CLAIMS

What is claimed is:

1. An engineered microbe-targeting molecule comprising:
    a. at least one microbe surface-binding domain;
    b. a substrate-binding domain adapted for orienting the microbe surface-binding domain away from a substrate; and
    c. at least one linker between the microbe surface-binding domain and the substrate-binding domain.
2. The engineered molecule of claim 1, wherein the microbe-surface binding domain comprises a carbohydrate recognition domain (CRD) or a fragment thereof.
3. The engineered molecule of claim 1 or 2, wherein the CRD or a fragment thereof further comprises at least a portion of a carbohydrate-binding protein.
4. The engineered molecule of claim 3, wherein the portion of the carbohydrate-binding protein excludes at least one of complement and coagulation activation region.
5. The engineered molecule of any of claims 2-4, wherein the CRD or the carbohydrate-binding protein is derived from a lectin, a ficolin, or a fragment thereof.
6. The engineered molecule of claim 5 wherein the lectin is C-type lectin, or a fragment thereof.
7. The engineered molecule of claim 6, wherein the C-type lectin is collectin, or a fragment thereof.
8. The engineered molecule of claim 7, wherein the collectin is mannose-binding lectin (MBL) or a fragment thereof.
9. The engineered molecule of any of claims 2-8, wherein the CRD is of SEQ ID NO. 4 or a fragment thereof.
10. The engineered molecule of any of claims 2-9, wherein the CRD or a fragment thereof further comprises a neck region of the carbohydrate-binding protein or a fragment thereof.
11. The engineered molecule of any of claims 1-10, wherein the substrate-binding domain comprises at least one amine.
12. The engineered molecule of any of claims 1-11, wherein the substrate-binding domain comprises at least one oligopeptide comprising an amino acid sequence of AKT.
13. The engineered molecule of any of claims 1-12, wherein the linker is adapted to provide flexibility and orientation of the carbohydrate recognition domain to bind to the microbe surface.

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14. The engineered molecule of any of claims 1-13, wherein the linker is adapted to facilitate expression and purification.
15. The engineered molecule of any of claims 1-14, wherein the linker comprises a portion of a Fc region of an immunoglobulin.
16. The engineered molecule of claim 15, wherein the immunoglobulin is selected from the group consisting of IgA, IgD, IgE, IgG, and IgM.
17. The engineered molecule of claim 15 or 16, wherein the immunoglobulin is IgG1.
18. The engineered molecule of any of claims 15-17, wherein the portion of the Fc region comprises at least one region selected from the group consisting of a hinge region, a CH2 region, a CH3 region, and any combinations thereof.
19. The engineered molecule of any of claims 15-18, wherein the portion of the Fc region comprises at least one hinge region, at least one CH2 region and at least one CH3 region.
20. The engineered molecule of any of claims 15-19, wherein the portion of the Fc region comprises at least one mutation.
21. The engineered molecule of claim 20, wherein the at least one mutation is selected to increase half-life of the engineered molecule.
22. The engineered molecule of any of claims 20-21, wherein the mutation is selected to modulate antibody-dependent cell-mediated cytotoxicity.
23. The engineered molecule of any of claims 20-22, wherein the mutation is selected to modulate complement-dependent cytotoxicity.
24. The engineered molecule of any of claims 20-23, wherein the mutation occurs at amino acid residue 82 of SEQ ID NO. 9 from asparagine to aspartic acid.
25. The engineered molecule of any of claims 15-24, wherein N-terminus of the Fc region is adapted for linking to the substrate-binding domain.
26. The engineered molecule of any of claims 1-25, wherein the linker is part of the carbohydrate-binding protein, the neck region, the Fc region, or any combinations thereof.
27. The engineered molecule of any of claims 1-26, wherein the engineered molecule is a dimer.
28. The engineered molecule of claim 27, wherein the dimer is formed by dimerizing the Fc region of two engineered molecules.
29. The engineered molecule of any of claims 1-28, further comprising a detectable label.

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30. The engineered molecule of claim 29, wherein the detectable label is selected from the group consisting of biotin, a fluorescent dye or particle, a luminescent or bioluminescent marker, a radiolabel, an enzyme, a microbial enzyme substrate, a quantum dot, an imaging agent, and any combinations thereof.
31. The engineered molecule of claim 30, wherein the enzyme causes a color change in the presence of an enzyme substrate.
32. The engineered molecule of claim 31, wherein the enzyme is a horseradish peroxidase or alkaline phosphatase.
33. An engineered mannose-binding lectin molecule comprising:
    a. at least one carbohydrate recognition domain (CRD) or a fragment thereof;
    b. a substrate-binding domain adapted for orienting the CRD away from a substrate; and
    c. at least one linker between the CRD and the substrate-binding domain.
34. The engineered lectin of claim 33, wherein the CRD is of SEQ ID NO. 4.
35. The engineered lectin of claim 33 or 34, wherein the CRD or a fragment thereof further comprises at least a portion of mannose-binding lectin (MBL).
36. The engineered lectin of any of claims 33-35, wherein the portion of the MBL excludes at least one of complement and coagulation activation region.
37. The engineered lectin of any of claims 33-36, wherein the CRD further comprises a neck region of the MBL.
38. The engineered lectin of any of claims 33-37, wherein the substrate-binding domain comprises at least one amine.
39. The engineered lectin of any of claims 33-38, wherein the substrate-binding domain comprises at least one oligopeptide comprising an amino acid sequence of AKT.
40. The engineered lectin of any of claims 33-39, wherein the linker is adapted to provide flexibility and orientation of the carbohydrate recognition domain to bind to the microbe surface.
41. The engineered lectin of any of claims 33-40, wherein the linker is adapted to facilitate expression and purification.
42. The engineered lectin of any of claims 33-41, wherein the linker comprises a portion of a Fc region of an immunoglobulin.
43. The engineered lectin of claim 42, wherein the immunoglobulin is selected from the group consisting of IgA, IgD, IgE, IgG, and IgM.
44. The engineered lectin of claim 42 or 43, wherein the immunoglobulin is IgG1.

