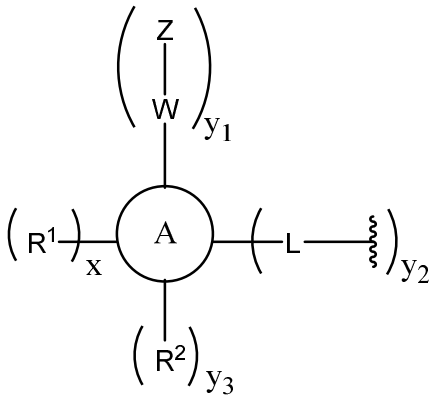
CLAIMS:

1. A porous polymeric material comprising a plurality of cyclodextrins crosslinked with a plurality of aryl diisocyanate crosslinkers, wherein one or more of the plurality of cyclodextrins are bound to a linker of formula (I):



(I)

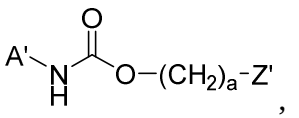
wherein

A is an aryl moiety;

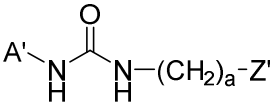
each R^1 is independently selected from the group consisting of H, C_1-C_6 alkyl, C_1-C_3 haloalkyl, aryl, heteroaryl, -CF_3, -SO_3H, –CN, -NO_2, -NH_2, -NCO, -$C(O)_2R^3$, -$C(O)N(R^3)_2$, and –halogen;

each R^2 is independently H, -OH, -O-metal cation, alkyl, aryl, heteroaryl, -SH, –S-metal cation, –S-alkyl, -$C(O)_2H$, or -$C(O)NH_2$;

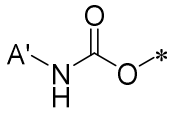
each R^3 is independently –H, –C_1-C_6 alkyl, –C_1-C_3 haloalkyl, –aryl, −$C(O)N(R^a)(R^b)$, −$C(O)R^c$, −CO_2R^c, −$SO_2N(R^a)(R^b)$, or −SOR^c, and each R^a, R^b and R^c is independently H, or C_1-C_6 alkyl;

each W is independently a bond, an alkylene group, an arylene group, a heteroarylene group, -O-arylene-, -$(CH_2)_a$-arylene-, -SO_2-arylene-, -NH-arylene-, -S-arylene-, -O-heteroarylene-, -$(CH_2)_a$-heteroarylene-, -SO_2-heteroarylene-, -NH-heteroarylene-, -S-heteroarylene-, –(–O–$(CH_2)_a$–)$_x$–, –(–NH–$(CH_2)_a$–)$_x$–, –(–S–$(CH_2)_a$–)$_x$–, 

,

or , wherein a is 0-100 and x is 1-100, and each arylene or heteroarylene moiety can be substituted or unsubstituted;

each Z is $-N(Me)_3^+$;

each L is ;

A' is a covalent bond to A;

Z' is a covalent bond to Z;

* is a covalent bond to ;

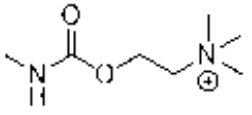
 is a point of attachment to the plurality of cyclodextrin carbon atoms;

x is 0-8;

y_1 is 1-4;

