Claims

1. A method of producing a hydrogel with a desired release profile for a biologic disposed therein, wherein the biologic is in a solid state formulation prior to being disposed in the hydrogel, wherein the hydrogel is characterized by a desired release period of one week to six months for at least 90% biologic release, the method comprising:

predetermining at least one of the following parameters:

(a) the number of nucleophilic groups in a first precursor;

(b) the number of electrophilic groups in a second precursor;

(c) the molecular weight of the first precursor;

(d) the molecular weight of the second precursor;

(e) a weight ratio of the biologic and excipient to the hydrogel;

(f) a weight percentage of the biologic in the solid state formulation; and

(g) a ratio of surface area to volume of the hydrogel;

determining a molar ratio of the total number of moles of the nucleophilic group to the total number of moles of the electrophilic group alone, or in combination with any one or more of the above parameters that is not predetermined, until the desired release profile is achieved, wherein the molar ratio of the nucleophilic group to the electrophilic group is in the range of 1.1 to 2; and

crosslinking the first precursor and the second precursor at the determined molar ratio around the solid state formulation under anhydrous conditions.

2. The method of claim 1, wherein the molar ratio of the total number of moles of the nucleophilic group to the total number of moles of the electrophilic group is in the range of 1.5 to 2.

3. The method of claim 1, wherein the molar ratio of the total number of moles of the nucleophilic group to the total number of moles of the electrophilic group is in the range of 1.3 to 1.8.

4. The method of any one of claims 1 to 3, wherein the biologic is a recombinant protein.

5. The method of claim 4, wherein the recombinant protein is an antibody or a Trap protein (a fusion protein with decoy receptor domains).

6. The method of any one of claims 1 to 5, wherein the nucleophilic group comprises a primary amine or a primary thiol.

7. The method of any one of claims 1 to 6, wherein the electrophilic group comprises succinimide, succinimide ester, n-hydroxysuccinimide, maleimide, succinate, nitrophenyl carbonate, aldehyde, vinylsulfone, azide, hydrazide, isocyanate, diisocyanate, tosyl, tresyl, or carbonyldiimidazole.

8. The method of any one of claims 1 to 7, wherein the number of the nucleophilic groups in the first precursor is in the range of 2 to 10.

9. The method of any one of claims 1 to 8, wherein the number of the electrophilic groups in the second precursor is in the range of 2 to 10.

10. The method of any one of claims 1 to 9, wherein the weight ratio of the biologic to the hydrogel is between 10% to 90%.

11. The method of any one of claims 1 to 9, wherein the weight percentage of the biologic in the solid state formulation is between 30% to 95%.

12. The method of any one of claims 1 to 11, wherein the desired release profile comprises

(a) a release period of two months to six months for at least 90% biologic release;
(b) a release period of one week to two months for at least 90% biologic release;
(c) near-linear release of the biologic over at least one week;
(d) a delayed-release portion;
(e) a sigmoidal shape;
(f) a linear portion;
(g) a non-linear portion;
(h) a logarithmic portion;
(i) an exponential portion;
or a combination thereof.

13. The method of any one of claims 1 to 12, wherein the crosslinking occurs in the presence of an organic solvent that is anhydrous and hydrophobic.

14. The method of claim 13, wherein the organic solvent is methylene chloride, ethyl acetate, dimethyl carbonate, chloroform, or a combination thereof.

15. The method of any one of claims 1 to 14, wherein the determining step is performed with a predictive model.

16. The method of claim 15, wherein the molar ratio has a continuous effect on release profile in the predictive model.

17. The method of claim 15, wherein the molecular weights of the first and second precursors have a non-continuous effect on release profile in the predictive model.

18. A method of producing a hydrogel having a biologic disposed therein, wherein the biologic is in a solid state formulation prior to being disposed in the hydrogel, and wherein the hydrogel is characterized by a desired release period of one week to six months for at least 90% biologic release, the method comprising:

selecting a first precursor that comprises two or more nucleophilic groups, wherein the first precursor has a molecular weight in the range of 1 kDa to 100 kDa;

selecting a second precursor that comprises two or more electrophilic groups, wherein the second precursor has a molecular weight in the range of 1 kDa to 100 kDa;

determining at least one of the following parameters alone, or in combination, until the desired release period is achieved:

(a) a molar ratio of the total number of moles of the nucleophilic group to the total number of moles of the electrophilic group;

(b) a weight ratio of the biologic and excipient to the hydrogel;

(c) a weight percentage of the biologic in the solid state formulation; and

(d) a ratio of surface area to volume of the hydrogel; and

crosslinking the first precursor and the second precursor at the determined molar ratio around the solid state formulation under anhydrous conditions, wherein the molar ratio of the total number of moles of the nucleophilic group to the total number of moles of the electrophilic group is in the range of 1.1 to 2.

19. The method of claim 18, wherein the molar ratio of the total number of moles of the nucleophilic group to the total number of moles of the electrophilic group is in the range of 1.5 to 2.

20. The method of claim 18, wherein the molar ratio of the total number of moles of the nucleophilic group to the total number of moles of the electrophilic group is in the range of 1.3 to 1.8.

21. The method of any one of claims 18 to 20, wherein the biologic is a recombinant protein.

22. The method of claim 21, wherein the recombinant protein is an antibody or a Trap protein (a fusion protein with decoy receptor domains).

23. The method of any one of claims 18 to 23, wherein the nucleophilic group comprises a primary amine or a primary thiol.

24. The method of any one of claims 18 to 23, wherein the electrophilic group comprises succinimide, succinimide ester, n-hydroxysuccinimide, maleimide, succinate, nitrophenyl carbonate, aldehyde, vinylsulfone, azide, hydrazide, isocyanate, diisocyanate, tosyl, tresyl, or carbonyldiimidazole.

25. The method of any one of claims 18 to 24, wherein the first precursor comprises 2 to 10 nucleophilic groups.

26. The method of any one of claims 18 to 25, wherein the second precursor comprises 2 to 10 electrophilic groups.

27. The method of any one of claims 18 to 26, wherein the weight ratio of the biologic to hydrogel is between 10% to 90%.

28. The method of any one of claims 18 to 26, wherein the weight percentage of the biologic in the solid state formulation is between 30% to 95%.

29. The method of any one of claims 18 to 28, wherein the desired release period comprises:
(a) a release period of two months to six months for at least 90% biologic release;
(b) a release period of one week to two months for at least 90% biologic release;

(c) near-linear release of the biologic over at least one week;
(d) a delayed-release portion;
(e) a sigmoidal shape;
(f) a linear portion;
(g) a non-linear portion;
(h) a logarithmic portion;
(i) an exponential portion;
or a combination thereof.

30. The method of any one of claims 18 to 29, wherein the crosslinking occurs in the presence of an organic solvent that is anhydrous and hydrophobic.

31. The method of claim 30, wherein the organic solvent is methylene chloride, ethyl acetate, dimethyl carbonate, chloroform, or a combination thereof.

32. The method of any one of claims 18 to 31, wherein the determining step is performed with a predictive model.

33. The method of claim 32, wherein the molar ratio has a continuous effect on release period in the predictive model.

34. The method of claim 32, wherein the molecular weights of the first and second precursors have a non-continuous effect on release period in the predictive model.

35. A hydrogel comprising a biologic produced by the method of any one of claims 1 to 34.