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45. The engineered lectin of any of claims 42-44, wherein the portion of the Fc region comprises at least one region selected from the group consisting of a hinge region, a CH2 region, a CH3 region, and any combinations thereof.
46. The engineered lectin of any of claims 42-45, wherein the portion of the Fc region comprises at least one hinge region, at least one CH2 region and at least one CH3 region.
47. The engineered lectin of any of claims 42-46, wherein the portion of the Fc region comprises at least one mutation.
48. The engineered lectin of claim 47, wherein the mutation is selected to increase half-life of the engineered molecule.
49. The engineered lectin of claim 48, wherein the mutation occurs at an amino acid residue 232 of SEQ ID NO. 9 from lysine to alanine.
50. The engineered lectin of any of claims 47-49, wherein the mutation is selected to modulate antibody-dependent cell-mediated cytotoxicity.
51. The engineered lectin of any of claims 47-50, wherein the mutation is selected to modulate complement-dependent cytotoxicity.
52. The engineered lectin of any of claims 47-51, wherein the mutation occurs at amino acid site 82 of SEQ ID NO. 9 from asparagine to aspartic acid.
53. The engineered lectin of any of claims 47-52, wherein N-terminus of the Fc region is adapted for linking to the substrate-binding domain.
54. The engineered lectin of any of claims 47-53, wherein the linker is part of the mannose-binding lectin, the neck region, the Fc region, or any combinations thereof.
55. The engineered lectin of any of claims 33-54, wherein the engineered molecule is a dimer.
56. The engineered lectin of claim 55, wherein the dimer is formed by dimerizing the Fc region of two engineered lectin molecules.
57. The engineered lectin of any of claims 33-56, further comprising a detectable label.
58. The engineered lectin of claim 57, wherein the detectable label or imaging agent is selected from the group consisting of biotin, a fluorescent dye or particle, a luminescent or bioluminescent marker, a radiolabel, an enzyme, a microbial enzyme substrate, a quantum dot, an imaging agent, and any combinations thereof.
59. The engineered lectin of claim 58, wherein the enzyme causes a color change in the presence of an enzyme substrate.

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60. The engineered lectin of claim 59, wherein the enzyme is a horseradish peroxidase or alkaline phosphatase.

61. An engineered microbe-targeting molecule comprising:
    a. at least one microbe surface-binding domain; and
    b. at least a portion of a Fc region of an immunoglobulin.

62. The engineered molecule of claim 61, wherein the portion of the Fc region is linked to N-terminal of the microbe surface-binding domain.

63. The engineered molecule of claim 61 or 62, wherein the microbe surface-binding domain comprises a carbohydrate recognition domain (CRD) or a fragment thereof.

64. The engineered molecule of claim 63, wherein the CRD or a fragment thereof further comprises at least a portion of a carbohydrate-binding protein.

65. The engineered molecule of claim 64, wherein the portion of the carbohydrate-binding protein excludes at least one of complement and coagulation activation region.

66. The engineered molecule of any of claims 63-65, wherein the CRD or the carbohydrate-binding protein is derived from a lectin, a ficolin, or a fragment thereof.

67. The engineered molecule of claim 66, wherein the lectin is C-type lectin, or a fragment thereof.

68. The engineered molecule of claim 67, wherein the C-type lectin is collectin, or a fragment thereof.

69. The engineered molecule of claim 68, wherein the collectin is mannose-binding lectin (MBL) or a fragment thereof.

70. The engineered molecule of any of claims 63-69, wherein the CRD is of SEQ ID NO. 4 or a fragment thereof.

71. The engineered molecule of any of claims 63-70, wherein the CRD or a fragment thereof further comprises a neck region of a carbohydrate-binding protein.

72. The engineered molecule of any of claims 61-71, wherein said at least a portion of the Fc region of the immunoglobulin further comprises a substrate-binding domain.

73. The engineered molecule of claim 72, wherein the substrate-binding domain comprises at least one amine.

74. The engineered molecule of any of claims 61-73, wherein the substrate-binding domain comprises at least one oligopeptide comprising an amino acid sequence of AKT.

