

WHAT IS CLAIMED:

1. A device comprising:
a nanotube or nanowell disposed within a support material, the nanotube comprising one or more sidewall electrodes, the nanowell comprising one or more sidewall electrodes and/or one or more bottom electrodes; and
an electroactive nanomembrane disposed over at least a portion of one electrode of the nanowell or nanotube, wherein the electroactive nanomembrane is configured to cause a chemical composition change in the electroactive nanomembrane in response to electrical stimuli.
2. The device of claim 1, wherein the electroactive nanomembrane is configured to change at least one dimension thereof, resulting from the electroactive response to the electrical stimuli.
3. The device of claim 1, wherein the electroactive nanomembrane is configured to cause polymerization or depolymerization in response to the electrical stimuli.
4. The device of claim 1, wherein the electroactive nanomembrane is at least in part disposed to be hydrophobic, hydrophilic, charged, chemically reactive, metal-binding, metallic, or combinations thereof.
5. The device of claim 1, wherein the electroactive nanomembrane comprises a conductive electroactive polymer, and one or more of a dielectric electroactive polymer, a ferroelectric electroactive polymer, and an ionic electroactive polymer.
6. The device of claim 1, wherein the electroactive nanomembrane comprises a metalized nanomembrane.

7. The device of claim 1, wherein the electroactive nanomembrane is an encircling nanomembrane on an interior surface of the nanowell or nanotube, thereby forming a nanopore.
8. The device of claim 1, wherein the electroactive nanomembrane is covalently attached to the at least a portion of the one electrode.
9. The device of claim 1, wherein the electroactive nanomembrane is non-covalently disposed on the at least a portion of the one electrode.
10. The device of claim 1, wherein the electroactive nanomembranes is configured to bridge at least a portion of two or more electrodes to provide an electrical connection between the electrodes.
11. The device of claim 1, wherein a composition of the electroactive nanomembrane comprises a doping agent, a dye, a quantum dot, or combinations thereof.
12. The device of claim 1, further comprising additional nanowells or nanotubes or combinations thereof, that are arranged as an array in a single support material.
13. The device of claim 1, further comprising one or more additional nanomembranes deposited between the electroactive nanomembrane and the at least a portion of the one electrode, wherein the one or more additional nanomembranes are electroactive or non-electroactive.
14. A device comprising:

a nanowell or nanotube disposed within a support material, the nanotube comprising one or more sidewall electrodes, the nanowell comprising one or more sidewall electrodes and/or one or more bottom electrodes;

a first nanomembrane disposed over at least a portion of one sidewall electrode of the nanowell or nanotube; and

a second nanomembrane disposed over the first nanomembrane to form a nanochannel or nanopore, or combinations thereof, wherein the second nanomembrane is configured to alter one or more of a molecular composition, a dimension, or a chemical property thereof in response to electrical stimuli.

15. The device of claim 14, wherein each of the nanowell, the nanotube, and the nanopore has a circular, square, rectangle, or polygon cross-section.

16. The device of claim 14, wherein the first nanomembrane is non-electroactive.

17. The device of claim 14, wherein the first nanomembrane is configured to alter a molecular composition, a dimension, or a property thereof in response to electrical stimuli.

18. The device of claim 14, wherein the property capable of alternating comprises one or more properties of hydrophobic, hydrophilic, charged, chemically reactive, metal-binding, metallic, or combinations thereof.

19. The device of claim 14, wherein the first nanomembrane is more electrically conductive than the second nanomembrane, and/or is less chemically reactive than the second nanomembrane.

20. The device of claim 14, wherein one or both of the first nanomembrane and the second nanomembrane are electrically conductive.

21. The device of claim 14, wherein one or both of the first nanomembrane and the second nanomembrane are capable of driving an electrochemical reaction.

