CLAIMS

What is claimed is:

1. A random polymer having structure (A), comprising,

a styrenic repeat unit of structure **(I)**, wherein R_{m1} is H or a C-1 to C-4 alkyl, R_1 is selected from a H, a C-1 to C-8 alkyl, and a C-1 to C-4 alkyloxy and n1 is the total number of this repeat units; wherein this repeat unit ranges from 10 mole % to 60 mole %, in said copolymer;

a 4-vinylbenzocyclobutene derived repeat unit of structure **(II),** wherein R_{m2} is H or a C-1 to C-4 alkyl, R_2 is H or a C-1 to C-8 alkyl, and n2 is the total number of this repeat units; wherein this repeat unit is from 15 mole % to 35 mole %, in said copolymer;

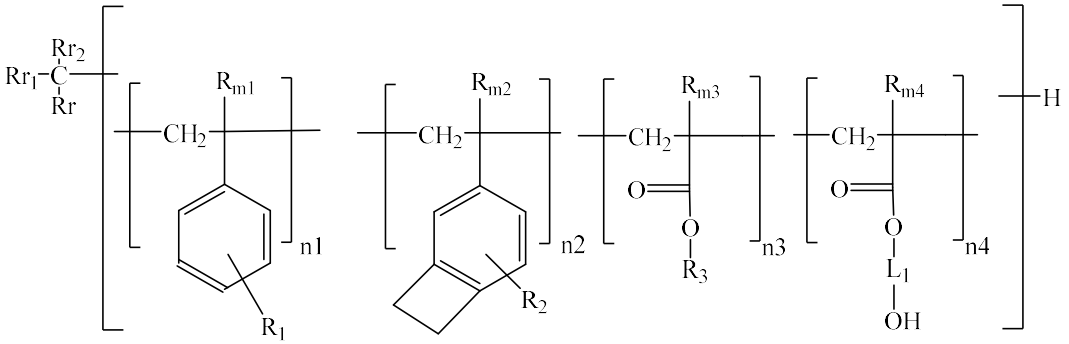
an alkyl acrylate or alkyl 2-methylenealkanoate derived repeat unit of structure (III), wherein R_{m3} is H or a C-1 to C-4 alkyl, R_3 is a C-1 to C-8 alkyl, n3 is the total number of this repeat units; wherein this repeat unit is from 15 mole % to 55 mole % in said copolymer;

a hydroxy substituted acrylate or 2-methylenealkanoate derived repeat unit of structure (IV), wherein R_{m4} is H or a C-1 to C-4 alkyl, R_I is a C-1 to C-8 alkyl, L_1 is a spacer moiety selected from a C-2 to C-12 alkylene spacer and a 1,4-phenylene spacer, wherein said alkylene spacer is selected from the group consisting of a C-2 to C-12 linear alkylene, a C-3 to C-12 branched alkylene, a C-3 to C-12 cyclic alkylene and a C-5 to C-12 alicyclic alkylene, where there is at least a two-carbon atoms between the carbonyl oxy moiety and the OH moiety, and these two moieties are individually attached to said alkylene spacer at different positions which are either a primary or secondary carbon on said alkylene moiety, and where said 1,4-phenylene spacer is one wherein the carboxyl oxy moiety and the OH moiety are in a 1,4 positions with respect to each other, n4 is the total number of this repeat units; wherein this repeat unit is from 1 mole % to 5 mole %, in said copolymer;

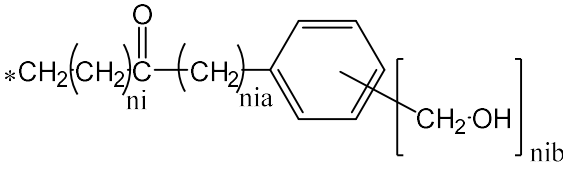
two end groups as shown in structure (A), one of which is H and the other is a methyl moiety substituted with Rr, Rr_1 and Rr_2, wherein Rr_1, is a C-1 to C-8 alkyl, Rr_2 is selected from a C-1 to C-8 alkyl, a C-1 to C-8 alkylene hydroxy moiety (-alkylene-OH), a C-1 to C-8 alkylenecarboxylic acid moiety (-alkylenne-CO_2H), or a benzylic alcohol comprising moiety of structure (B) wherein ni is an integer ranging from 0 to 5, nia is an integer from 1 to 5, nib is an integer from 1 to 5, and "*" designates the attached point of this moiety,

Rr is a cyano moiety (-CN) or a carbonylalkyl moiety (-C(=O)-Ri), wherein Ri is a C-1 to C-8 alkyl or an aryl moiety and further,

wherein the sum of the individual mole % of repeat units of structure (I), (II), (III), and (IV) is either smaller than or equal to 100 mole % of the total repeat units present in said copolymer:



(I) (II) (III) (IV) **(A)**



(B).