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75. The engineered molecule of any of claims 61-74, wherein the immunoglobulin is selected from the group consisting of IgA, IgD, IgE, IgG, and IgM.
76. The engineered molecule of any of claims 61-75, wherein the immunoglobulin is IgG1.
77. The engineered molecule of any of claims 61-76, wherein the portion of the Fc region comprises at least one region selected from the group consisting of a hinge region, a CH2 region, a CH3 region, and any combinations thereof.
78. The engineered molecule of any of claims 61-77, wherein the portion of the Fc region comprises at least one hinge region, at least one CH2 region and at least one CH3 region.
79. The engineered molecule of any of claims 61-78, wherein the portion of the Fc region comprises at least one mutation.
80. The engineered molecule of claim 79, wherein the at least one mutation is selected to increase half-life of the engineered microbe-binding molecule.
81. The engineered molecule of any of claims 61-80, wherein the mutation is selected to modulate antibody-dependent cell-mediated cytotoxicity.
82. The engineered molecule of any of claims 61-81, wherein the mutation is selected to modulate complement-dependent cytotoxicity.
83. The engineered molecule of any of claims 61-82, wherein the mutation occurs at amino acid residue 82 of SEQ ID NO. 9 from asparagine to aspartic acid.
84. The engineered molecule of any of claims 61-83, wherein the engineered molecule is a dimer.
85. The engineered molecule of claim 84, wherein the dimer is formed by dimerizing the Fc region of two engineered molecules.
86. The engineered molecule of any of claims 61-85, further comprising a detectable label.
87. The engineered molecule of claim 86, wherein the detectable label is selected from the group consisting of biotin, a fluorescent dye or particle, a luminescent or bioluminescent marker, a radiolabel, an enzyme, a microbial enzyme substrate, a quantum dot, an imaging agent, and any combinations thereof.
88. The engineered molecule of claim 87, wherein the enzyme causes a color change in the presence of an enzyme substrate.
89. The engineered molecule of claim 88, wherein the enzyme is a horseradish peroxidase or alkaline phosphatase.

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90. A microbe-targeting substrate or a product comprising a substrate, and at least one engineered microbe-targeting molecule of any of claims 1-32 and 61-89 or at least one engineered mannose-binding lectin molecule of any of claims 33-60, wherein the substrate comprises on its surface said at least one engineered microbe-targeting molecule or at least one engineered mannose-binding lectin molecule.

91. The microbe-targeting substrate or the product of claim 90, wherein the substrate-binding domain of the engineered microbe-targeting molecule or mannose-binding lectin molecule is adapted for binding to the substrate.

92. The microbe-targeting substrate or the product of claim 90 or 91, wherein the substrate is selected from the group consisting of a nucleic acid scaffold, a protein scaffold, a lipid scaffold, a dendrimer, microparticle or a microbead, a nanotube, a microtiter plate, a medical apparatus or implant, a microchip, a filtration device, a membrane, a diagnostic strip, a dipstick, an extracorporeal device, a spiral mixer, and a hollow-fiber reactor.

93. The microbe-targeting substrate or the product of any of claims 90-92, wherein the substrate is a microparticle.

94. The microbe-targeting substrate or the product of claim 93, wherein the microparticle is a magnetic microparticle.

95. The microbe-targeting substrate or the product of claim 93, wherein the microparticle is a fluorescent microparticle or a quantum dot.

96. The microbe-targeting substrate or the product of claim 93, wherein the microparticle is a drug delivery vehicle.

97. The microbe-targeting substrate or the product of any of claims 90-96, wherein the substrate is a dipstick.

98. The microbe-targeting substrate or the product of any of claims 90-96, wherein the substrate is a membrane.

99. The microbe-targeting substrate or the product of claim 97 or 98, wherein the dipstick or the membrane comprises on its surface at least an area adapted for use as a reference area.

100. The microbe-targeting substrate or the product of any of claims 90-99, wherein the substrate is a living cell, or a biological tissue or organ.

101. The microbe-targeting substrate or the product of any of claims 90-100, wherein the substrate is functionalized.

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102. The microbe-targeting substrate or the product of any of claims 90-101, wherein the substrate is treated to become less adhesive to a biological molecule.

103. The microbe-targeting substrate or the product of claim 102, wherein the biological molecule is selected from the group consisting of blood cells and components, proteins, nucleic acids, peptides, small molecules, therapeutic agents, cells or fragments thereof, and any combinations thereof.

104. A pharmaceutical composition comprising at least one engineered microbe-targeting molecule of any of claims 1-32 and 61-89 or at least one engineered mannose-binding lectin molecule of any of claims 33-60 or at least one microbe-targeting substrate of any of claims 90-103, and a pharmaceutically acceptable carrier.

105. A kit comprising:

a. one or more containers containing a population of engineered microbe-targeting molecules of any of claims 1-32 and 61-89 or a population of engineered mannose-binding lectin molecules of any of claims 33-60; and

b. at least one reagent.

106. The kit of claim 105, further comprising one or more substrates to which the engineered microbe-targeting molecules or engineered mannose-binding lectin molecules are conjugated.

107. The kit of claim 105 or 106, wherein the substrates are selected from the group consisting of a nucleic acid scaffold, a protein scaffold, a lipid scaffold, a dendrimer, microparticle or a microbead, a nanotube, a microtiter plate, a medical apparatus or implant, a microchip, a filtration device, a membrane, a diagnostic strip, a dipstick, an extracorporeal device, a spiral mixer, and a hollow-fiber reactor.

108. The kit of any of claims 105-107, wherein the substrates include a population of the microbeads.

109. The kit of claim 108, wherein the microbeads are magnetic microbeads.

110. A kit comprising:

a. one or more microbe-targeting substrates of any of claims 90-104; and

b. at least one reagent.