22. A device comprising:

one or more nanowells or nanotubes or combinations thereof disposed in a support material, each nanotube comprising one or more sidewall electrodes, each nanowell comprising one or more sidewall electrodes and/or one or more bottom electrodes; and

one or more electroactive nanomembranes disposed over at least one sidewall electrode of the one or more nanowells or nanotubes or combinations thereof to form a nanochannel, or a nanopore, or combinations thereof, wherein the electroactive nanomembrane is configured to change at least one dimension of the electroactive nanomembrane resulting from electrical stimuli, and is at least in part disposed to be a hydrophobic, hydrophilic, charged, chemically reactive, metal binding, metallic, or combinations thereof.

23. The device of claim 22, wherein the electroactive nanomembrane is configured to cause a composition change in response to the electrical stimuli.

24. A device comprising:

one or more nanowells or nanotubes or combinations thereof disposed within a support material, each nanotube comprising one or more sidewall electrodes, each nanowell comprising one or more sidewall electrodes and/or one or more bottom electrodes;

one or more electroactive nanomembranes disposed on at least a portion of the one or more electrodes of the one or more nanowells or nanotubes or combinations thereof; and

a lipid bilayer supported by the one or more electroactive nanomembranes, wherein the lipid bilayer is configured to allow insertion of a molecule.

25. The device of claim 24, wherein the lipid bilayer is configured to provide insertion and functionality testing of one or more lipophilic molecules comprising

detergents, oils, fats, lipids, surfactants, or combinations thereof, or

proteins comprising porins, ion channels, protein nanopores, membrane proteins, membrane enzymes, membrane receptors, membrane channel proteins, membrane transport proteins, complexes with and by thereof, or combinations thereof, and wherein the insertion comprises an insertion of one molecule of protein.

26. The device of claim 24, wherein the one or more electroactive nanomembranes have a hydrophobic surface as a nucleation site or an adhesion site configured to promote nucleation of formation or stabilization of a lipid bilayer.

27. The device of claim 24, wherein number of lipophilic molecules or proteins or protein complexes able to be inserted in the one or more electroactive nanomembranes is controllable or restricted by a dimension alteration of the one or more electroactive nanomembranes to decrease a surface area spanned by the lipid bilayer.

28. The device of claim 24, wherein the one or more electroactive nanomembranes comprise a hydrophobic surface is configured to allow nucleation of formation of the lipid bilayer or to stabilize the lipid bilayer.

29. The device of claim 24, further comprising a nanochannel or nanopore formed by the one or more electroactive nanomembranes to support or stabilize the lipid bilayer.

30. A method for molecular separation, purification, and sensing, the method comprising:

providing one or more nanotubes or nanowells or combinations thereof in a support material, each nanotube comprising one or more sidewall electrodes, each nanowell comprising one or more sidewall electrodes and/or one or more bottom electrodes, wherein an electroactive nanomembrane is disposed on at least a portion of one electrode of the one or more nanotubes or nanowells, or combinations thereof to form a nanopore or a nanochannel within a corresponding nanotube or nanowell, and wherein the electroactive nanomembrane

is configured to alter one or more of a dimension, composition, hydrophobicity, hydrophilicity, charge, chemical binding, metallic, and metal binding property of the electroactive nanomembrane; and

moving an analyte in the one or more of the nanopores or nanowells, or combinations thereof.

31. The method of claim 30, further comprising modulating a property of the electroactive nanomembrane over time such that one or more analytes are separated, partitioned, isolated, fractionated, purified, or combinations thereof according to their size as the one or more analytes pass through the nanopore or the nanochannel formed by the electroactive nanomembrane.

32. The method of claim 30, further comprising modulating a property of the electroactive nanomembrane over time such that one or more analytes are separated, partitioned, isolated, fractionated, purified, or combinations thereof, according to their hydrophobicity / hydrophilicity as the one or more analytes pass through the nanopore or the nanochannel formed by the electroactive nanomembrane.

33. The method of claim 30, further comprising modulating over time a property of the electroactive nanomembrane such that one or more analytes are separated, partitioned, isolated, fractionated, purified, and combinations thereof according to their charges as the one or more analytes pass through the nanopore or the nanochannel formed by the electroactive nanomembrane.

