CLAIMS

1. A polymer comprising acidic monomers and ionic monomers connected to form a polymeric backbone,

wherein each acidic monomer comprises at least one Bronsted-Lowry acid, and

wherein each ionic monomer independently comprises at least one nitrogen-containing cationic group or phosphorous-containing cationic group, wherein one or more of the ionic monomers each further comprise a linker connecting the nitrogen-containing cationic group or the phosphorous-containing cationic group to the polymeric backbone, and

wherein the linker of the one or more ionic monomers at each occurrence is independently selected from the group consisting of unsubstituted or substituted alkylene, unsubstituted or substituted cycloalkylene, unsubstituted or substituted alkenylene, unsubstituted or substituted arylene, unsubstituted or substituted heteroarylene, unsubstituted or substituted alkylene ether, and unsubstituted or substituted alkylene carbamate.

2. The polymer of claim 1, wherein the Bronsted-Lowry acid at each occurrence is independently selected from the group consisting of sulfonic acid, phosphonic acid, acetic acid, isophthalic acid, boronic acid, and perfluorinated acid.

3. The polymer of claim 1, wherein the Bronsted-Lowry acid at each occurrence is sulfonic acid.

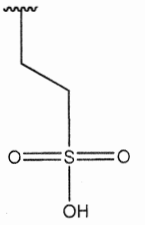
4. The polymer of claim 1, wherein the Bronsted-Lowry acid at each occurrence is phosphonic acid.

35. The polymer of any one of claims 1 to 4 ~~or 2~~, wherein one or more of the acidic monomers are directly connected to the polymeric backbone.

46. The polymer of any one of claims 1 to 4~~or 2~~, wherein one or more of the acidic monomers each further comprise a linker connecting the Bronsted-Lowry acid to the polymeric backbone.

~~57~~. The polymer of claim ~~46~~, wherein the linker of the one or more acidic monomers at each occurrence is independently selected from the group consisting of unsubstituted or substituted alkylene, unsubstituted or substituted cycloalkylene, unsubstituted or substituted alkenylene, unsubstituted or substituted arylene, unsubstituted or substituted heteroarylene, unsubstituted or substituted alkylene ether, unsubstituted or substituted alkylene ester, and unsubstituted or substituted alkylene carbamate.

~~68~~. The polymer of claim ~~46~~, wherein the Bronsted-Lowry acid and the linker form an acidic side chain, wherein each acidic side chain is independently selected from the group consisting of:



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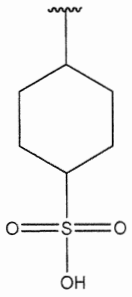

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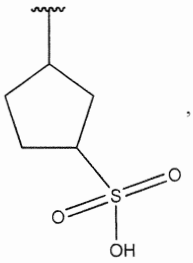

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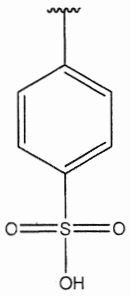

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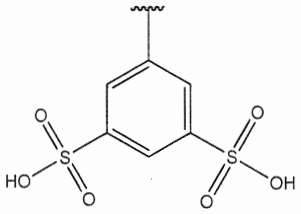

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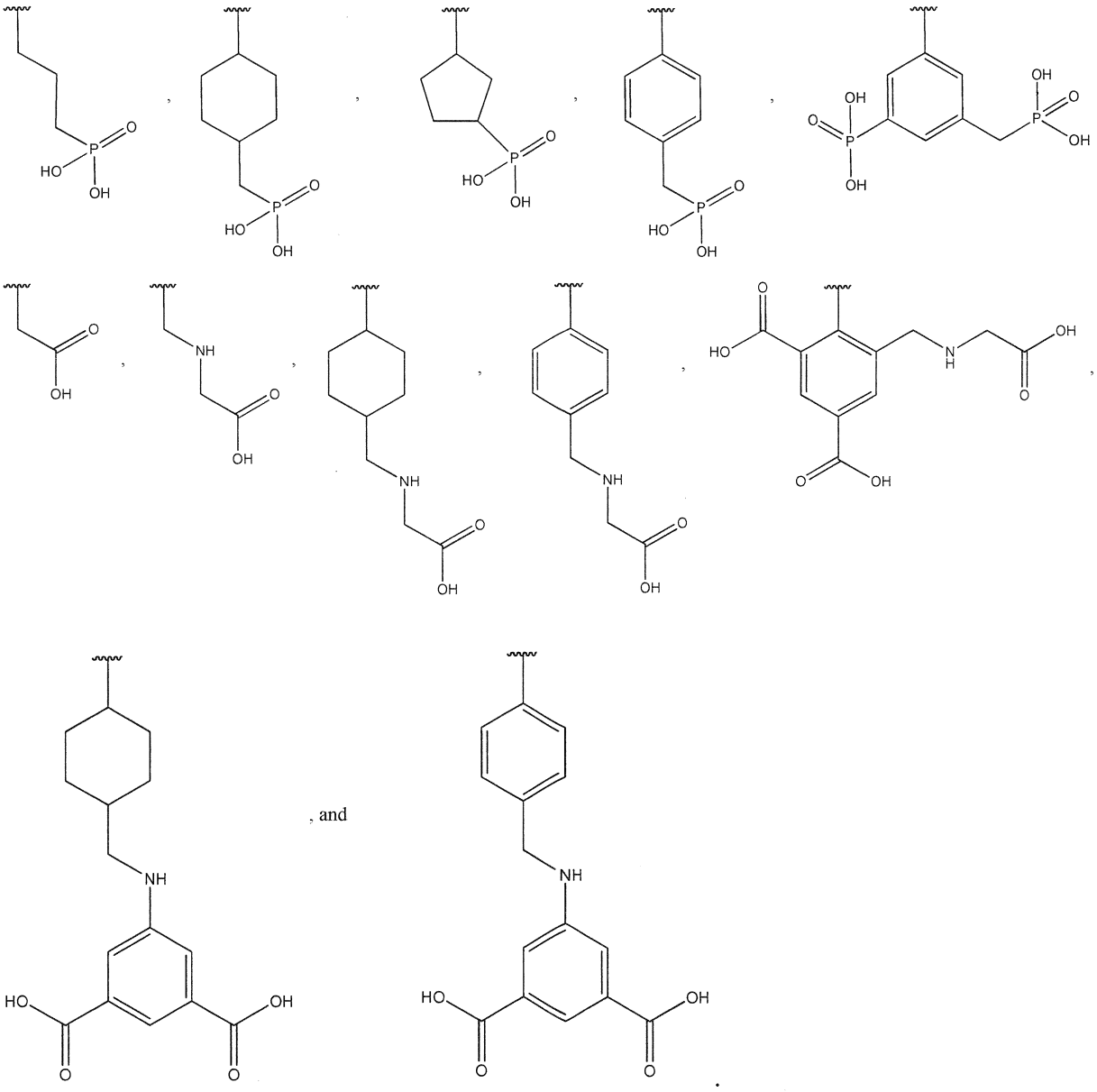

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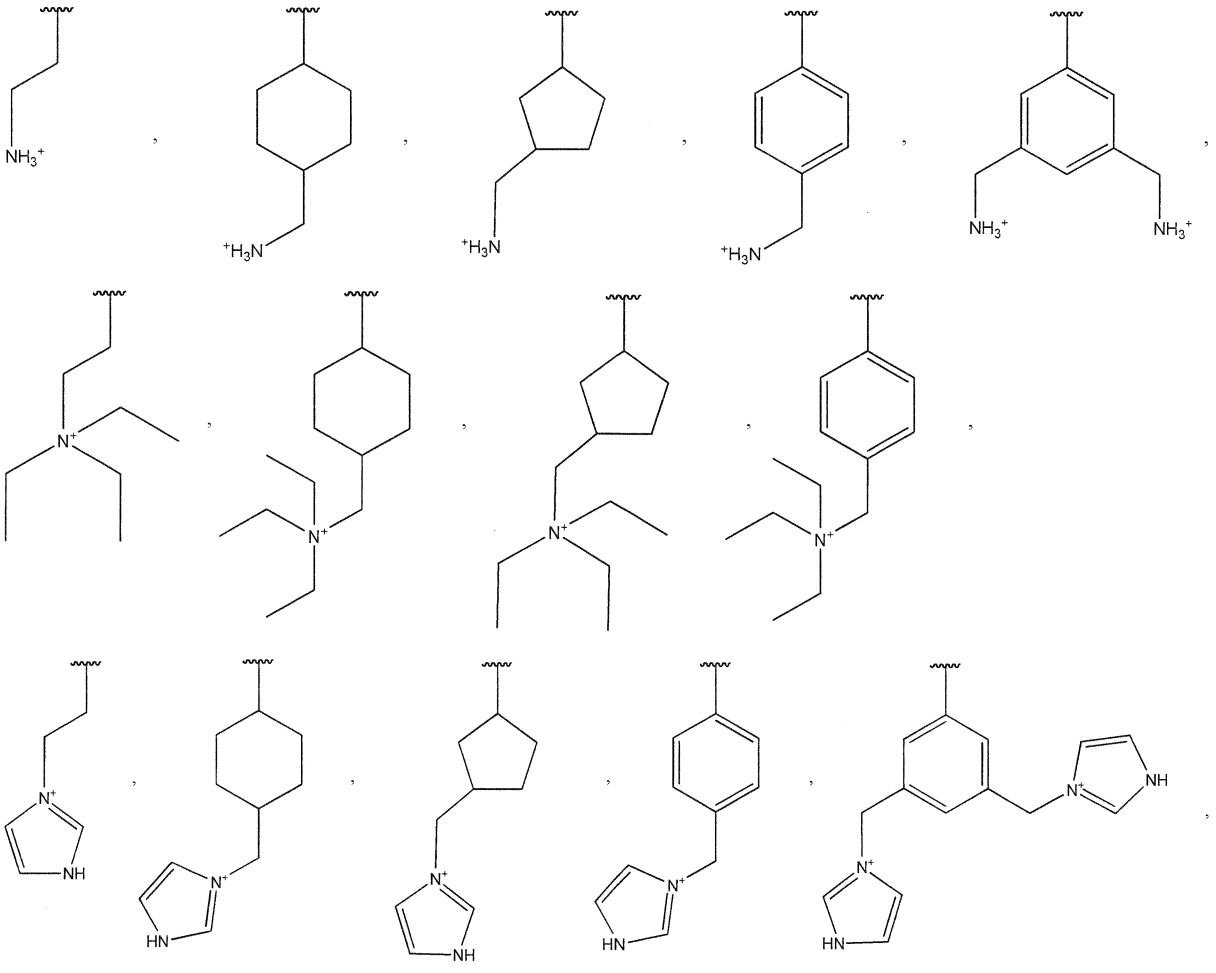
79. The polymer of any one of claims 1 to 68, wherein the nitrogen-containing cationic group at each occurrence is independently selected from the group consisting of pyrrolium, imidazolium, pyrazolium, oxazolium, thiazolium, pyridinium, pyrimidinium, pyrazinium, pyradizimium, thiazinium, morpholinium, piperidinium, piperizinium, and pyrollizinium.

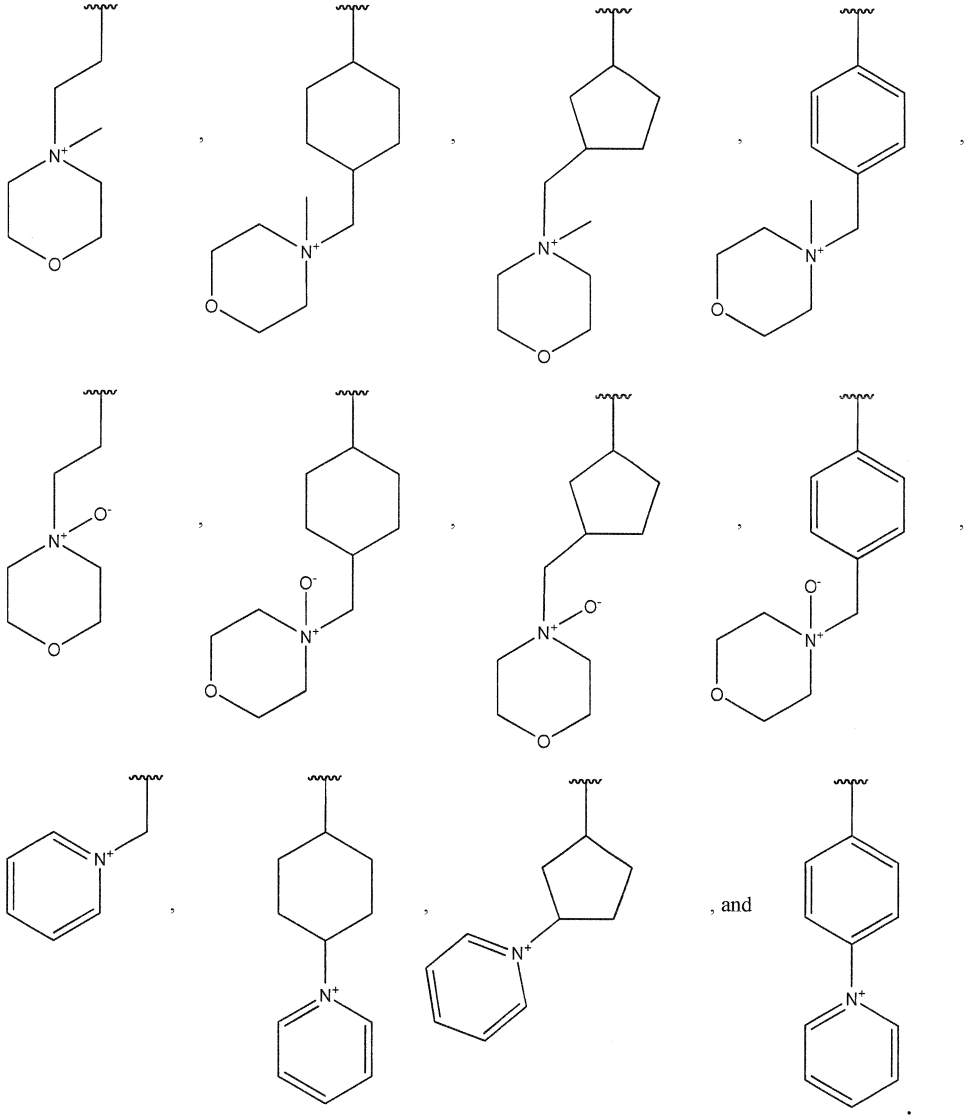
810. The polymer of any one of claims 1 to 68, wherein the phosphorous-containing cationic group at each occurrence is independently selected from the group consisting of triphenyl phosphonium, trimethyl phosphonium, triethyl phosphonium, tripropyl phosphonium, tributyl phosphonium, trichloro phosphonium, and trifluoro phosphonium.

~~9. The polymer of any one of claims 1 to 8, wherein one or more of the ionic monomers are directly connected to the polymeric backbone.~~

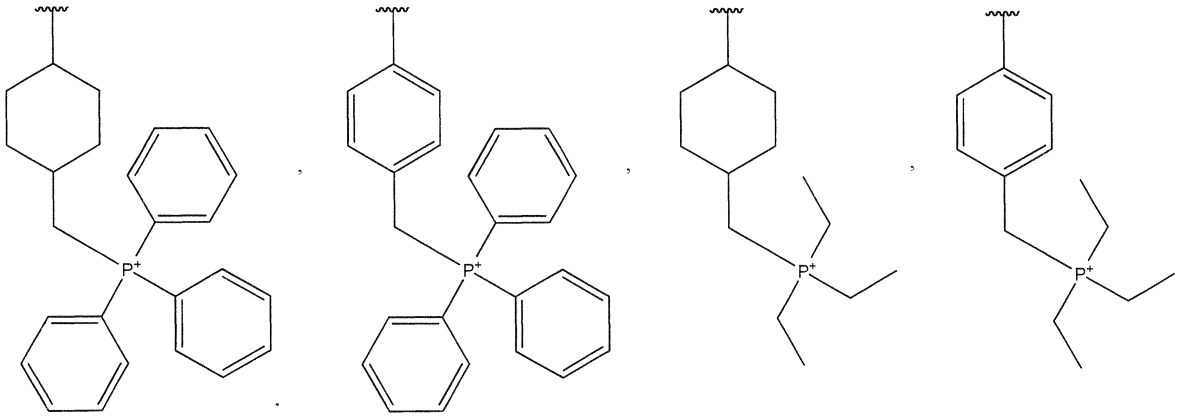
~~10. The polymer of any one of claims 1 to 8, wherein one or more of the ionic monomers each further comprise a linker connecting the nitrogen-containing cationic group or the phosphorous-containing cationic group to the polymeric backbone.~~

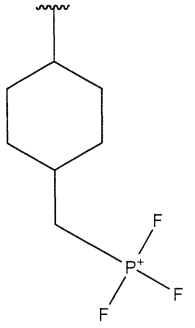
11. The polymer of claim ~~10~~1, wherein the nitrogen-containing cationic group and the linker form a nitrogen-containing side chain, wherein each nitrogen-containing side chain is independently selected from the group consisting of:





12. The polymer of claim ~~101~~, wherein the phosphorous-containing cationic group and the linker form a phosphorous-containing side chain, wherein each phosphorous-containing side chain is independently selected from the group consisting of:





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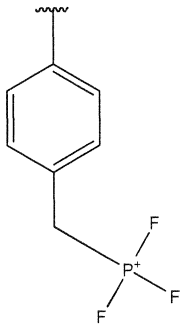

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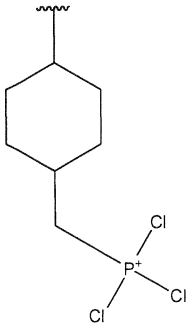

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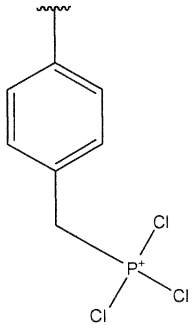

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13. The polymer of claim ~~101~~, wherein the linker of the one or more ionic monomers at each occurrence is independently selected from the group consisting of unsubstituted or substituted alkylene, unsubstituted or substituted cycloalkylene, unsubstituted or substituted alkenylene, and unsubstituted or substituted arylene~~, unsubstituted or substituted heteroarylene, unsubstituted or substituted alkylene ether, unsubstituted or substituted alkylene ester, and unsubstituted or substituted alkylene carbamate~~.

14. The polymer of any one of claims 1 to 13, wherein the polymeric backbone is selected from the group consisting of polyethylene, polypropylene, polyvinyl alcohol, polystyrene, polyurethane, polyvinyl chloride, polyphenol-aldehyde, polytetrafluoroethylene, polybutylene terephthalate, polycaprolactam, poly(acrylonitrile butadiene styrene), polyalkyleneammonium, polyalkylenediammonium, polyalkylenepyrrolium, polyalkyleneimidazolium, polyalkylenepyrazolium, polyalkyleneoxazolium, polyalkylenethiazolium, polyalkylenepyridinium, polyalkylenepyrimidinium, polyalkylenepyrazinium, polyalkylenepyradizimium, polyalkylenethiazinium, polyalkylenemorpholinium, polyalkylenepiperidinium, polyalkylenepiperizinium, polyalkylenepyrollizinium, polyalkylenetriphenylphosphonium, polyalkylenetrimethylphosphonium, polyalkylenetriethylphosphonium, polyalkylenetripropylphosphonium, polyalkylenetributylphosphonium, polyalkylenetrichlorophosphonium, polyalkylenetrifluorophosphonium, and polyalkylenediazolium.

15. The polymer of any one of claims 1 to 14, wherein the polymer is cross-linked.

16. The polymer of any one of claims 1 to 15, wherein the acidic monomers and the ionic monomers are randomly arranged in an alternating sequence or in blocks of monomers.

17. The polymer of claim 16, wherein each block has no more than twenty monomers.

18. The polymer of any one of claims 1 to 17, further comprising hydrophobic monomers connected to the polymeric backbone, wherein each hydrophobic monomer comprises a hydrophobic group.

19. The polymer of claim 18, wherein the hydrophobic group at each occurrence is independently selected from the group consisting of an unsubstituted or substituted alkyl, an unsubstituted or substituted cycloalkyl, an unsubstituted or substituted aryl, or an unsubstituted or substituted heteroaryl.

20. The polymer of claim 18 or 19, wherein the hydrophobic group is directly connected to the polymeric backbone.

21. The polymer of any one of claims 1 to 20, further comprising acidic-ionic monomers connected to the polymeric backbone, wherein each acidic-ionic monomer comprises a Bronsted-Lowry acid and a cationic group.

22. The polymer of claim 21, wherein the cationic group is a nitrogen-containing cationic group or a phosphorous-containing cationic group.

23. The polymer of claim 21 or 22, wherein one or more of the acidic-ionic monomers each further comprise a linker connecting the Bronsted-Lowry acid or the cationic group to the polymeric backbone.

24. The polymer of claim 23, wherein the linker of the one or more acidic-ionic monomers at each occurrence is independently selected from the group consisting of unsubstituted or substituted alkylene, unsubstituted or substituted cycloalkylene, unsubstituted or substituted alkenylene, unsubstituted or substituted arylene, unsubstituted or substituted heteroarylene, unsubstituted or substituted alkylene ether, unsubstituted or substituted alkylene ester, and unsubstituted or substituted alkylene carbamate.

25. The polymer of claim 23, wherein the Bronsted-Lowry acid, the cationic group and the linker form an acidic-ionic side chain, wherein each acidic-ionic side chain is independently selected from the group consisting of:

38. The polymer of claim 37, wherein the total amount of perfluorinated acid in the polymer is between 0.01 and 5 mmol per gram of polymer.

39. The polymer of any one of claims 1 to 38, wherein each ionic monomer further comprises a counterion for each nitrogen-containing cationic group or phosphorous-containing cationic group.

