There is a need to provide a curable composition that overcomes, or at least ameliorates, one or more of the disadvantages described above.

Summary

There is provided a curable composition comprising (i) a resin composition, wherein the resin composition comprises:

a compound C1 having an X group and an optionally substituted aryl group;

a compound C2 having an X group and an optionally substituted carbocyclyl group;

a compound C3 having at least two X groups; and

a photoinitiator,

wherein X is acrylate or methacrylate.

In one aspect of the present disclosure, there is provided a curable composition comprising:

(i) a resin composition, wherein the resin composition comprises:

a compound C1 having an X group and an optionally substituted aryl group;

a compound C2 having an X group and an optionally substituted carbocyclyl group;

a compound C3 having at least three X groups; and

a photoinitiator, and

(ii) a metal oxide,

wherein the curable composition does not contain a photoabsorber, and

wherein X is acrylate or methacrylate.

In another aspect of the present disclosure, there is provided a method of forming a shape memory polymer, the method comprising exposing a curable composition disclosed herein to ultraviolet light.

In a further aspect of the present disclosure, there is provided a shape memory polymer comprising the curable composition disclosed herein, wherein the curable composition has been cured by ultraviolet light.

Advantageously, the curable compositions of the present disclosure allow for fast UV curing into shape memory polymers (SMP). The working temperature of the SMP may be brought closer to body temperature, even after extensive post-treatment is applied. This advantageously makes it easier to trigger its shape memory effect without having to heat the

SMP to high temperatures. Further advantageously, the SMPs may have high recovery ratio of 99% at 40 °C.

In an example, the curable compositions of the present disclosure may further comprise metal oxides, such as zinc oxide. The addition of metal oxide not only speeds up the curing process, it also helps to improve the print quality of the product by reducing flashes. It also provides slight improvement in the mechanical properties at both room temperature and body temperature.

The addition of metal oxide also advantageously reduces the amount of energy needed to cure a layer of resin, while preventing excessive unwanted cure during the printing process. In addition, the inclusion of metal oxide increases the toughness of the material, with some compromise on the tensile strength and Young's Modulus.

Also advantageously, the curable compositions of the present disclosure do not contain photoabsorbers, such as 1-phenylazo-2-naphthol (Sudan I), 1-[4-(phenylazo)phenylazo]-2-naphthol (Sudan III), and $C_{28}H_{31}ClN_2O_3$ (Rhodamine B). Although they can be used to reduce the cure depth (thus preventing unwanted cure due to excessive UV exposures), photoabsorbers tend to also increase the critical energy of the resin, which the minimum amount of energy needed for the resin to start curing. This could result in longer exposure time, as well as the overall printing time, hence they are undesirable.

Claims

1. A curable composition comprising:

(i) a resin composition, wherein the resin composition comprises:

a compound C1 having an X group and an optionally substituted aryl group;

a compound C2 having an X group and an optionally substituted carbocyclyl group;

a compound C3 having at least three X groups; and

a photoinitiator, and

(ii) a metal oxide,

wherein the curable composition does not contain a photoabsorber, and

wherein X is acrylate or methacrylate.

2. The curable composition of claim 1, wherein the optionally substituted aryl group of compound C1 is an unsubstituted C_{6-12} aryl group.

3. The curable composition of claim 1 or 2, wherein compound C1 is 2-phenoxyethyl acrylate (2PA).

4. The curable composition of any one of claims 1 to 3, wherein the optionally substituted carbocyclyl group of compound C2 is substituted C_3 to C_{12} carbocyclyl group.

5. The curable composition of any one of claims 1 to 4, wherein the optionally substituted carbocyclyl group of compound C2 is substituted with at least one alkyl group.

6. The curable composition of any one of claims 1 to 5, wherein compound C2 is isobornyl acrylate (IBOA).

7. The curable composition of any one of claims 1 to 6, wherein compound C3 has at least three acrylate groups.

8. The curable composition of any one of claims 1 to 7, wherein compound C3 is trimethylolpropane ethoxylate triacrylate (TMPEOTA).

9. The curable composition of any one of claims 1 to 8, wherein the photoinitiator is bis (2, 4, 6-trimethylbenzoyl) phosphine oxide (BAPO) or diphenyl 2,4,6-trimethylbenzoyl phosphine oxide.

10. The curable composition of any one of claims 1 to 9, wherein the metal of the metal oxide is selected from the group consisting of aluminium, magnesium, chromium, iron, cobalt, nickel, and zinc.

11. The curable composition of any one of claims 1 to 10, wherein the metal oxide is in the form of nanoparticles.

12. The curable composition of claim 11, wherein the nanoparticles have a particle size less than about 100 nm.

13. The curable composition of any one of claims 1 to 12, wherein the metal oxide is zinc oxide.

14. The curable composition of any one of claims 1 to 13, wherein the resin composition comprises about 40 wt% to about 50 wt% of compound C1, based on the total weight of the resin composition.

15. The curable composition of any one of claims 1 to 14, wherein the resin composition comprises about 30 wt% to about 45 wt% of compound C2, based on the total weight of the resin composition.

16. The curable composition of any one of claims 1 to 15, wherein the resin composition comprises about 15 wt% to about 25 wt% of compound C3, based on the total weight of the resin composition.

17. The curable composition of any one of claims 1 to 16, wherein the weight ratio of resin composition to metal oxide is about 200:1 to about 5:1.

18. A method of forming a shape memory polymer, the method comprising exposing a curable composition of any one of claims 1 to 17 to ultraviolet light.

19. A shape memory polymer comprising the curable composition of any one of claims 1 to 17, wherein the curable composition has been cured by ultraviolet light.