34. The method of claim 30, further comprising modulating a property of the electroactive nanomembrane over time such that one or more analytes are separated, partitioned, isolated, fractionated, purified, or combinations thereof according to their chemical reactivity as the one or more analytes pass through the nanopore or the nanochannel

formed by the electroactive nanomembrane.

35. The method of claim 30, further comprising modulating a property of the electroactive nanomembrane over time such that one or more analytes are separated, partitioned, isolated, fractionated, purified, or combinations thereof, according to their being bound by one or more types of nanomembrane-attached functionalization as the one or more analytes pass through the nanopore or the nanochannel formed by the electroactive nanomembrane, the functionalization comprising proteins, antibodies, enzymes, antibody fragments, lectins, phage, nucleic acid oligomers, nucleic acid components, aptamers, peptides, amino acids, modified amino acids, lipids, ions, small molecules, drugs, or combinations thereof.

36. The method of claim 30, further comprising modulating a property of the electroactive nanomembrane over time such that one or more analytes are separated, partitioned, isolated, fractionated, purified, and combinations thereof according to one or more properties selected from size, wettability, charge, chemical reactivity, functionalization, or a combination thereof, as the one or more analytes pass through the nanopore or the nanochannel formed by the electroactive nanomembrane.

37. The method of claim 30, wherein moving the analyte comprises subjecting a passive diffusion movement, an electrophoretic force, a mechanical force, or their combinations to the analyte.

38. The method of claim 30, wherein moving the analyte comprises altering a dimension of the electroactive nanomembrane by imposing electric stimuli on the electroactive nanomembrane.

39. The method of claim 30, wherein moving the analyte comprises electrokinetically introducing a plurality of ionized molecules into the nanochannel or nanopore formed by the

electroactive nanomembrane; and wherein the plurality of ionized molecules comprises ionized salts, nucleic acid oligomers, nucleic acid components, and combinations thereof.

40. The method of claim 30, wherein the nanopore or the nanochannel forms one or more testing columns or wells for liquid chromatography (LC) or gas chromatography (GC).

41. A method for molecular separation, purification, and sensing, the method comprising:

providing one or more nanotubes or nanowells or combinations thereof in a support material, each nanotube comprising one or more sidewall electrodes, each nanowell comprising one or more sidewall electrodes and/or one or more bottom electrodes, wherein an electroactive nanomembrane is disposed on at least a portion of one electrode of the one or more nanotubes or nanowells, or combinations thereof to form a nanopore or a nanochannel within a corresponding nanotube or nanowell, and wherein the electroactive nanomembrane is configured to alter one or more of a dimension, composition, hydrophobicity, hydrophilicity, charge, chemical binding, metallic, and metal binding property of the electroactive nanomembrane;

moving an analyte in the one or more of the nanopores or nanowells, or combinations thereof; and

immobilizing the analyte by neutralizing a net charge of the analyte by applying electrical stimuli as the analyte moves across the one or more electroactive nanomembranes.

42. The method of claim 41, further comprising mobilizing or isolating the immobilized analytes by changing the dimension or composition of the electroactive nanomembrane.

43. The method of claim 41, further comprising mobilizing or isolating the immobilized analyte by applying a fluid to interact with the electroactive nanomembrane by electrostatic, hydrophobic, or hydrophilic interactions, or to disrupt target or functionalization interactions,

wherein the fluid is formulated with one or more components comprising ions, ionic material, detergents, proteins, antibodies, enzymes, antibody fragments, lectins, carbohydrates, phage, ligands, nucleic acid oligomers, nucleic acid components, aptamers, peptides, amino acids, modified amino acids, lipids, small molecules, drugs, or combinations thereof.

44. The method of claim 41, further comprising mobilizing or isolating the immobilized analyte by changing a temperature or a pressure of the electroactive nanomembrane.

