

Claims

1. A superabsorbent hydrogel comprising a crosslinked polymeric network comprising polymeric chains grafted onto particles of okara, wherein the crosslinks are formed through:
the polymeric chains; and/or
each okara particle being bonded to one or more polymeric chains.
2. The hydrogel according to Claim 1, wherein the okara particles are one or more of unfractionated okara particles, water-insoluble okara particles, and water-soluble okara particles.
3. The hydrogel according to Claim 1 or Claim 2, wherein the hydrogel further comprises a plant nutrient material.
4. The hydrogel according to Claim 3, wherein the plant nutrient material is urea.
5. The hydrogel according to any one of the preceding claims, wherein the polymeric chains are formed from poly(acrylic acid), poly(acrylamide) or copolymers thereof.
6. The hydrogel according to Claim 5, wherein the crosslinks formed through the polymeric chains are derived from a bisacrylamide crosslinking agent, optionally wherein the bisacrylamide crosslinking agent is N, N'-methylenebisacrylamide.
7. The hydrogel according to Claim 5, wherein the crosslinking agent is present in the hydrogel in an amount of from 0.010 to 2 dry wt% of the hydrogel, such as from 0.1 to 1 dry wt%, such as from 0.16 to 0.34 dry wt%.
8. The hydrogel according to any one of Claims 5 to 7, wherein the okara particles form from 15 to 50 dry wt% and the polymeric chain forms from 50 to 85 dry wt% of the hydrogel, such as from 20 to 50 dry wt% of okara particles and from 50 to 80 dry wt% of polymeric chain, such as from 25 to 40 dry wt% of okara particles and from 60 to 75 dry wt% of polymeric chain, such as from 30 to 34 dry wt% of okara particles and from 66 to 70 dry wt% of polymeric chain.
9. The hydrogel according to any one of Claims 5 to 8, wherein the polymeric chains are a copolymer of acrylic acid and acrylamide.

10. The hydrogel according to Claim 9, wherein the weight to weight ratio of acrylic acid to acrylamide in the polymeric chains is from 1:10 to 10:1, such as from 3:7 to 7:3, such as 7:3.
11. The hydrogel according to any one of Claims 5 to 10, wherein the hydrogel has an equilibrium swelling value of from 90 to 500 at a pH value of around 7.
12. The hydrogel according to any one of Claims 1 to 4, wherein the hydrogel is formed by the reaction of carboxylated okara particles that comprise one or more carboxylic acid functional groups with polymeric chains that comprise two or more epoxide groups, where an ester linkage is formed by reaction of a carboxylate group with an epoxide.
13. The hydrogel according to Claim 12, wherein the polymeric chains that comprise two or more epoxide linkages are polyethylene glycol diglycidyl ether.
14. The hydrogel according to Claim 12 or Claim 13, wherein the weight to weight ratio of carboxylated okara to polymeric chains that comprise two or more epoxide groups is from 1:2 to 2:1, such as from 1:1.2 to 1:0.6.
15. The hydrogel according to any one of Claims 12 to 14, wherein the hydrogel has an equilibrium swelling value of from 10 to 110.
16. Use of a superabsorbent hydrogel as defined in any one of Claims 1 to 15 in agriculture.
17. The use of Claim 16, wherein the hydrogel further comprises a plant nutrient material, optionally wherein the plant nutrient material is urea.
18. A composite material for use in growing plants, comprising a soil and a superabsorbent hydrogel as defined in any one of Claims 1 to 15.
19. The composite material according to Claim 18, wherein the composite material comprises from 0.5 to 10 dry wt% of the hydrogel.
20. The composite material according to Claim 19, wherein the composite material comprises from 1 to 5 dry wt% of the hydrogel, such as from 2 to 3 dry wt%.

21. The composite material according to Claim 19 or Claim 20, which has a water holding percentage of from 125 to 250%, such as from 145 to 230%, such as from 175 to 225%.

22. The composite material according to any one of Claims 19 to 21, wherein the hydrogel further comprises a plant nutrient, optionally wherein the plant nutrient is urea.

23. The composite material according to Claim 22, wherein the plant nutrient is released from the composite material over a period of from 3 to 20 days, such as from 4 to 18 days, such as from 10 to 15 days, such as 14 days.

24. A method of forming a superabsorbent hydrogel as defined in any one of Claims 5 to 11, the method comprising the steps of:

- (a) providing an aqueous suspension of okara;
- (b) adding a radical initiator to the aqueous suspension to form a first reaction mixture that was aged for a first period of time;
- (c) adding acrylic acid and/or acrylamide with a crosslinking agent to the first reaction mixture to form a second reaction mixture that was aged for a second period of time to form the superabsorbent hydrogel.

25. A method of forming a superabsorbent hydrogel as defined in any one of Claims 12 to 15, the method comprising the steps of:

- (a) providing an aqueous suspension of carboxylated okara in an alkaline aqueous solution; and
- (b) adding a polymeric chain material that has two or more epoxide groups to the aqueous suspension to react with the carboxylated okara to form the superabsorbent hydrogel.