111. The kit of any of claims 105-108, wherein the one or more microbe-targeting substrates include dipsticks.

112. The kit of any of claims 105-109, wherein the one or more microbe-targeting substrates include a population of microbe-targeting microbeads.

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113. The kit of claim 108, 109 or 112, wherein the population of microbes or microbe-targeting microbeads is provided in one or more separate containers.

114. The kit of any of claims 108, 109, and 112-113, wherein the population of the microbeads or microbe-targeting microbeads comprises at least one distinct subset, the distinct subset comprising microbeads or microbe-targeting microbeads having a dimension different from the rest of the population.

115. The kit of any of claims 110-114, wherein the microbe-targeting microbeads each further comprises a detection label.

116. The kit of any of claims 105-115, further comprising one or more containers each containing a population of detectable labels, wherein each of the detectable label is conjugated to a molecule.

117. The kit of claim 116, wherein at least one of the containers contains a distinct population of detectable labels.

118. The kit of any of claims 116-117, wherein the molecule is an engineered microbe-targeting molecule of any of claims 1-32 and 61-89 or an engineered mannose-binding lectin molecules of any of claims 33-60.

119. The kit of claim 118, wherein the molecule comprises at least a carbohydrate recognition domain (CRD) or a fragment thereof.

120. The kit of claim 119, wherein at least one population of the molecule comprises SEQ ID NO.4 or a fragment thereof.

121. The kit of any of claims 116-120, wherein the molecule further comprises a Fc region of an immunoglobulin.

122. The kit of any of claims 116-120, wherein the molecule includes an antibody specific to the microbe.

123. The kit of any of claims 116-122, wherein the detectable label comprises an enzyme that produces a color change in the presence of an enzyme substrate.

124. The kit of claim 123, wherein the enzyme is a horseradish peroxidase, an alkaline phosphatase, or any combinations thereof.

125. The kit of any of claims 105-124, further comprising one or more containers containing an enzyme substrate that changes color in the presence of the enzyme.

126. The kit of any of claims 116-125, wherein the detectable label comprises a fluorescent molecule.

127. The kit of any of claims 105-126, wherein the at least one reagent is a wash buffer, a dilution buffer, a stop buffer, a buffered solution containing a chelating agent, a

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coupling agent used for conjugation of the engineered molecule to the substrate, or any combinations thereof.

128. The kit of any of claims 105-127, further comprising at least one microtiter plate.

129. The kit of any of claims 108-128, wherein the population of microbeads or microbe-targeting microbeads is lyophilized.

130. The kit of any of claims 105-129, further comprising at least one blood collection container.

131. The kit of claim 130, wherein the population of the microbe-targeting microbeads is pre-loaded into said at least one blood collection container.

132. The kit of claim 130 or 131, wherein the blood collection container further comprises an anti-coagulant agent.

133. The kit of any of claims 112-132, wherein the engineered microbe-targeting microbeads are microbe-targeting magnetic microbeads.

134. The kit of claim 133, further comprising a magnet adapted for collecting the microbe-targeting magnetic microbeads in the blood collection container.

135. The kit of any of claims 105-134, further comprising a reference for comparison with a readout determined from a test sample.

136. The kit of any of claims 110-135, wherein one or more microbe-targeting substrates are individually packaged.

137. A method of detaching a microbe and/or microbial matter from a microbe-targeting molecule, the method comprising incubating the substrate with buffer having an acidic pH.

138. The method of claim 137, wherein the buffer has a pH about 6.5 or lower.

139. The method of claim 137 or 138, wherein the buffer comprises 0.2M glycine and has a pH of about 2.8.

140. A method of detaching a microbe and/or microbial matter from a microbe-targeting molecule, the method comprising incubating the substrate with a buffer comprising an ion which forms a salt with Ca^{2+} ion and wherein the said salt is insoluble in the buffer.

141. The method of claim 140, wherein said ion is selected from the group consisting of phosphate, oxalate, carbonate, sulfate, fluoride, gluconic acid, oxido-trioxo-manganese, stearic acid, and any combinations thereof.

142. The method of claim 140 or 141, wherein said ion is present at a concentration of about 0.05M to about 5M.

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143. The method of any of claims 140-142, wherein the buffer comprises about 0.1M sodium phosphate and has pH of about 6.8.

144. The method of any of claims 140-143, wherein the interaction between the microbe and the microbe-targeting molecule is mediated by a Ca^{2+} ion.

145. The method of any of claims 140-144, wherein the aqueous solution further comprises a chelating agent.

146. The method of claim 145, wherein the chelating agent is selected from the group consisting of 1,2-bis(2-Aminophenoxy)ethane-N,N,N',N'-tetraacetic acid; ethylenediaminetetraacetic acid (EDTA); ethylene glycol-bis(2-aminoethylether)-N,N,N',N'-tetraacetic acid (EGTA); ethylene glycol-bis(β-aminoethyl ether)-N,N,N′,N′-tetraacetic acid, 1,2-bis(o-aminophenoxy)ethane-N,N,N',N'-tetraacetic acid (BAPTA), nitrile-2,2',2"-triacetic acid (NTA), and any combinations thereof.