45. A method of forming a device comprising:

providing an array formed by one or more of a nanowell, a nanotube, and combinations thereof, in a support material, the nanotube comprising one or more sidewall electrodes, the nanowell comprising one or more sidewall electrodes and/or one or more bottom electrodes; and

depositing an electroactive nanomembrane over at least a portion of one electrode in the array, wherein the electroactive nanomembrane is configured to change at least one dimension, chemical composition or a property of the electroactive nanomembrane resulting from an electroactive response.

46. The method of claim 45, wherein depositing the electroactive nanomembrane uses a deposition process comprising spraying, vapor-phase deposition, sputtering, spin coating, precipitation, in situ non-electrochemical deposition using one or more of heat and photo energy, multilayer deposition, chemical deposition, and combinations thereof.

47. The method of claim 45, wherein providing the array in the support material comprises

providing two or more parts of the support material containing portions of one or more nanowells or nanotubes, or combinations thereof in the array; and

bringing together the two or more parts of the support material for binding.

48. The method of claim 45, wherein depositing the electroactive nanomembrane comprises

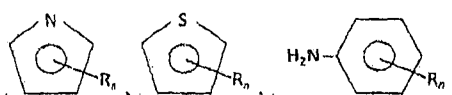
depositing an electroactive nanomembrane over each of two or more parts of the support material containing portions of the one or more nanowells or nanotubes, or combinations thereof in the array;

bringing the two or more parts of the support material together; and

binding the deposited electroactive nanomembranes over the two or more parts of the support material.

49. The method of claim 45, wherein depositing the electroactive nanomembrane utilizes a direct or indirect electrochemical deposition comprising selecting monomers for the electrochemical deposition such that the formed electroactive nanomembrane is at least initially electrically conductive.

50. The method of claim 45, wherein depositing the electroactive nanomembrane comprises using a precursor material comprising



, or combinations thereof that are configured to undergo a direct or indirect electrochemically induced polymerization reaction and bearing an R_n group, wherein R_n represents

(1) hydrogen;

(2) one or more substitution groups that are made to a monomer's structure as a core structure;

(3) one or more substitution groups, at least one of which is a hydrophobic group comprising a group comprising a saturated or unsaturated hydrocarbons having sufficient carbon-chain lengths, or combinations thereof;

(4) one or more substitution group(s), at least one of which is a hydrophilic group comprising a group comprising an hydroxyl, a carboxylic acid, a sulfonic acid, a thiol, a polyethylene glycol, an amine, or combinations thereof;

(5) one or more substitution groups, at least one of which is charged comprising a group comprising an hydroxyl, a carboxylic acid or their salts, a sulfonic acid or their salts, a thiol, a polyethylene glycol, an amine, or combinations thereof;

(6) one or more substitution groups, at least one of which is chemically reactive comprising a group comprising an hydroxyl, a carboxylic acid, an ester, an activated ester, an aldehyde, a ketone, a halogen, a sulfonate ester, a thiol, an azide, and alkene, an alkyne, a phosphene, an amine, or combinations thereof;

(7) one or more substitution groups, at least one of which is metal binding comprising a group comprising a thiol, an ethylenediaminetetraacetic acid (EDTA), an ethyleneglycoltetraacetic acid (EGTA), a Glycine-Glycine-Histidine peptide, or combinations thereof; or

any combination selected from (1)-(7).

51. The method of claim 45, wherein depositing the electroactive nanomembrane comprises using a precursor material comprising a metal ion to form a metallic nanomembrane, wherein the metal ion comprises silver, gold, platinum, copper, iron, tungsten, aluminum, titanium, or combinations thereof.

52. The method of claim 45, wherein depositing the electroactive nanomembrane is

controllable over an extent to which space within a nanowell or nanotube is occupied.

53. The method of claim 45, wherein the deposited electroactive nanomembrane is controllable to change a dimension or composition or property of the electroactive nanomembrane after the deposition.

54. The method of claim 45, wherein the deposited electroactive nanomembrane is controllable by at least applying electrical stimuli to at least one sidewall electrode after the deposition to generate a polymerization or depolymerization reaction.