40. The polymer of claim 39, wherein the counterion at each occurrence is independently selected from the group consisting of halide, nitrate, sulfate, formate, acetate, or organosulfonate.

41. The polymer of claim 39 or 40, wherein the polymer has a total amount of nitrogen-containing cationic groups and counterions or a total amount of phosphorous-containing cationic groups and counterions of between 0.01 and 10 mmol per gram of polymer.

42. The polymer of any one of claims 39 to 41, wherein at least a portion of the ionic monomers comprise imidazolium.

43. The polymer of claim 42, wherein the total amount of imidazolium and counterions in the polymer is between 0.01 and 8 mmol per gram of polymer.

44. The polymer of any one of claims 39 to 43, wherein at least a portion of the ionic monomers comprise pyridinium.

45. The polymer of claim 44, wherein the total amount of pyridinium and counterions in the polymer is between 0.01 and 8 mmol per gram of polymer.

46. The polymer of any one of claims 39 to 45, wherein at least a portion of the ionic monomers comprise triphenyl phosphonium.

47. The polymer of claim 46, wherein the total amount of triphenyl phosphonium and counterions in the polymer is between 0.01 and 5 mmol per gram of polymer.

48. ~~The polymer of claim 1, wherein the~~A polymer ~~is~~ selected from the group consisting of:

poly(butyl-vinylimidazolium chloride–*co*–butylimidazolium bisulfate–*co*–4-vinylbenzenesulfonic acid);

poly(butyl-vinylimidazolium bisulfate–*co*–butylimidazolium bisulfate–*co*–4-vinylbenzenesulfonic acid);

poly(benzyl alcohol-*co*-4-vinylbenzylalcohol sulfonic acid-*co*-vinylbenzyltriphenylphosphonium chloride-*co*-divinylbenzyl alcohol); and

poly(benzyl alcohol-*co*-4-vinylbenzylalcohol sulfonic acid-*co*-vinylbenzyltriphenylphosphonium bisulfate-*co*-divinylbenzyl alcohol).

49. The polymer according to any one of claims 1 to 48, wherein the polymer has one or more catalytic properties selected from the group consisting of:

a) disruption of a hydrogen bond in cellulosic materials;

b) intercalation of the polymer into crystalline domains of cellulosic materials; and

c) cleavage of a glycosidic bond in cellulosic materials.

50. The polymer according to any one of claims 1 to 48, wherein the polymer has a greater specificity for cleavage of a glycosidic bond than dehydration of a monosaccharide in cellulosic materials.

51. The polymer according to any one of claims 1 to 48, wherein the polymer is capable of degrading biomass into one or more sugars at a first-order rate constant of at least 0.001 per hour.

52. The polymer of claim 51, wherein the polymer is capable of degrading of the biomass to produce the sugars occurs at a first-order rate constant of at least 0.1 per hour.

53. The polymer according to any one of claims 1 to 48, wherein the polymer is capable of converting biomass into one or more sugars and residual biomass, wherein the residual biomass has a degree of polymerization of less than 300.

54. The ~~method~~polymer of claim 53, wherein the polymer is capable of converting biomass into one or more sugars and residual biomass, wherein the residual biomass has a degree of polymerization of less than 100.

55. The polymer according to any one of claims 1 to 48, wherein the polymer is substantially insoluble in water or an organic solvent.

56. A solid particle comprising a solid core and a polymer ~~according to any one of claims 1 to 48~~ coated on the surface of the solid core, wherein the polymer comprises acidic monomers and ionic monomers connected to form a polymeric backbone,

wherein each acidic monomer comprises at least one Bronsted-Lowry acid, and

wherein each ionic monomer independently comprises at least one nitrogen-containing cationic group or phosphorous-containing cationic group.

57. The solid particle of claim 56, wherein the Bronsted-Lowry acid at each occurrence in the polymer is independently selected from the group consisting of sulfonic acid, phosphonic acid, acetic acid, isophthalic acid, boronic acid, and perfluorinated acid.

58. The solid particle of claim 56 or 57, wherein the nitrogen-containing cationic group in the polymer at each occurrence is independently selected from the group consisting of pyrrolium, imidazolium, pyrazolium, oxazolium, thiazolium, pyridinium, pyrimidinium, pyrazinium, pyradizinium, thiazinium, morpholinium, piperidinium, piperizinium, and pyrollizinium; and

wherein the phosphorous-containing cationic group in the polymer at each occurrence is independently selected from the group consisting of triphenyl phosphonium, trimethyl phosphonium, triethyl phosphonium, tripropyl phosphonium, tributyl phosphonium, trichloro phosphonium, and trifluoro phosphonium.

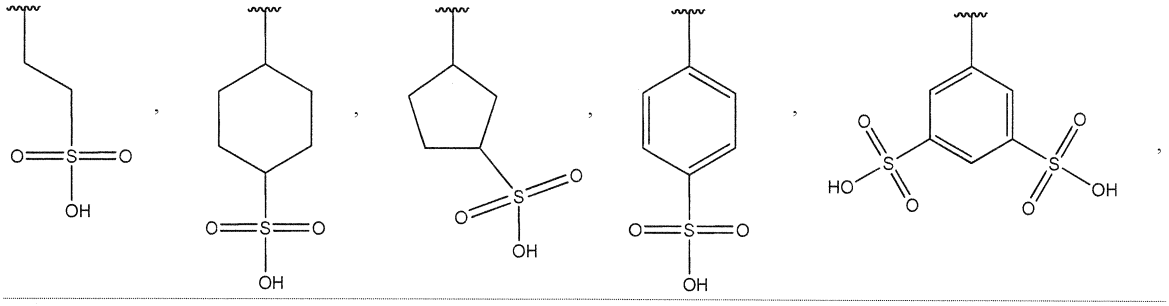
59. The solid particle of any one of claims 56 to 58, wherein one or more of the acidic monomers in the polymer each further comprise a linker connecting the Bronsted-Lowry acid to the polymeric backbone.

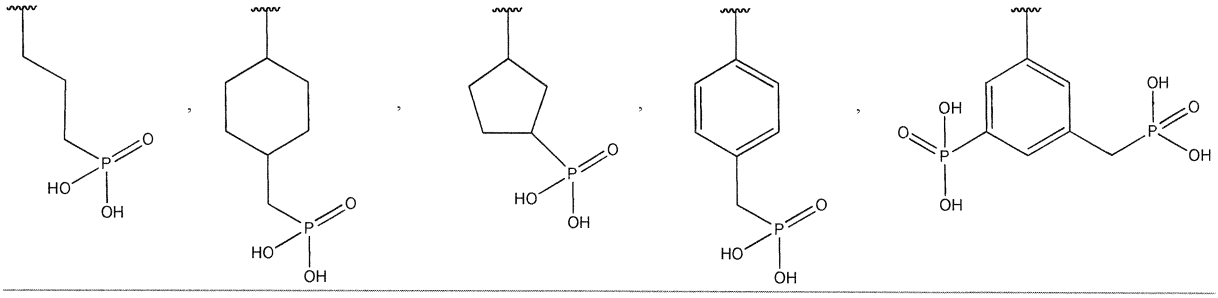
60. The solid particle of any one of claims 56 to 59, wherein one or more of the ionic monomers of the polymer each further comprise a linker connecting the nitrogen-containing cationic group or the phosphorous-containing cationic group to the polymeric backbone.

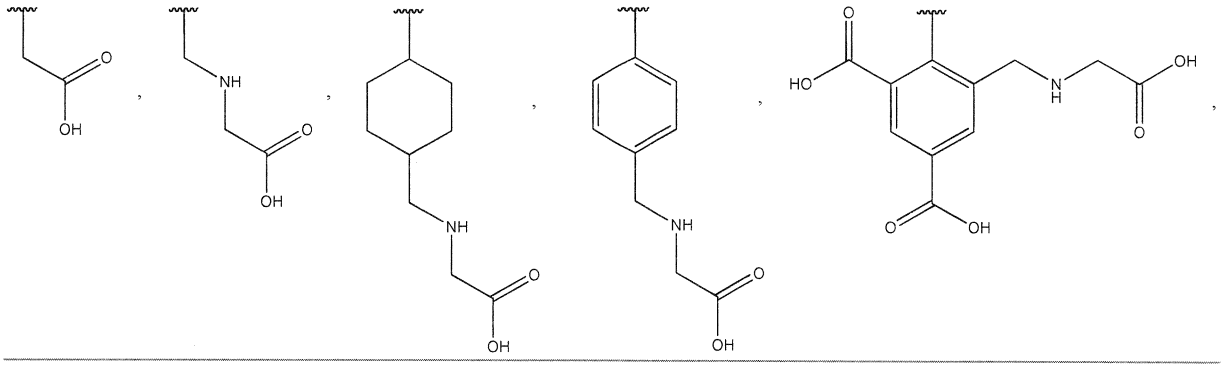
61. The solid particle of claim 59 or 60, wherein the linker at each occurrence is independently selected from the group consisting of unsubstituted or substituted alkylene,

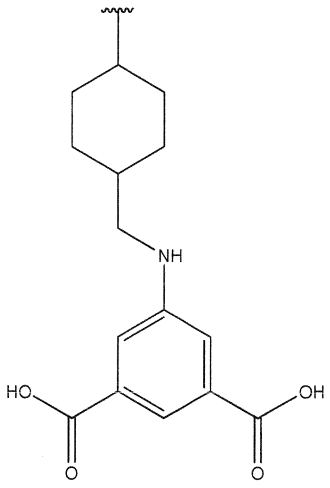
unsubstituted or substituted cycloalkylene, unsubstituted or substituted alkenylene, unsubstituted or substituted arylene, unsubstituted or substituted heteroarylene, unsubstituted or substituted alkylene ether, unsubstituted or substituted alkylene ester, and unsubstituted or substituted alkylene carbamate.

62. The solid particle of claim 59, wherein the Bronsted-Lowry acid and the linker form an acidic side chain, wherein each acidic side chain is independently selected from the group consisting of:









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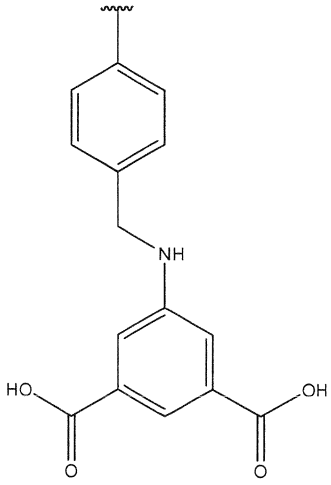
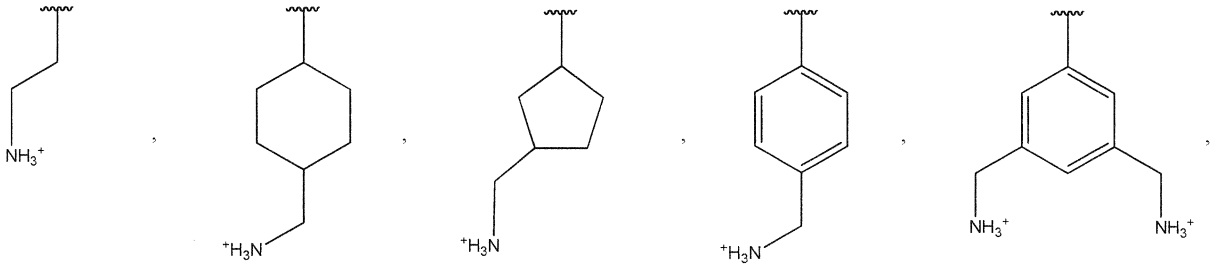
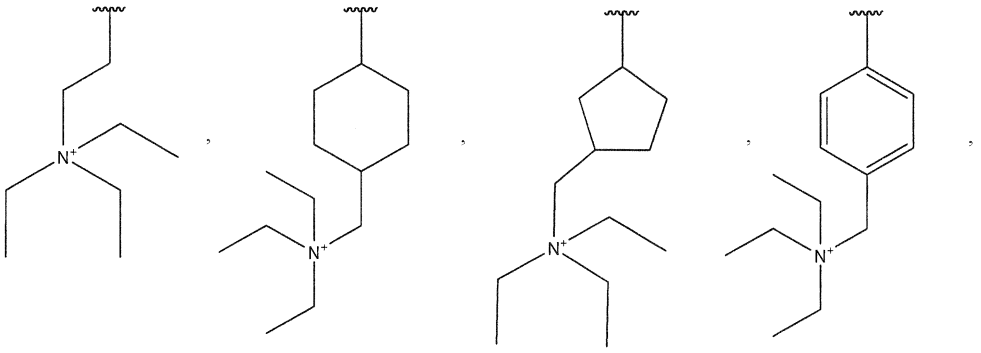
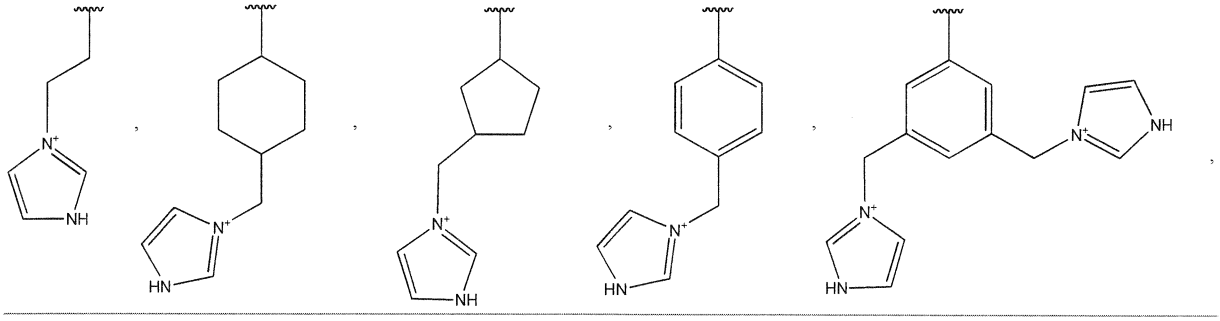
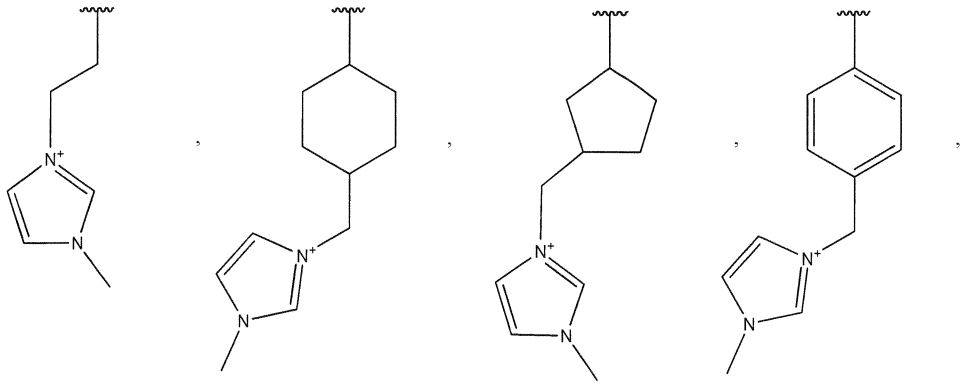


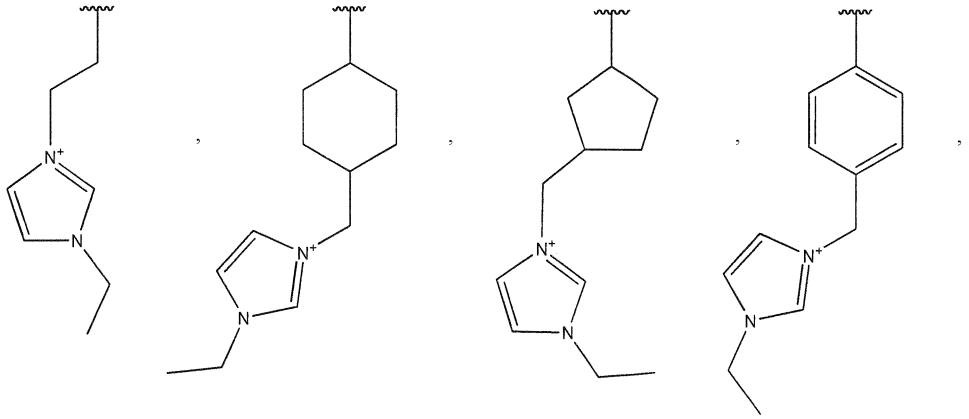
63. The solid particle of claim 60, wherein the nitrogen-containing cationic group and the linker form a nitrogen-containing side chain, wherein each nitrogen-containing side chain is independently selected from the group consisting of:

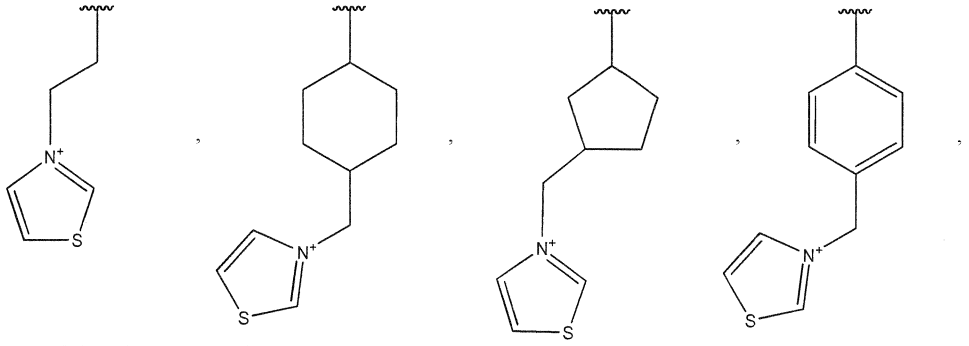


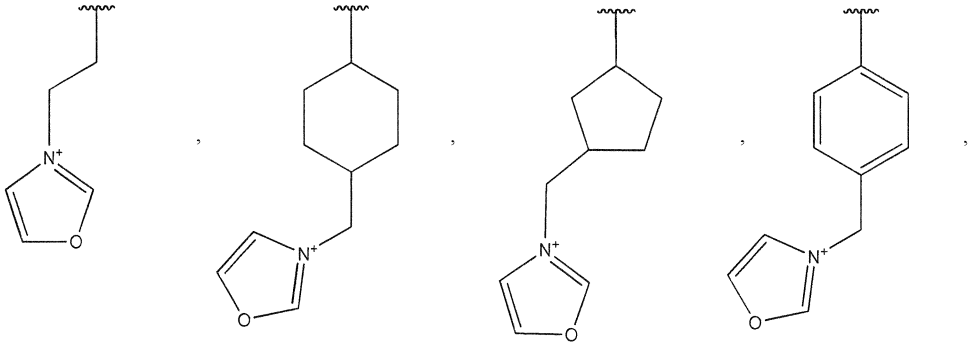


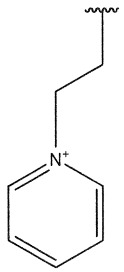








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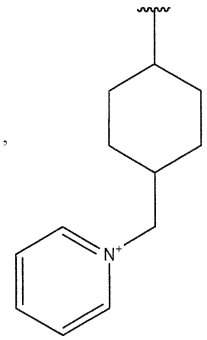
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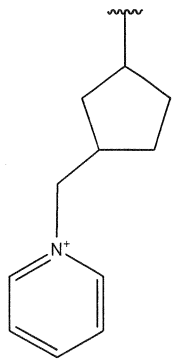
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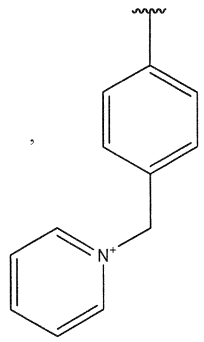
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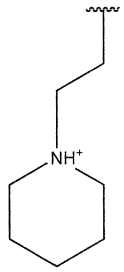
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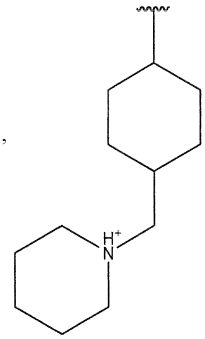
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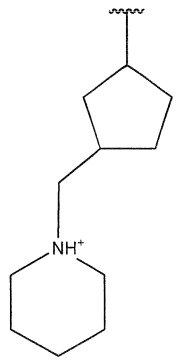
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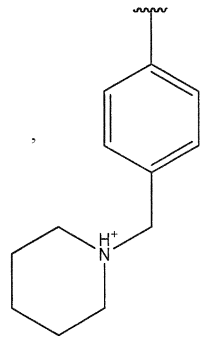
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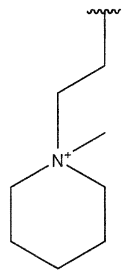
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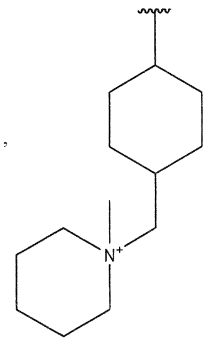
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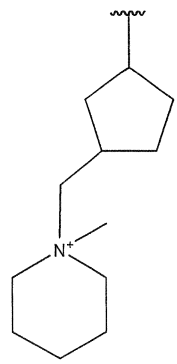
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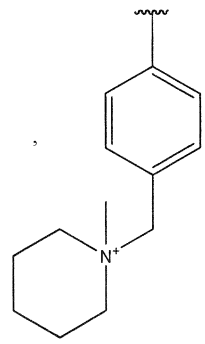
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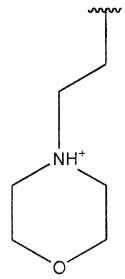
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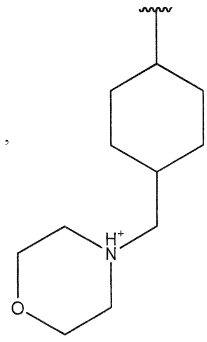
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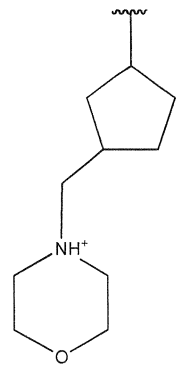
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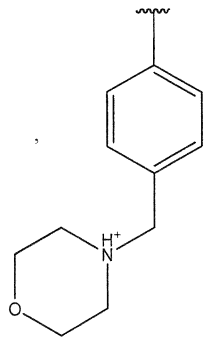
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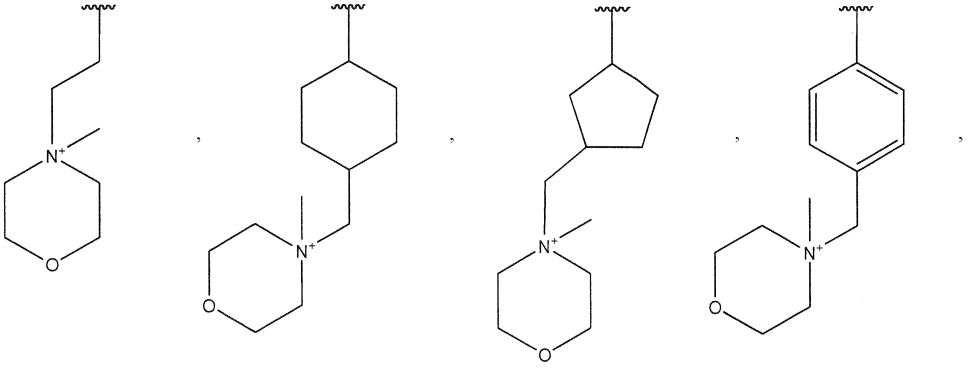
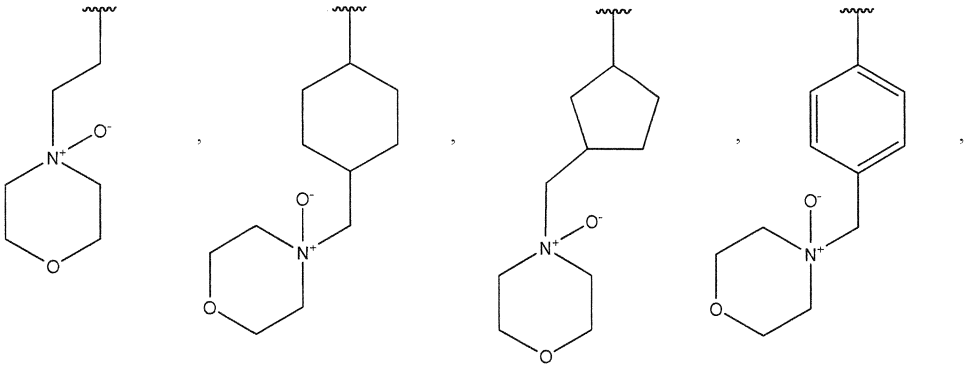
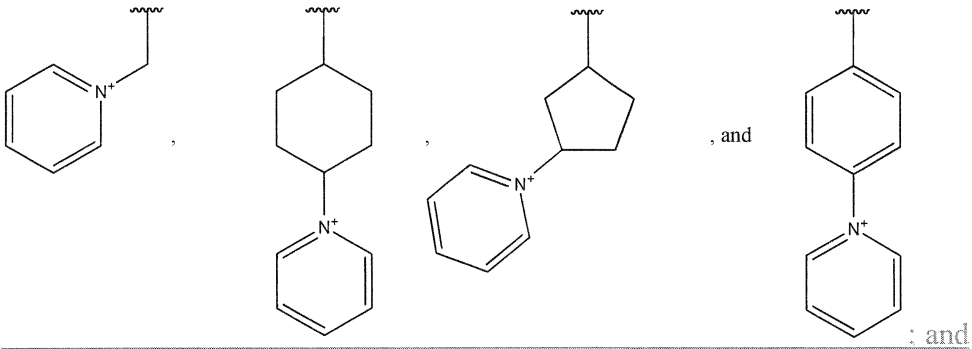
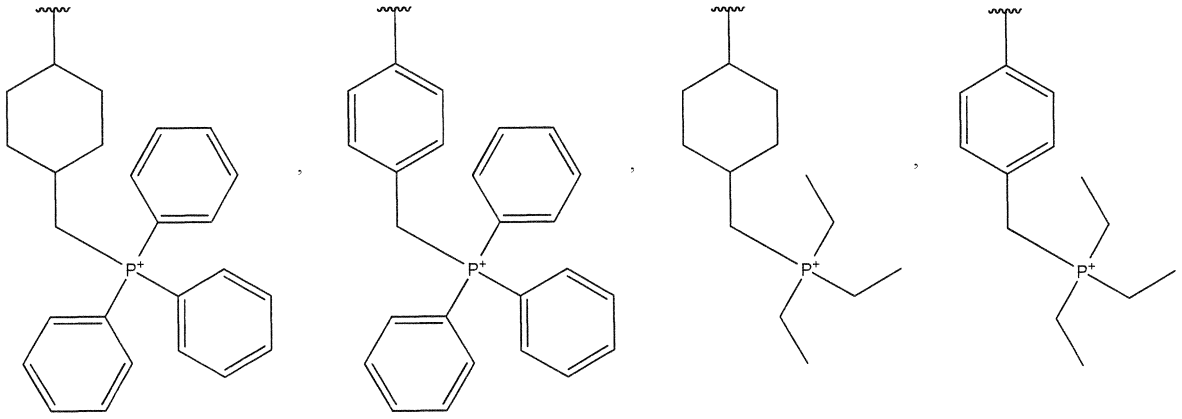


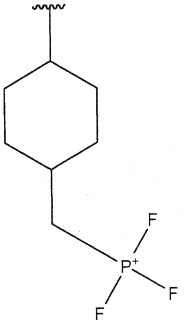



, and

: and

wherein the phosphorous-containing cationic group and the linker form a phosphorous-containing side chain, wherein each phosphorous-containing side chain is independently selected from the group consisting of:





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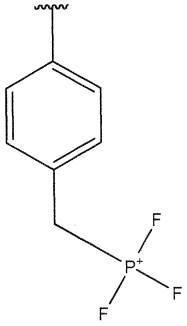

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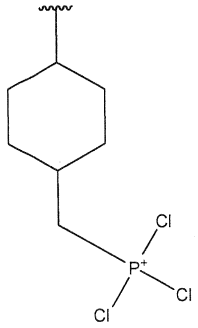

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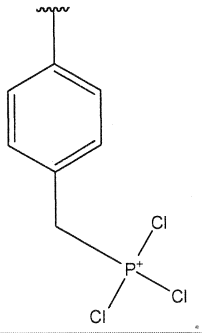
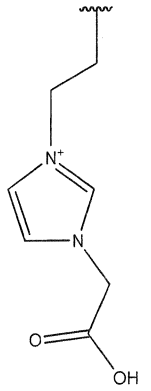


.

64. The solid particle of any one of claims 56 to 63, wherein the polymer further comprises acidic-ionic monomers connected to the polymeric backbone, wherein each acidic-ionic monomer comprises a Bronsted-Lowry acid and a cationic group, wherein the cationic group is a nitrogen-containing cationic group or a phosphorous-containing cationic group.

65. The solid particle of claim 64, wherein one or more of the acidic-ionic monomers each further comprise a linker connecting the Bronsted-Lowry acid or the cationic group to the polymeric backbone, and wherein the Bronsted-Lowry acid, the cationic group and the linker form an acidic-ionic side chain, wherein each acidic-ionic side chain is independently selected from the group consisting of:



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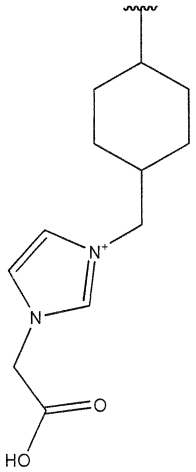

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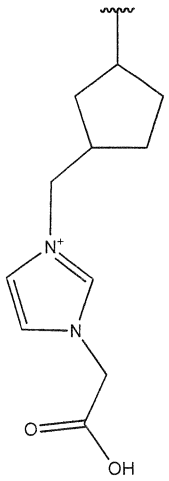

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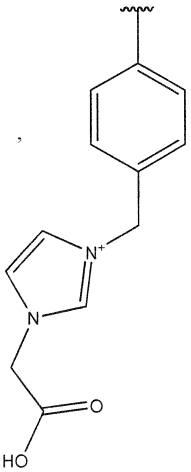

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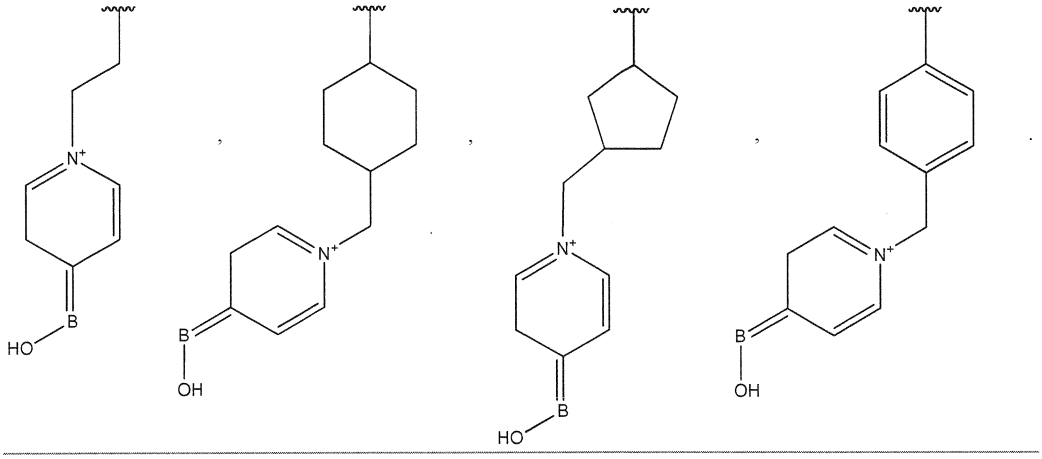
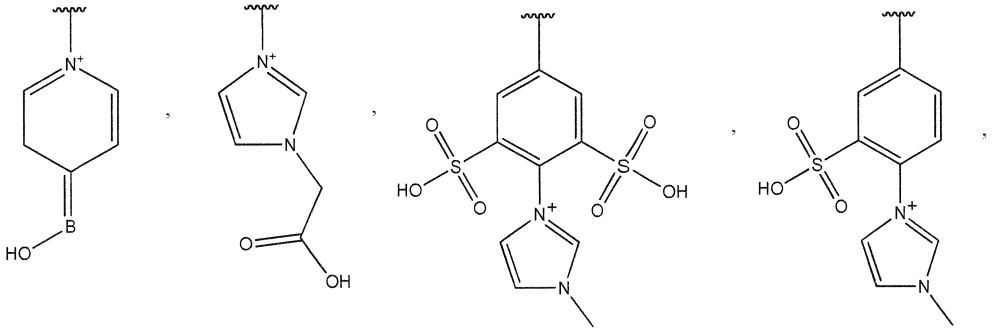
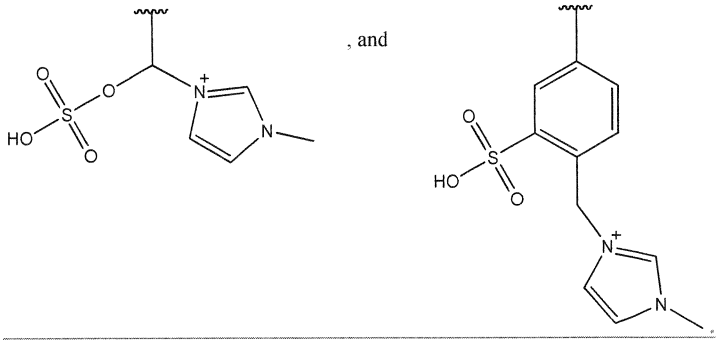






, and

66. The solid particle of any one of claims 56 to 65, wherein the polymer further comprises hydrophobic monomers connected to form the polymeric backbone,

wherein each hydrophobic monomer comprises a hydrophobic group,

wherein the hydrophobic group at each occurrence is independently selected from the group consisting of an unsubstituted or substituted alkyl, an unsubstituted or substituted cycloalkyl, an unsubstituted or substituted aryl, or an unsubstituted or substituted heteroaryl.

67. The solid particle of any one of claims 56 to 66, wherein the polymeric backbone in the polymer is selected from the group consisting of polyethylene, polypropylene, polyvinyl alcohol,

polystyrene, polyurethane, polyvinyl chloride, polyphenol-aldehyde, polytetrafluoroethylene, polybutylene terephthalate, polycaprolactam, poly(acrylonitrile butadiene styrene), polyalkyleneammonium, polyalkylenediammonium, polyalkylenepyrrolium, polyalkyleneimidazolium, polyalkylenepyrazolium, polyalkyleneoxazolium, polyalkylenethiazolium, polyalkylenepyridinium, polyalkylenepyrimidinium, polyalkylenepyrazinium, polyalkylenepyradizinium, polyalkylenethiazinium, polyalkylenemorpholinium, polyalkylenepiperidinium, polyalkylenepiperizinium, polyalkylenepyrollizinium, polyalkylenetriphenylphosphonium, polyalkylenetrimethylphosphonium, polyalkylenetriethylphosphonium, polyalkylenetripropylphosphonium, polyalkylenetributylphosphonium, polyalkylenetrichlorophosphonium, polyalkylenetrifluorophosphonium, and polyalkylenediazolium.

~~57~~68. The solid particle of any one of claims 56 to 67, wherein the solid core comprises an inert material or a magnetic material.

~~58~~69. The solid particle of any one of claims 56 ~~or 57~~to 68, wherein the solid particle is substantially free of pores.

~~59~~70. The solid particle of any one of claims 56 to ~~58~~69, wherein the solid particle has catalytic activity.

~~60~~71. The solid particle of claim ~~59~~70, wherein at least about 50% of the catalytic activity of the solid particle is present on or near the exterior surface of the solid particle.

~~61~~72. A composition comprising:

biomass; and

a polymer ~~according to any one of claims 1 to 48~~, wherein the polymer comprises acidic monomers and ionic monomers connected to form a polymeric backbone,

wherein each acidic monomer comprises at least one Bronsted-Lowry acid, and

wherein each ionic monomer independently comprises at least one nitrogen-containing cationic group or phosphorous-containing cationic group.

~~62~~73. The composition of claim ~~61~~72, further comprising a solvent.

~~63~~74. The composition of claim ~~62~~73, wherein the solvent comprises water.

~~64~~75. The composition of any one of claims ~~61~~-72 to ~~63~~74, wherein the biomass comprises cellulose, hemicellulose, or a combination thereof.

~~65~~76. A chemically-hydrolyzed biomass composition comprising:

a polymer ~~according to any one of claims 1 to 48;~~, wherein the polymer comprises acidic monomers and ionic monomers connected to form a polymeric backbone,

wherein each acidic monomer comprises at least one Bronsted-Lowry acid, and

wherein each ionic monomer independently comprises at least one nitrogen-containing cationic group or phosphorous-containing cationic group;

one or more sugars; and

residual biomass.

~~66~~77. The composition of claim ~~65~~76, wherein the one or more sugars are one or more monosaccharides, one or more oligosaccharides, or a mixture thereof.

~~67~~78. The composition of claim ~~65~~-76 or ~~66~~77, wherein the one or more sugars are two or more sugars comprising at least one C4-C6 monosaccharide and at least one oligosaccharide.

~~68~~79. The composition of claim ~~65~~-76 or ~~66~~78, wherein the one or more sugars are selected from the group consisting of glucose, galactose, fructose, xylose, and arabinose.

80. A composition comprising:

one or more saccharides; and

a polymer;

wherein the polymer comprises acidic monomers and ionic monomers connected to form a polymeric backbone, wherein each acidic monomer comprises at least one Bronsted-Lowry acid, and wherein each ionic monomer independently comprises at least one nitrogen-containing cationic group or at least one phosphorous-containing cationic group.

81. The composition of claim 80, further comprising a solvent.

82. The composition of claim 81, wherein the solvent comprises water.

83. The composition of any one of claims 80 to 82, wherein the one or more saccharides are one or more monosaccharides, or one or more oligosaccharides, or a mixture thereof.

84. The composition of any one of claims 80 to 82, wherein the one or more saccharides are two or more saccharides, wherein at least one of the two or more saccharides is a C4-C6 monosaccharide, and at least one of the two or more saccharides is an oligosaccharide.

85. The composition of any one of claims 80 to 82, wherein the one or more saccharides are selected from the group consisting of glucose, galactose, fructose, xylose, mannose, and arabinose.

86. The composition of any one of claims 80 to 82, wherein the one or more saccharides are one or more monosaccharides.

87. The composition of any one of claims 80 to 82, wherein the one or more saccharides are one or more oligosaccharides.

88. The composition of any one of claims 72 to 87, wherein the Bronsted-Lowry acid at each occurrence in the polymer is independently selected from the group consisting of sulfonic acid, phosphonic acid, acetic acid, isophthalic acid, boronic acid, and perfluorinated acid.

89. The composition of any one of claims 72 to 88, wherein the nitrogen-containing cationic group in the polymer at each occurrence is independently selected from the group consisting of pyrrolium, imidazolium, pyrazolium, oxazolium, thiazolium, pyridinium, pyrimidinium, pyrazinium, pyradizinium, thiazinium, morpholinium, piperidinium, piperizinium, and pyrollizinium; and

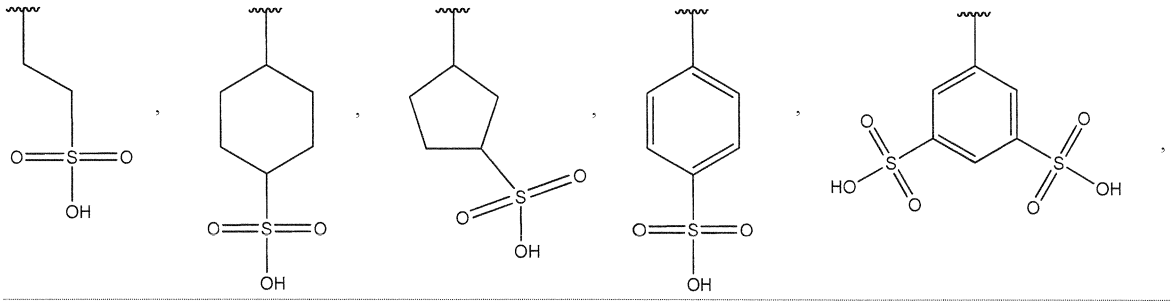
wherein the phosphorous-containing cationic group in the polymer at each occurrence is independently selected from the group consisting of triphenyl phosphonium, trimethyl phosphonium, triethyl phosphonium, tripropyl phosphonium, tributyl phosphonium, trichloro phosphonium, and trifluoro phosphonium.

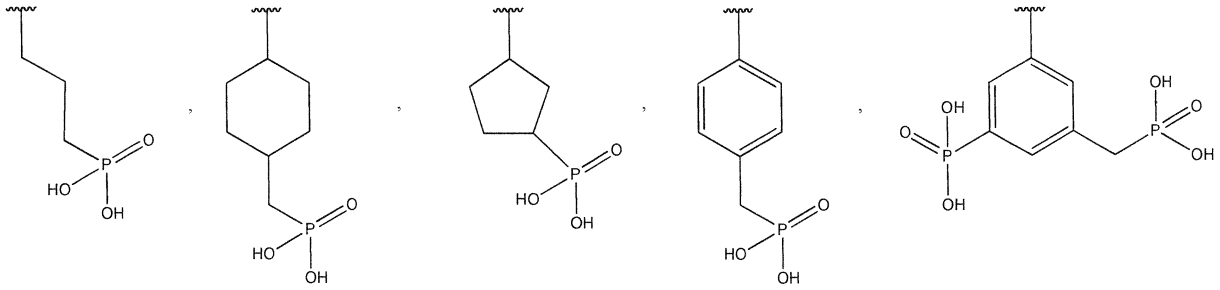
90. The composition of any one of claims 72 to 89, wherein one or more of the acidic monomers in the polymer each further comprise a linker connecting the Bronsted-Lowry acid to the polymeric backbone.

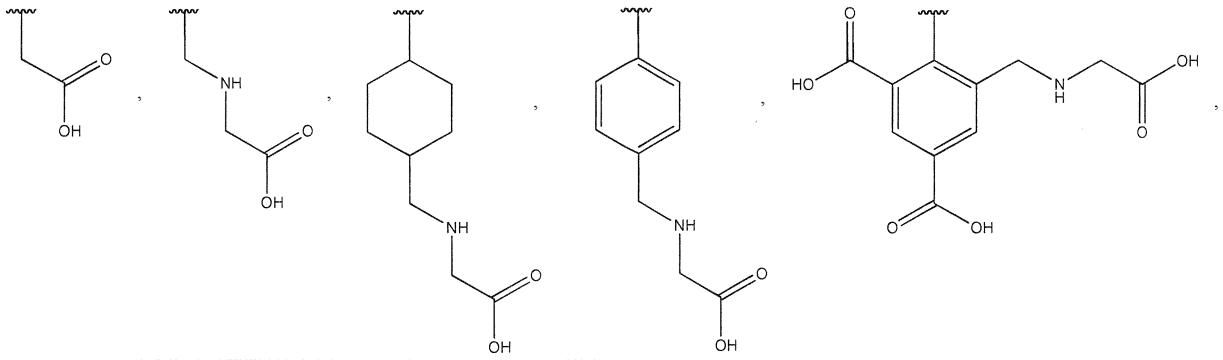
91. The composition of any one of claims 72 to 90, wherein one or more of the ionic monomers of the polymer each further comprise a linker connecting the nitrogen-containing cationic group or the phosphorous-containing cationic group to the polymeric backbone.

