branching monomer;

(ii) a diacrylate component of formula (I)



(I)

wherein Z2 is a linear or branched carbon chain of 1 to 30 carbon atoms, a linear or branched heteroatom-containing carbon chains of 1 to 30 atoms, a carbocycle containing 3 to 30 carbon atoms, or a heterocycle containing 3 to 30 atoms; wherein Z2 is unsubstituted or substituted with at least one of a halogen, a hydroxyl, an amino group, a sulfonyl group, a sulphonamide group, a thiol, a C1-C6 alkyl, a C1-C6 alkoxy, a C1-C6 ether, a C1-C6 thioether, a C1-C6 sulfone, a C1-C6 sulfoxide, a C1-C6 primary amide, a C1-C6 secondary amide, a halo C1-C5 alkyl, a carboxyl group, a cyano group, a nitro group, a nitroso group, -OC(0)NR'R', -N(R')C(0)NR'R, -N(R')C(0)0-C1-C6 alkyl, C3-C6 cycloalkyl, C3-C6 heterocyclyl, C2-C5 heteroaryl and C6-C10 aryl; wherein each R' is independently selected, from the group consisting of hydrogen and C1-C6 alkyl

(iii) a first amine component comprising 3 to 20 atoms,
wherein said amine component is unsubstituted or substituted with at least one of a halogen, a hydroxyl, an amino group, a sulfonyl group, a sulphonamide group, a thiol, a C1-C6 alkyl, a C1-C6 alkoxy, a C1-C6 ether, a C1-C6 thioether, a C1-C6 sulfone, a C1-C6 sulfoxide, a C1~C6 primary amide, a C1-C6 secondary amide, a halo C1-C6 alkyl, a carboxyl group, a cyano group, a nitro group, a nitroso group, -OC(0)NR'R', -N(R')C(0)NR'R, -N(R')C(0)0-C1-C6 alkyl, C3-C6 cycloalkyl, C3-C6 heterocyclyl, C2-C5 heteroaryl and C6-C10 aryl; wherein each R' is independently selected, from the group consisting of hydrogen and C1-C6 alkyl; and

(iv) a second amine component comprising 3 to 20 atoms,
wherein said amine component is unsubstituted or substituted with at least one of a halogen, a hydroxyl, an amino group, a sulfonyl group, a sulphonamide group, a thiol, a C1-C6 alkyl, a C1-C6 alkoxy, a C1-C6 ether, a C1-C6 thioether, a C1-C6 sulfone, a C1-C6 sulfoxide, a C1~C6 primary amide, a C1-C6 secondary amide, a halo C1-C6 alkyl, a carboxyl group, a cyano group, a nitro group, a nitroso group, -

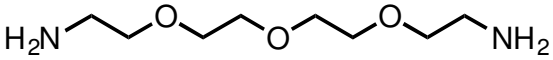
OC(0)NR'R', -N(R')C(0)NR'R, -N(R')C(0)0-C1-C6 alkyl, C3-C6 cycloalkyl, C3-C6 heterocyclyl, C2-C5 heteroaryl and C6-C10 aryl; wherein each R' is independently selected, from the group consisting of hydrogen and C1-C6 alkyl.

16. A method according to Claim 15, in which the diacrylate and first amine components are reacted together to form a first oligomer, the first oligomer and second amine component are reacted together to form a second oligomer, and the second oligomer and four branching monomer are reacted together to form the hyperbranched polymer.

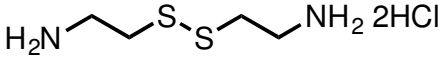
17. A method according to Claim 15, in which the four-branching monomer, diacrylate component, and first amine are reacted together in a Michael addition reaction to form a first polymer, and the first polymer and second amine component are reacted together in a Michael addition reaction to form the hyperbranched polymer.

18. A method according to any of Claims 15 to 17, in which the four-branching monomer is selected from a diamine component, a tetraacrylate component, a tetra acrylamide component, a tetrathiol component, a tetraepoxy component, and a tetra-substituted silane.

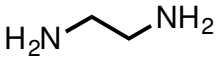
19. A method according to Claim 18, in which the four-branching monomer is selected from the group consisting of:



DATA,122, Mw=192.26



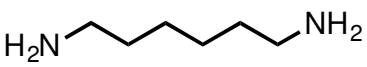
Cystamine, Mw=225.20



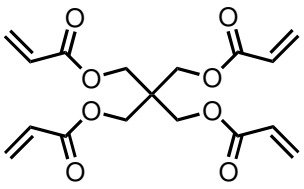
EDA,102, Mw=60



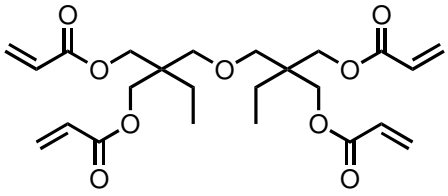
DA,103, Mw=74.13



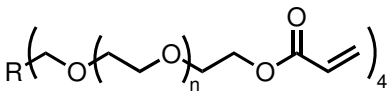
HMDA,106, Mw=116.21



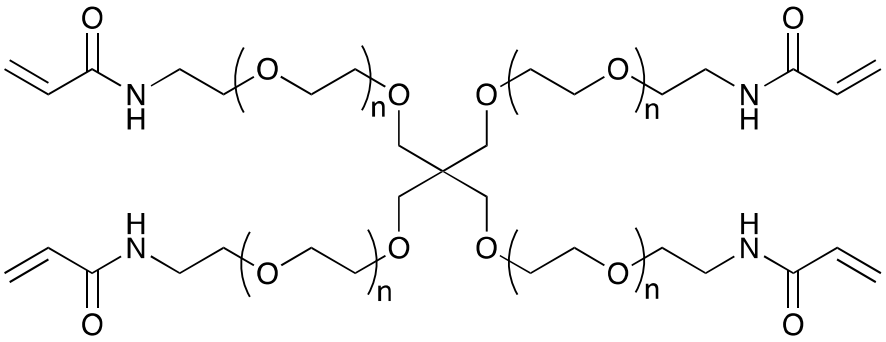
PTTA, Mw=352.34

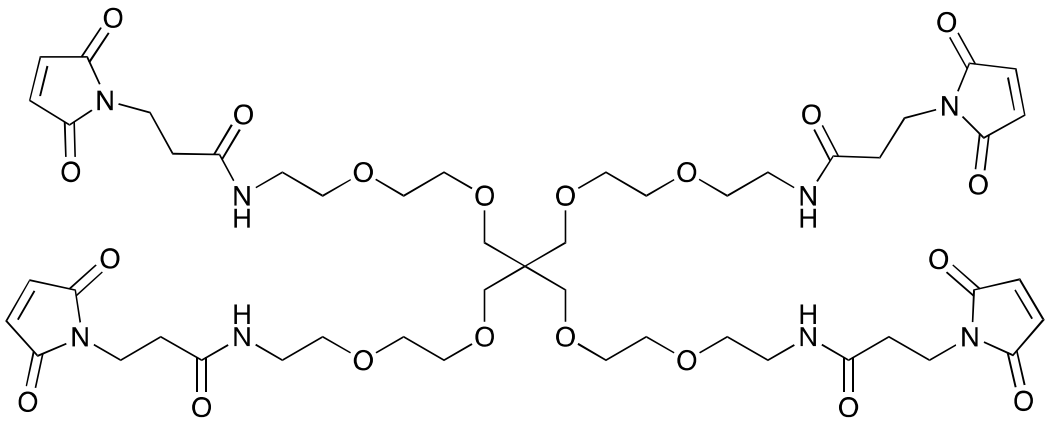


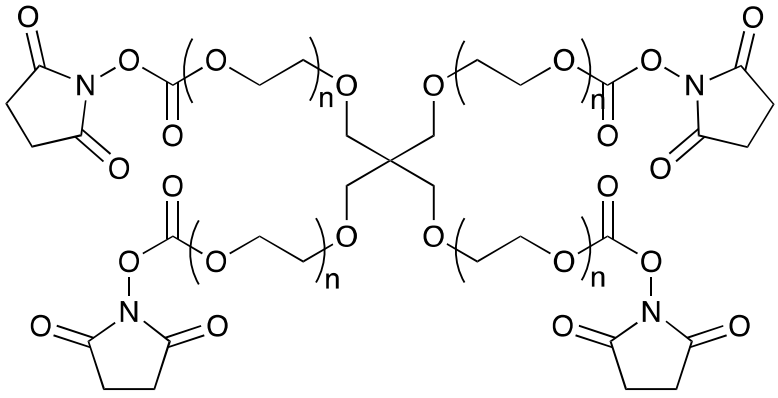
DTTA, Mw=466

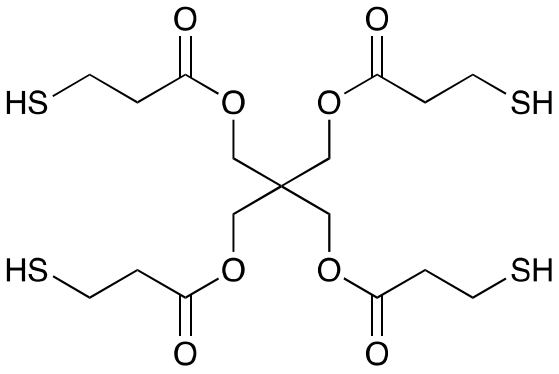


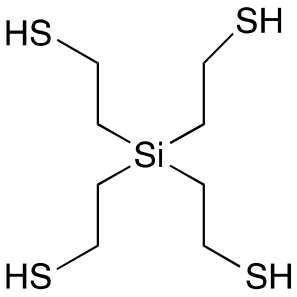
4-arm-PEG-acrylate

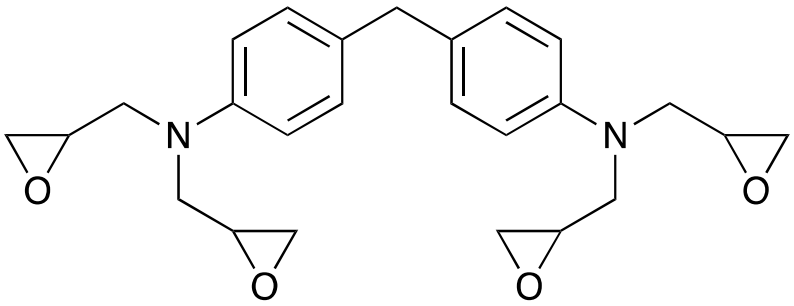