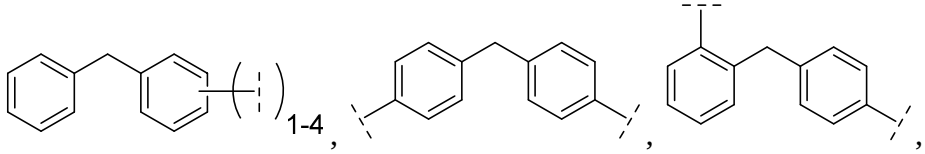
y_2 is 1-4; and

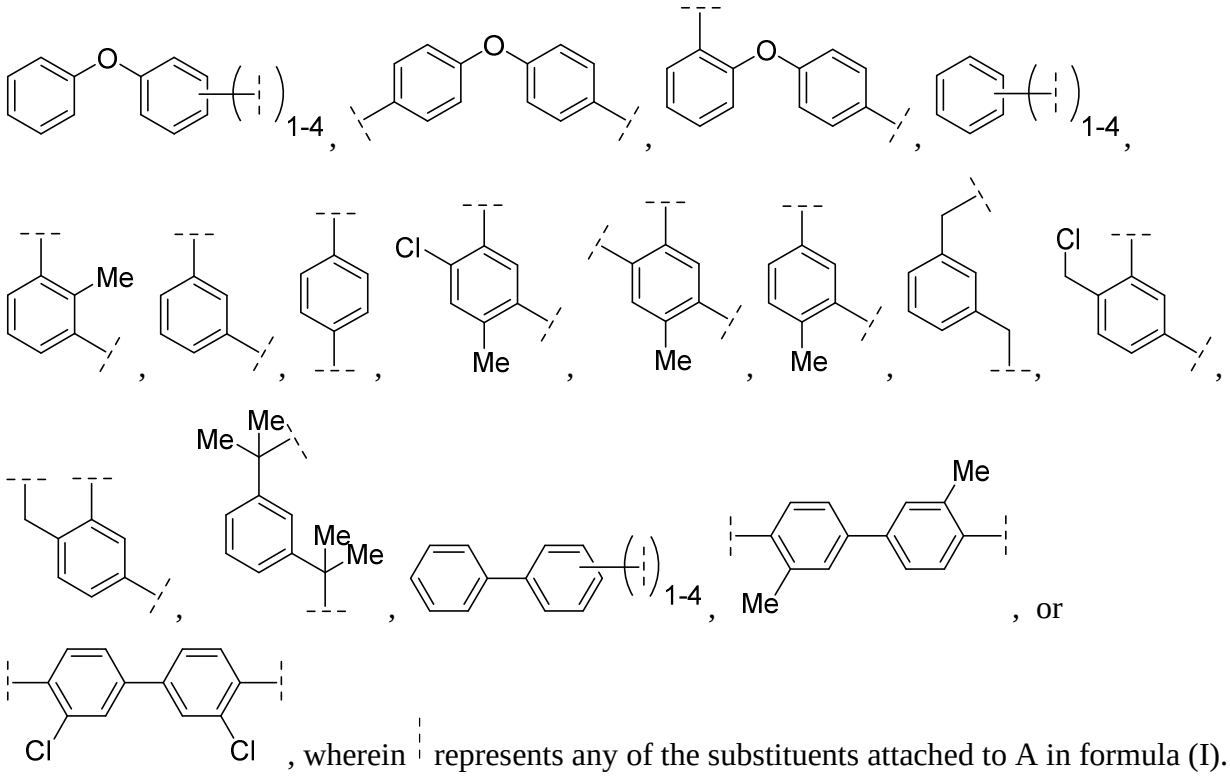
y_3 is 0-4.

2. The porous polymeric material of claim 1, wherein each instance of –W–Z is taken together to form .

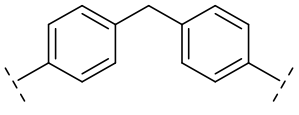
3. The porous polymeric material of claim 1, wherein each cyclodextrin is selected from the group consisting of α-cyclodextrin, β-cyclodextrin, γ-cyclodextrin, and combinations thereof.

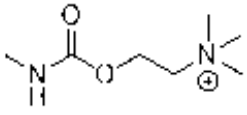
4. The porous polymeric material of claim 1, wherein x and y_3 are each 0.

5. The porous polymeric material of claim 1, wherein the aryl moiety is 

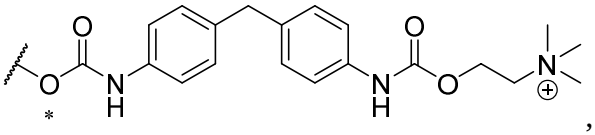


, wherein ¦ represents any of the substituents attached to A in formula (I).