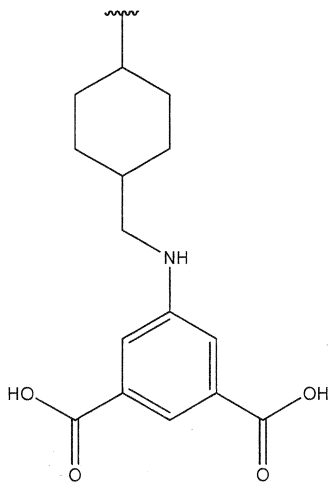
92. The composition of claim 90 or 91, wherein the linker at each occurrence is independently selected from the group consisting of unsubstituted or substituted alkylene, unsubstituted or substituted cycloalkylene, unsubstituted or substituted alkenylene, unsubstituted or substituted arylene, unsubstituted or substituted heteroarylene, unsubstituted or substituted alkylene ether, unsubstituted or substituted alkylene ester, and unsubstituted or substituted alkylene carbamate.

93. The composition of claim 90, wherein the Bronsted-Lowry acid and the linker form an acidic side chain, wherein each acidic side chain is independently selected from the group consisting of:

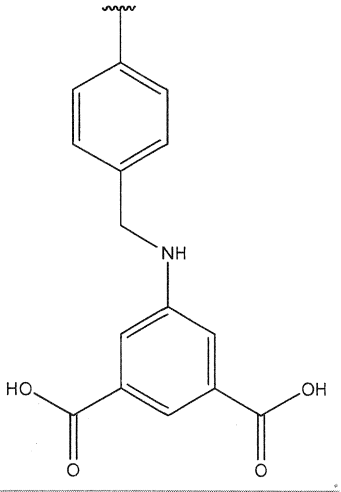




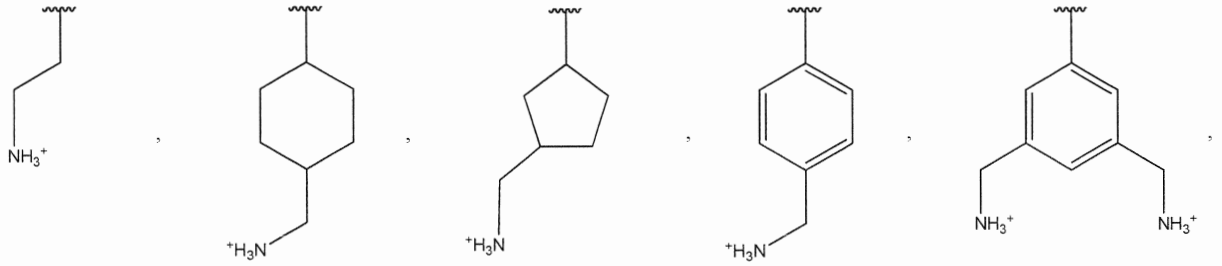


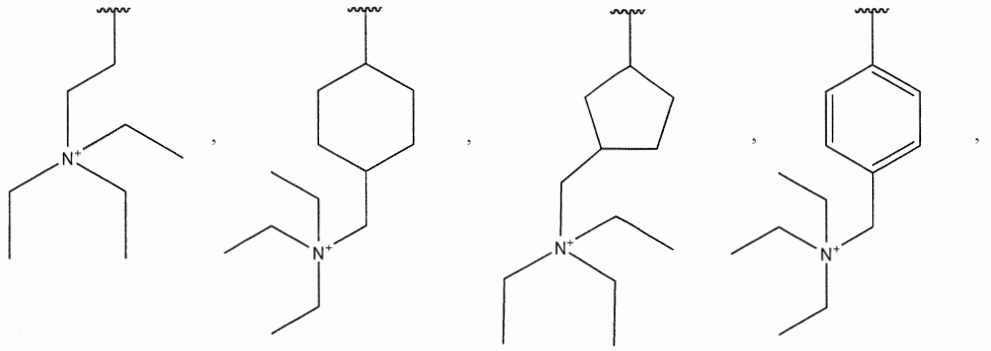


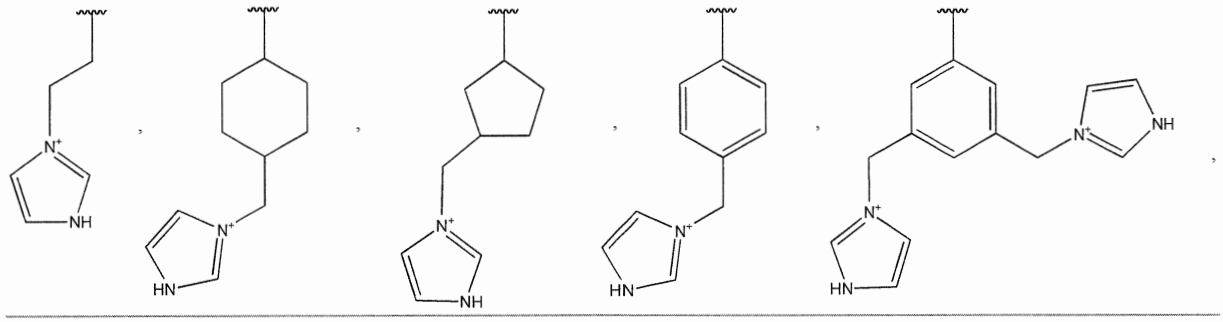
, and

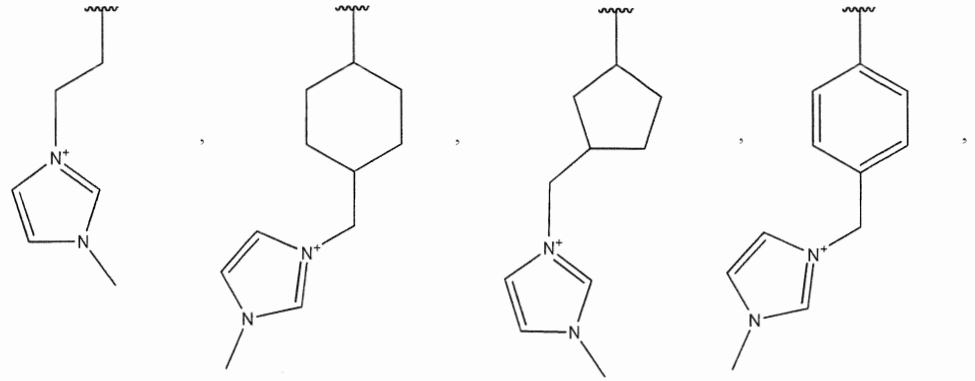


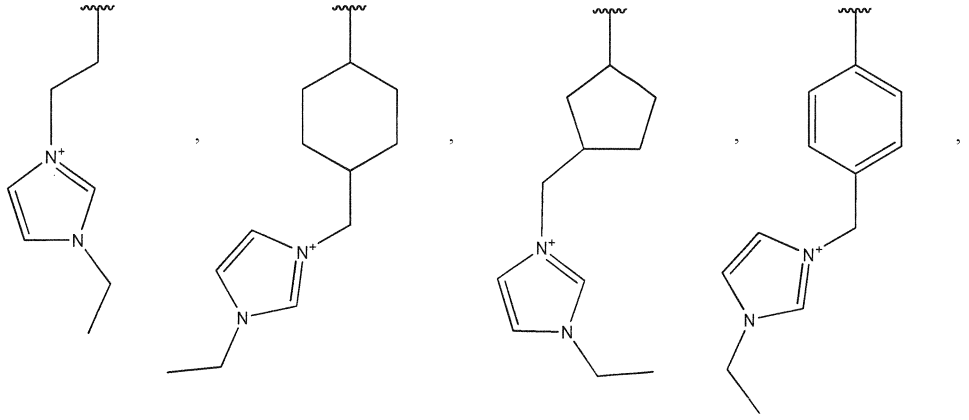
94. The composition of claim 91, wherein the nitrogen-containing cationic group and the linker form a nitrogen-containing side chain, wherein each nitrogen-containing side chain is independently selected from the group consisting of:

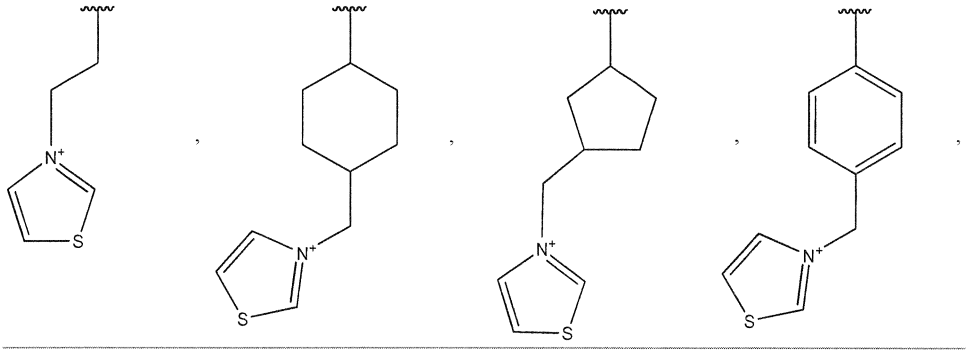


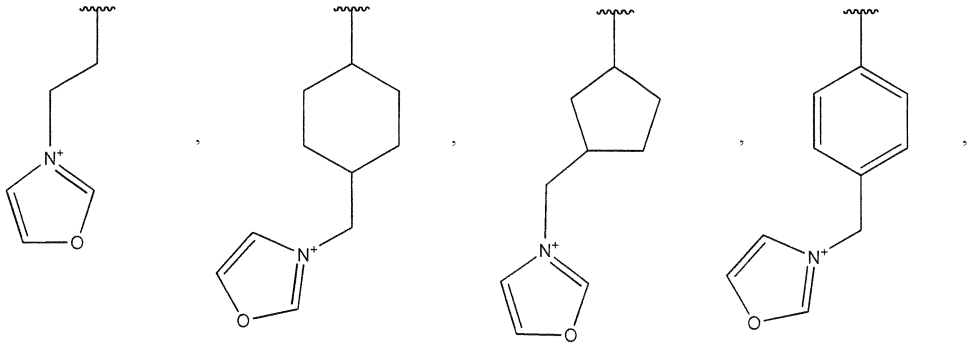


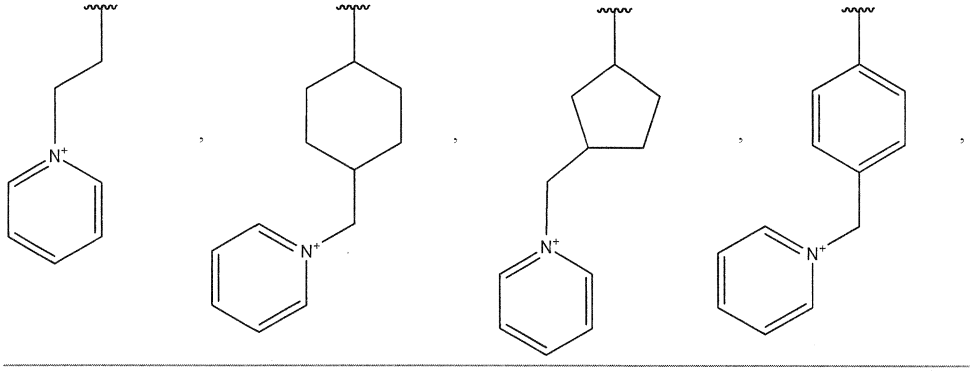


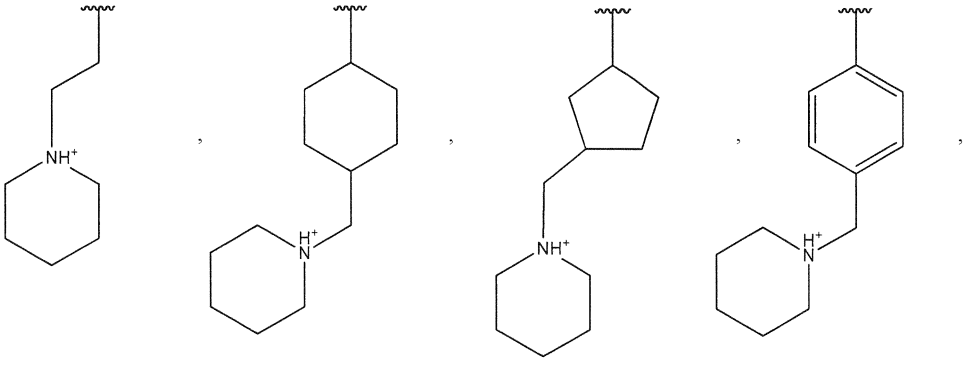


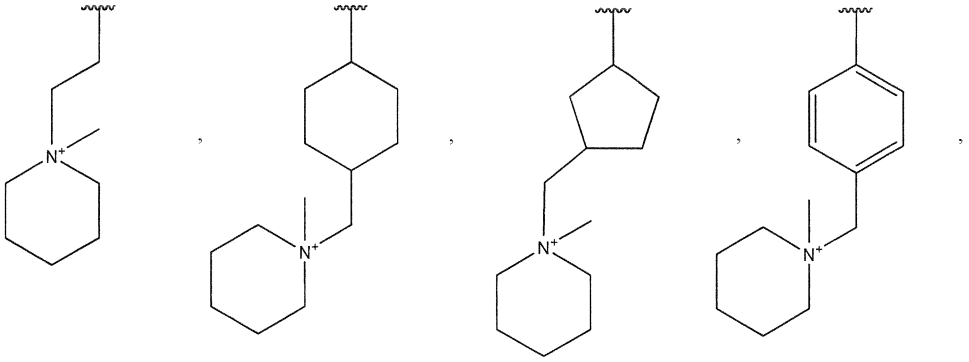


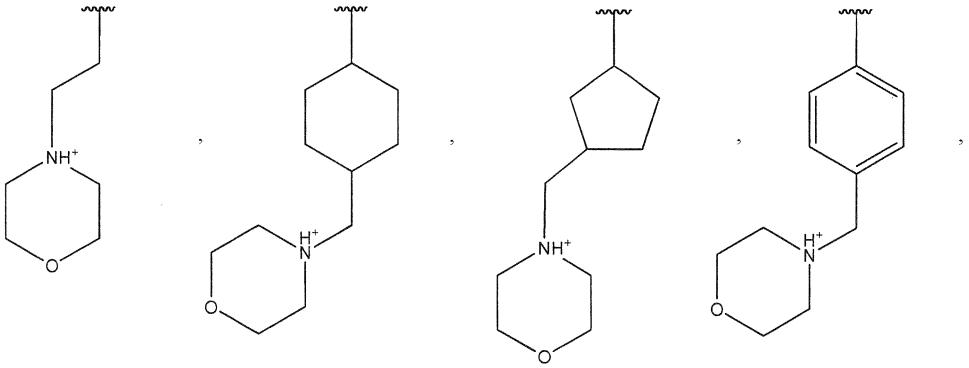


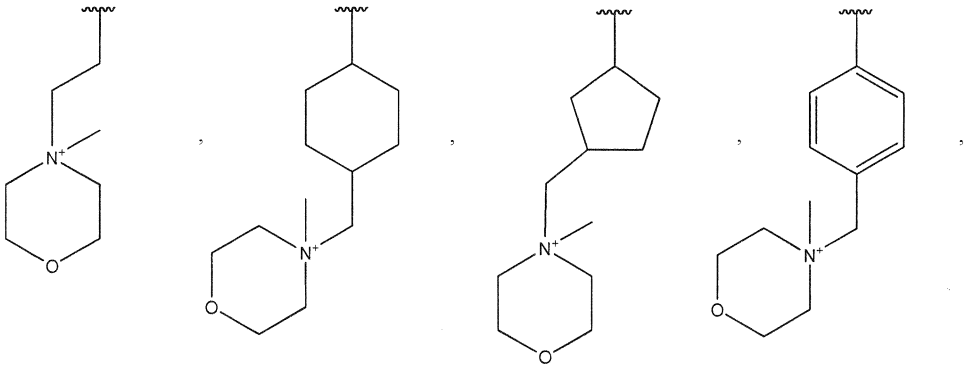


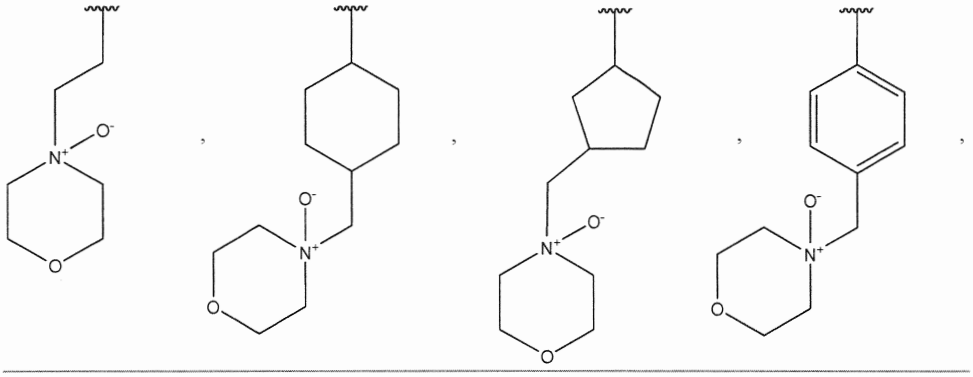


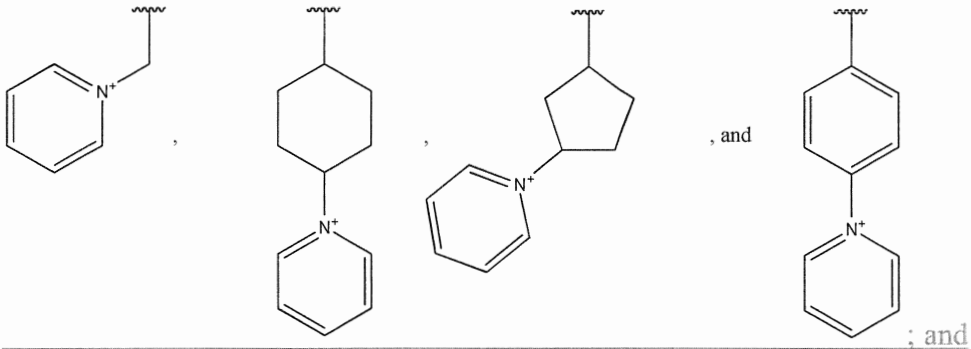






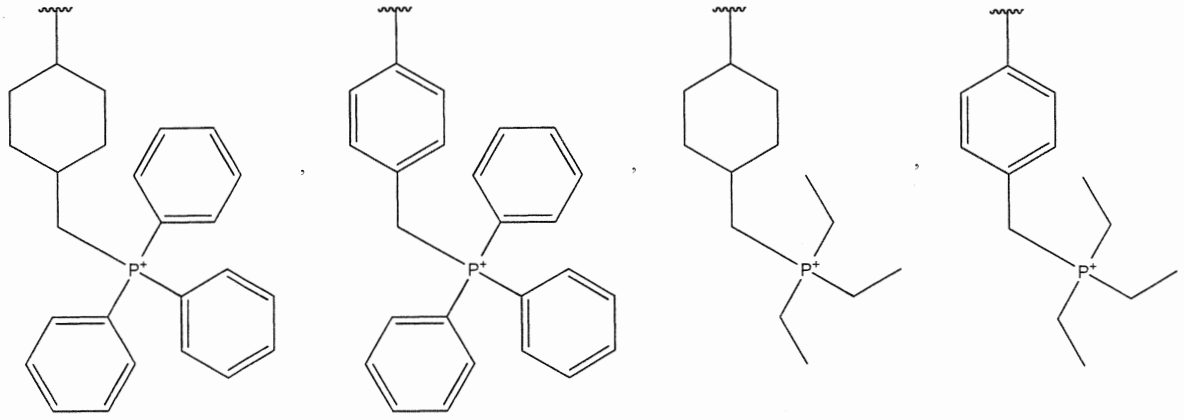


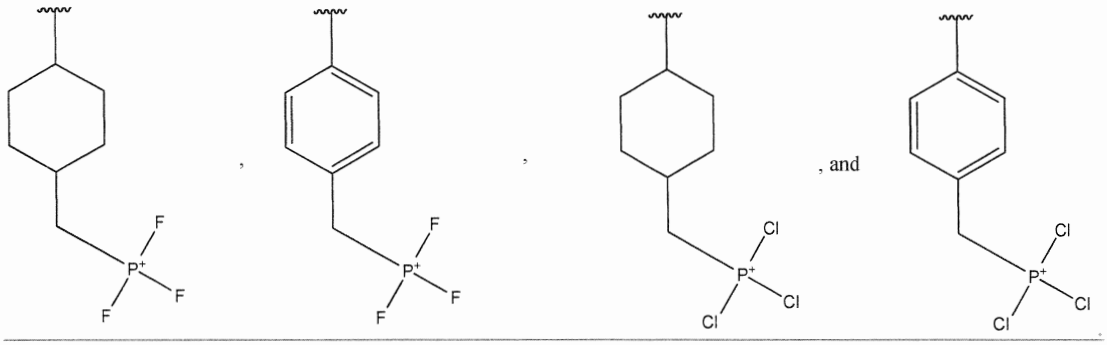




; and

wherein the phosphorous-containing cationic group and the linker form a phosphorous-containing side chain, wherein each phosphorous-containing side chain is independently selected from the group consisting of:





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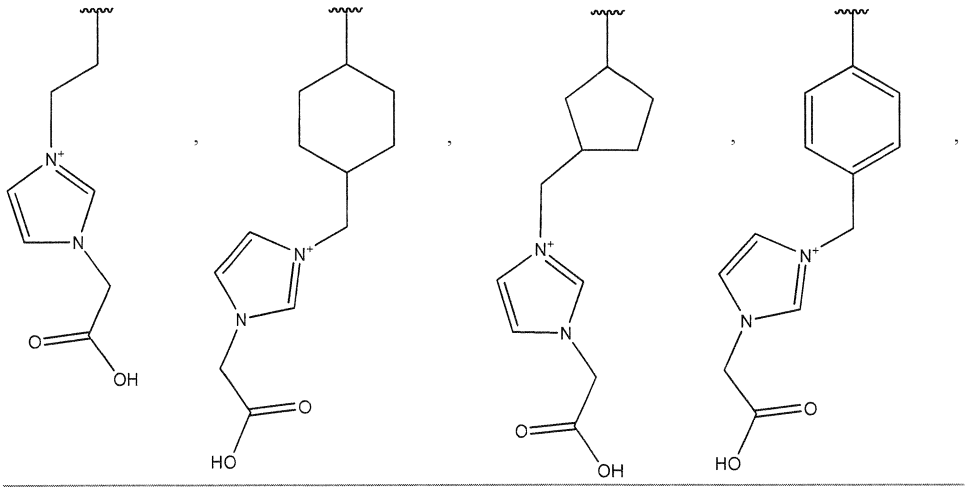
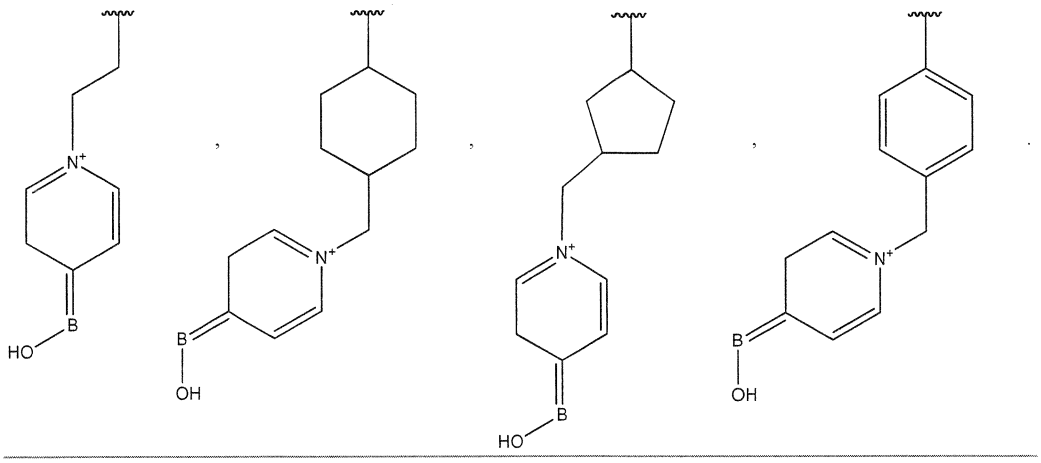
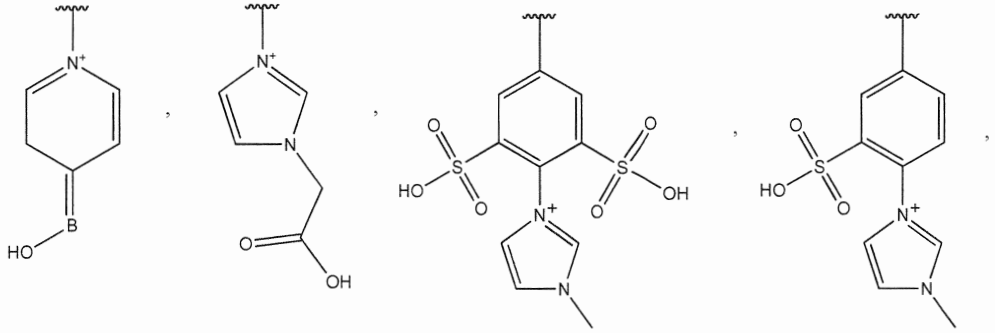
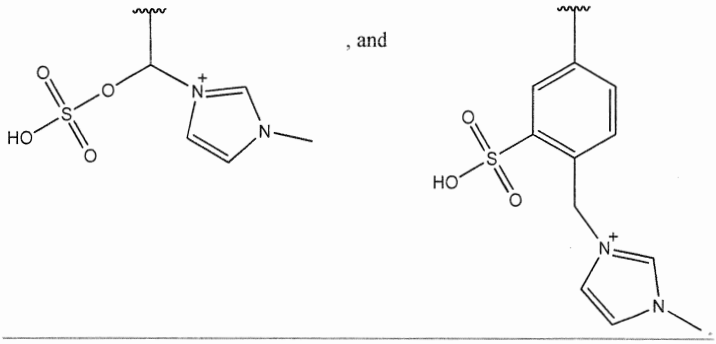
95. The composition of any one of claims 72 to 94, wherein the polymer further comprises acidic-ionic monomers connected to the polymeric backbone, wherein each acidic-ionic monomer comprises a Bronsted-Lowry acid and a cationic group, wherein the cationic group is a nitrogen-containing cationic group or a phosphorous-containing cationic group.

96. The composition of claim 95, wherein one or more of the acidic-ionic monomers each further comprise a linker connecting the Bronsted-Lowry acid or the cationic group to the polymeric backbone, and wherein the Bronsted-Lowry acid, the cationic group and the linker form an acidic-ionic side chain, wherein each acidic-ionic side chain is independently selected from the group consisting of:









97. The composition of any one of claims 72 to 96, wherein the polymer further comprises hydrophobic monomers connected to form the polymeric backbone,

wherein each hydrophobic monomer comprises a hydrophobic group,

wherein the hydrophobic group at each occurrence is independently selected from the group consisting of an unsubstituted or substituted alkyl, an unsubstituted or substituted cycloalkyl, an unsubstituted or substituted aryl, or an unsubstituted or substituted heteroaryl.

98. The composition of any one of claims 72 to 97, wherein the polymeric backbone in the polymer is selected from the group consisting of polyethylene, polypropylene, polyvinyl alcohol, polystyrene, polyurethane, polyvinyl chloride, polyphenol-aldehyde, polytetrafluoroethylene, polybutylene terephthalate, polycaprolactam, poly(acrylonitrile butadiene styrene), polyalkyleneammonium, polyalkylenediammonium, polyalkylenepyrrolium, polyalkyleneimidazolium, polyalkylenepyrazolium, polyalkyleneoxazolium, polyalkylenethiazolium, polyalkylenepyridinium, polyalkylenepyrimidinium, polyalkylenepyrazinium, polyalkylenepyradizinium, polyalkylenethiazinium, polyalkylenemorpholinium, polyalkylenepiperidinium, polyalkylenepiperizinium, polyalkylenepyrollizinium, polyalkylenetriphenylphosphonium, polyalkylenetrimethylphosphonium, polyalkylenetriethylphosphonium, polyalkylenetripropylphosphonium, polyalkylenetributylphosphonium,

polyalkylenetrichlorophosphonium, polyalkylenetrifluorophosphonium, and polyalkylenediazolium.

~~69~~99. A saccharification intermediate comprising a polymer ~~according to any one of claims 1 to 48~~ hydrogen-bonded to biomass,

wherein the polymer comprises acidic monomers and ionic monomers connected to form a polymeric backbone,

wherein each acidic monomer comprises at least one Bronsted-Lowry acid, and

wherein each ionic monomer independently comprises at least one nitrogen-containing cationic group or phosphorous-containing cationic group, and

wherein the biomass comprises cellulose, hemicellulose or a combination thereof.

~~70~~100. A method for degrading biomass into one or more sugars, comprising:

a) providing biomass;

b) contacting the biomass with a polymer ~~according to any one of claims 1 to 48~~ and a solvent for a period of time sufficient to produce a degraded mixture,

wherein the polymer comprises acidic monomers and ionic monomers connected to form a polymeric backbone,

wherein each acidic monomer comprises at least one Bronsted-Lowry acid, and

wherein each ionic monomer independently comprises at least one nitrogen-containing cationic group or phosphorous-containing cationic group, and

wherein the degraded mixture comprises a liquid phase and a solid phase, wherein the liquid phase comprises one or more sugars, and wherein the solid phase comprises residual biomass;

c) isolating at least a portion of the liquid phase from the solid phase; and

d) recovering the one or more sugars from the isolated liquid phase.

~~71~~101. The method of claim ~~70~~100, wherein the isolating of at least a portion of the liquid phase from the solid phase produces a residual biomass mixture, and wherein the method further comprises:

i) providing a second biomass;

ii) contacting the second biomass with the residual biomass mixture for a period of

time sufficient to produce a second degraded mixture, wherein the second degraded mixture comprises a second liquid phase and a second solid phase, wherein the second liquid phase comprises one or more second sugars, and wherein the second solid phase comprises second residual biomass;

iii) isolating at least a portion of the second liquid phase from the second solid phase; and

iv) recovering the one or more second sugars from the isolated second liquid phase.

~~72~~102. The method of claim ~~71~~101, further comprising contacting the second biomass and the residual biomass mixture with a second polymer ~~according to any one of claims 1 to 48.~~,

wherein the second polymer comprises acidic monomers and ionic monomers connected to form a polymeric backbone,

wherein each acidic monomer comprises at least one Bronsted-Lowry acid, and

wherein each ionic monomer independently comprises at least one nitrogen-containing cationic group or phosphorous-containing cationic group.

~~73~~103. The method of claim ~~71~~101, further comprising contacting the second biomass and the residual biomass mixture with a second solvent.

~~74~~104. The method of claim ~~71~~101, further comprising recovering the polymer after isolating at least a portion of the second liquid phase.

~~75~~105. The method of any one of claims ~~70~~-100 to ~~74~~104, wherein the solvent comprises water.

~~76~~106. The method of any one of claims ~~70~~-100 to ~~75~~105, wherein the biomass comprises cellulose and hemicellulose, and wherein the biomass is contacted with the polymer and the solvent at a temperature and at a pressure suitable to preferentially hydrolyze the cellulose or suitable to preferentially hydrolyze the hemicellulose.

~~77~~107. The method of any one of claims ~~70~~-100 to ~~76~~106, wherein the one or more sugars are selected from the group consisting of one or more monosaccharides, one or more oligosaccharides, or a combination thereof.

~~78~~108. The method of claim ~~77~~107, wherein the one or more monosaccharides are one or more C4-C6 monosaccharides.

~~79~~109. The method of any one of claims ~~70~~-100 to ~~78~~108, wherein the one or more sugars are selected from the group consisting of glucose, galactose, fructose, xylose, and arabinose.

~~80~~110. The method of any one of claims ~~70~~-100 to ~~79~~109, further comprising pretreating the biomass before contacting the biomass with the polymer.

~~81~~111. The method of claim ~~80~~110, wherein the pretreatment of the biomass is selected from the group consisting of washing, solvent-extraction, solvent-swelling, comminution, milling, steam pretreatment, explosive steam pretreatment, dilute acid pretreatment, hot water pretreatment, alkaline pretreatment, lime pretreatment, wet oxidation, wet explosion, ammonia fiber explosion,

organosolvent pretreatment, biological pretreatment, ammonia percolation, ultrasound, electroporation, microwave, supercritical CO_2, supercritical H_2O, ozone, and gamma irradiation, or a combination thereof.

~~82~~112. The method of any one of claims ~~70~~ 100 to ~~81~~111, the residual biomass has a degree of polymerization of less than 300.

~~83~~113. The method of claim ~~82~~112, wherein the residual biomass has a degree of polymerization of less than 100.

~~84~~114. The method of any one of claims ~~70~~ 100 to ~~83~~113, wherein the degrading of the biomass to produce the sugars occurs at a first-order rate constant of at least 0.001 per hour.

~~85~~115. The method of claim ~~84~~114, wherein the degrading of the biomass to produce the sugars occurs at a first-order rate constant of at least 0.1 per hour.

~~86~~116. A method for pretreating biomass before hydrolysis of the biomass to produce one or more sugars, comprising:

a) providing biomass;

b) contacting the biomass with a polymer ~~according any one of claims 1 to 48 and~~ a solvent for a period of time sufficient to partially degrade the biomass,

wherein the polymer comprises acidic monomers and ionic monomers connected to form a polymeric backbone,

wherein each acidic monomer comprises at least one Bronsted-Lowry acid, and

wherein each ionic monomer independently comprises at least one nitrogen-containing cationic group or phosphorous-containing cationic group; and

c) pretreating the partially degraded biomass before hydrolysis to produce one or more sugars.

~~87~~117. The method of claim ~~86~~116, wherein the biomass comprises cellulose, hemicellulose, or a combination thereof.

~~88~~118. The method of claim ~~86~~ 116 or ~~87~~117, wherein the pretreatment of the partially degraded biomass mixture is selected from the group consisting of washing, solvent-extraction, solvent-swelling, comminution, milling, steam pretreatment, explosive steam pretreatment, dilute acid pretreatment, hot water pretreatment, alkaline pretreatment, lime pretreatment, wet oxidation, wet explosion, ammonia fiber explosion, organosolvent pretreatment, biological pretreatment, ammonia percolation, ultrasound, electroporation, microwave, supercritical CO_2, supercritical H_2O, ozone, and gamma irradiation, or a combination thereof.

~~89~~119. A method of hydrolyzing pretreated biomass to produce one or more sugars, comprising:

a) providing biomass pretreated according any one of claims ~~86~~ 116 to ~~88~~118; and

b) hydrolyzing the pretreated biomass to produce one or more sugars.

~~90~~120. The method of claim ~~89~~119, wherein the pretreated biomass is chemically hydrolyzed or enzymatically hydrolyzed.

~~91~~121. The method of claim ~~89~~ 119 or ~~90~~120, wherein the one or more sugars are selected from the group consisting of glucose, galactose, fructose, xylose, and arabinose.

122. The method of any one of claims 100 to 121, wherein the Bronsted-Lowry acid at each occurrence in the polymer is independently selected from the group consisting of sulfonic acid, phosphonic acid, acetic acid, isophthalic acid, boronic acid, and perfluorinated acid.

123. The method of any one of claims 100 to 122, wherein the nitrogen-containing cationic group in the polymer at each occurrence is independently selected from the group consisting of pyrrolium, imidazolium, pyrazolium, oxazolium, thiazolium, pyridinium, pyrimidinium, pyrazinium, pyradizinium, thiazinium, morpholinium, piperidinium, piperizinium, and pyrollizinium; and

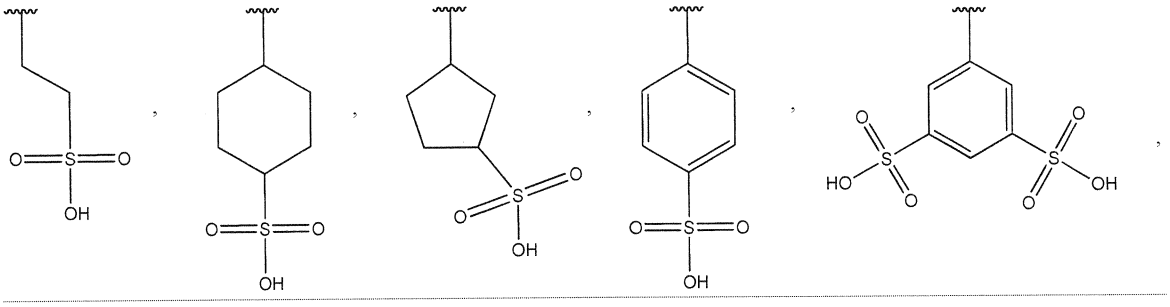
wherein the phosphorous-containing cationic group in the polymer at each occurrence is independently selected from the group consisting of triphenyl phosphonium, trimethyl phosphonium, triethyl phosphonium, tripropyl phosphonium, tributyl phosphonium, trichloro phosphonium, and trifluoro phosphonium.

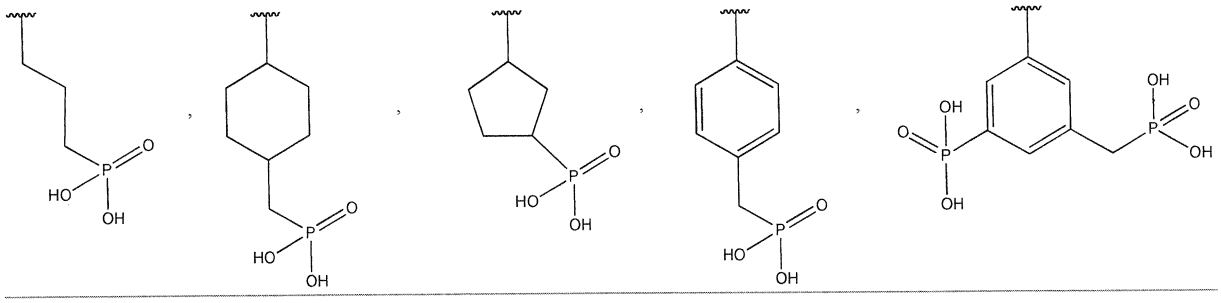
124. The method of any one of claims 100 to 123, wherein one or more of the acidic monomers in the polymer each further comprise a linker connecting the Bronsted-Lowry acid to the polymeric backbone.

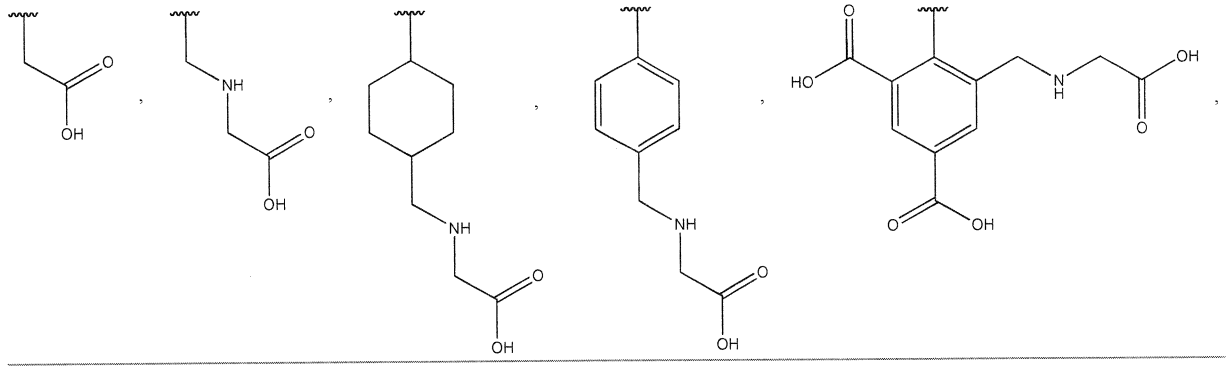
125. The method of any one of claims 100 to 124, wherein one or more of the ionic monomers of the polymer each further comprise a linker connecting the nitrogen-containing cationic group or the phosphorous-containing cationic group to the polymeric backbone.

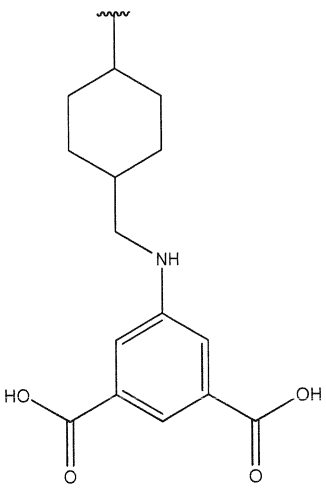
126. The method of claim 124 or 125, wherein the linker at each occurrence is independently selected from the group consisting of unsubstituted or substituted alkylene, unsubstituted or substituted cycloalkylene, unsubstituted or substituted alkenylene, unsubstituted or substituted arylene, unsubstituted or substituted heteroarylene, unsubstituted or substituted alkylene ether, unsubstituted or substituted alkylene ester, and unsubstituted or substituted alkylene carbamate.