147. The method of any of claims 137-146, wherein the substrate is microparticle.

148. The method of any of claims 137-147, wherein the substrate is a magnetic microparticle.

149. The method of any of claims 137-148, wherein the microbe-targeting molecule is an engineered microbe-targeting molecule of any of claims 1-32 or 61-89, or an engineered mannose-binding ligand of any of claims 33-60.

150. The method of any of claims 137-149, further comprising heating or cooling the buffer during said contacting.

151. The method of any of claims 137-150, further comprising shaking the substrate in the buffer.

152. The method of any of claims 137-151, wherein said incubation is for at least 5 minutes.

153. The method of any of claims 137-152, further comprising washing the substrate with after detachment of the microbe.

154. The method of any of claims 137-153, wherein the microbe-targeting molecule binds to a substrate.

155. A composition for treating and/or preventing a microbial infection or a microbial contamination comprising at least one engineered microbe-targeting molecule of any of claims 1-32 or 61-89 or at least one engineered mannose-binding lectin molecule of any of claims 33-60 or at least one microbe-targeting substrate of any of claims 90-103.

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156. The composition of claim 155, wherein the composition is formulated for treating and/or preventing a microbial infection or a microbial contamination present in an environment surface.

157. The composition of claim 156, wherein the environmental surface includes a medical device, an implantable device, a surface in a hospital or clinic (e.g., an operating room or an intensive-care unit), a machine or working surface for manufacturing or processing food or pharmaceutical products, a cell culture, a water treatment plant, a water reservoir or a botanical plant.

158. The composition of any of claims 155-157, wherein the composition is formulated for treating and/or preventing a microbial infection in a body fluid of a subject.

159. The composition of any of claims of 155-158, wherein the composition is formulated for treating and/or preventing a microbial infection in a tissue of a subject.

160. The composition of claim 158 or 159, wherein the subject is a mammalian subject.

161. The composition of any of claims 155-160, wherein said at least one engineered microbe-targeting molecule is present in an amount effective to reduce the growth and/or spread of the microbe.

162. The composition of any of claims 155-161, further comprising at least one of an antimicrobial agent and a drug delivery vehicle.

163. The composition of claim 162, wherein at least one of the engineered microbe-targeting molecule and the antimicrobial agent is coated on a surface of the drug delivery vehicle.

164. The composition of claim 162 or 163, wherein the drug delivery vehicle is selected from the group consisting of a peptide particle, a polymeric particle, a dendrimer, a vesicle, a liposome, a hydrogel, a nucleic acid scaffold, an aptamer, and any combinations thereof,

165. The composition of any of claims 162-164, wherein the antimicrobial agent is fused with said at least one engineered microbe-targeting molecule.

166. The composition of any of claims 162-165, wherein the antimicrobial agent is selected from the group consisting of silver nanoparticle, an antimicrobial metalloendopeptidase, an antimicrobial peptide, an antibiotic, and any combinations thereof.

167. The composition of any of claims 155-166, wherein a microbe causing the microbial infection or microbial contamination is a protein A-expressing microbe, a protein G-expressing microbe or any combinations thereof.

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168. The composition of claim 167, wherein the protein A-expressing microbe includes *Staphylococcus* or the protein G-expressing microbe includes *Streptococcus.*

169. The composition of claim 167 or 168, wherein the protein A-expressing microbe includes *Staphylococcus aureus.*

170. The composition of any of claims 167-169, wherein the microbe is resistant to at least one antimicrobial agent.

171. The composition of claim 170, wherein the antimicrobial agent is an antibiotic.

172. The composition of claim 171, wherein the antibiotic is selected from the group consisting of aminoglycosides, ansamycins, carbacephem, carbapenems, cephalosporins, glycopeptides, lincosamides, lipopeptide, macrolides, monobactams, nitrofurans, penicillins, polypeptides, quinolones, sulfonamides, tetracyclines, methicillin, vancomycin, and any combinations thereof.

173. The composition of any of claims 167-172, wherein the protein A-expressing microbe includes methicillin-resistant *Staphylococcus aureus*.

174. The composition of any of claims 167-173, wherein the protein A-expressing microbe includes vancomycin-resistant *Staphylococcus aureus.*

175. The composition of any of claims 155-174, wherein the composition is adapted for use as a wound dressing.

176. The composition of any of claims 155-175, wherein the immunoglobulin is a human immunoglobulin.

177. A method for removing a microbe and/or microbial matter from a target area comprising contacting the target area with a composition of any of claims 155-176.

178. A method for treating and/or preventing a microbial infection or microbial contamination in a target area comprising contacting the target area with a first composition of any of claims 155-176.

179. The method of claim 177 or 178, wherein the target area includes an environmental surface.

180. The method of claim 179, wherein the environmental surface includes a medical device, an implantable device, a surface in a hospital or clinic (e.g., an operating room or an intensive-care unit), a machine or working surface for manufacturing or processing food or pharmaceutical products, a cell culture, a water treatment plant, a water reservoir or a botanical plant.

181. The method of claim 177 or 178, wherein the target area is present in a body fluid of a subject.

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182. The method of claim 177 or 178, wherein the target area is present in a tissue of a subject.

183. The method of claim 182, further comprising replacing the first composition in contact with the tissue with a second composition of any of claims 157-178 after a period of time.

