WHAT IS CLAIMED IS:

1. A polymer bead for performing multiple co-assay reactions, comprising:

a hydrogel polymer precursor;

a crosslinker; and

a biomolecule disposed within the polymer bead, wherein the bead comprises pores that allow diffusion of a reagent through the bead while retaining the biomolecule.

2. The bead of claim 1, wherein the bead is a porous hydrogel bead or a porous hollow bead.

3. The bead of claim 1, wherein the bead comprises multiple polymer layers, wherein each layer has a distinct pore size and pore density.

4. The bead of claim 1, wherein the pores are modulated in size based on charge, pH, or temperature.

5. The bead of claim 1, wherein the bead has a diameter of about 50 μm to about 150 μm.

6. The bead of claim 1, wherein the hydrogel polymer comprises polyethylene glycol (PEG)-thiol/PEG-acrylate, PEG/maleimide (PEG/MAL), acrylamide/N,N'-bis(acryloyl)cystamine (BACy), N,N'-(1,2-dihydroxyethylene)bisacrylamide (DHEBA), PEG/polypropylene oxide (PPO), polyacrylic acid, poly(hydroxyethyl methacrylate) (PHEMA), poly(methyl methacrylate) (PMMA), poly(N-isopropylacrylamide) (PNIPAAm), poly(lactic acid) (PLA), poly(lactic-co-glycolic acid) (PLGA), polycaprolactone (PCL), poly(vinylsulfonic acid) (PVSA), poly(L-aspartic acid), poly(L-glutamic acid), polylysine, agar, agarose, alginate, heparin, alginate sulfate, dextran sulfate, hyaluronan, pectin, carrageenan, gelatin, chitosan, cellulose, or collagen.

7. The bead of claim 1, wherein the crosslinker comprises bisacrylamide, diacrylate, diallylamine, triallylamine, divinyl sulfone, diethyleneglycol diallyl ether, ethyleneglycol diacrylate, polymethyleneglycol diacrylate, polyethyleneglycol diacrylate, trimethylopropoane trimethacrylate, ethoxylated trimethylol triacrylate, or ethoxylated pentaerythritol tetracrylate.

8. The bead of claim 1, wherein the biomolecule is a nucleic acid.

9. The bead of claim 8, wherein the nucleic acid is a long DNA molecule of 50,000 base pairs or greater.

10. The bead of claim 1, wherein the reagent comprises enzymes, chemicals, and primers having a size of less than 50 base pairs.

11. The bead of claim 1, wherein the reagent comprises lysozyme, proteinase K, random hexamers, polymerase (Φ29 DNA polymerase, Taq polymerase, Bsu polymerase), transposase (Tn5), primers (P5 and P7 adaptor sequences), ligase, catalyzing enzyme, deoxynucleotide triphosphates, buffers, or bivalent cations.

12. The bead of claim 1, wherein the bead further comprises a stabilized shell that encapsulates the bead.

13. The bead of claim 12, wherein the stabilized shell comprises N,N'-(1,2-dihydroxyethylene)bisacrylamide (DHEBA), acrylate-PEG, and potassium peroxydisulfate (KPS).

14. The bead of claim 1, further comprising a fluorescent compound bound to the hydrogel polymer precursor.

15. The bead of claim 14, wherein the fluorescent compound is fluorescein isothiocyanate (FITC).

16. A method of performing multiple sequential co-assays on a biomolecule encapsulated within a polymer bead, comprising:

obtaining a polymer bead encapsulating a biomolecule of claim 1; and

sequentially contacting the single cell with reagents to perform multiple sequential co-assays.

17. The method of claim 16, further comprising modulating the size of pores of the polymer bead by adjusting the charge, pH, or temperature.

18. The method of claim 16, wherein the polymer bead comprises multiple polymer layers, and wherein each polymer layer has pores of distinct sizes, and wherein the pore size of each polymer layer is specifically modulated by changing the charge, pH, or temperature.

19. The method of claim 16, wherein the multiple sequential co-assays comprise lysis, DNA analysis, RNA analysis, protein analysis, tagmentation, nucleic acid amplification, nucleic acid sequencing, DNA library preparation, assay for transposase

accessible chromatic using sequencing (ATAC-seq), contiguity-preserving transposition (CPT-seq), single cell combinatorial indexed sequencing (SCI-seq), or single cell genome amplification, or any combination thereof performed sequentially.

20. The method of claim 16, wherein the polymer bead encapsulating a biomolecule is seeded on a solid support.

21. The method of claim 20, wherein the solid support is an etched surface, a well, a flow-cell device, a microfluidic channel, a bead, or a column.

22. The method of claim 16, wherein the biomolecule is a nucleic acid.

23. The method of claim 22, wherein the nucleic acid is a long DNA molecule of 50,000 base pairs or greater.

24. The method of claim 16, further comprising performing a nucleic acid amplification reaction on nucleic acid encapsulated within the polymer bead prior to performing the tagmentation reaction.

25. The method of claim 24, wherein the nucleic acid amplification reaction comprises multiple displacement amplification (MDA).

26. The method of claim 25, wherein the tagmentation reaction comprises contacting a biomolecule with a transposase mixture comprising adapter sequences and transposomes.

27. The method of claim 19, further comprising seeding the DNA library on a solid support.

28. The method of claim 27, wherein seeding comprises cleaving the bead to release the DNA library from the bead.

29. The method of claim 28, wherein the bead is cleaved by contacting the bead with a cleavage mix or by heating the bead to about 90°C to release the DNA library.