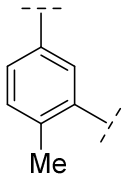
6. The porous polymeric material of claim 5, wherein the aryl diisocyanate crosslinker is 4,4'-methylene diphenyl diisocyanate, the aryl moiety is  and x and y_3 are each 0.

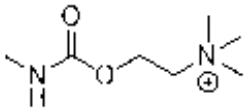
7. The porous polymeric material of claim 6, wherein each instance of –W–Z is taken together to form .

8. The porous polymeric material of claim 7, wherein each cyclodextrin is a β-cyclodextrin.

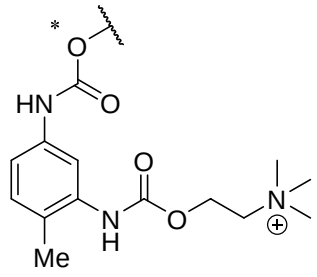
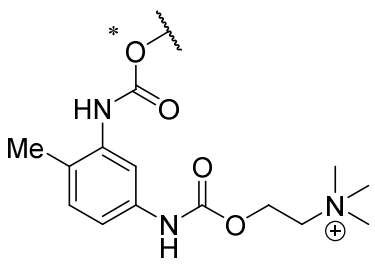
9. The porous polymeric material of claim 8, wherein the linker comprising formula (I) has the following structure , wherein the oxygen atom denoted with the * is a glycosidic oxygen from one of the plurality of cyclodextrins.

10. A method of purifying a fluid sample comprising one or more pollutants, the method comprising contacting the fluid sample with the porous polymeric material of claim 9, whereby at least 50 wt. % of the total amount of the one or more pollutants in the fluid sample is adsorbed by the porous polymeric material.

11. The porous polymeric material of claim 5, wherein the aryl diisocyanate crosslinker is toluene 2,4-diisocyanate, the aryl moiety is  and x and y_3 are each 0.

12. The porous polymeric material of claim 11, wherein each instance of –W–Z is taken together to form .

13. The porous polymeric material of claim 12, wherein each cyclodextrin is a β-cyclodextrin.

14. The porous polymeric material of claim 13, wherein the linker comprising formula (I) has the following structure  or  wherein the

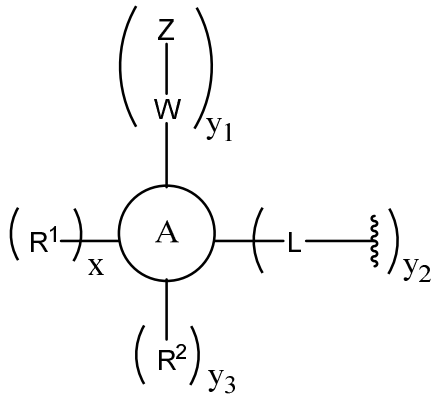
oxygen atom denoted with the * is a glycosidic oxygen from one of the plurality of cyclodextrins.

15. A method of purifying a fluid sample comprising one or more pollutants, the method comprising contacting the fluid sample with the porous polymeric material of claim 14, whereby at least 50 wt. % of the total amount of the one or more pollutants in the fluid sample is adsorbed by the porous polymeric material.

16. The porous polymeric material of claim 1, wherein the porous polymeric material has a surface area from 10 m^2/g to 2,000 m^2/g.

17. A method of purifying a fluid sample comprising one or more pollutants, the method comprising contacting the fluid sample with the porous polymeric material of claim 1, whereby at least 50 wt. % of the total amount of the one or more pollutants in the fluid sample is adsorbed by the porous polymeric material.