184. The method of claim 182 or 183, further comprising administering an additional treatment to the tissue.

185. The method of claim 184, wherein the additional treatment includes a negative-pressure treatment, a vacuum-assisted debridement, administration of an antimicrobial agent, or any combinations thereof.

186. An assay for determining the presence or absence of a microbe and/or microbial matter in a test sample, the assay comprising:

contacting a test sample with a microbe-targeting substrate of any of claims 90-103.

187. An assay of determining the presence or absence of a microbe and/or microbial matter in a test sample, the method comprising:

contacting a test sample with a plurality of microbe-targeting substrates of any of claims 90-103, wherein the plurality of microbe-targeting substrates comprises a first subset of microbe-targeting substrates and a second subset of microbe-targeting substrates; and

wherein the first subset of microbe-targeting substrates each has a first pre-determined dimension; and

wherein the second subset of microbe-targeting substrates each has a second pre-determined dimension.

188. The assay of claim 187, wherein the first subset and the second subset are added to the test sample to form a single mixture.

189. The assay of claim 187, wherein the second subset is added to the test sample after isolation of the first subset previously added to the test sample.

190. The assay of any of claim 186-189, wherein the microbe-targeting substrate is in a form of a microbead.

191. The assay of claim 190, wherein the first pre-determined dimension and the second pre-determined dimension of the microbead range from about 10 nm to about 10 μm.

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192. The assay of claim 190, wherein the first pre-determined dimension and the second pre-determined dimensionof the microbead range from about 50 nm to about 200 nm.

193. The assay of any of claims 190-192, wherein the microbead is a magnetic microbead.

194. The assay of any of claims 186-193, further comprising analyzing the microbe-targeting substrate for the presence or absence of a bound microbe and/or microbial matter, wherein the presence of a microbe-targeting substrate-bound microbe and/or microbial matter indicates that the test sample is infected with a microbe; and the absence of a microbe-targeting substrate-bound microbe and/or microbial matter indicates the test sample contains no detectable microbes or microbial matter.

195. The assay of any of claims 186-194, wherein the microbial matter includes endotoxin.

196. An assay for determining the presence or absence of a protein-A expressing microbe, a protein-G expressing microbe, or microbial matter thereof, in a test sample, the assay comprising:

contacting a test sample with a microbe-targeting substrate of any of claims 90 to 103 in the presence of a chelating agent.

197. The assay of claim 196, further comprising analyzing the microbe-targeting substrate for the presence or absence of a bound microbe, wherein the presence of a microbe-targeting substrate-bound microbe indicates the presence of a protein-A expressing microbe or a protein G-expressing microbe in the test sample; and the absence of a microbe-targeting substrate-bound microbe indicates the absence of a protein-A expressing or a protein G-expressing microbe in the test sample.

198. The assay of claim 197, wherein in the absence of a microbe-targeting substrate-bound microbe, the test sample is further contacted with the microbe-targeting substrate in the presence of free calcium ions.

199. An assay for detecting a protein-A expressing microbe, a protein-G expressing microbe, or microbial matter thereof, in a test sample, the assay comprising:

i. contacting a test sample with a microbe-targeting substrate of any of claims 90 to 103;

ii. contacting the microbe-binding molecule with a solution comprising a chelating agent; and

iii. analyzing the microbe-targeting substrate for the presence or absence of a bound microbe, wherein the presence of a microbe-targeting substrate-bound microbe indicates the presence of a protein A-expressing microbe or a protein G-expressing microbe in the test sample; and the absence of a microbe-targeting substrate-bound

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microbe indicates the absence of a protein A-expressing microbe or a protein G-expressing microbe in the test sample.

200. The assay of claim 199, further comprising isolating the microbe-targeting substrate from the test sample before contacting with the solution comprising the chelating agent.

201. The assay of any of claims 186-200, further comprising isolating the microbe-targeting substrate from the test sample or the solution comprising the chelating agent before the analyzing step.

202. The assay of claim 201, wherein the analyzing comprises an immunoassay, ELISA, Gram staining, immunostaining, microscopy, spectroscopy, immunofluorescence, western blot, PCR, RT-PCR, fluorescence *in situ* hybridization, sequencing, mass spectroscopy, and any combinations thereof.

203. The assay of any of claims 186-202, further comprising culturing the microbe bound on the microbe-targeting substrate.

204. The assay of any of claims 186-203, further comprising subjecting the microbe bound on the microbe-targeting substrate to an antibiotic.

205. The assay of any of claims 186-204, wherein the microbe-targeting substrate is preformed from at least a substrate and said at least one engineered microbe-binding molecule before the contacting.

206. The assay of any of claims 186-204, wherein the microbe-targeting substrate is formed from at least said substrate and said at least one engineered microbe-binding molecule during the contacting.

207. The assay of any of claims 196-206, wherein the presence of the chelating agent reduces the likelihood of a protein A- and protein G-negative microbe, if present, in the test sample, to bind with said at least one engineered microbe-binding molecule.

208. The assay of any of claims 186-207, further comprising detaching the bound microbe from the microbe-targeting substrate.

209. The assay of claim 208, further comprising contacting the isolated microbe-targeting substrate with a low pH buffer.