55. The method of claim 45, wherein the deposited electroactive nanomembrane is controllable by at least applying electrical stimuli to at least one sidewall electrode after the deposition to add or remove molecules to alter one or more of a surface composition and an internal composition of the electroactive nanomembrane.

56. The method of claim 45, wherein depositing an electroactive nanomembrane comprises an electrochemical polymerization on the at least a portion of one electrode in the array as a primary electrode.

57. The method of claim 56, further comprising

applying electrical stimuli to at least one secondary electrode selected from any electrodes different from the primary electrode of the nanowell or nanotube to attract the deposited, or continually depositing, electroactive nanomembrane towards a surface of the secondary electrode such that the electroactive nanomembrane extends from the primary electrode and contacts the secondary electrode to form an electrically conducting bridge between the primary and the secondary electrodes.

58. A method of forming a device comprising:

providing an array formed by one or more nanowells or nanotubes or combinations thereof in a support material, each nanotube comprising one or more sidewall electrodes, each nanowell comprising one or more sidewall electrodes and/or one or more bottom

depositing a first nanomembrane over at least a portion of one electrode of the array;
and

tunably depositing a second electroactive nanomembrane over the first nanomembrane to form a nanochannel or nanopore, or combinations thereof, within a corresponding nanowell or a corresponding nanotube in the array, wherein the second electroactive nanomembrane is configured to alter one or more of a molecular composition, a dimension, or a property thereof in response to electrical stimuli.

59. The method of claim 58, wherein depositing the first nanomembrane comprises a deposition process comprising spraying, vapor phase deposition, sputtering, spin coating, precipitation, in situ non-electrochemical deposition using one or more of heat and photo energy, multilayer deposition, chemical deposition, or combinations thereof.

60. The method of claim 58, wherein tunably depositing the second electroactive nanomembrane comprises tuning one or more of: electrical stimuli for an electrochemical deposition, a direct current, an alternating current, a current or voltage modulated as a sine, square, or saw-tooth waveform, a cyclic voltammetry-driven current or voltage, an electric waveform supplied at constant voltage, constant current, or constant power, a voltage or current varying in a type of amplitude or frequency or both, a voltage or current varying in their duration or number of pulses, or combinations thereof.

61. A method of forming a device comprising:

providing one or more nanowells or nanotubes or combinations thereof in a support material, each nanotube comprising one or more sidewall electrodes, each nanowell comprising one or more sidewall electrodes and/or one or more bottom electrodes;

selecting a first precursor material;

depositing a first nanomembrane from the first precursor material over at least a portion of one electrode of the one or more nanowells or nanotubes or combinations thereof;

replacing the first precursor material with a second precursor material; and

electrochemically depositing a second electroactive nanomembrane over the first nanomembrane from the second precursor material to form a nanopore or nanochannel within a corresponding nanowell or nanotube, wherein at least a portion of the first or second electroactive nanomembrane comprises a chemically reactive material, a charge-binding material, a hydrophobic material, a hydrophilic material, a charged material, a metal-binding material, a metallic material, an electro-conducting material, or combinations thereof.

62. The method of claim 61, wherein the chemically reactive material comprises a material that can be reacted with a cross-linker, a heterobifunctional cross-linker, a light-activated cross-linker, or combinations thereof.

63. The method of claim 61, wherein the second electroactive nanomembrane is directly or indirectly chemically reactive to proteins, antibodies, enzymes, antibody fragments, lectins, phage, nucleic acid oligomers, nucleic components, aptamers, peptides, amino acids, modified amino acids, lipids, ions, small molecules, drugs, or combinations thereof, to functionalize a surface of the nanochannel or nanopore.

64. The method of claim 63, wherein the enzymes comprise kinases, phosphatases, nucleases, synthases, oxidases, peroxidases, reductases, or combinations thereof.

65. The method of claim 61, wherein depositing the first nanomembrane or the second electroactive nanomembrane comprises an indirect electrochemical deposition comprising a 1,4-benzoquinone reaction.

