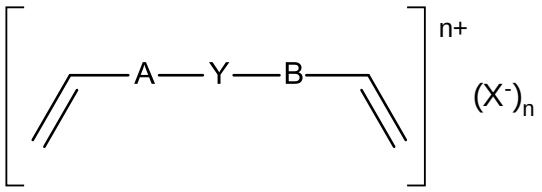
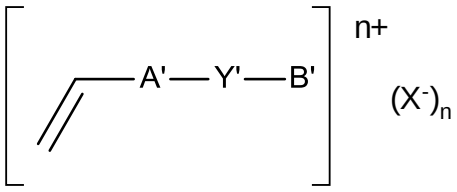
CLAIMS

1. A polymer obtainable by radical co-polymerisation of a first monomer comprising a compound of general formula (I) or (II) or a mixture thereof:



(I)



(II)

wherein each of A and A' is a 5- or 6-membered positively charged heteroaryl ring containing a quaternary nitrogen atom or when Y or Y' is $–NR^{20}–(C=Z)–N–R^{20}–$, A or A' is a 5- or 6-membered aryl or heteroaryl ring optionally substituted with halo, C_{1-6} haloalkyl or nitro;

each of B and B' is a 5- or 6-membered positively charged heteroaryl ring containing a quaternary nitrogen atom; or a 5- or 6-membered aryl or heteroaryl ring optionally substituted with one or more substituents selected from halo, C_{1-6} haloalkyl or nitro;

each of Y and Y' is a linking group comprising 1-6 $–CH_2–$ units wherein a $–CH_2–$ unit is optionally replaced by a C_{5-14} aryl or heteroaryl group optionally substituted with one or more substituents selected from H, halogen, NH_2, C_{1-4} alkyl, C_{1-4} alkoxy, C_{1-4} haloalkyl or C_{1-4} haloalkoxy or

when each of A or A' and B or B' is a 5- or 6-membered aryl or heteroaryl ring optionally substituted with one or more substituents selected halo, C_{1-6} haloalkyl or nitro, each of Y and Y' may be $–NR^{20}–(C=Z)–N–R^{20}–$, wherein

each R^{20} is independently H, methyl or ethyl; and

Z is O or S;

n is 1 or 2; or when Y and Y' is $–NR^{20}–(C=Z)–N–R^{20}–$, n is 0;

X^- is a halide ion or a hydrophobic anion such as PF_6^-;

with a second, cross-linking monomer and optionally with one or more further co-monomers;

wherein the molar ratio of the first monomer to the sum of the second monomer and the one or more further co-monomers (if present) is less than or equal to 1:5.

2. The polymer according to claim 1 wherein, in the monomer of general formulae (I) or (II), X^- is a halide or a PF_6^- ion.

3. The polymer according to claim 1 or claim 2 wherein, in the monomer of general formulae (I) or (II) the linking group Y is bonded to the quaternary nitrogen moiety of the group A or A'.

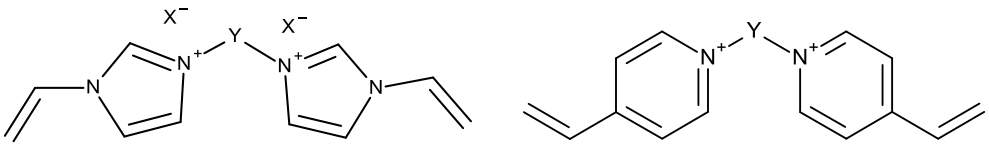
4. The polymer according to claim 1 wherein, in the monomer of general formula (I) or (II), the group A or A' is a pyridinium or imidazolium ion wherein:
when A or A' is a pyridinium ion, the group $–CH=CH_2$ is connected at the pyridinium 4-position; and
when A or A' is an imidazolium ion, the group $–CH=CH_2$ is linked to the non-quaternary ring nitrogen atom.

5. The polymer according to claim 1 wherein, in the monomer of general formula (I) or (II), the group B or B' is a 5- or 6-membered positively charged heteroaryl ring containing a quaternary nitrogen atom wherein the linking group y is suitably bonded to the quaternary nitrogen moiety.

6. The polymer according to claim 5 wherein the group B or B' is a pyridinium or imidazolium ion.

7. The polymer according to claim 6 wherein B is a pyridinium ion and the group $–CH=CH_2$ is connected at the pyridinium 4-position; or B is an imidazolium ion and the group $–CH=CH_2$ is linked to the non-quaternary ring nitrogen atom.