210. The assay of any of claims 196-209, wherein the chelating agent is a metal-ion chelating agent.

211. The assay of any of claims 196-210, wherein the chelating agent chelates a calcium ion.

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212. The assay of claim 211, wherein the calcium-chelating agent is selected from the group consisting of 1,2-bis(2-aminophenoxy)ethane-N,N,N',N'-tetraacetic acid, ethylenediaminetetraacetic acid (EDTA); ethylene glycol-bis(2-aminoethylether)-N,N,N',N'-tetraacetic acid; ethylene glycol-bis(β-aminoethyl ether)-N,N,N?,N?-tetraacetic acid (EGTA), 1,2-bis(o-aminophenoxy)ethane-N,N,N',N'-tetraacetic acid (BAPTA), a buffer containing citrate, N,N-Bis(2-(bis-(carboxymethyl)amino)ethyl)-glycine (DTPA), nitrilo-2,2',2''-triacetic acid (NTA), a buffer that precipitates a calcium ion from the test sample, a low pH buffer, any derivatives thereof, and any combinations thereof.

213. The assay of any of claims 209-212, wherein the low pH buffer has a pH less than 7.

214. The assay of any of claims 209-213, wherein the low pH buffer is selected from the group consisting of arginine and pyrophosphate.

215. The assay of any of claims 196-214, wherein the protein A-expressing microbe includes Staphylococcus, or the protein G-expressing microbe includes Streptococcus.

216. The assay of claim 215, wherein the protein A-expressing microbe includes Staphylococcus aureus.

217. The assay of claim 215, wherein the Staphylococcus species excludes Staphylococcus epidermidis.

218. The assay of any of claims 186-217, further comprising analyzing at least one microbe-targeting substrate upon contact with the test sample before contacting the microbe-binding molecule with the solution comprising the chelating agent.

219. The assay of claim 186-218, wherein the microbe-targeting substrate is in a form of a microbead.

220. The assay of claim 219, wherein the microbead is a magnetic microbead.

221. A method of determining the presence or absence of *Staphylococcus aureus* infection in a subject, comprising performing the assay of any of claims 190-214, wherein the binding of a microbe to said at least one engineered microbe-targeting substrate in the presence of a chelating agent is indicative of Staphylococcus aureus infection in the subject.

222. The method of claim 221, further comprising administering or prescribing to the subject a first antimicrobial agent when the subject is detected with Staphylococcus aureus.

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223. The method of claim 221 or 222, further comprising analyzing the test sample or the solution comprising the chelating agent after isolating the engineered microbe-targeting substrate therefrom to determine the presence or absence of a protein A-negative or a protein G-negative microbe.

224. The method of claim 223, further comprising administering or prescribing to the subject a second antimicrobial agent when the subject is detected with a protein A-negative or a protein G-negative microbe.

225. The method of claim 224, wherein the protein A-negative or the protein G-negative microbe include *E. coli*.

226. The method of any of claims 221-225, further comprising administering or prescribing to the subject a composition comprising at least one engineered microbe-targeting molecule of any of claims 1-32 or 61-89, or at least one engineered mannose-binding lectin molecule of any of claims 33-60.

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CLAIMS

1. A microbe-binding molecule comprising:

(i) at least one microbe surface-binding domain;

(ii) a substrate-binding domain adapted for orienting the microbe surface-binding domain away from the solid substrate surface; and

(iii) at least one linker between the microbe surface-binding domain and the substrate-binding domain; and

(iv) a detectable label.

2. A microbe-binding molecule according to Claim 1, in which the microbe surface-binding domain comprises a carbohydrate recognition domain derived from at least one carbohydrate-binding protein selected from the group consisting of lectin, collectin, ficolin, mannose-binding lectin (MBL), maltose-binding protein, arabinose-binding protein, glucose-binding protein, *Galanthus nivalis* agglutinin, peanut lectin, lentil lectin, DC-SIGN, C-reactive protein, and any combinations thereof.

3. A microbe-binding molecule according to Claim 1 or 2, in which the microbe surface-binding domain comprises a carbohydrate recognition domain derived from mannose-binding lectin (MBL).

4. A microbe-binding molecule according to Claim 3, in which the carbohydrate recognition comprises an amino acid sequence selected from SEQ ID NOs: 1-4.

5. A microbe-binding molecule according to any preceding claim, in which the detectable label is selected from the group consisting of biotin, a fluorescent dye or particle, a luminescent or bioluminescent marker, a radiolabel, an enzyme, a microbial enzyme substrate, a quantum dot, an imaging agent, and any combinations thereof.

6. A microbe-binding molecule according to Claim 5, in which the detectable label comprises an enzyme which causes a colour change in the presence of an enzyme substrate.

7. A microbe-binding molecule according to Claim 5 or 6, in which the detectable label is a horseradish peroxidase or alkaline phosphatase.

8. A microbe-binding molecule according to any preceding claim, in which the linker comprises a portion of a Fc region of an immunoglobulin.

9. A microbe-binding molecule according to Claim 8, in which the portion of the Fc region comprises a hinge region, a CH2 region, a CH3 region, or any combinations thereof.

10. A microbe-binding molecule according to Claim 8 or 9, in which the portion of the Fc region comprises a mutation selected to increase half-life of the microbe-binding molecule, to modulate antibody-dependent cell-mediated cytotoxicity, to modulate complement-dependent cytotoxicity, or any combinations thereof.