66. A method for molecular separation, purification, and sensing, the method comprising:
providing one or more nanowells or nanotubes or combinations thereof in a support material, each nanotube comprising one or more sidewall electrodes, each nanowell comprising one or more sidewall electrodes and/or one or more bottom electrodes, wherein one or more electroactive nanomembranes are provided on at least a portion of the one or more sidewall or bottom electrodes, or combinations thereof;

nucleating and forming a lipid bilayer at the one or more electroactive nanomembranes;

inserting a protein nanopore into the lipid bilayer;

applying an ion funnel current or voltage to move nucleic acids towards and through the protein nanopore; and

deriving a sequence of the nucleic acids by comparing measured signals of a passage of the nucleic acids through the protein nanopore with predetermined signals.

67. The method of claim 66, further comprising stabilizing formation of a lipid bilayer at the one or more electroactive nanomembranes.

68. The method of claim 66, wherein the protein nanopore comprises α -hemolysin or mycobacterium smegmatis porin A.

69. The method of claim 66, wherein the lipid bilayer is size-restricting to prevent more than one protein nanopore to be inserted in the lipid bilayer.

70. The method of claim 66, wherein the nucleic acids comprise single stranded nucleic acids, double-stranded nucleic acids, partially double-stranded nucleic acids, or combinations thereof.
71. The method of claim 66, wherein the nucleic acids are single stranded nucleic acids, and wherein one or more complementary nucleic acid oligomers are hybridized with the single stranded nucleic acids in a length or under conditions that provide for sufficient stability to maintain at least a partially double-stranded form for testing.
72. The method of claim 66, wherein the nucleic acids comprise a strand of RNA for sequencing, wherein no reverse transcriptase or optical detection method is used for sequencing the strand of RNA.
73. The method of claim 66, wherein the nucleic acids are double stranded DNA and wherein the double stranded DNA is sequenced without making the double stranded DNA single-stranded.
74. The method of claim 66, wherein the method is a signal detection method using a chloride / silver / silver chloride measuring system.
75. The method of claim 66, wherein the one or more nanomembranes are configured to alter one or more of a molecular composition, a dimension, or a property thereof in response to electrical stimuli, wherein the property comprises one or more of hydrophobic, hydrophilic, charged, chemically reactive, metal-binding, or metallic property, or combinations thereof.
76. A method for molecular separation, purification, and sensing, the method comprising:
providing one or more nanowells or nanotubes or combinations thereof within a support material, each nanotube comprising one or more sidewall electrodes, each nanowell

comprising one or more sidewall electrodes and/or one or more bottom electrodes, wherein one or more electroactive nanomembranes are provided on at least a portion of the one or more sidewall or bottom electrodes, or combinations thereof to form a nanopore or a nanochannel by the one or more electroactive nanomembranes;

placing nucleic acids above the nanopore or the nanochannel;

applying an ion funnel current or voltage to move the nucleic acids towards and through the nanopore or the nanochannel; and

deriving a sequence of the nucleic acids by comparing measured signals of a passage of the nucleic acids through the nanopore or nanochannel with predetermined signals.

77. The method of claim 76, wherein the nucleic acids comprise single stranded nucleic acid and wherein a complementary nucleic acid oligomer is hybridized with the single stranded nucleic acids in a length or under conditions that provide for sufficient stability to maintain a double-stranded form for testing.

78. The method of claim 76, wherein the nucleic acids comprise a strand of RNA for sequencing, wherein no reverse transcriptase or optical detection method is used for sequencing the strand of RNA.

79. The method of claim 76, wherein the nucleic acids are double stranded DNA and wherein the double stranded DNA is sequenced without making the double stranded DNA single-stranded.

80. The method of claim 76, wherein the method is a signal detection method using a chloride / silver / silver chloride measuring system.