2. The copolymer of claim 1, consisting of the repeat units of structures (I), (II), (III) and (IV), where the sum of these repeat units is 100 mole %.

3. The copolymer of claim 1, wherein

said repeat unit of structure (I) is from 13 mole% to 48 mole %,

said repeat unit of structure (II) is from 25 mole % to 35 mole %,

said repeat unit of structure (III) is from 15 mole % to 55 mole %,

said repeat unit of structure (IV), is 1 mole % to 2 mole %, and L_1 is said C-2 to C-12 alkylene spacer, and the sum of individual mole % for the repeat units of structures (I), (II), (III) and (IV) equals 100 mole % of the total repeat units in said copolymer; or

wherein

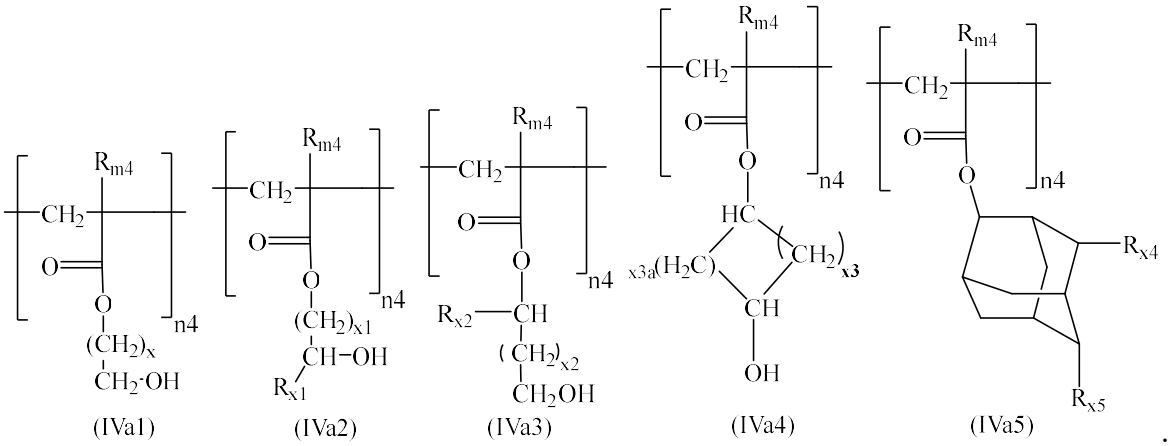
said repeat unit of structure (I) is from 23 mole% to 48 mole %,

said repeat unit of structure (II) is from 25 mole % to 35 mole %,

said repeat unit of structure (III) is from 15 mole % to 45 mole %,

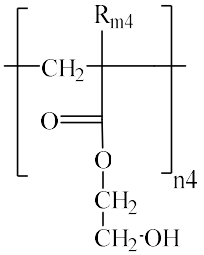
said repeat unit of structure (IV), is from 2 to 5 mole %, and L_1 is a 1,4-phenylene spacer, and further where the sum of individual mole % for the repeat units of structures (I), (II), (III) and (IV) equals 100 mole % of the total repeat units in said copolymer.

4. The copolymer of any one of claims 1 to 3, wherein in the repeat unit of structure (IV), L_1 is said alkylene spacer and is selected from either structure (IVa1), structure (IVa2), structure (IVa3), structure (IVa4) or structure (IVa5), wherein x is an integer from 1 to 11, x1 is an integer from 1 to 8, x2 is an integer from 1 to 8, x3 is an integer from 1 to 2, x3a is an integer from 1 to 3, R_{x1} is a C-1 to C-4 alkyl, R_{x2} is a C-1 to C-4 alkyl, and in the repeat unit of structure (IVa5) only one of substituents R_{x4}, or R_{x5}, is OH, wherein further the remaining other substituents in the repeat unit of structure (IVa5) is H,

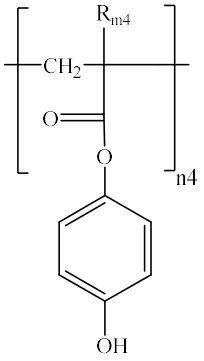


(IVa1) (IVa2) (IVa3) (IVa4) (IVa5)

