BRIEF SUMMARY OF THE DISCLOSURE

[0008] The present disclosure surprisingly provides processes to prepare three dimensional printed ("3D") parts with a reduced need for washing of the part as well as providing a 3D part that is cured and/or has as surface that has been treated to provide surface modification of the 3D part.

[0008a] According to an aspect of the present disclosure, there is provided a process to cure and/or modify a three dimensional (3D) printed part including the steps: providing a three dimensional printed part containing reactive moieties, and immersing the three dimensional (3D) printed part containing reactive moieties into a liquid bath to effect polymerization of the reactive moieties and change the degree of polymerization of the 3D printed part, characterized in that the process further comprises adding a reactive molecule to the liquid bath to react with the three dimensional (3D) printed part, wherein adding the reactive molecule to the liquid bath preferably includes adding the reactive molecule to react with the surface of the three dimensional (3D) printed part, and wherein the reactive molecule either is an acrylate, methacrylate, vinyl containing group, olefin, or a thiol containing group or includes a siloxane group, a fluorinated group, or a hydroxyl group.

[0009] For example, in one embodiment, a process to cure and/or modify the surface of a three dimensional (3D) printed part comprises the steps of immersing a 'green' three dimensional (3D) printed part containing reactive moieties into liquid bath at an elevated temperature to effect the degree of polymerization of the reactive moieties within the 3D printed part to provide a cured 3D printed part. In another embodiment, the liquid bath can contain molecules with reactive moieties which can react with the surface of the 3D printed part. For example, radical initiated polymerization, can occur between the reactive moiety of the 3D printed part and the reactive molecule. Generally, an initiator or other reactive group is present in and/or at the surface of the 3D printed part which is responsible for the additional curing process and the reactivity with the dispersed reactive molecules at the part's surface. The initiator can be a photo-initiator or thermal initiator. The initiation can come from a thermally activated catalyst. The initiation can come from a thermally cleavable group or the product of a decomposition mechanism. In some aspects, the remaining initiator in the bulk of the part and/or at the surface of the part can be referred to as residual initiator.

[0010] Thus, as an example, rapid curing of parts produced by 3D printing techniques which utilize either photo-initiated or thermally-initiated polymerization reactions are disclosed herein. The processes described herein help reduce surface tack (number of dangling bonds) of resultant 3D parts and can be used to add additional chemical coatings which modify the touch and/or feel of the final part.

CLAIMS

What is claimed is:

1. A process to cure and/or modify a three dimensional (3D) printed part comprising the steps:

providing a three dimensional printed part containing reactive moieties, and

immersing the three dimensional (3D) printed part containing reactive moieties into a liquid bath to effect polymerization of the reactive moieties and change the degree of polymerization of the 3D printed part,

characterized in that the process further comprises adding a reactive molecule to the liquid bath to react with the three dimensional (3D) printed part, wherein adding the reactive molecule to the liquid bath preferably includes adding the reactive molecule to react with the surface of the three dimensional (3D) printed part, and wherein the reactive molecule either is an acrylate, methacrylate, vinyl containing group, olefin, or a thiol containing group or includes a siloxane group, a fluorinated group, or a hydroxyl group.

2. The process of claim 1, wherein providing the 3D printed part includes washing the 3D printed part with a solvent.

3. The process of claim 1, wherein the liquid bath has a temperature within the range of ~~about~~ 30º C to ~~about~~ 300º C and immersing include subjecting the 3D printed part to the liquid bath for a period within the range of ~~about~~ 1 minute to ~~about~~ 24 hours.

4. The process of claim 1, wherein the liquid bath is a poor solvent having passed the polymer/solvent theta point for causing polymeric collapse.

5. The process of claim 1, wherein immersing includes changing the temperature of the liquid bath between a first temperature and a second temperature.

6. The process of claim 5, wherein the second temperature of the liquid bath is greater than the first temperature and is less than the heat deflection temperature of the 3D printed part.

7. The process of claim 5, wherein the 3D printed part is within the liquid bath during changing of the temperature of the liquid bath between the first and second temperatures.

8. The process of claim 5, wherein changing the temperature of the liquid bath between the first and second temperature includes at least one period of linear change.

9. The process of claim 5, wherein changing the temperature of the liquid bath between the first and second temperature includes at least one period of non-linear change.

10. The process of claim 5, wherein changing the temperature of the liquid bath between a first temperature and a second temperature includes at least one step-wise period providing no change in temperature.

11. The process of claim 1, wherein the 3D printed part with reactive moieties is formed from a thermo-set or a photo-set resin comprising an acrylic resin, a methacrylic resin, a silicone resin, a fluororesin, a styrene resin, a polyolefin resin, a thermoplastic elastomer, a polyoxyalkylene resin, a polyester resin, a polyvinyl chloride resin, a polycarbonate resin, a polyphenylene sulfide resin, a cellulose resin, a polyacetal resin, a melamine resin, a polyurethane resin or a polyamide resin.

12. The process of claim 1, wherein the reactive moieties include one or more crosslinking reactive moieties selected from the group acrylate, methacrylate, olefin, dithiol, diol, methoxysilane, ethoxysilane, and sulfide.

13. The process of claim 1, wherein the liquid bath is a silicone oil bath, an aqueous glycol bath, a fluorinated polyether bath, an aqueous DMSO bath, or a DMSO bath.

14. The process of claim 1, wherein the 3D printed part includes at least one of a UV stabilizer and a UV blocker.

15. The process of claim 1, wherein a thermal initiator is present in and/or on the three dimensional printed part containing reactive moieties.

16. The process of claim 15, wherein the thermal initiator has an activation temperature of with the range of ~~about~~ 50 to ~~about~~ 140 °C.

17. The process of claim 15, wherein immersing includes changing the temperature of the liquid bath between a first temperature and a second temperature, wherein the second temperature of the liquid bath is greater than the first temperature and is less than the heat deflection temperature of the 3D printed part, and the activation temperature of the initiator is within the first and second temperatures.

~~18. The process of any of claims 1 through 17, further comprising adding a reactive molecule to the liquid bath to react with the three dimensional (3D) printed part.~~

~~19. The process of claim 18, wherein adding the reactive molecule to the liquid bath includes adding the reactive molecule to react with the surface of the three dimensional (3D) printed part.~~

~~20. The process of claim 18, wherein the reactive molecule is an acrylate, methacrylate, vinyl containing group, olefin, or a thiol containing group.~~

~~21. The process of claim 18, wherein the reactive molecule includes a siloxane group, a fluorinated group, or a hydroxyl group.~~

~~22~~18. The process of claim 1, wherein providing includes providing the three dimensional printed part having a cure percentage within the range of ~~about~~ 20% to ~~about~~ 80%.

~~23~~19. The process of claim 1, further comprising subjecting the three dimensional printed part to UV light treatment during a period including at least one of prior to immersing, during immersing, and after immersing.

20. The process according to any one of claims 1 to 19, wherein the reactive moieties are polymeric resins that retain some unreacted portion(s) of the monomers, or remaining monomer itself, used to prepare a polymeric resin so that the polymeric resin, which forms the 3D printed part, is not fully cured to 100% of all potential reactive sites.