11. A microbe-binding molecule according to any preceding claim, in which the substrate-binding domain comprises at least one oligopeptide comprising an amino acid sequence of Alanine-Lysine-Threonine (AKT).

12. A microbe-binding molecule according to any preceding claim for use in a method of diagnosing an infection in a subject, the method comprising administering to the subject the microbe-binding molecule and detecting binding of a microbe or microbial matter to the microbe-binding molecule.

13. A microbe-binding molecule according to Claim 12 for a use as specified therein, in which the method further comprises collecting a test sample from the subject for detecting the binding of a microbe or microbial matter to the microbe-binding molecule.

14. A microbe-binding molecule according to Claim 13 for a use as specified therein, in which the test sample is a body fluid or a tissue sample.

15. A method of detecting a microbe or microbial matter in a test sample comprising contacting *in vitro* or *ex-vivo* a test sample with a microbe-binding molecule according to any of Claims 1 to 11 and detecting binding of a microbe or microbial matter to the microbe-binding molecule.

16. An assay comprising:

(a) contacting a test sample with microbe-binding molecules, in which the microbe-binding molecules are conjugated to a surface of a solid substrate, and in which the engineered microbe-binding molecules each comprises:

(i) at least one microbe surface-binding domain;

(ii) a substrate-binding domain adapted for orienting the microbe surface-binding domain away from the solid substrate surface; and

(iii) at least one linker between the microbe surface-binding domain and the substrate-binding domain; and

(b) detecting binding of a microbe or microbial matter to at least a portion of the microbe-binding molecules.

17. An assay according to Claim 16, in which the detecting is performed by spectroscopy, electrochemical detection, polynucleotide detection, fluorescence anisotropy, fluorescence resonance energy transfer, electron transfer, enzyme assay, magnetism, electrical conductivity, isoelectric focusing, chromatography, immunoprecipitation, immunoseparation, aptamer binding, filtration, electrophoresis, use of a CCD camera, immunoassay, ELISA, Gram staining, immunostaining, microscopy, immunofluorescence, western blot, polymerase chain reaction (PCR), RT-PCR, fluorescence in situ hybridization, sequencing, mass spectroscopy, or any combination thereof.

18. An assay according to Claim 16 or 17, further comprising contacting the bound microbe or microbial matter with a labelling molecule prior to the detecting step.

19. An assay according to Claim 18, in which the labelling molecule comprises wheat germ agglutinin, lectins, antibodies, antigen binding fragments of antibodies, aptamers, or ligands of cell-surface receptors.

20. An assay according to Claim 18 or 19, in which the labelling molecule binds to a specific microbial class, strain or species.

21. An assay according to Claim 18, 19 or 20 in which the labelling molecule is conjugated to an enzyme that produces a colour change in the presence of an enzyme substrate.

22. The assay according to Claim 21, in which the enzyme comprises a beta-galactosidase, a peroxidase, a catalase, an alkaline phosphatase.

23. The assay according to any of Claims 16 to 22, in which the detecting further comprises identifying the microbe or microbial matter bound to the microbe-binding molecules based on a microbe signature determined by mass spectrometric analysis.

24. The assay according to Claim 23, further comprising, prior to the mass spectrometric analysis, detaching the bound microbe or microbial matter from at least a portion of the microbe-binding molecules.

25. An assay according to Claim 24, in which the detaching comprises incubating the microbe-binding molecules comprising the bound microbe or microbial matter in a buffer (i) having an acidic pH or (ii) comprising an ion which forms a salt with Ca^{2+} ion, and in which the salt is insoluble in the buffer.

26. An assay according to any of Claims 16 to 25, in which the surface of the solid substrate further comprises at least one reference area for comparison with a readout signal determined upon contact of the test sample with the microbe-binding molecules.

27. An assay according to any of Claims 16 to 26, in which the solid substrate is a dipstick, a test strip, or a microtiter plate.

28. An assay according to any of Claims 16 to 27, further comprising subjecting the bound microbe to at least one antibiotic.

29. An assay according to Claim 28, further comprising evaluating a response of the bound microbe to the at least one antibiotic.

30. An assay according to Claim 29, further identifying a treatment of an infection caused by the microbe.

31. A kit comprising:

(a) one or more containers containing a population of microbe-binding microparticles; in which the engineered microbe-binding microparticles each comprises on its surface at least one microbe-binding molecule, in which the at least one microbe-binding molecule comprises

(i) at least one microbe surface-binding domain;

(ii) a substrate-binding domain adapted for orienting the microbe surface-binding domain away from the solid substrate surface; and

(iii) at least one linker between the microbe surface-binding domain and the substrate-binding domain; and

(b) one or more containers containing a population of labelling molecules, in which the labelling molecules are conjugated to an enzyme; and

(c) one or more containers containing an enzyme substrate that produces a colour change in the presence of the enzyme.

32. A kit according to Claim 31, in which the population of engineered microbe-binding molecules are pre-loaded in one or more blood collection tubes.

33. A kit according to Claim 32, in which the blood collection tube further comprises an anti-coagulant agent.

34. A kit according to Claim 31, 32 or 33, in which the population of engineered microbe-binding microparticles comprises a first subset having on their surfaces a first density of the microbe-binding molecules and a second subset having on their surfaces a second density of the microbe-binding molecules, in which the second density is different from the first density.