5. The copolymer of any one of claims 1 to 3, wherein the repeat unit of structure (IV) has structure (IVa) or structure (IVb),

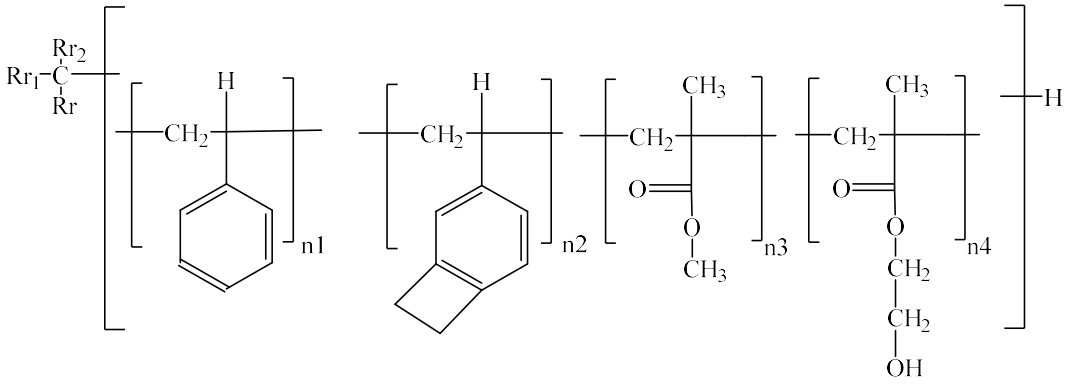


(IVa)

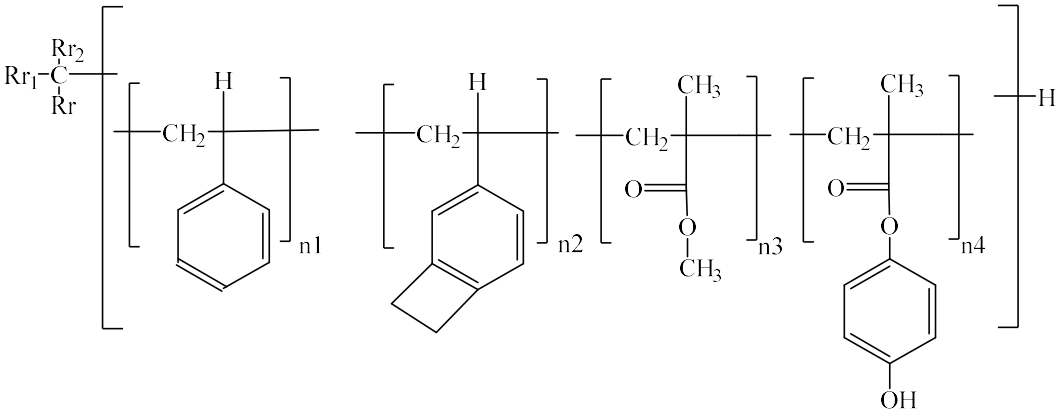


(IVb) .

6. The copolymer of any one of claims 1 to 3, wherein said copolymer has structure (A-1) or structure (A-2),



(Ia) (IIa) (IIIa) (IVc) **(A-1)**



(Ia) (IIa) (IIIa) (IVd) **(A-2).**

7. A composition comprising a copolymer of any one of claims 1 to 3, and an organic spin casting solvent.

8. The composition of claim 7, wherein in said copolymer Rr_2 is said C-1 to C-8 alkyl.

9. The composition of claim 7, wherein in said copolymer Rr_2 is selected from a C-1 to C-8 alkylene hydroxy moiety (-alkylene-OH), a C-1 to C-8 alkylenecarboxylic acid moiety (-alkylenne-CO_2H), and a benzylic alcohol comprising moiety of structure (B).

10. A process for forming a crosslinked or grafted and cross-linked coating of a copolymer on a substrate comprising the steps:

i) forming a coating of a composition of any one of claims 7 to 9 on a substrate,

ii) heating the coating at a temperature from 90°C to 180°C to remove solvent and to form a crosslinked or a grafted and crosslinked coating of the copolymer,

iii) heating the crosslinked or a grafted and crosslinked coating of step ii) from 200°C to 250°C to form a fully cross-linked or fully crosslinked and grafted copolymer coating.