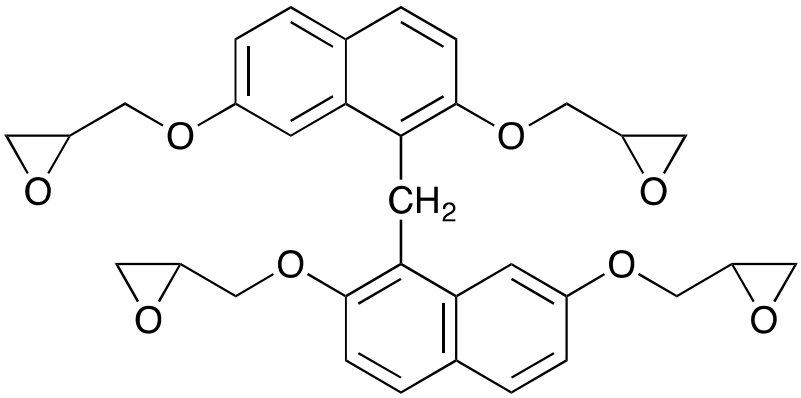


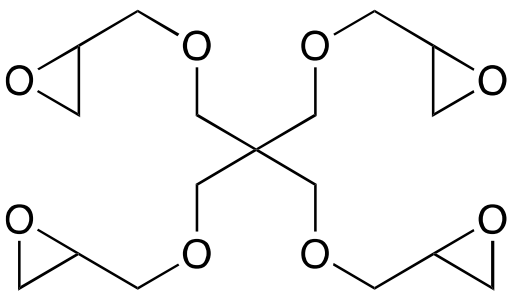


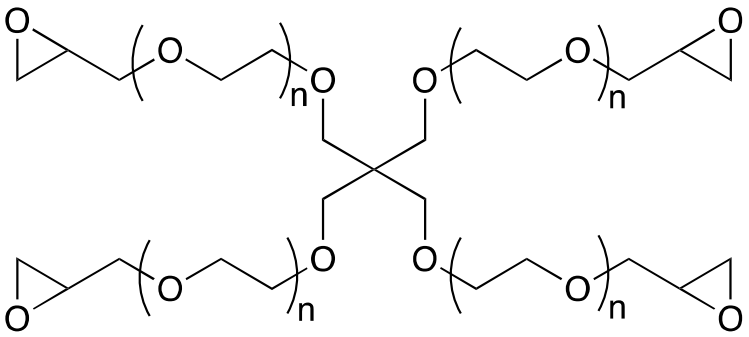




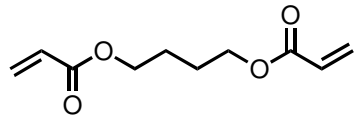




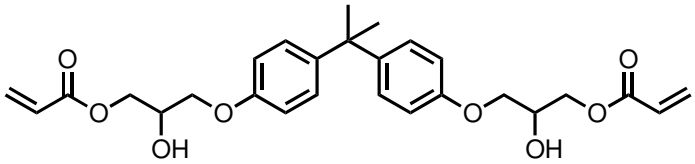




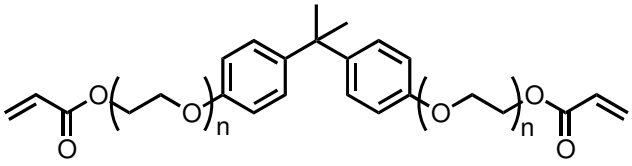
20. A method according to any of Claims 15 to 19, in which the diacrylate component of formula (I) is selected from



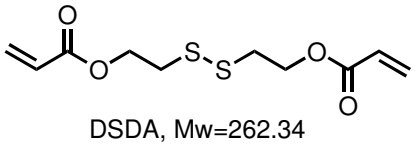
BDA, Mw=198.22



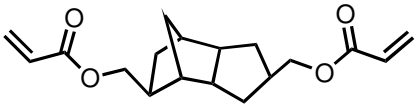
BPGDA, Mw=484.54



BPEDA, E/P=1.5, Mn=468



DSDA, Mw=262.34



NPGDA, Mw=304.39