127. The method of claim 124, wherein the Bronsted-Lowry acid and the linker form an acidic side chain, wherein each acidic side chain is independently selected from the group consisting of:

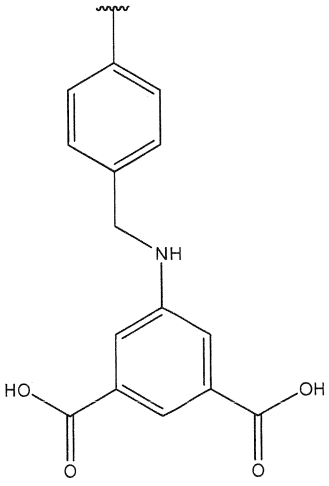




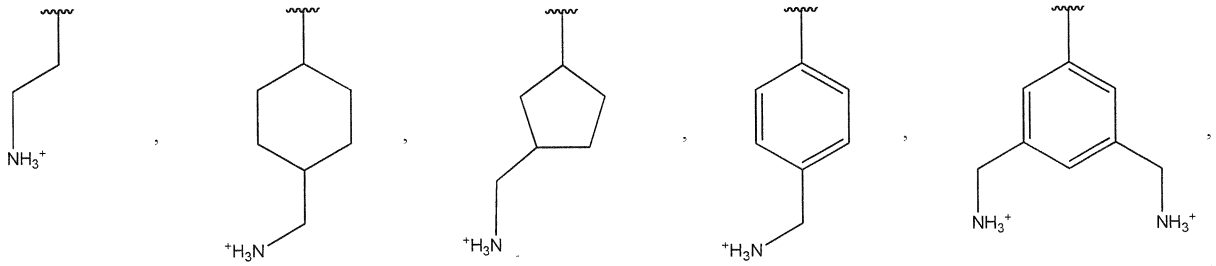


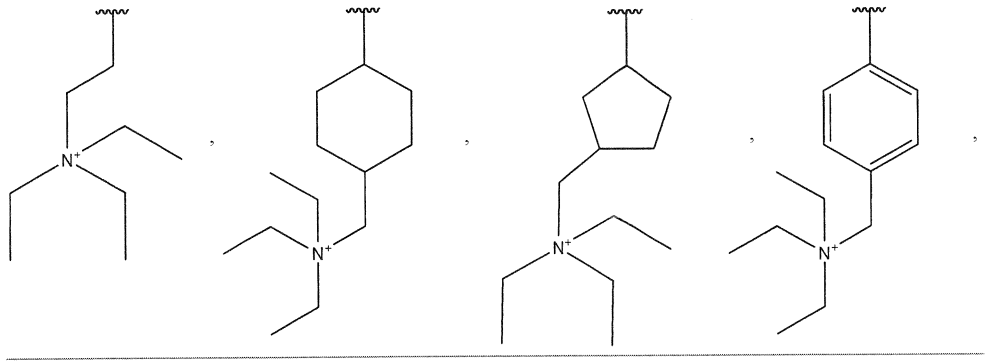


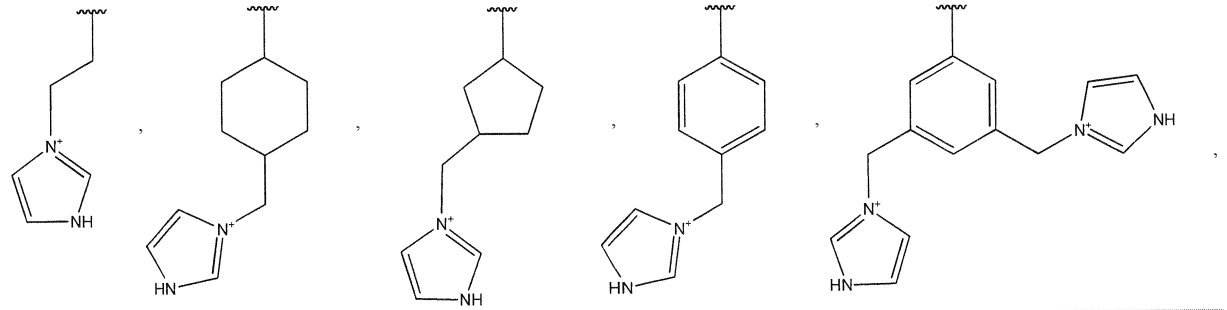
, and

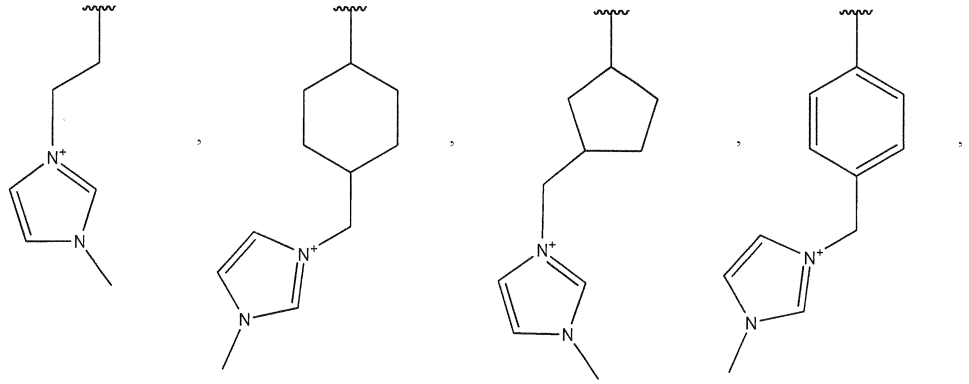


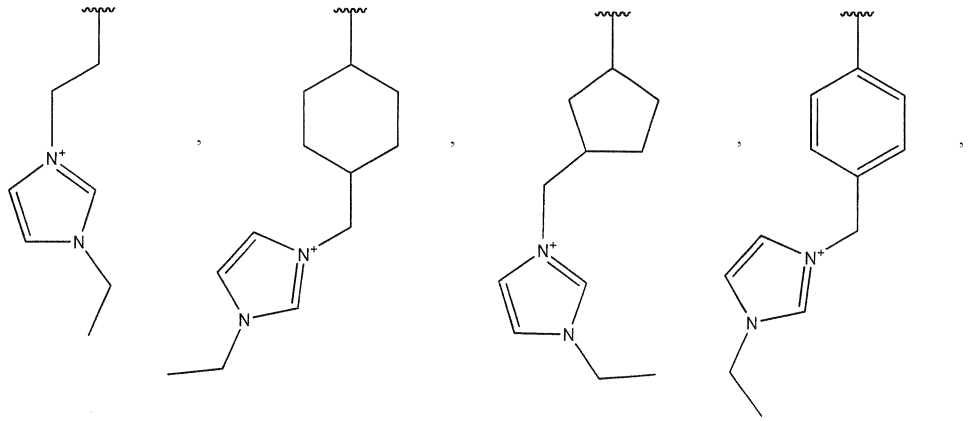
128. The method of claim 125, wherein the nitrogen-containing cationic group and the linker form a nitrogen-containing side chain, wherein each nitrogen-containing side chain is independently selected from the group consisting of:

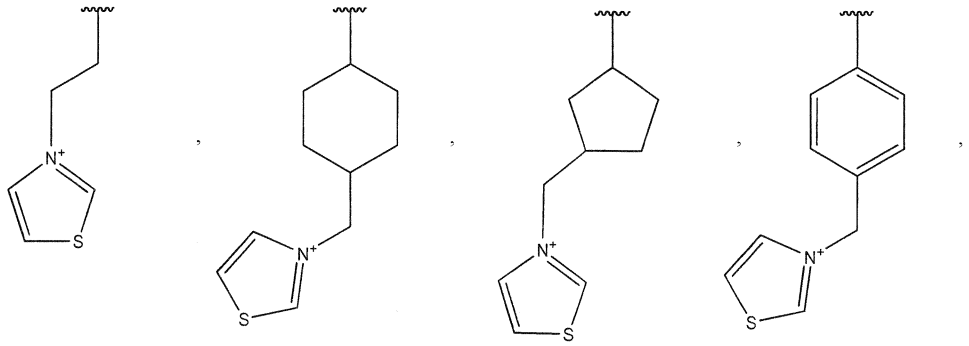


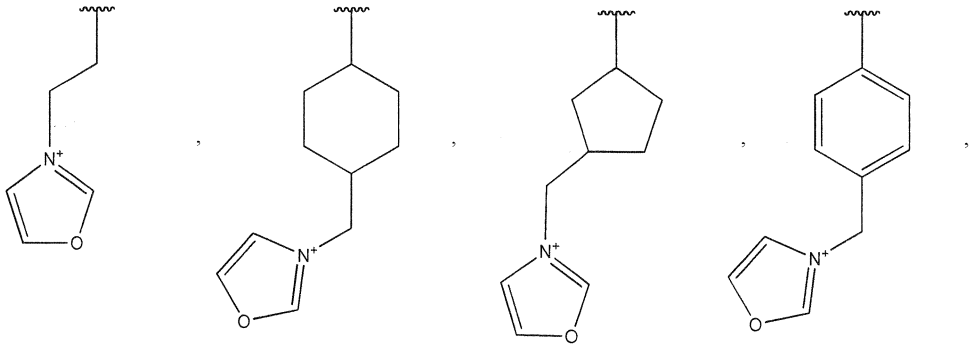


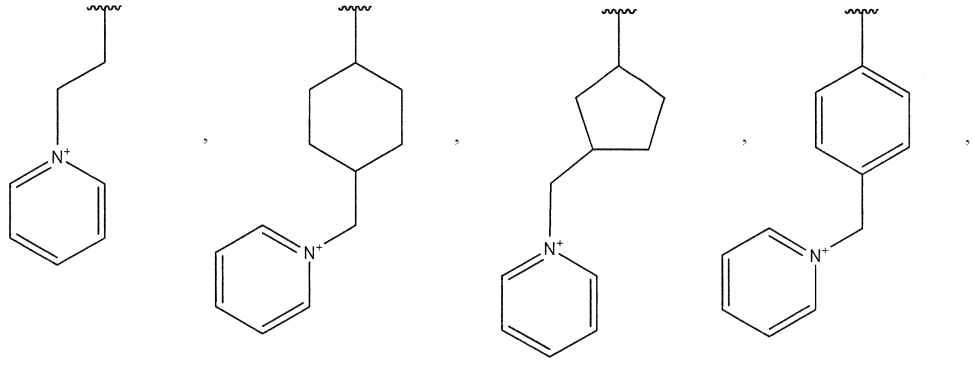


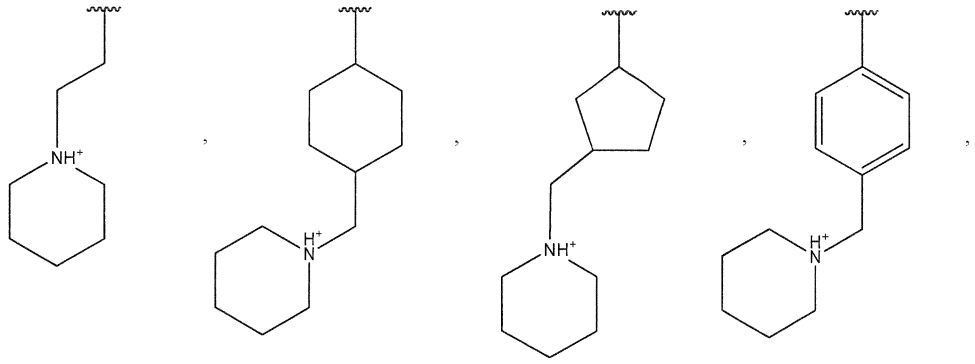


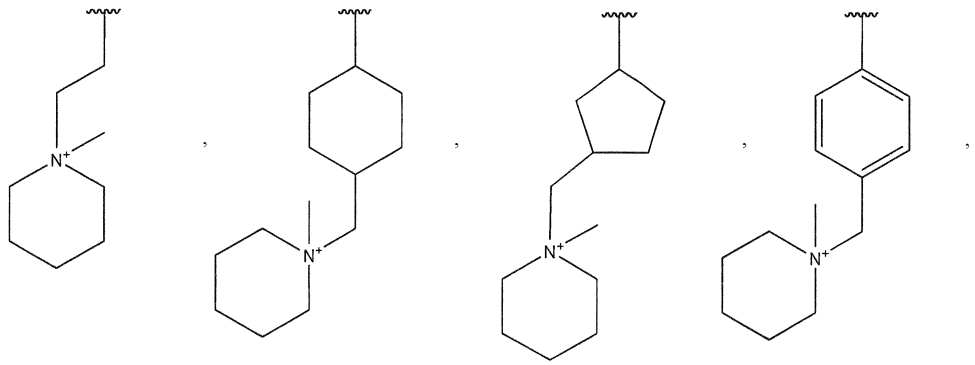


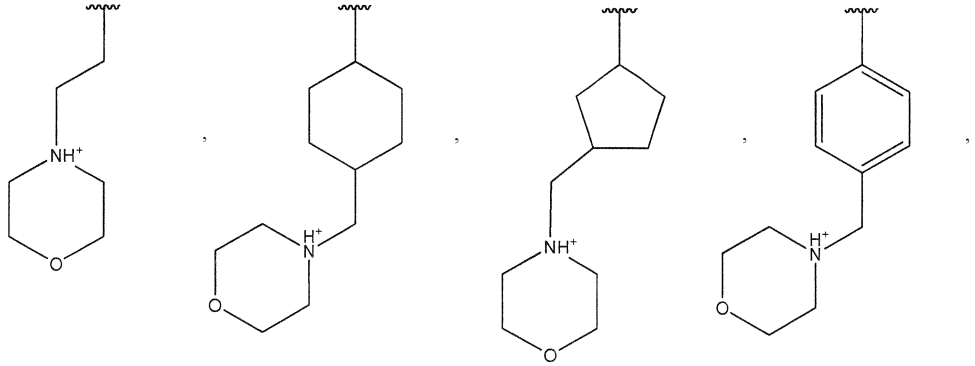


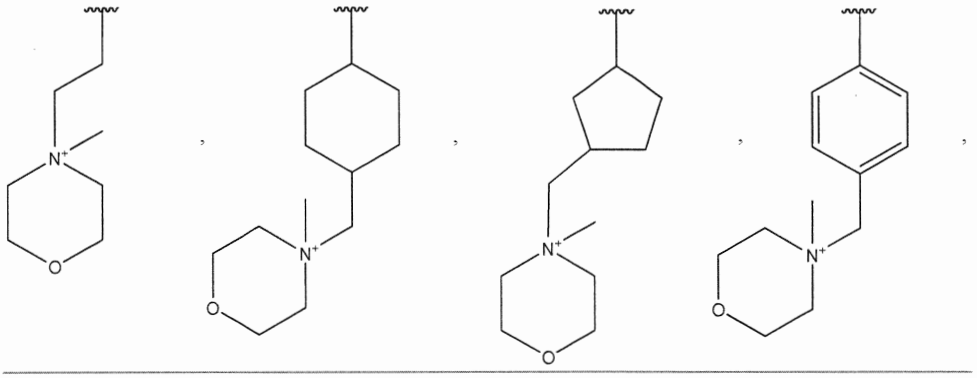


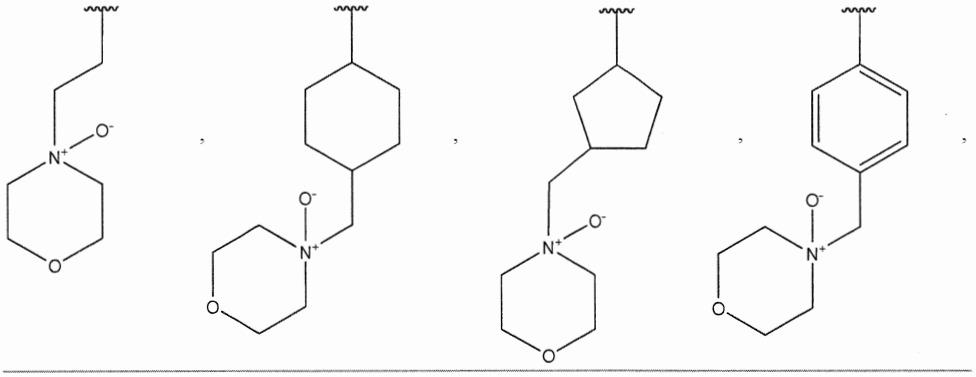


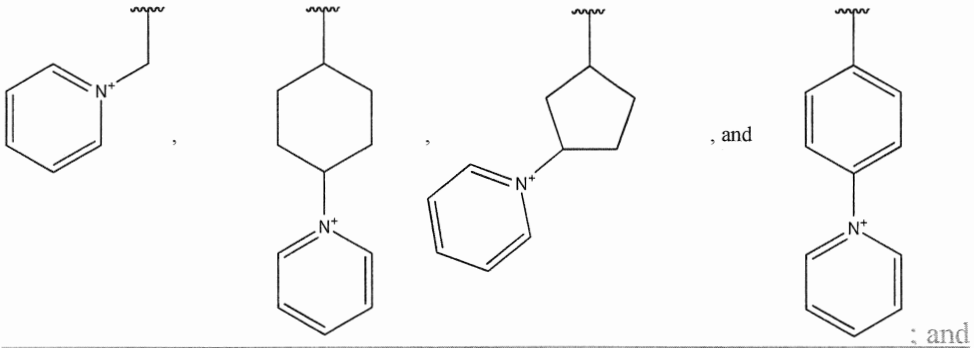






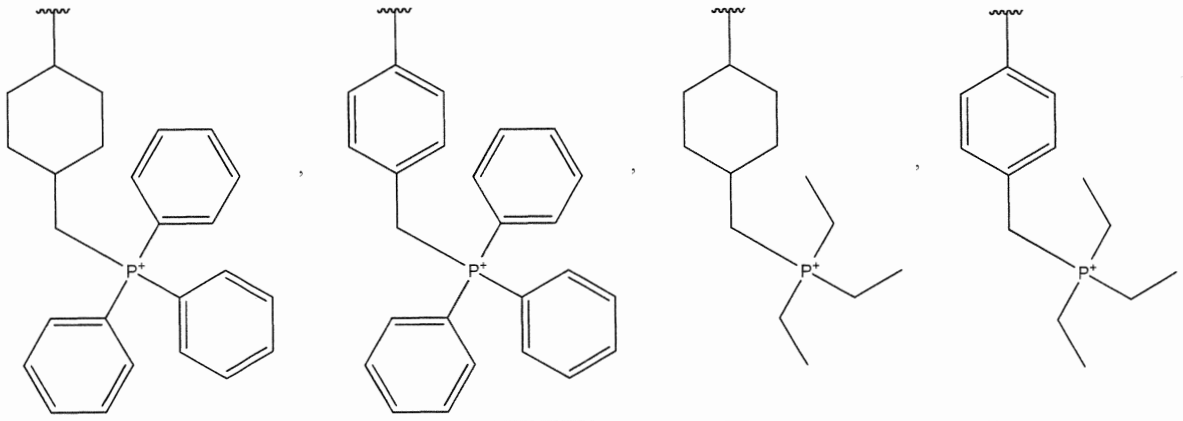


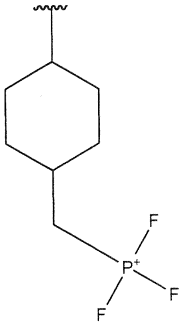



, and

; and

wherein the phosphorous-containing cationic group and the linker form a phosphorous-containing side chain, wherein each phosphorous-containing side chain is independently selected from the group consisting of:





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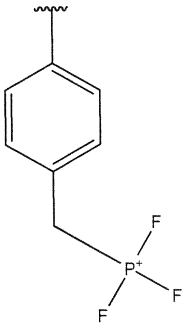

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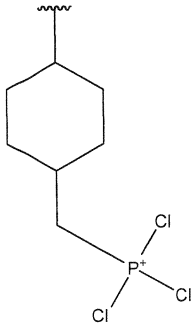

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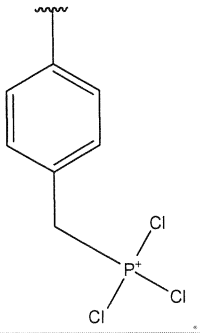
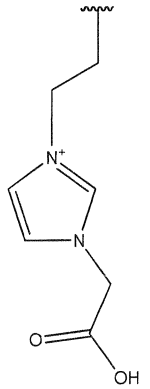


.

129. The method of any one of claims 100 to 128, wherein the polymer further comprises acidic-ionic monomers connected to the polymeric backbone, wherein each acidic-ionic monomer comprises a Bronsted-Lowry acid and a cationic group, wherein the cationic group is a nitrogen-containing cationic group or a phosphorous-containing cationic group.

130. The method of claim 129, wherein one or more of the acidic-ionic monomers each further comprise a linker connecting the Bronsted-Lowry acid or the cationic group to the polymeric backbone, and wherein the Bronsted-Lowry acid, the cationic group and the linker form an acidic-ionic side chain, wherein each acidic-ionic side chain is independently selected from the group consisting of:



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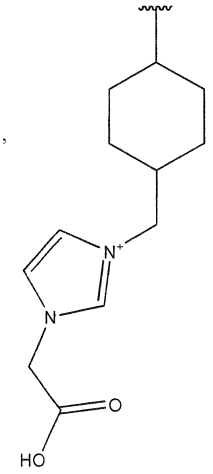

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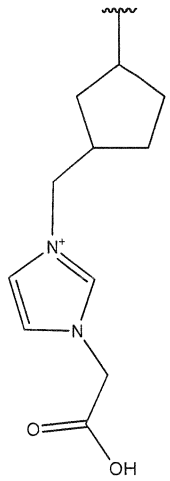

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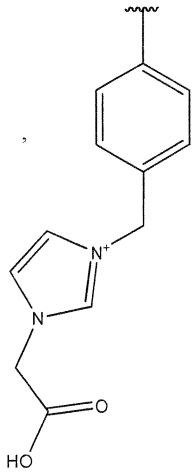

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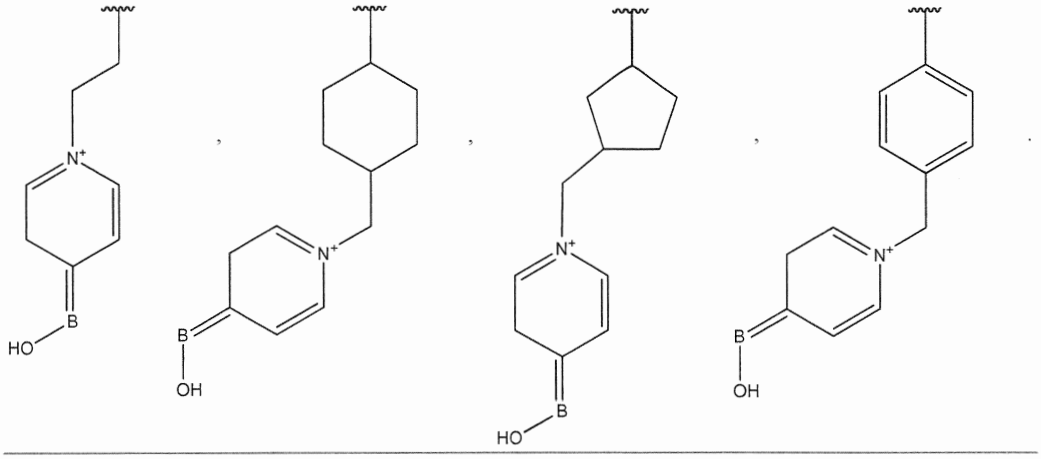
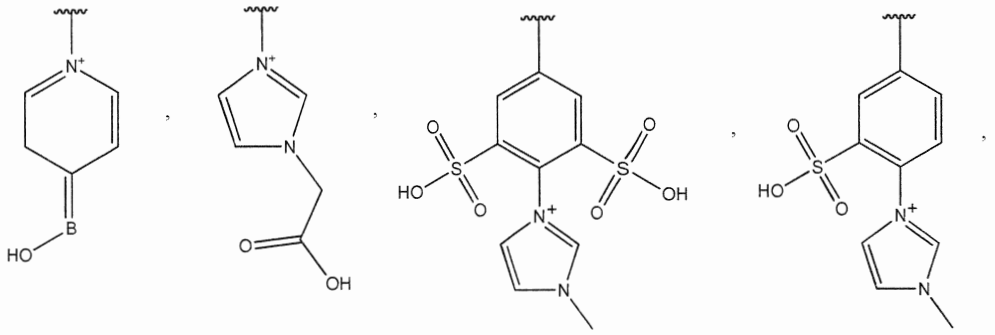
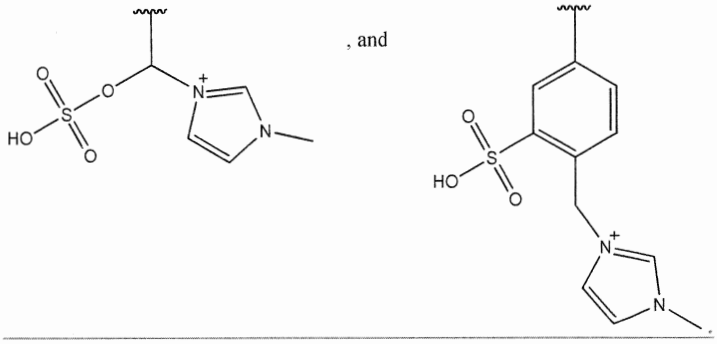






, and

131. The method of any one of claims 100 to 130, wherein the polymer further comprises hydrophobic monomers connected to form the polymeric backbone,

wherein each hydrophobic monomer comprises a hydrophobic group,

wherein the hydrophobic group at each occurrence is independently selected from the group consisting of an unsubstituted or substituted alkyl, an unsubstituted or substituted cycloalkyl, an unsubstituted or substituted aryl, or an unsubstituted or substituted heteroaryl.