11. The process of claim 10, wherein the process is for forming a crosslinked neutral coating on a substrate and the composition is the composition of claim 8; or wherein the process is for forming a grafted and crosslinked neutral coating on a substrate and the composition is the composition of claim 9.

12. A process for forming a self-assembled block copolymer coating on a neutral coating comprising the steps:

id) forming neutral coating according to claim 10 or 11,

iid) applying a block copolymer over the neutral coating and annealing until directed self-assembly of the block copolymer coating occurs.

13. A process of graphoepitaxy, directed self-assembly of a block copolymer coating used to form an image comprising the steps:

ie) forming neutral coating according to claim 10 or 11,

iie) providing a coating of a photoresist coating over the neutral coating, and forming a pattern in the photoresist coating,

iiie) applying a block copolymer comprising an etch resistant block and a highly etchable block over the photoresist pattern and annealing until directed self-assembly occurs; and,

ive) etching the block copolymer, thereby removing the highly etchable block of the copolymer overcoating areas of the substrate and simultaneously forming a pattern in the substrate selectively in these areas.

14. A process of chemoepitaxy, directed self-assembly of a block copolymer coating used to form an image comprising the steps:

if) forming neutral coating on a substrate according to claim 10 or 11,

iif) providing a coating of a photoresist coating over the neutral coating, and forming a pattern in the photoresist coating, thereby forming regions in which the neutral coating is uncovered by the resist,

iiif) treating the uncovered neutral coating to remove it, forming a pinning area,

ivf) removing the photoresist, uncovering the unaffected neutral coating forming a chemoepitaxy pattern containing neutral and pinning areas,

vf) applying a block copolymer comprising an etch resistant block and a highly etchable block over the neutral coating and annealing until directed self-assembly occurs; and

vif) etching the block copolymer, thereby removing the highly etchable block of the copolymer overcoating areas of the substrate and simultaneously forming a pattern in the substrate selectively in these areas.

15. The use of the random polymer of any one of claims 1 to 3 or of the composition of any one of claims 8 to 9 for forming a coating on a substrate.

16. The copolymer of claim 2, wherein

said repeat unit of structure (I) is from 13 mole% to 48 mole %,

said repeat unit of structure (II) is from 25 mole % to 35 mole %,

said repeat unit of structure (III) is from 15 mole % to 55 mole %,

said repeat unit of structure (IV), is 1 mole % to 2 mole %, and L_1 is said C-2 to C-12 alkylene spacer, and the sum of individual mole % for the repeat units of structures (I), (II), (III) and (IV) equals 100 mole % of the total repeat units in said copolymer; or

wherein

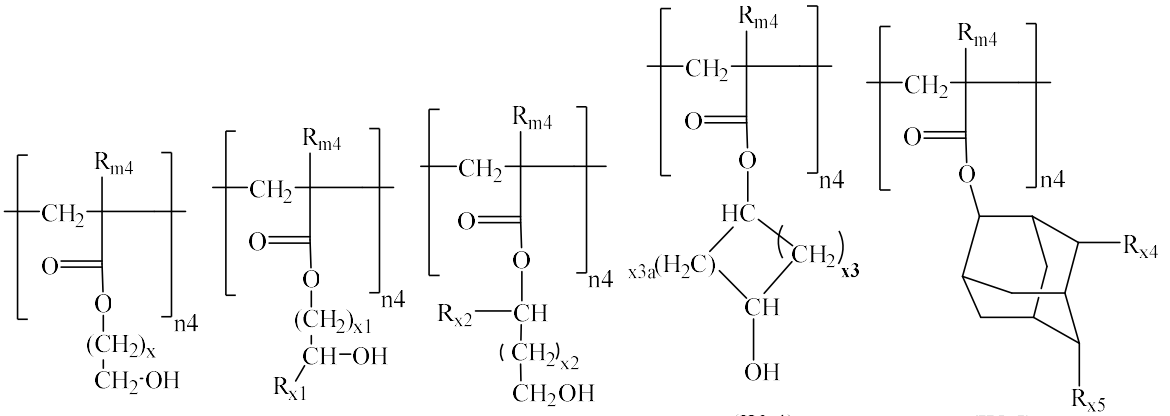
said repeat unit of structure (I) is from 23 mole% to 48 mole %,

