CLAIMS

1. A printable shape memory polymer composition for use in fabricating a 4D printed dental aligner, the composition comprising:

a first (meth)acrylate monomer containing one (meth)acrylate functional group selected from the group consisting of benzyl methacrylate, 2-phenoxyethyl methacrylate and 2-hydroxyethyl acrylate;

a second (meth)acrylate monomer containing one (meth)acrylate functional group, and one or more second functional groups selected from the group consisting of hydroxyl, isobornyl and benzyl, which provides reversible non-covalent transient crosslinks to the printable shape memory polymer composition via hydrogen bonding and/or van der Waals interactions;

one or more crosslinkers, containing two or more (meth)acrylate functional groups; and

a photoinitiator,

wherein the printable shape memory polymer composition is responsive to change in temperature at T_g to become flexible, allowing the printable shape memory polymer composition to be shaped and reshaped at temperature T_g, and responsive to change at a temperature higher than T_g but lower than or at 100 °C for resetting the shape of the shape memory polymer.

2. The composition of claim 1, wherein the second (meth)acrylate monomer is selected from the group consisting of isobornyl acrylate (IBOA), isobornyl methacrylate and 2-hydroxyethyl methacrylate.

3. The composition of claim 1, wherein the one or more crosslinkers are selected from the group consisting of polyethylene glycol diacrylate, trimethylolpropane ethoxylate triacrylate (TMPEOTA) and polyethylene glycol dimetacrylate.

4. The composition of claim 1, wherein the photoinitiator is selected from the group consisting of diphenyl(2,4,6-trimethylbenzoyl)phosphine oxide and phenylbis(2,4,6-trimethylbenzoyl)phosphine oxide (BAPO).

5. The composition of claim 1, wherein the composition comprises:

10 to 50 mol% of the first (meth)acrylate monomer;

10 to 50 mol% of the second (meth)acrylate monomer;

20 to 60 mol% of the one or more crosslinkers; and

0.05 to 1.0 mol% of the photoinitiator, based on the total number of moles of the printable shape memory polymer composition.

6. The composition of claim 1, wherein the first (meth)acrylate monomer is benzyl methacrylate, and the second (meth)acrylate monomer is 2-hydroxyethyl methacrylate.

7. The composition of claim 6, wherein the crosslinkers are polyethylene glycol diacrylate and polyethylene glycol dimetacrylate.

8. The composition of claim 7, wherein the photoinitiator is diphenyl(2,4,6-trimethylbenzoyl)phosphine oxide.

9. The composition of claim 1, wherein the temperature T_g ranges from 35 °C to less than 100 °C.

10. A 4D printed dental aligner comprising:

a printable shape memory polymer composition comprising:

a first (meth)acrylate monomer containing one (meth)acrylate functional group selected from the group consisting of benzyl methacrylate, 2-phenoxyethyl methacrylate and 2-hydroxyethyl acrylate;

a second (meth)acrylate monomer containing one (meth)acrylate functional group, and one or more second functional groups selected from the group consisting of hydroxyl, isobornyl and benzyl, which provides reversible non-covalent transient crosslinks to the printable shape memory polymer composition via hydrogen bonding and/or van der Waals interactions;

one or more crosslinkers, containing two or more (meth)acrylate functional groups; and

a photoinitiator,

wherein the printable shape memory polymer composition is responsive to change in temperature at T_g to become flexible, allowing the 4D printed dental aligner comprising the printable shape memory polymer composition to be shaped and reshaped at temperature T_g, and responsive to change at a temperature higher than T_g but lower than or at 100 °C for resetting the shape of the shape memory polymer.

11. The 4D printed dental aligner of claim 10, wherein the second (meth)acrylate monomer is selected from the group consisting of isobornyl acrylate, isobornyl methacrylate and 2-hydroxyethyl methacrylate.

12. The 4D printed dental aligner of claim 10, wherein the one or more crosslinkers are selected from the group consisting of polyethylene glycol diacrylate, trimethylolpropane ethoxylate triacrylate and polyethylene glycol dimetacrylate.

13. The 4D printed dental aligner of claim 10, wherein the photoinitiator is selected from the group consisting of diphenyl(2,4,6-trimethylbenzoyl)phosphine oxide and phenylbis(2,4,6-trimethylbenzoyl)phosphine oxide.

14. The 4D printed dental aligner of claim 10, wherein the printable shape memory polymer composition comprises:

10 to 50 mol% of the first (meth)acrylate monomer;

10 to 50 mol% of the second (meth)acrylate monomer;

20 to 60 mol% of the crosslinker; and

0.05 to 1.0 mol% of the photoinitiator, based on the total number of moles of the printable shape memory polymer composition.

15. The 4D printed dental aligner of claim 10, wherein the first (meth)acrylate monomer is benzyl methacrylate, and the second (meth)acrylate monomer is 2-hydroxyethyl methacrylate, the crosslinkers are polyethylene glycol diacrylate and polyethylene glycol dimetacrylate, and the photoinitiator is diphenyl(2,4,6-trimethylbenzoyl)phosphine oxide.

16. The 4D printed dental aligner of claim 10, wherein the temperature T_g ranges from 35 °C to less than 100 °C.

17. The 4D printed dental aligner of claim 10, wherein the 4D printed dental aligner comprising the printable shape memory polymer composition is programmed to have a first preparation temperature ranging from 35 °C to the T_g of the printable shape memory polymer composition.

18. The 4D printed dental aligner of claim 17, wherein the 4D printed dental aligner comprising the printable shape memory polymer composition is programmed to have a second preparation temperature ranging from 35 °C to the T_g of the printable shape memory polymer composition, but lower than the first preparation temperature, for teeth alignment.

19. The 4D printed dental aligner of claim 10, wherein the 4D printed dental aligner can be shaped and reshaped multiple times.

20. The 4D printed dental aligner of claim 10, wherein the 4D printed dental aligner is configured to accommodate at least 0.5 mm of teeth displacement when in use during first cycle of teeth alignment.

21. The 4D printed dental aligner of claim 10, wherein the 4D printed dental aligner comprising the printable shape memory polymer composition acts as a retainer and is programmed to have a first preparation temperature ranging from 35 °C to the T_g of the printable shape memory polymer composition.

22. The 4D printed dental aligner of claim 21, wherein the 4D printed dental aligner which acts as the retainer is programmed to have a second preparation temperature ranging from 35 °C to the T_g of the printable shape memory polymer composition, but higher than the first preparation temperature, for teeth realignment.

23. The 4D printed dental aligner of claim 22, wherein the 4D printed dental aligner which acts as the retainer is configured to accommodate at least 0.5 mm of teeth displacement when in use during subsequent cycle of teeth alignment.