132. The method of any one of claims 100 to 131, wherein the polymeric backbone in the polymer is selected from the group consisting of polyethylene, polypropylene, polyvinyl alcohol, polystyrene, polyurethane, polyvinyl chloride, polyphenol-aldehyde, polytetrafluoroethylene,

polybutylene terephthalate, polycaprolactam, poly(acrylonitrile butadiene styrene), polyalkyleneammonium, polyalkylenediammonium, polyalkylenepyrrolium, polyalkyleneimidazolium, polyalkylenepyrazolium, polyalkyleneoxazolium, polyalkylenethiazolium, polyalkylenepyridinium, polyalkylenepyrimidinium, polyalkylenepyrazinium, polyalkylenepyradizinium, polyalkylenethiazinium, polyalkylenemorpholinium, polyalkylenepiperidinium, polyalkylenepiperizinium, polyalkylenepyrollizinium, polyalkylenetriphenylphosphonium, polyalkylenetrimethylphosphonium, polyalkylenetriethylphosphonium, polyalkylenetripropylphosphonium, polyalkylenetributylphosphonium, polyalkylenetrichlorophosphonium, polyalkylenetrifluorophosphonium, and polyalkylenediazolium.

~~92~~133. Use of a polymer ~~according to any one of claims 1 to 48~~ for degrading biomass into one or more monosaccharides, one or more oligosaccharides, or a combination thereof, ~~:~~

wherein the polymer comprises acidic monomers and ionic monomers connected to form a polymeric backbone,

wherein each acidic monomer comprises at least one Bronsted-Lowry acid, and

wherein each ionic monomer independently comprises at least one nitrogen-containing cationic group or phosphorous-containing cationic group.

~~93~~134. The use of claim ~~92~~133, wherein the one or more monosaccharides are one or more C4-C6 monosaccharides.

~~94~~135. The use of claim ~~93~~134, wherein the one or more sugars are selected from the group consisting of glucose, galactose, fructose, xylose, and arabinose.

~~95~~136. The use of any one of claims ~~92~~ 134 to ~~94~~135, wherein the biomass comprises cellulose, hemicellulose, or a combination thereof.

~~96~~137. Use of a polymer ~~according to any one of claims 1 to 48~~ for pretreating biomass before further treatment using one or more methods selected from the group consisting of washing, solvent-extraction, solvent-swelling, comminution, milling, steam pretreatment, explosive steam pretreatment, dilute acid pretreatment, hot water pretreatment, alkaline pretreatment, lime

pretreatment, wet oxidation, wet explosion, ammonia fiber explosion, organosolvent pretreatment, biological pretreatment, ammonia percolation, ultrasound, electroporation, microwave, supercritical CO_2, supercritical H_2O, ozone, and gamma irradiation.

wherein the polymer comprises acidic monomers and ionic monomers connected to form a polymeric backbone,

wherein each acidic monomer comprises at least one Bronsted-Lowry acid, and

wherein each ionic monomer independently comprises at least one nitrogen-containing cationic group or phosphorous-containing cationic group.

138. The use of any one of claims 133 to 137, wherein the Bronsted-Lowry acid at each occurrence in the polymer is independently selected from the group consisting of sulfonic acid, phosphonic acid, acetic acid, isophthalic acid, boronic acid, and perfluorinated acid.

139. The use of any one of claims 133 to 138, wherein the nitrogen-containing cationic group in the polymer at each occurrence is independently selected from the group consisting of pyrrolium, imidazolium, pyrazolium, oxazolium, thiazolium, pyridinium, pyrimidinium, pyrazinium, pyradizinium, thiazinium, morpholinium, piperidinium, piperizinium, and pyrollizinium; and

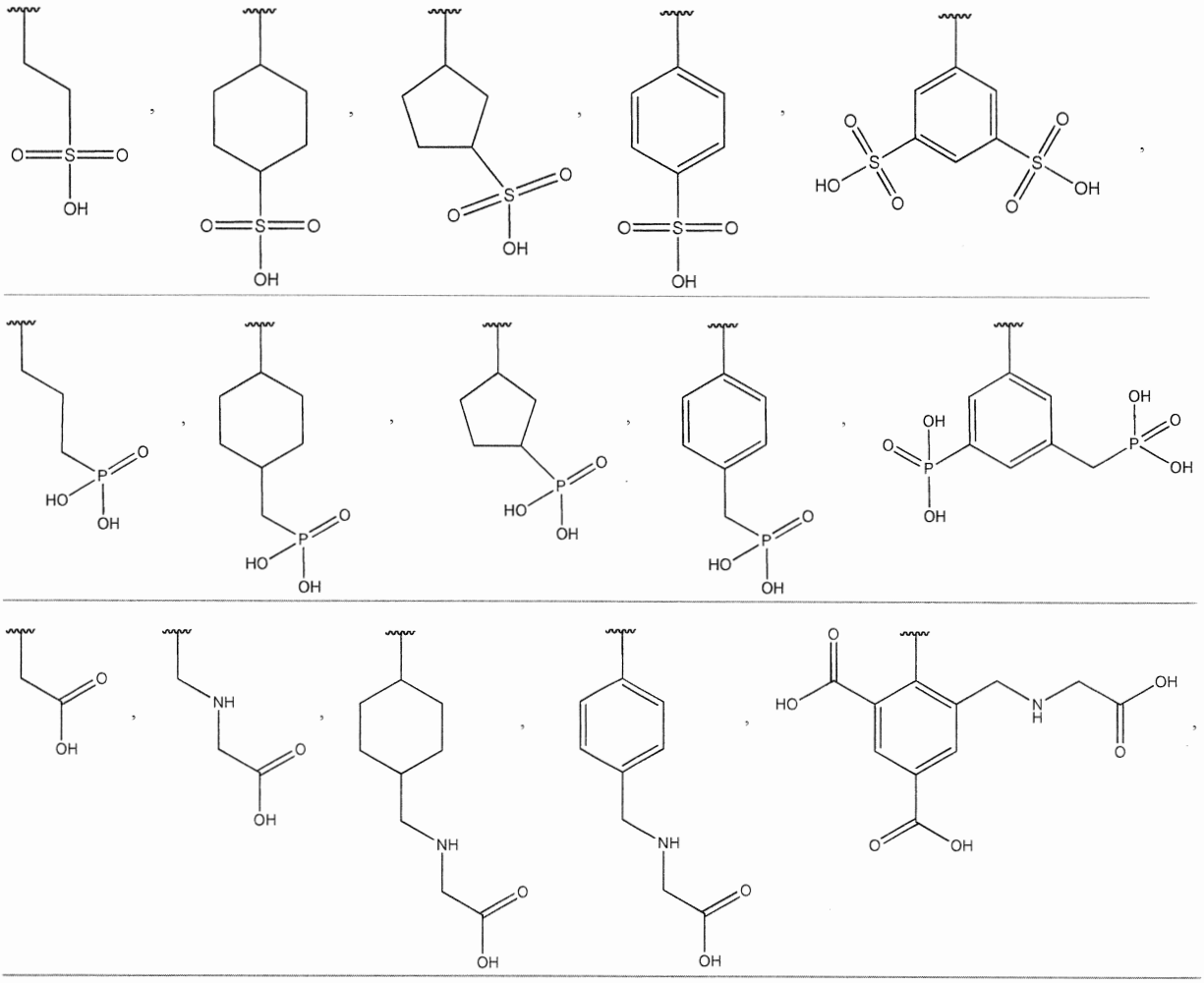
wherein the phosphorous-containing cationic group in the polymer at each occurrence is independently selected from the group consisting of triphenyl phosphonium, trimethyl phosphonium, triethyl phosphonium, tripropyl phosphonium, tributyl phosphonium, trichloro phosphonium, and trifluoro phosphonium.

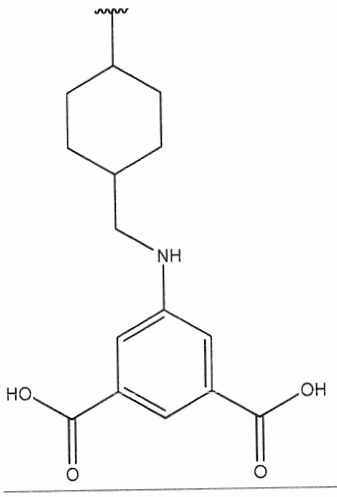
140. The use of any one of claims 133 to 139, wherein one or more of the acidic monomers in the polymer each further comprise a linker connecting the Bronsted-Lowry acid to the polymeric backbone.

141. The use of any one of claims 133 to 140, wherein one or more of the ionic monomers of the polymer each further comprise a linker connecting the nitrogen-containing cationic group or the phosphorous-containing cationic group to the polymeric backbone.

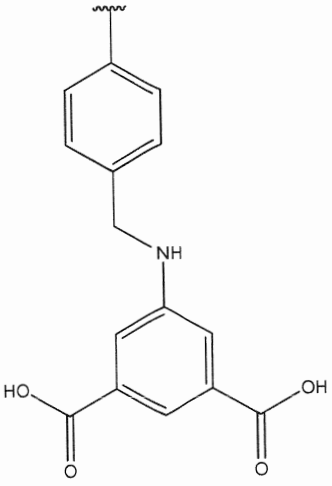
142. The use of claim 140 or 141, wherein the linker at each occurrence is independently selected from the group consisting of unsubstituted or substituted alkylene, unsubstituted or substituted cycloalkylene, unsubstituted or substituted alkenylene, unsubstituted or substituted arylene, unsubstituted or substituted heteroarylene, unsubstituted or substituted alkylene ether, unsubstituted or substituted alkylene ester, and unsubstituted or substituted alkylene carbamate.

143. The use of claim 140, wherein the Bronsted-Lowry acid and the linker form an acidic side chain, wherein each acidic side chain is independently selected from the group consisting of:





, and



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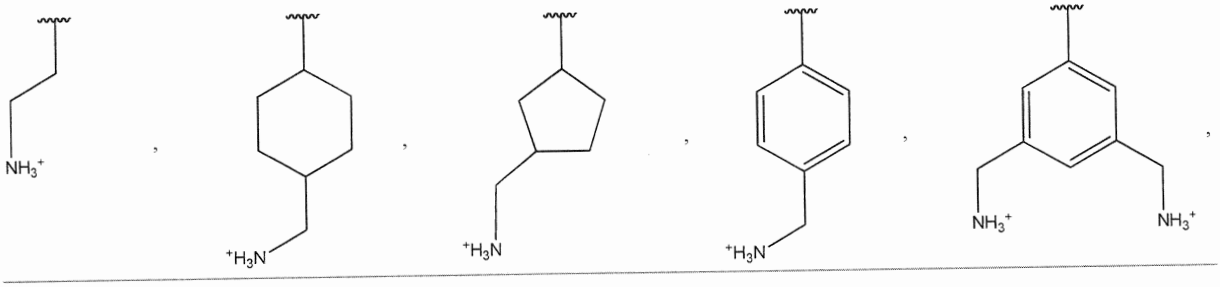
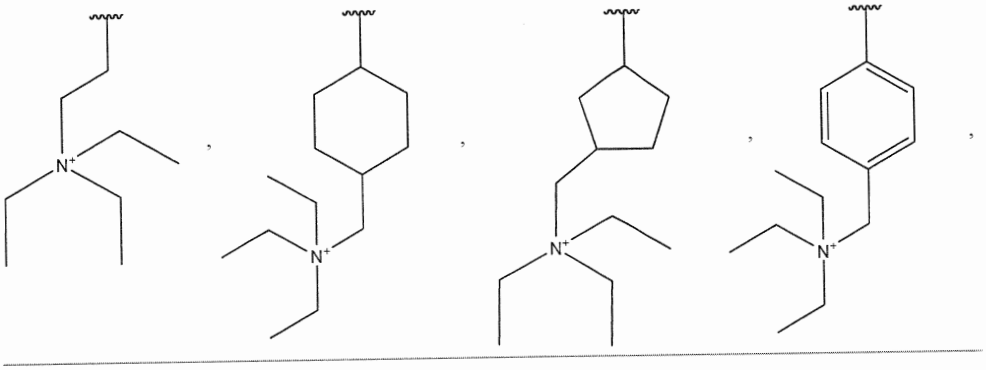
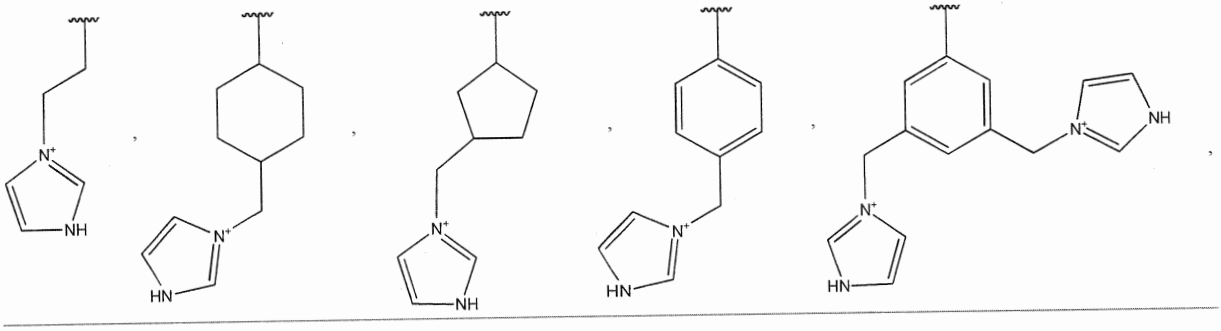
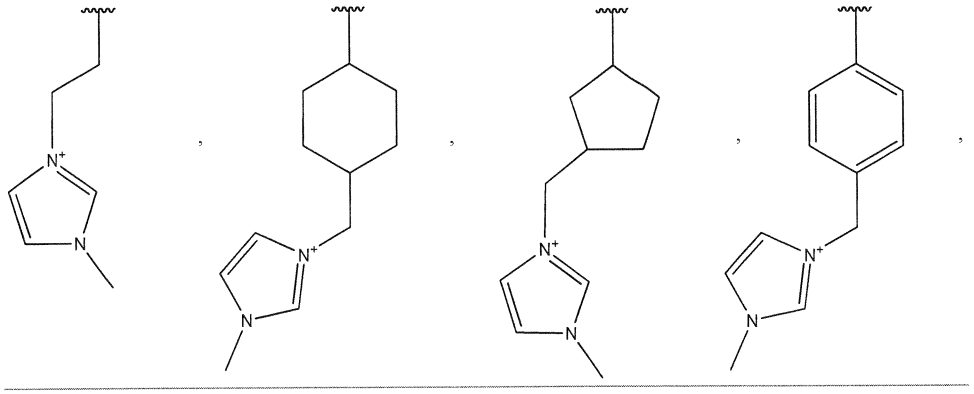
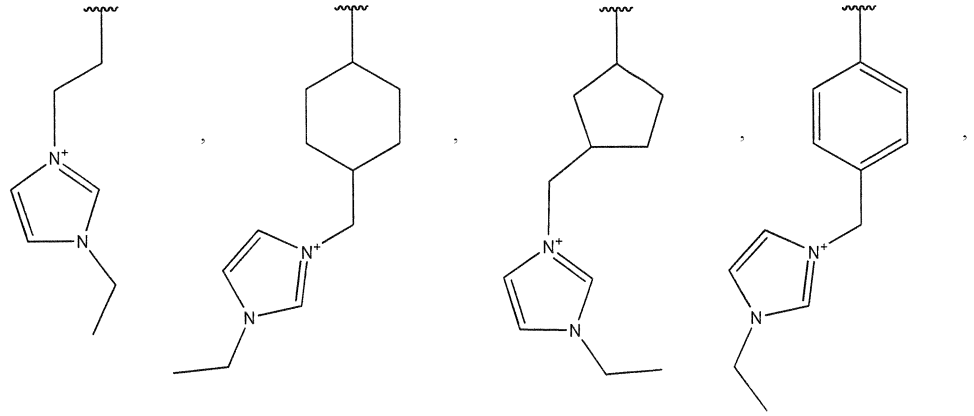
144. The use of claim 141, wherein the nitrogen-containing cationic group and the linker form a nitrogen-containing side chain, wherein each nitrogen-containing side chain is independently selected from the group consisting of:

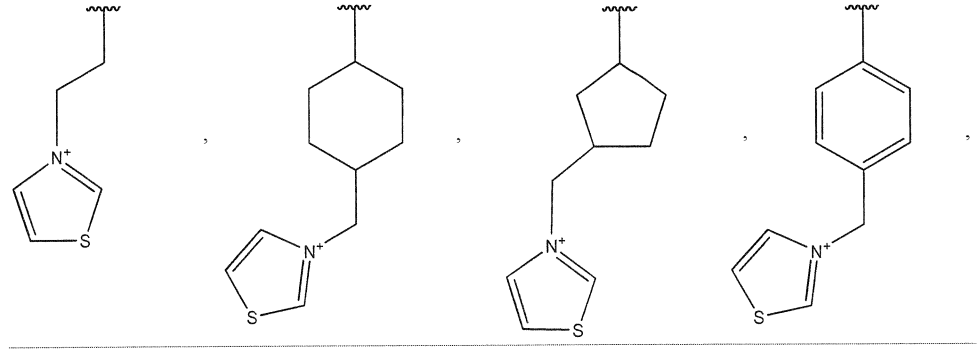


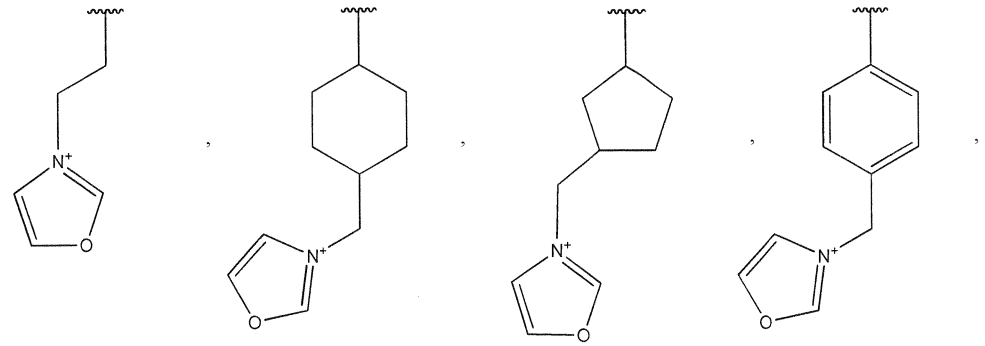


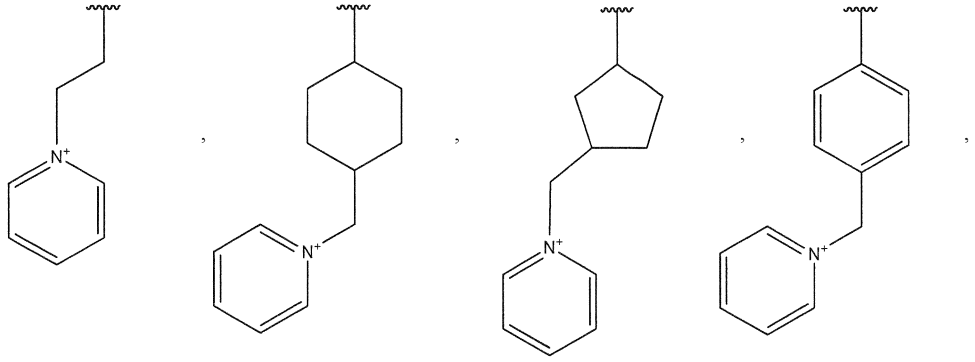


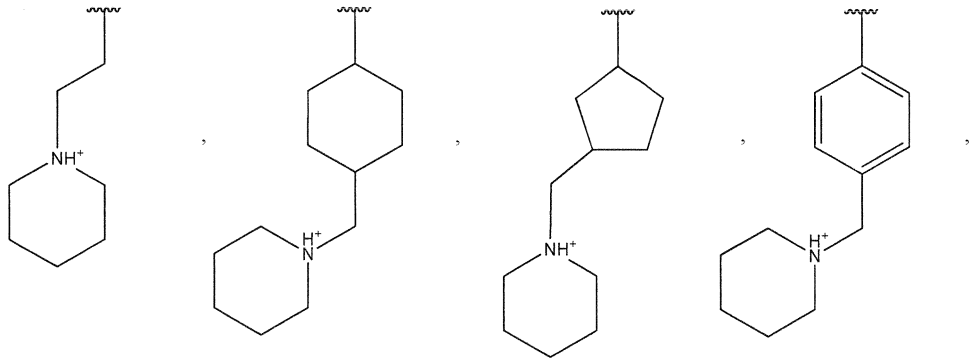


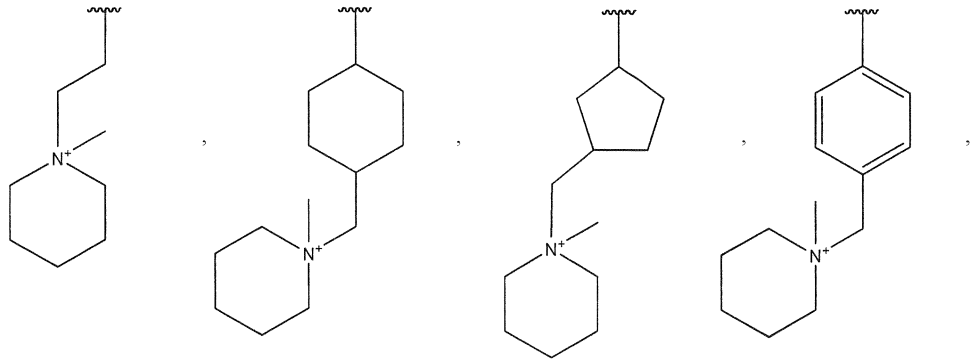


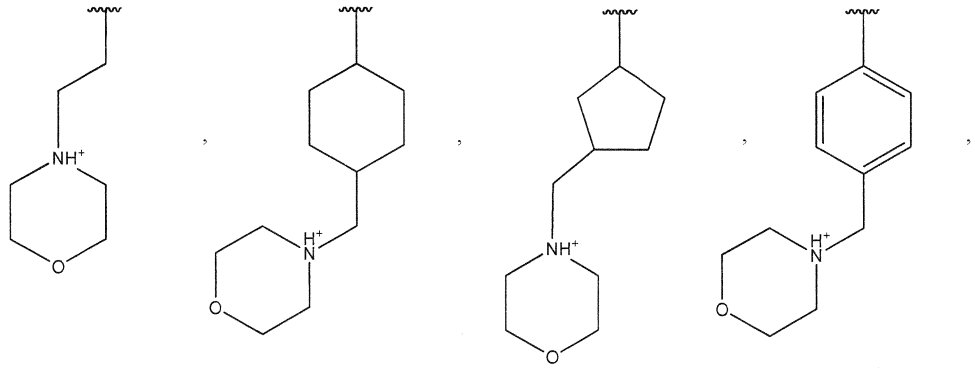


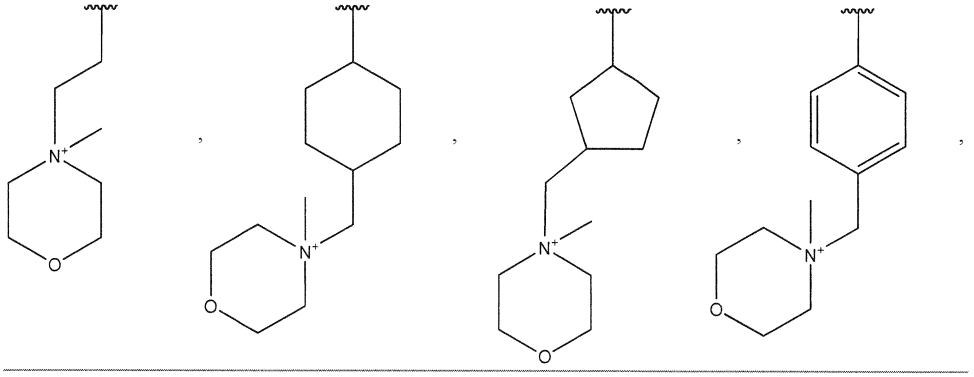


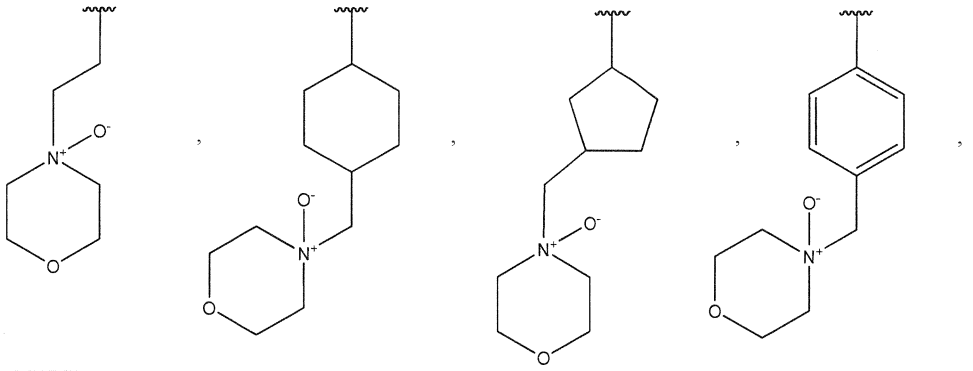


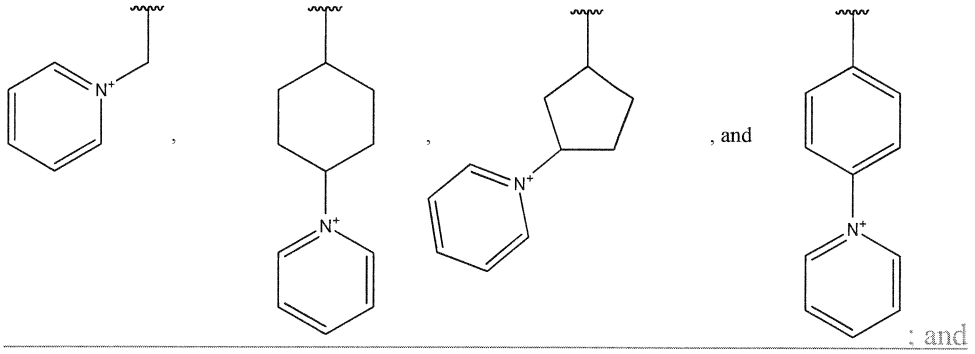






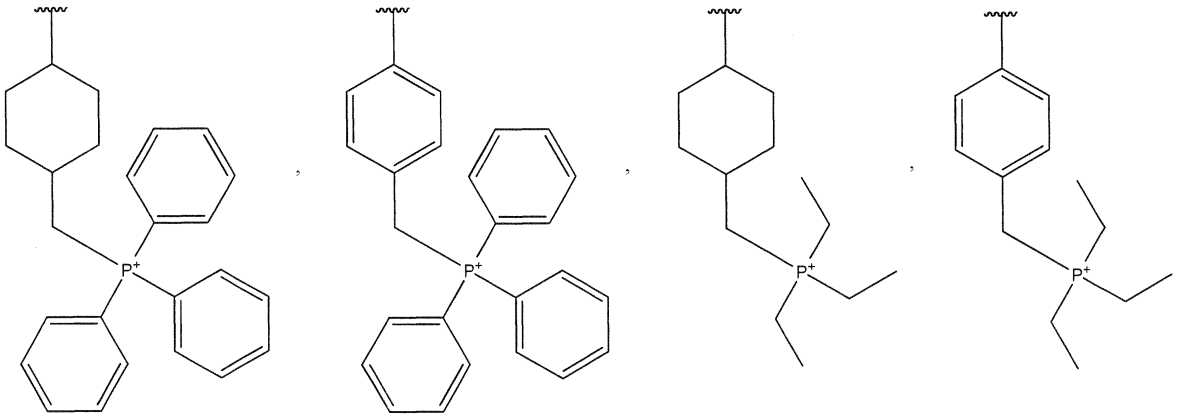


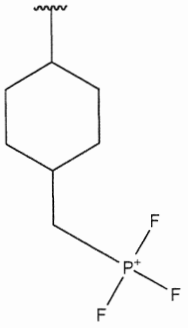



, and

: and

wherein the phosphorous-containing cationic group and the linker form a phosphorous-containing side chain, wherein each phosphorous-containing side chain is independently selected from the group consisting of:





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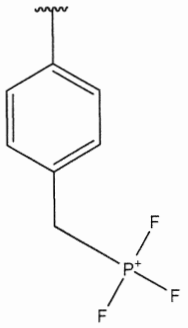

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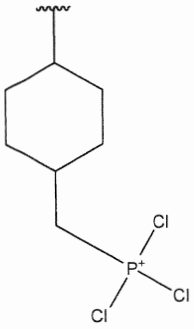

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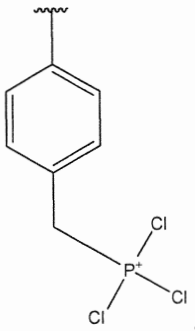

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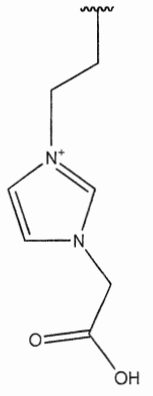
145. The use of any one of claims 133 to 144, wherein the polymer further comprises acidic-ionic monomers connected to the polymeric backbone, wherein each acidic-ionic monomer comprises a Bronsted-Lowry acid and a cationic group, wherein the cationic group is a nitrogen-containing cationic group or a phosphorous-containing cationic group.

146. The use of claim 145, wherein one or more of the acidic-ionic monomers each further comprise a linker connecting the Bronsted-Lowry acid or the cationic group to the polymeric backbone, and wherein the Bronsted-Lowry acid, the cationic group and the linker form an acidic-ionic side chain, wherein each acidic-ionic side chain is independently selected from the group consisting of:



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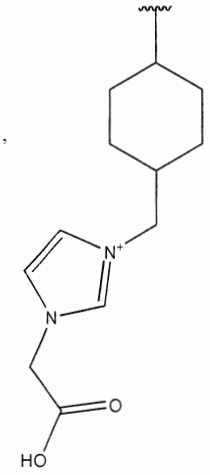

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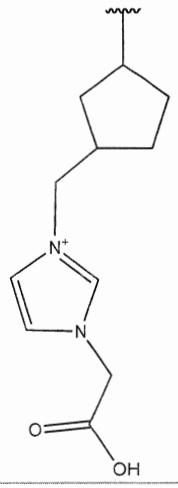

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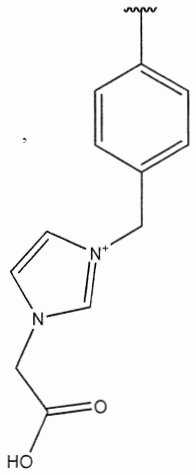

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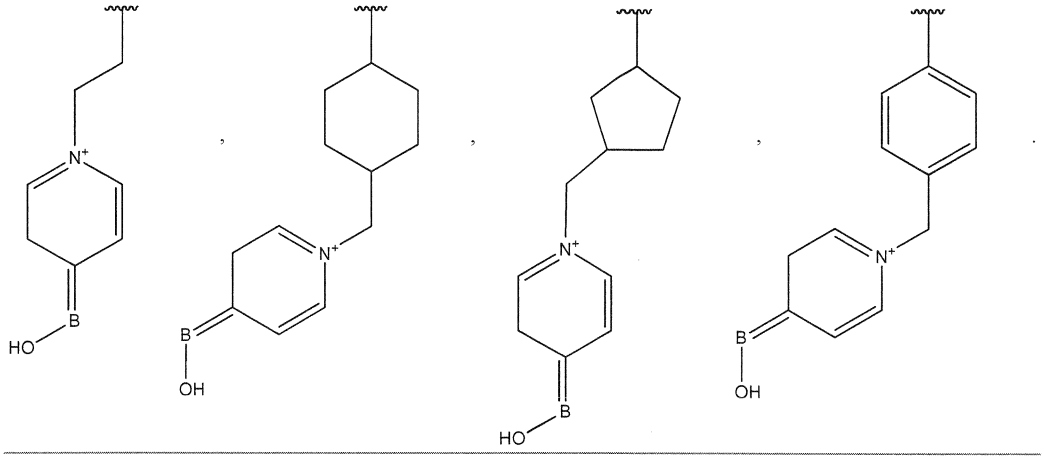

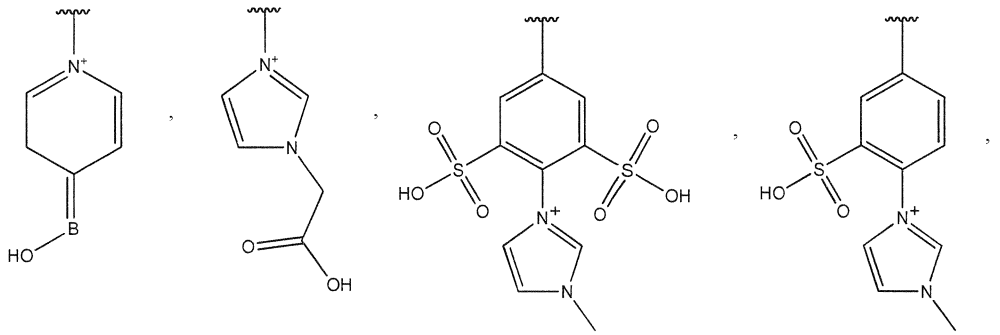

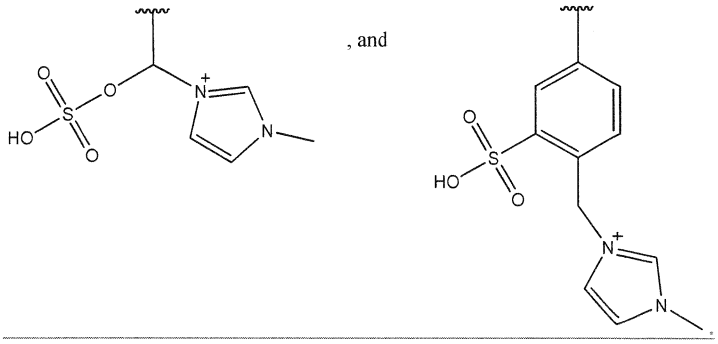

, and

147. The use of any one of claims 133 to 146, wherein the polymer further comprises hydrophobic monomers connected to form the polymeric backbone,

wherein each hydrophobic monomer comprises a hydrophobic group,

wherein the hydrophobic group at each occurrence is independently selected from the group consisting of an unsubstituted or substituted alkyl, an unsubstituted or substituted cycloalkyl, an unsubstituted or substituted aryl, or an unsubstituted or substituted heteroaryl.

148. The use of any one of claims 133 to 147, wherein the polymeric backbone in the polymer is selected from the group consisting of polyethylene, polypropylene, polyvinyl alcohol, polystyrene, polyurethane, polyvinyl chloride, polyphenol-aldehyde, polytetrafluoroethylene,

polybutylene terephthalate, polycaprolactam, poly(acrylonitrile butadiene styrene), polyalkyleneammonium, polyalkylenediammonium, polyalkylenepyrrolium, polyalkyleneimidazolium, polyalkylenepyrazolium, polyalkyleneoxazolium, polyalkylenethiazolium, polyalkylenepyridinium, polyalkylenepyrimidinium, polyalkylenepyrazinium, polyalkylenepyradizinium, polyalkylenethiazinium, polyalkylenemorpholinium, polyalkylenepiperidinium, polyalkylenepiperizinium, polyalkylenepyrollizinium, polyalkylenetriphenylphosphonium, polyalkylenetrimethylphosphonium, polyalkylenetriethylphosphonium, polyalkylenetripropylphosphonium, polyalkylenetributylphosphonium, polyalkylenetrichlorophosphonium, polyalkylenetrifluorophosphonium, and polyalkylenediazolium.

~~97~~149. A sugar composition obtained by the method according to any one of claims ~~70~~ 100 to ~~85~~115.

~~98. A sugar composition obtained by contacting biomass with a polymer according to any one of claims 1 to 48 for a period of time sufficient to hydrolyze the biomass into one or more sugars.~~

~~99~~150. The sugar composition of claim ~~97 or 98~~149, comprising at least 0.1% by weight a mixture of sugars, wherein the mixture of sugars comprises one or more C4-C6 monosaccharides and one or more oligosaccharides.

~~100~~151. The sugar composition of claim ~~99~~150, wherein the one or more C4-C6 monosaccharides are selected from the group consisting of glucose, galactose, fructose, xylose, and arabinose.

~~101~~152. A biofuel composition derived from a sugar composition according to ~~any one of claims 97 to 100~~claim 150 or 151.

~~102~~153. The biofuel composition of claim ~~101~~152, comprising butanol, ethanol, or a mixture thereof.

~~103~~154. A method of preparing a polymer according to any one of claims 1 to 48, comprising:

a) providing a starting polymer;

b) reacting the starting polymer with a nitrogen-containing or phosphorous-containing compound to produce an ionic polymer; and

c) reacting the ionic polymer with an acid to produce a polymer according to any one of claims 1 to 48.

~~104~~155. The method of claim ~~103~~154, wherein the starting polymer is selected from the group consisting of polyethylene, polypropylene, polyvinyl alcohol, polycarbonate, polystyrene, polyurethane, or a combination thereof.

~~105~~156. The method of claim ~~104~~155, wherein the starting polymer is a polystyrene.

~~106~~157. The method of claim ~~105~~156, wherein the starting polymer is poly(styrene-*co*-vinylbenzylhalide-*co*-divinylbenzene).

~~107~~158. The method of claim ~~106~~157, wherein the starting polymer is poly(styrene-*co*-vinylbenzylchloride-*co*-divinylbenzene).

~~108~~159. The method of any one of claims ~~103~~-154 to ~~107~~158, wherein the nitrogen-containing compound is selected from the group consisting of a pyrrolium compound, an imidazolium compound, a pyrazolium compound, an oxazolium compound, a thiazolium compound, a pyridinium compound, a pyrimidinium compound, a pyrazinium compound, a pyradizimium compound, a thiazinium compound, a morpholinium compound, a piperidinium compound, a piperizinium compound, and a pyrollizinium compound.

~~109~~160. The method of any one of claims ~~103~~-154 to ~~108~~159, wherein the acid is selected from the group consisting of sulfuric acid, phosphonic acid, hydrochloric acid, acetic acid and boronic acid.

~~110~~161. A method of preparing a polymer according to any one of claims 1 to 48, comprising:

a) providing a polystyrene;

b) reacting the polystyrene with a nitrogen-containing compound to produce an ionic polymer; and

c) reacting the ionic polymer with an acid to produce a polymer according to any one of claims 1 to 48.

~~111~~162. The method of claim ~~110~~161, wherein the polystyrene is poly(styrene-*co*-vinylbenzylhalide-*co*-divinylbenzene).

~~112~~163. The method of claim ~~111~~162, wherein the polystyrene is poly(styrene-*co*-vinylbenzylchloride-*co*-divinylbenzene).

~~113~~164. The method of any one of claims ~~110~~-161 to ~~112~~163, wherein the nitrogen-containing compound is selected from the group consisting of a pyrrolium compound, an imidazolium compound, a pyrazolium compound, an oxazolium compound, a thiazolium compound, a pyridinium compound, a pyrimidinium compound, a pyrazinium compound, a pyradizimium compound, a thiazinium compound, a morpholinium compound, a piperidinium compound, a piperizinium compound, and a pyrollizinium compound.

~~114~~165. The method of any one of claims ~~110~~-161 to ~~113~~164, wherein the acid is selected from the group consisting of sulfuric acid, phosphonic acid, hydrochloric acid, acetic acid and boronic acid.

~~115~~166. A polymer prepared according to the method of any one of claims ~~110~~-161 to ~~114~~165.

~~116~~167. The polymer of claim ~~115~~166, wherein the polymer has one or more catalytic properties selected from the group consisting of:

a) disruption of a hydrogen bond in cellulosic materials;

b) intercalation of the polymer into crystalline domains of cellulosic materials; and

c) cleavage of a glycosidic bond in cellulosic materials.

~~117~~168. Use of a polymer prepared according to the method of any one of claims ~~110~~161 to ~~114~~165 for degrading biomass into one or more monosaccharides, one or more oligosaccharides, or a combination thereof.

~~118~~169. Use of a polymer prepared according to the method of any one of claims ~~110~~161 to ~~114~~165 for partially digesting biomass before pretreatment using one or more methods selected from the group consisting of washing, solvent-extraction, solvent-swelling, comminution, milling, steam pretreatment, explosive steam pretreatment, dilute acid pretreatment, hot water pretreatment, alkaline pretreatment, lime pretreatment, wet oxidation, wet explosion, ammonia fiber explosion, organosolvent pretreatment, biological pretreatment, ammonia percolation, ultrasound, electroporation, microwave, supercritical CO_2, supercritical H_2O, ozone, and gamma irradiation.