30. The method of claim 29, wherein the cleavage mix comprises dithiothreitol (DTT), tris(2-carboxyethyl)phosphine (TCEP), or tris(3-hydroxypropyl)phosphine (THP).

31. The method of claim 27, wherein the solid support is a flow cell device.

CLAIMS:

1. A polymer bead for performing multiple co-assay reactions, comprising:

a hydrogel polymer precursor;

a crosslinker; and

a biomolecule disposed within the polymer bead, wherein the bead is a porous hollow bead that comprises multiple polymer layers, wherein each polymer layer comprises a distinct pore size and a distinct pore density that allows diffusion of a reagent through the bead while retaining the biomolecule.

2. The bead of claim 1, wherein the pore size of each polymer layer is specifically modulated based on charge, pH, or temperature.

3. The bead of claim 1, wherein the bead has a diameter of about 50 μm to about 150 μm.

4. The bead of claim 1, wherein the hydrogel polymer precursor comprises polyethylene glycol (PEG)-thiol/PEG-acrylate, PEG/maleimide (PEG/MAL), acrylamide/N,N'-bis(acryloyl)cystamine (BACy), N,N'-(1,2-dihydroxyethylene)bisacrylamide (DHEBA), PEG/polypropylene oxide (PPO), polyacrylic acid, poly(hydroxyethyl methacrylate) (PHEMA), poly(methyl methacrylate) (PMMA), poly(N-isopropylacrylamide) (PNIPAAm), poly(lactic acid) (PLA), poly(lactic-co-glycolic acid) (PLGA), polycaprolactone (PCL), poly(vinylsulfonic acid) (PVSA), poly(L-aspartic acid), poly(L-glutamic acid), polylysine, agar, agarose, alginate, heparin, alginate sulfate, dextran sulfate, hyaluronan, pectin, carrageenan, gelatin, chitosan, cellulose, or collagen.

5. The bead of claim 1, wherein the crosslinker comprises bisacrylamide, diacrylate, diallylamine, triallylamine, divinyl sulfone, diethyleneglycol diallyl ether, ethyleneglycol diacrylate, polymethyleneglycol diacrylate, polyethyleneglycol diacrylate, trimethylolpropane trimethacrylate, ethoxylated trimethylol triacrylate, or ethoxylated pentaerythritol tetraacrylate.

6. The bead of claim 1, wherein the biomolecule is a nucleic acid.

7. The bead of claim 6, wherein the nucleic acid is a long DNA molecule of 50,000 base pairs or greater.

8. The bead of claim 1, wherein the reagent comprises enzymes, chemicals, and primers having a size of less than 50 base pairs.

9. The bead of claim 1, wherein the reagent comprises lysozyme, proteinase K, random hexamers, polymerase, transposase, primers, ligase, catalyzing enzyme, deoxynucleotide triphosphates, buffers, or bivalent cations.

10. The bead of claim 1, wherein the bead further comprises a stabilized shell that encapsulates the bead.

11. The bead of claim 10, wherein the stabilized shell comprises N,N'-(1,2-dihydroxyethylene) bisacrylamide (DHEBA), acrylate-PEG, and potassium peroxydisulfate (KPS).

12. The bead of claim 1, further comprising a fluorescent compound bound to the hydrogel polymer precursor.

13. The bead of claim 12, wherein the fluorescent compound is fluorescein isothiocyanate (FITC).

14. A method of performing multiple sequential co-assays on a biomolecule encapsulated within a polymer bead, comprising:

obtaining the polymer bead of claim 1; and

sequentially contacting the polymer bead with reagents to perform multiple sequential co-assays.

15. The method of claim 14, further comprising modulating the size of pores of the polymer bead by adjusting the charge, pH, or temperature.

16. The method of claim 14, wherein the pore size of each polymer layer is specifically modulated by changing the charge, pH, or temperature.

17. The method of claim 14, wherein the multiple sequential co-assays comprise lysis, DNA analysis, RNA analysis, protein analysis, tagmentation, nucleic acid amplification, nucleic acid sequencing, DNA library preparation, assay for transposase accessible chromatic using sequencing (ATAC-seq), contiguity-preserving transposition (CPT-seq), single cell combinatorial indexed sequencing (SCI-seq), or single cell genome amplification, or any combination thereof performed sequentially.

18. The method of claim 14, wherein the polymer bead encapsulating a biomolecule is seeded on a solid support.

19. The method of claim 18, wherein the solid support is an etched surface, a well, a flow-cell device, a microfluidic channel, a bead, or a column.

20. The method of claim 14, wherein the biomolecule is a nucleic acid.

21. The method of claim 20, wherein the nucleic acid is a long DNA molecule of 50,000 base pairs or greater.

22. The method of claim 14, further comprising performing a nucleic acid amplification reaction on nucleic acid encapsulated within the polymer bead prior to performing the tagmentation reaction.

23. The method of claim 22, wherein the nucleic acid amplification reaction comprises multiple displacement amplification (MDA).

24. The method of claim 23, wherein the tagmentation reaction comprises contacting a biomolecule with a transposase mixture comprising adapter sequences and transposomes.

25. The method of claim 17, further comprising seeding the DNA library on a solid support.

26. The method of claim 25, wherein seeding comprises cleaving the bead to release the DNA library from the bead.

27. The method of claim 26, wherein the bead is cleaved by contacting the bead with a cleavage mix or by heating the bead to about 90°C to release the DNA library.

28. The method of claim 27, wherein the cleavage mix comprises dithiothreitol (DTT), tris(2-carboxyethyl)phosphine (TCEP), or tris(3-hydroxypropyl)phosphine (THP).

29. The method of claim 25, wherein the solid support is a flow cell device.