

Claims

1. A substrate comprising:
 (c) keratin derivative; and
 (d) natural biopolymer,
 5 wherein the keratin derivative and natural biopolymer are crosslinked.
2. The substrate of claim 1, wherein the keratin derivative is selected from the group
 consisting of keratin intermediate filament protein, kerateine, keratose, and
 combinations thereof.
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3. The substrate of claim 1 or 2, wherein the keratin derivative is derived from any human
 and/or animal source selected from the group consisting of hair, nail, wool, fur, horn,
 hoof, feather, scales, and combinations thereof.
- 15 4. The substrate of any one of the preceding claims, wherein the natural biopolymer is a
 modified natural biopolymer.
5. The substrate of any one of the preceding claims, wherein the natural biopolymer or
 modified natural biopolymer comprises hydroxyl, amine, carboxyl, thiol, aldehyde,
 20 and/or methacrylate groups.
6. The substrate of any one of the preceding claims, wherein the natural biopolymer is
 selected from the group consisting of cellulose, modified cellulose, nanocellulose,
 modified nanocellulose, chitosan, modified chitosan, chitin, modified chitin, collagen,
 25 modified collagen, fibrinogen, modified fibrinogen, polysaccharide, modified
 polysaccharide, starch, modified starch, alginate, modified alginate, silk fibroin,
 modified silk fibroin, sericin, modified sericin, pullulan, modified pullulan, and
 combinations thereof.
- 30 7. The substrate of claim 6, wherein the nanocellulose is selected from the group
 consisting of cellulose nanocrystals, modified cellulose nanocrystals, cellulose
 nanofibrils, modified cellulose nanofibrils, bacterial nanocellulose, and modified
 bacterial nanocellulose.
- 35 8. The substrate of any one of the preceding claims, wherein the molecular weight of the
 keratin derivative is about 40 kDa to about 60 kDa.
9. The substrate of any one of the preceding claims, comprising about 0.5 wt% to about
 2.0 wt% keratin derivative, based on the total weight of the substrate.
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10. The substrate of any one of the preceding claims, comprising about 0.25 wt% to about
 1.0 wt% natural biopolymer, based on the total weight of the substrate.
- 45 11. The substrate of any one of the preceding claims, wherein the weight percentage ratio
 of keratin derivative to natural biopolymer is about 5:1 to about 5:3.

12. The substrate of any one of the preceding claims, wherein the substrate further comprises:
(c) micronutrients, macronutrients, pesticides and/or bioactives.
- 5 13. The substrate of claim 12, wherein the micronutrient is selected from the group consisting of metal oxides, metal salts, silica, carbon dots, and combinations thereof.
- 10 14. The substrate according to claim 12, wherein the bioactive is selected from the group consisting of biomolecules, antimicrobial agents, omega 3, folic acid, boron and calcium.
- 15 15. The substrate of claim 13, wherein the metal is selected from the group consisting of zinc, copper, iron, magnesium, manganese, titanium, molybdenum, cobalt, nickel, silver, gold and combinations thereof.
16. The substrate of any one of claims 12-14, wherein the micronutrients are particulates with an average diameter of about 1 nm to about 500 nm.
- 20 17. The substrate of any one of claims 12-15, wherein the concentration of the micronutrient, pesticide or bioactive, when present, in the substrate is independently about 0.005 mg/ml to about 1.0 mg/ml, and the concentration of the macronutrient, when present, in the substrate is about 1 mg/ml to about 50 mg/ml .
- 25 18. The substrate of any one of the preceding claims, wherein the substrate has a pore size of about 100 μm to about 200 μm .
19. The substrate according to anyone of the preceding claims, wherein the substrate comprises:
(i) keratin intermediate filament protein;
30 (ii) cellulose nanofibrils; and
(iii) particulate micronutrients selected from the group consisting of metal oxides, metal salts, silica, carbon dots, and combinations thereof,
wherein the metal is selected from the group consisting of zinc, copper,
iron, magnesium manganese, titanium, molybdenum, cobalt, nickel,
35 silver, gold and combinations thereof.
20. A method of forming a substrate of any one of the preceding claims, wherein the method comprises:
(i) mixing a solution of keratin derivative with a solution of natural biopolymer;
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(ii) drying the resulting solution of step (i) to obtain the substrate.
21. The method of claim 20, further comprising step (i') dispersing micronutrients, macronutrients, pesticides, and/or bioactives, into the solution of keratin derivative,
45 wherein step (i') occurs before step (i).

22. The method of claim 20 or 21, wherein step (ii) comprises drying the resulting solution for at least 24 hours.
- 5 23. The method of any one of claims 20-22, wherein step (ii) comprises freeze drying the solution of step (i) at a temperature of about -10°C to about -80°C.
24. Use of a substrate of any one of claims 1-19 as a plant growth medium or a hydroponic support medium.