8. The polymer according to claim 1, in the monomer of general formula (I), wherein A and B are the same and the monomer of general formula (I) is a compound of general formula (Ia) or (Ib):

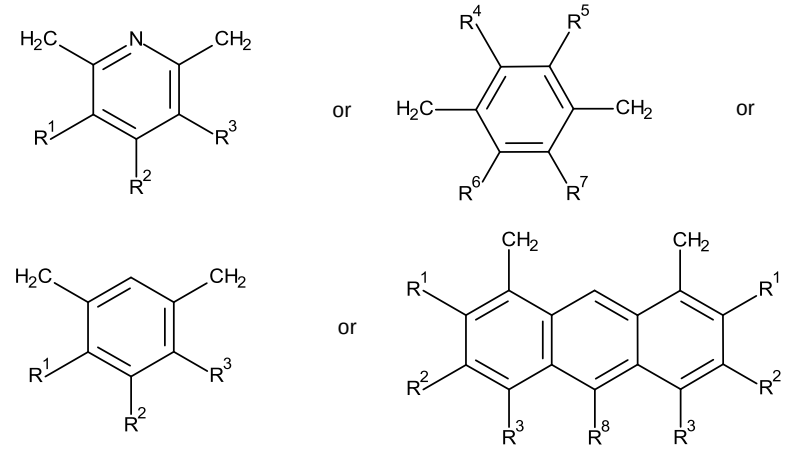


(Ia) (Ib).

9. The polymer according to claim 8 wherein the monomer of general formula (I) is a monomer of formula (Ia).

10. The polymer according to claim 1 wherein, in the monomer of general formula (I) or (II), the group B or B' is a 5- or 6-membered aryl or heteroaryl ring.

11. The polymer according to claim 1 wherein, in the monomer of general formulae (I) or (II), Y is a linker group selected from:



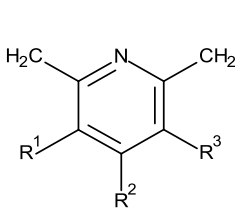
wherein

each of R^1, R^2 and R^3 is independently selected from H, halogen, NH_2, C_{1-4} alkyl, C_{1-4} alkoxy, C_{1-4} haloalkyl, C_{1-4} haloalkoxy or R^1 and R^2 or R^2 and R^3 may together form a 5- or 6-membered carbocyclic, heterocyclic, aryl or heteroaryl ring;

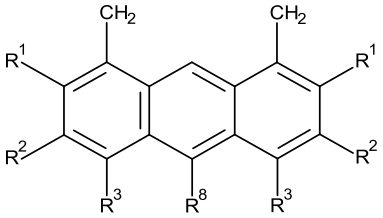
each of R^4, R^5, R^6 and R^7 is independently selected from H, halogen, NH_2, C_{1-4} alkyl, C_{1-4} alkoxy, C_{1-4} haloalkyl, C_{1-4} haloalkoxy or R^4 and R^5 or R^6 and R^7 may together form a 5- or 6-membered carbocyclic, heterocyclic, aryl or heteroaryl ring;

R^8 is H, halogen, NH_2, C_{1-4} alkyl, C_{1-4} alkoxy, C_{1-4} haloalkyl, C_{1-4} haloalkoxy.

12. The polymer according to claim 11 wherein, in the monomer of general formula (I) or (II), Y is:

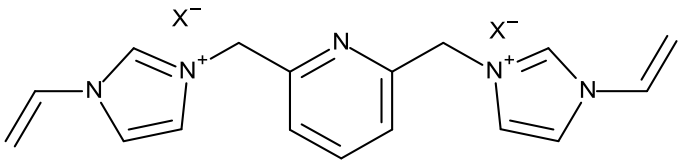


or



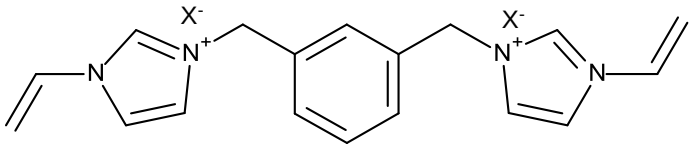
wherein each of R^1, R^2, R^3 and R^8.