18. A porous polymeric material comprising a plurality of cyclodextrins crosslinked with a plurality of aryl diisocyanate crosslinkers, wherein one or more of the plurality of cyclodextrins are bound to a linker of formula (I):



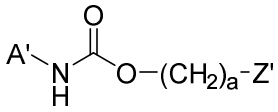
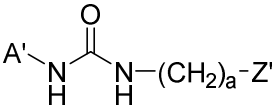
(I)

wherein

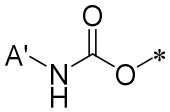
A is an aryl moiety;

each R^1 is independently H or C_1-C_6 alkyl;

each R^2 is independently H or alkyl;

each W is independently a bond, an alkylene group, an arylene group, a heteroarylene group, -O-arylene-, -$(CH_2)_a$-arylene-, -SO_2-arylene-, -NH-arylene-, -S-arylene-, -O-heteroarylene-, -$(CH_2)_a$-heteroarylene-, -SO_2-heteroarylene-, -NH-heteroarylene-, -S-heteroarylene-, –(–O–$(CH_2)_a$–)$_x$–, –(–NH–$(CH_2)_a$–)$_x$–, –(–S–$(CH_2)_a$–)$_x$–, , or , wherein a is 0-100 and x is 1-100, and each arylene or heteroarylene moiety can be substituted or unsubstituted;

each Z is a cationic moiety;

each L is ;

A’ is a covalent bond to A;

Z’ is a covalent bond to Z;

* is a covalent bond to ;

 is a point of attachment to the plurality of cyclodextrin carbon atoms;

x is 0-8;

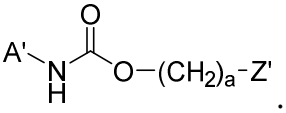
y_1 is 1-4;

y_2 is 1-4; and

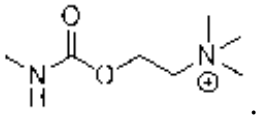
y_3 is 0-4.

19. The porous polymeric material of claim 18, wherein each Z is independently -$N(R^3)_3^+$, -$P(R^3)_3^+$, -$S(R^3)_2^+$, or heteroaryl$^+$, wherein each R^3 is independently -H, -C_1-C_6 alkyl, -C_1-C_3 haloalkyl, -aryl, -C(O)N(R^a)(R^b), -C(O)R^c, -CO_2R^c, -SO_2N(R^a)(R^b), or -SOR^c, wherein each R^a, R^b and R^c is independently H or C_1-C_6 alkyl.

20. The porous polymeric material of claim 19, wherein Z is -$N(R^3)_3^+$.

21. The porous polymeric material of claim 19, wherein W is .

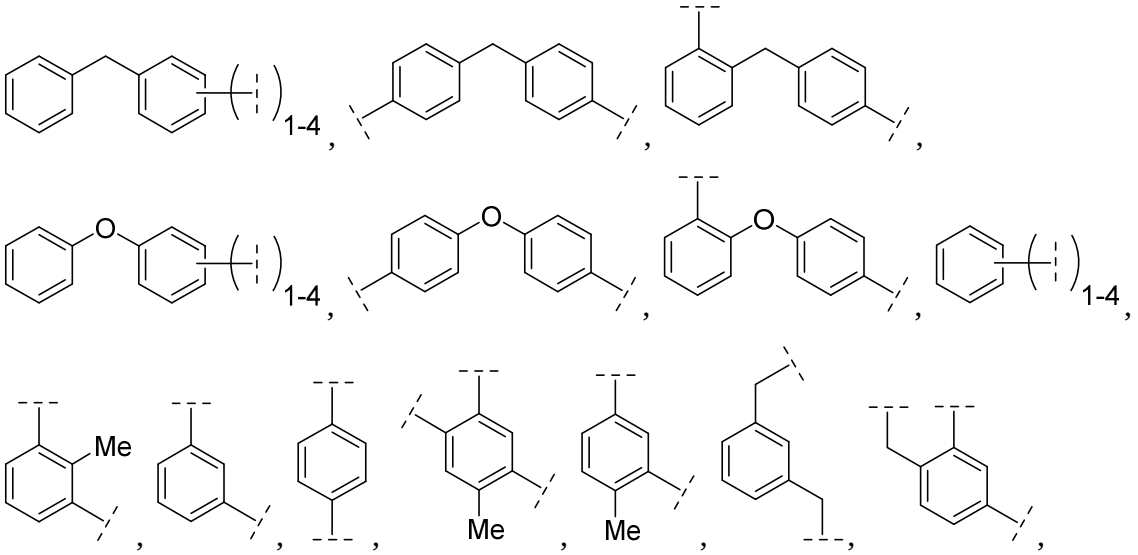
22. The porous polymeric material of claim 21, wherein Z is $-N(R^3)_3^+$.

