

CLAIMS

What is claimed as new and desired to be protected by Letters Patent of the United States is:

1. A composition useful in forming a structure comprising a substantially interconnected vascular network, the composition comprising a powder including a carbohydrate powder and an anti-caking agent, wherein the powder:
 - has a granular form, and
 - has a specific energy of less than 6 millijoules per milliliter (mJ/mL).
2. The composition of claim 1, wherein the carbohydrate powder comprises at least one of dextran or isomalt.
3. The composition of claim 1 or claim 2, wherein
 - the anti-caking agent comprises at least one of cornstarch, silicon dioxide, or xanthan gum.
4. The composition of any one of claims 1-3, wherein:
 - the powder is configured to be a free-flowing powder, and
 - the powder has a maximum particle size of 250 micrometers (μm) or less.
5. A three-dimensional structure comprising the composition of any one of claims 1-3.
6. The three-dimensional structure of claim 4, further comprising a surface coating comprising a hydrophobic polymer.
7. The three-dimensional structure of claim 4, wherein the powder has been fused together into a solid, contiguous filament using a laser.
8. The three-dimensional structure of Claim 4, wherein the powder has been fused together into a solid, filament network using a laser.
9. The three-dimensional structure of any one of claims 4-7, wherein the structure has undergone a surface smoothing using a smoothing solution.
10. The three-dimensional structure of any one of claims 4-8, wherein a smoothed structure has been subsequently coated in a hydrophobic polymer.
11. A structure comprising a substantially interconnected vascular network, comprising:
 - a matrix material through which a structural material is disposed; wherein
 - the structural material is capable of dissolving or degrading in water, and
 - the structural material is formed from a powder that is fused into a solid when irradiated with an energy beam,

wherein the powder:

has a granular form, and

has a specific energy of less than 6 mJ/mL.

12. The structure of claim 11, wherein the powder has been fused together into a solid, contiguous filament using a laser.
13. The structure of claim 11, wherein the powder has been fused together into a solid, contiguous three-dimensional filament network using a laser.
14. The structure of any one of claims 11-13, wherein a surface of the structure has smooth topography.
15. The structure of any one of claims 11-14, wherein the powder further comprises an anti-caking agent.
16. The structure of any one of claims 11-15, wherein the structural material comprises at least one carbohydrate.
17. The structure of any one of claims 11-16, wherein the structural material comprises at least one of dextran or isomalt.
18. The structure any one of claims 11-17, wherein
the structural material comprises at least one of photoresist, agarose, gelatin, carbohydrates, sucrose, glucose, fructose, lactose, isomalt, dextran, cellulose, methylcellulose, poly(lactic acid), or poly(ethylene glycol).
19. The structure of claim 15, wherein
the anti-caking agent comprises one or more materials that improve at least one of flow, friction characteristics, or particle packing of the structural material.
20. The structure of any one of claim 15 or claim 19, wherein
the anti-caking agent comprises at least one of cornstarch, silicon dioxide, or xanthan gum.
21. The structure of any one of claims 11-20, wherein a particle size of the powder is 250 μm diameter or less.
22. The structure of any one of claims 11-21, wherein a surface of the structure has a hydrophobic coating.
23. The structure of claim 22, wherein
the hydrophobic coating comprises at least one of polycaprolactone, poly(L-lactide), polylactic acid, poly(lactic co-glycolic acid), collagen, gelatin, zein, shellac, starch, wax, or petroleum jelly.

24. The structure of any one of claims 11-23, wherein
the matrix material comprises at least one of polyamide, poly(2-hydroxy ethyl methacrylate), poly(vinyl alcohol), polyacrylamide, poly(ethylene glycol), a polyurethane, collagen, agarose, albumin, alginate, chitosan, starch, hyaluronic acid, gelatin, fibrin, matrigel, glycerol, glycol, mannitol, inositol, xylitol, adonitol, glycine, arginine, biological polymeric molecules, or peptide amphiphiles, or monomers, dimers, or oligomers thereof.
25. The structure of any one of claims 11-24,
wherein the powder is configured to be a free-flowing powder.
26. A method of forming a substantially interconnected vascular network, comprising:
solidifying a powder by fusing with an energy beam to form a filament network; wherein
the filament network comprises a plurality of filaments and defines a void space, and
the plurality of filaments is capable of dissolving or degrading in water;
backfilling the void space of the filament network with a matrix material; and
removing the filaments to form the substantially interconnected vascular network comprising fluidic channels.
27. The method of claim 26, wherein
the matrix material is an aqueous solution comprising a biomaterial.
28. The method of claim 27, further comprises crosslinking the biomaterial to form a hydrogel in the void space.
29. The method of any one of claims 26-28, wherein
the powder comprises a carbohydrate powder and an anti-caking agent, wherein the powder:
has a granular form, and
has a specific energy of less than 6 mJ/mL, and
the energy beam is a laser.
30. The method of any one of claims 26-29, further comprising:
surface smoothing the plurality of filaments with a smoothing solution, wherein
the surface smoothing otherwise does not alter an architecture of the filaments.
31. The method of claim 30, wherein

- the smoothing solution comprises at least one of isomalt, dextran, sucrose, glucose, lactose, trehalose, maple syrup, or sugar cane syrup.
32. The method of any one of claims 26-31, further comprising:
- surface coating the plurality of filaments with a surface coating material, wherein:
 - the surface coating material does not backfill the void space, and
 - the matrix material and the surface coating material are different materials.
33. The method of claim 32, wherein
- the surface coating material comprises at least one of polycaprolactone, poly(L-lactide), polylactic acid, poly(lactic co-glycolic acid), collagen, gelatin, zein, shellac, a starch, wax, or petroleum jelly.
34. The method of any one of claims 26-33, wherein the filament network is disposed in a three-dimensionally branched pattern.
35. The method of any one of claims 26-34, wherein the filament network is disposed in an interpenetrating geometry.
36. The method of any one of claims 26-35, wherein the filaments are configured in an unsupported geometry during fabrication.
37. The method of any one of claims 26-36, wherein removing the filaments is performed by dissolution or degradation.
38. The method of claim 27, wherein the aqueous solution further comprises a suspension of living cells and wherein the step of removing the filaments does not damage the living cells.
39. The method of claim 27, wherein
- the matrix material is a crosslinked biomaterial, and the biomaterial comprises at least one of polyamide, poly(2-hydroxy ethyl methacrylate), poly(vinyl alcohol), polyacrylamide, poly(ethylene glycol), a polyurethane, collagen, agarose, albumin, alginate, chitosan, starch, hyaluronic acid, gelatin, fibrin, matrigel, glycerol, glycol, mannitol, inositol, xylitol, adonitol, glycine, arginine, biological polymeric molecules, or peptide amphiphiles, or monomers, dimers, or oligomers thereof.
40. The method of any one of claims 26-39, wherein:
- the powder is configured to be a free-flowing powder, and
 - the powder has a maximum particle size of 250 μm or less.