13. The polymer according to claim 1 wherein the monomer of general formula (I) or formula (II) is Monomer 1, which has the structure:



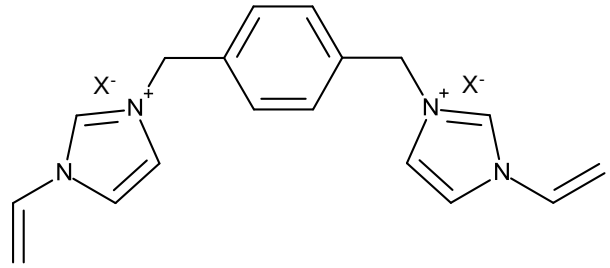
where X^- is as defined in claim 1 but is most suitably Br^-; or

Monomer 2, which has the structure:



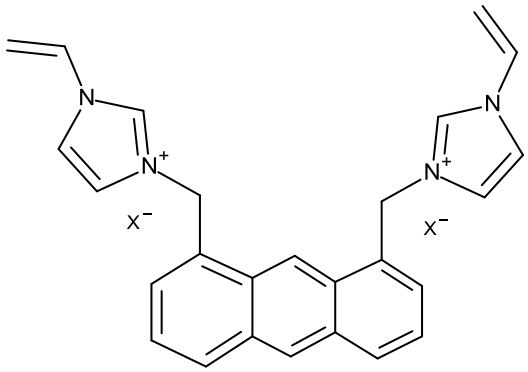
where X^- is as defined in claim 1 but is most suitably Br^-; or

Monomer 3, which has the structure:



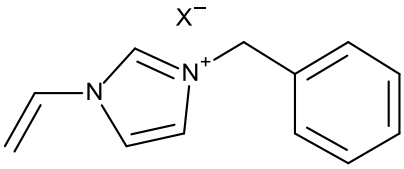
where X^- is as defined above but is most suitably Br^-; or

Monomer 5, which has the structure:



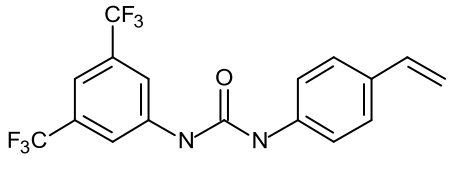
where X^- is as defined above but is most suitably Br^-; or

Monomer 4, which has the structure:



where X^- is as defined above but is most suitably Br^-; or

Monomer 6 which has the structure:



;

or a combination thereof.

14. The polymer according to claim 1 wherein the second cross linking monomer is selected from di- and tri-methacrylate monomers, dialkenyl benzene monomers and bis acrylamide monomers.

15. The polymer according to claim 14 wherein the second cross linking monomer is ethyleneglycol dimethacrylate (EGDMA), divinylbenzene (DVB), diisopropenylbenzene, (DIB), trimethylolpropanetrimethacrylate (TRIM),

pentaerythritoltriacrylate (PETA), ethylenebisacrylamide (EBA), piperazinebisacrylamide (PBA), or methylenebisacrylamide (MBA).

16. The polymer according to claim 1 wherein the first monomer is Monomer 1 or a combination of Monomer 1 with one or more other monomers of general formula (I) or general formula (II); and the second monomer is EGDMA.

17. The process for the preparation of a polymer according to claim 1, the process comprising the radical co-polymerisation of a first monomer of general formula (I) or general formula (II) with a second, cross-linking monomer and optionally with one or more further co-monomers; characterised in that the molar ratio of the first monomer to the sum of the second monomer and the one or more further co-monomers (if present) is less than or equal to 1:5;
wherein the second, cross-linking monomer is ethyleneglycol dimethacrylate (EGDMA), divinylbenzene (DVB), diisopropenylbenzene, (DIB), trimethylolpropanetrimethacrylate (TRIM), pentaerythritoltriacrylate (PETA), ethylenebisacrylamide (EBA), piperazinebisacrylamide (PBA), or methylenebisacrylamide (MBA).

18. The process according to claim 17 wherein the molar ratio of the first monomer of general formula (I) or general formula (II) to the sum of the second monomer and the one or more further co-monomers (if present) is from 1:80 to 1:20.

19. A solid phase material comprising the polymer according to claim 1.

20. A separation device comprising the solid phase material according to claim 19.

21. The separation device according to claim 20 which comprises a chromatography column.

22. A kit for isolating phosphate ester compounds from a mixture comprising one or more such compounds, the kit comprising the solid phase material according to claim 19; instructions for the use of the material and optionally one or more standards.