said repeat unit of structure (II) is from 25 mole % to 35 mole %,

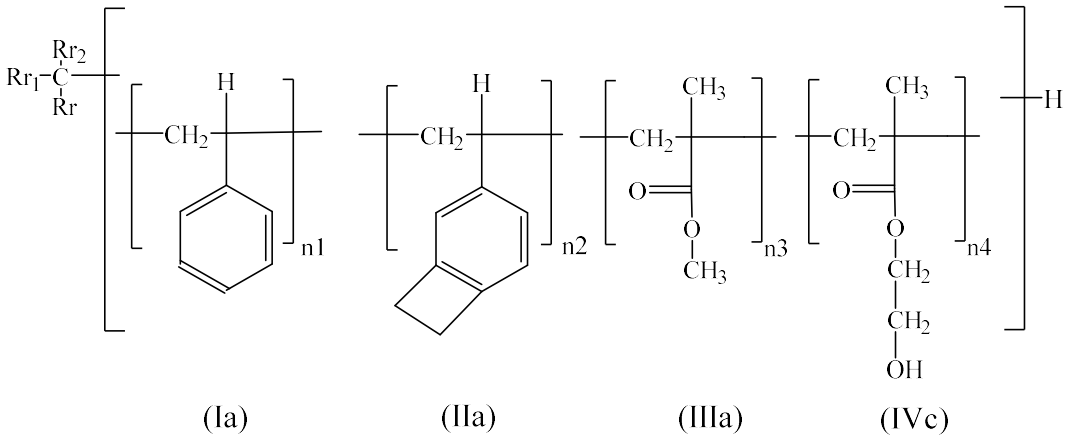
said repeat unit of structure (III) is from 15 mole % to 45 mole %,

said repeat unit of structure (IV), is from 2 to 5 mole %, and L_1 is a 1,4-phenylene spacer, and further where the sum of individual mole % for the repeat units of structures (I), (II), (III) and (IV) equals 100 mole % of the total repeat units in said copolymer.

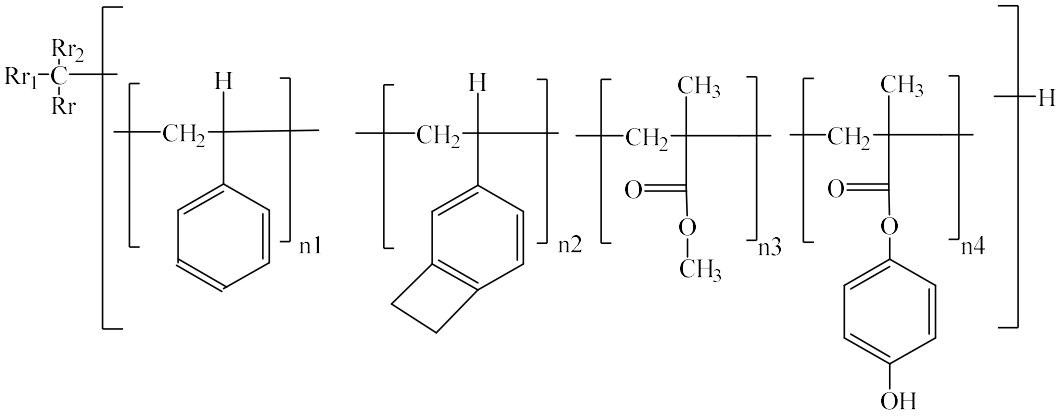
17. The copolymer of claim 4, wherein the repeat unit of structure (IV), L_1 is said alkylene spacer and is selected from either structure (IVa1), structure (IVa2), structure (IVa3), structure (IVa4) or structure (IVa5), wherein x is an integer from 1 to 11, x1 is an integer from 1 to 8, x2 is an integer from 1 to 8, x3 is an integer from 1 to 2, x3a is an integer from 1 to 3, R_{x1} is a C-1 to C-4 alkyl, R_{x2} is a C-1 to C-4 alkyl, and in the repeat unit of structure (IVa5) only one of substituents R_{x4}, or R_{x5}, is OH, wherein further the remaining other substituents in the repeat unit of structure (IVa5) is H,



18. The copolymer of claim 4, wherein wherein said copolymer has structure (A-1) or structure (A-2),



(Ia) (IIa) (IIIa) (IVc) **(A-1)**



(Ia) (IIa) (IIIa) (IVd) **(A-2).**

19. A composition comprising a copolymer of any one of claims 16, 17 or 18, and an organic spin casting solvent.

20. The use of the random polymer of any of claims 16, 17, or 18 or of the composition of claim 7 for forming a coating on a substrate.