81. The method of claim 76, wherein the one or more nanomembranes are configured to alter one or more of a molecular composition, a dimension, or a property thereof in response

to electrical stimuli, wherein the property comprises one or more of hydrophobic, hydrophilic, charged, chemically reactive, metal-binding, or metallic property, or combinations thereof.

82. A method for molecular separation, purification, and sensing, the method comprising:

providing one or more nanowells or nanotubes or combinations thereof within a support material, each nanotube comprising one or more sidewall electrodes, each nanowell comprising one or more sidewall electrodes and/or one or more bottom electrodes, wherein one or more electroactive nanomembranes are provided on at least a portion of the one or more sidewall or bottom electrodes, or combinations thereof to form a nanopore or a nanochannel by the one or more electroactive nanomembranes;

functionalizing the one or more electroactive nanomembranes by attaching nucleases thereto;

placing nucleic acids above the nanopore or nanochannel, wherein nucleic acid bases are formed from the nucleic acids by the enzymatic activity of the nucleases;

applying an ion funnel current or voltage to move the nucleic acid bases towards and through the nanopore or the nanochannel; and

deriving a sequence of the nucleic acids by comparing measured signals of a passage of the nucleic acid bases through the nanopore or the nanochannel with predetermined signals.

83. The method of claim 82, wherein the nucleic acids comprise a strand of RNA for sequencing, wherein no DNA polymerase or reverse transcriptase or optical detection is used for sequencing the strand of RNA.

84. The method of claim 82, wherein the nucleic acids are double stranded DNA and

wherein the double stranded DNA is sequenced without making the double stranded DNA single-stranded.

85. The method of claim 82, wherein the method is a signal detection method using a chloride / silver / silver chloride measuring system.

WHAT IS CLAIMED:

1. A device comprising:

a nanotube or nanowell disposed within a support material, the nanotube comprising one or more sidewall electrodes, the nanowell comprising one or more sidewall electrodes and/or one or more bottom electrodes;

an electroactive nanomembrane disposed over at least a portion of one electrode of the nanowell or nanotube, wherein a composition in the electroactive nanomembrane is changed in response to electrical stimuli; and

wherein the composition comprises a doping agent, a dye, a quantum dot, or combinations thereof.

2. The device of claim 1, wherein the electroactive nanomembrane is configured to change at least one dimension thereof, resulting from the electroactive response to the electrical stimuli.

3. The device of claim 1, wherein the electroactive nanomembrane is configured to cause polymerization or depolymerization in response to the electrical stimuli.

4. The device of claim 1, wherein the electroactive nanomembrane is at least in part disposed to be hydrophobic, hydrophilic, charged, chemically reactive, metal-binding, metallic, or combinations thereof.

5. The device of claim 1, wherein the electroactive nanomembrane comprises a conductive electroactive polymer, and one or more of a dielectric electroactive polymer, a ferroelectric electroactive polymer, and an ionic electroactive polymer.

6. The device of claim 1, wherein the electroactive nanomembrane comprises a. metalized

nanomembrane.

7. The device of claim 1, wherein the electroactive nanomembrane is an encircling nanomembrane on an interior surface of the nanowell or nanotube, thereby forming a nanopore.

8. The device of claim 1, wherein the electroactive nanomembrane is covalently attached to the at least a portion of the one electrode.

9. The device of claim 1, wherein the electroactive nanomembrane is non-covalently disposed on the at least a portion of the one electrode.

10. The device of claim 1, wherein the electroactive nanomembranes is configured to bridge at least a portion of two or more electrodes to provide an electrical connection between the electrodes.

11. The device of claim 1, further comprising additional nanowells or nanotubes or combinations thereof, that are arranged as an array in a single support material.

12. The device of claim 1, further comprising one or more additional nanomembranes deposited between the electroactive nanomembrane and the at least a portion of the one electrode, wherein the one or more additional nanomembranes are electroactive or non-electroactive.