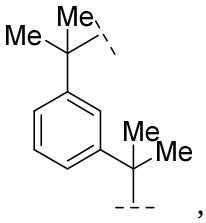
23. The porous polymeric material of claim 18, wherein each instance of –W–Z is taken together to form .

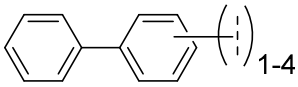
24. The porous polymeric material of claim 18, wherein each cyclodextrin is independently selected from the group consisting of α-cyclodextrin, β-cyclodextrin, and γ-cyclodextrin.

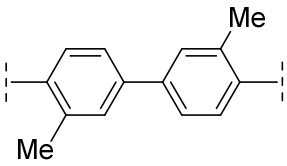
25. The porous polymeric material of claim 18, wherein R^1 and R^2 are H.

26. The porous polymeric material of claim 18, wherein the aryl moiety is



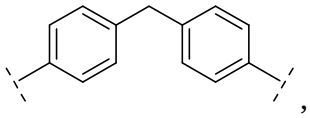
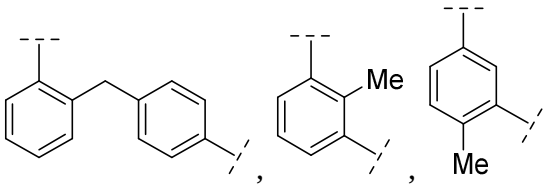


, 

, or 

, wherein ⋮ represents any of the substituents attached to A in formula (I).

27. The porous polymeric material of claim 26, wherein the plurality of aryl diisocyanate crosslinkers comprise 4,4'-methylene diphenyl diisocyanate, 2,4'-methylene diphenyl diisocyanate, 2,4-toluene diisocyanate, 2,6-toluene diisocyanate, or combinations thereof;

the aryl moiety is selected from the group consisting of 
,


and combinations thereof;

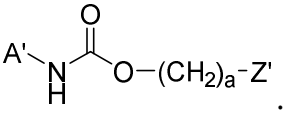
each R^1 is H; and

each R^2 is H or alkyl.

28. The porous polymeric material of claim 27, wherein the plurality of aryl diisocyanate crosslinkers comprise 4,4'-methylene diphenyl diisocyanate.

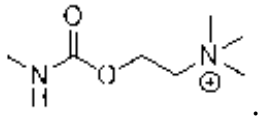
29. The porous polymeric material of claim 27, wherein each Z is independently $-N(R^3)_3^+$, $-P(R^3)_3^+$, $-S(R^3)_2^+$, or heteroaryl$^+$, wherein each R^3 is independently -H, $-C_1$-C_6 alkyl, $-C_1$-C_3 haloalkyl, -aryl, $-C(O)N(R^a)(R^b)$, $-C(O)R^c$, $-CO_2R^c$, $-SO_2N(R^a)(R^b)$, or $-SOR^c$, wherein each R^a, R^b, and R^c is independently H or C_1-C_6 alkyl.

30. The porous polymeric material of claim 29, wherein Z is $-N(R^3)_3^+$.

31. The porous polymeric material of claim 29, wherein W is 

.

32. The porous polymeric material of claim 31, wherein Z is $-N(R^3)_3^+$.

33. The porous polymeric material of claim 27, wherein each instance of –W–Z is taken together to form .

34. A method of purifying a fluid sample comprising one or more pollutants, the method comprising contacting the fluid sample with the porous polymeric material of claim 18, whereby at least 50 wt. % of the total amount of the one or more pollutants in the fluid sample is adsorbed by the porous polymeric material.

35. A method of purifying a fluid sample comprising one or more pollutants, the method comprising contacting the fluid sample with the porous polymeric material of claim 27, whereby at least 50 wt. % of the total amount of the one or more pollutants in the fluid sample is adsorbed by the porous polymeric material.