13. A device comprising:

a nanowell or nanotube disposed within a support material, the nanotube comprising one or more sidewall electrodes, the nanowell comprising one or more sidewall electrodes and/or one or more bottom electrodes;

a first nanomembrane disposed over at least a portion of one sidewall electrode of the

nanowell or nanotube;

a second nanomembrane disposed over the first nanomembrane to form a nanochannel or nanopore, or combinations thereof, wherein the second nanomembrane is configured to alter one or more of a molecular composition, a dimension, or a chemical property thereof in response to electrical stimuli; and

wherein the first nanomembrane is configured to alter a molecular composition, a dimension, or a property thereof in response to electrical stimuli.

14. The device of claim 13, wherein each of the nanowell, the nanotube, and the nanopore has a circular, square, rectangle, or polygon cross-section.

15. The device of claim 13, wherein the first nanomembrane is non-electroactive.

16. The device of claim 13, wherein the property capable of alternating comprises one or more properties of hydrophobic, hydrophilic, charged, chemically reactive, metal-binding, metallic, or combinations thereof.

17. The device of claim 13, wherein the first nanomembrane is more electrically conductive than the second nanomembrane, and/or is less chemically reactive than the second nanomembrane.

18. The device of claim 13, wherein one or both of the first nanomembrane and the second nanomembrane are electrically conductive.

19. The device of claim 13, wherein, one or both of the first nanomembrane and the second nanomembrane are capable of driving an electrochemical reaction.

20. A device comprising:

one or more nanowells or nanotubes or combinations thereof disposed in a support material, each nanotube comprising one or more sidewall electrodes, each nanowell comprising one or more sidewall electrodes and/or one or more bottom electrodes;

one or more electroactive nanomembranes disposed over at least one sidewall electrode of the one or more nanowells or nanotubes or combinations thereof to form a nanochannel, or a nanopore, or combinations thereof, wherein the electroactive nanomembrane is configured to change at least one dimension of the electroactive nanomembrane resulting from electrical stimuli, and is at least in part disposed to be a hydrophobic, hydrophilic, charged, chemically reactive, metal binding, metallic, or combinations thereof; and

wherein a composition of the electroactive nanomembrane comprises a doping agent, a dye, a quantum dot, or combinations thereof.

21. The device of claim 20, wherein the electroactive nanomembrane is configured to cause a composition change in response to the electrical stimuli.

22. A device comprising:

one or more nanowells or nanotubes or combinations thereof disposed within a support material, each nanotube comprising one or more sidewall electrodes, each nanowell comprising one or more sidewall electrodes and/or one or more bottom electrodes;

one or more electroactive nanomembranes disposed on at least a portion of the one or more electrodes of the one or more nanowells or nanotubes or combinations thereof; and

a lipid bilayer supported by and in direct contact with the one or more electroactive nanomembranes, wherein the lipid bilayer is configured to allow insertion of a molecule.

23. The device of claim 22, wherein the lipid bilayer is configured to provide insertion and functionality testing of one or more lipophilic molecules comprising
detergents, oils, fats, lipids, surfactants, or combinations thereof, or
proteins comprising porins, ion channels, protein nanopores, membrane proteins, membrane enzymes, membrane receptors, membrane channel proteins, membrane transport proteins, complexes with and by thereof, or combinations thereof, and wherein the insertion comprises an insertion of one molecule of protein.
24. The device of claim 22, wherein the one or more electroactive nanomembranes have a hydrophobic surface as a nucleation site or an adhesion site configured to promote nucleation of formation or stabilization of a lipid bilayer.
25. The device of claim 22, wherein number of lipophilic molecules or proteins or protein complexes able to be inserted in the one or more electroactive nanomembranes is controllable or restricted by a dimension alteration of the one or more electroactive nanomembranes to decrease a surface area spanned by the lipid bilayer.
26. The device of claim 22, wherein the one or more electroactive nanomembranes comprise a hydrophobic surface is configured to allow nucleation of formation of the lipid bilayer or to stabilize the lipid bilayer.
27. The device of claim 22, further comprising a nanochannel or nanopore formed by the one or more electroactive nanomembranes to support or stabilize the lipid bilayer.