The polymer used for forming the nanoparticle according to the disclosure may exhibit aggregated induced emission. Hence, in a dissolved state (for example in pure THF solution), the polymer may not exhibit fluorescent activity. However, upon increasing polarity (increasing the water content in the THF/water solvent mixture) the polymer forms said polymeric nanoparticle and emits fluorescence. The fluorescence intensity may increase with increased polarity, for example, for a 1:9 THF/water mixture the fluorescence may be 200 times higher than for a 9:1 THF/water mixture.

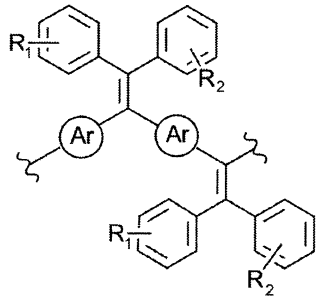
[00032] "Alkyl" as a group or part of a group refers to a linear or branched aliphatic hydrocarbon group, preferably a C_{1-25} alkyl, more preferably a C_{1-12} alkyl, most preferably C_{1-4} unless otherwise noted. Examples of suitable straight and branched C_{1-25} alkyl substituents include methyl, ethyl, n-propyl, 2-propyl, n-butyl, sec-butyl, t-butyl, hexyl, and the like. The group may be a terminal group or a bridging group.

[00033] "Aromatic ring" as a group or part of a group denotes (i) an optionally substituted monocyclic, polycyclic, or fused polycyclic aromatic carbocycle (ring structure having ring atoms that are all carbon) preferably having from 5 to 18 atoms per ring. The terminology also includes a system wherein a monocyclic ring may be connected to another monocyclic ring via a triple bond. Examples of aromatic rings include phenyl, naphthyl, benzene, 1,1'-biphenyl, 1,2-diphenylethyne, fluorene, terphenyl and the like; (ii) an optionally substituted partially saturated polycyclic aromatic carbocyclic moiety in which at least one phenyl and a C_{5-7} cycloalkyl or C_{5-7} cycloalkenyl group are fused together to form a cyclic structure, such as tetrahydronaphthyl, indenyl, indanyl or fluorene. The group may be a terminal group or a bridging group. Typically an aromatic ring is a C_{3-18} aryl group.

[00034] "Heteroaromatic ring" either alone or part of a group refers to groups containing an aromatic ring (preferably a 5 or 6 membered aromatic ring) having one or more heteroatoms as ring atoms in the aromatic ring with the remainder of the ring atoms being carbon atoms. Suitable heteroatoms include nitrogen, oxygen and sulphur. Examples of heteroaromatic rings include thiophene, benzothiophene, benzofuran, benzimidazole, benzoxazole, benzothiazole, benzisothiazole, naphtho[2,34j]thiophene, furan, isoindolizine, xantholene, phenoxatine, pyrrole, imidazole, pyrazole, pyridine, pyrazine, pyrimidine, pyridazine, tetrazole, indole, isoindole, 1H-indazole, purine, quinoline, isoquinoline, phthalazine, naphthyridine, quinoxaline, cinnoline, carbazole, phenanthridine, acridine, phenazine, thiazole, isothiazole, phenothiazine, oxazole,

CLAIMS

1. Polymeric nanoparticles having a unit structure represented by formula (I),



(I)

wherein

R_1 and R_2 are independently selected from the group consisting of hydrogen, alkyl, cyano, formyl, alkyl carbonyl, carboxylic acid, alkyl carboxylic acid, carboxylic ester, alkyl carboxylic ester, alkylaldehyde, and ketone;

(Ar) is selected from the group consisting of substituted or unsubstituted aromatic rings and substituted or unsubstituted heteroaromatic rings, wherein the aromatic rings and heteroaromatic rings comprise monocyclic moieties, optionally connected to another monocyclic ring via a triple bond, or fused or unfused polycyclic moieties, wherein the substituents are independently selected from the group consisting of C_{1-12} alkyl and wherein the heteroatom is independently selected from the group consisting of N, S, and O; and

$\wr$ indicates the attachment point of the next unit.

2. The polymeric nanoparticles of claim 1, wherein R_1 and R_2 of formula (I) are independently selected from the group consisting of hydrogen, cyano, C_{1-12} alkyl, -C(O)H, -C_{1-12} alkyl-C(O)H, -$C(O)CH_3$, -C_{1-12} alkyl-$C(O)CH_3$, -C(O)OH, -C_{1-12} alkyl-C(O)OH, -$C(O)OCH_3$ and -C_{1-12} alkyl-$C(O)OCH_3$.

3. The polymeric nanoparticles of claim 1 or 2, wherein (Ar) of formula (I) is selected from the group consisting of benzene, 1,1'-biphenyl, 1,2-diphenylethyne,

benzo[c][1,2,5]thiadiazole, thiophene, 2,2'-bithiophene, fluorene, 9,9-dihexyl-fluorene, 9,9-didodecyl-fluorene, naphthalene, terphenyl, and benzo[c]thiophene.

4. The polymeric nanoparticles of any one of claims 1 to 3, wherein the polymeric nanoparticles exhibit fluorescent activity, preferably when present in a solution of tetrahydrofuran (THF) / H_2O, wherein the volume ratio of THF and H_2O is in the range from about 9:1 to about 1:9.

5. The polymeric nanoparticles of any one of claims 1 to 4, wherein the mean particle size of the polymeric nanoparticles is in the range from about 50 nm to about 1500 nm, preferably from about 100 nm to about 1300 nm, more preferably from about 200 nm to about 1200 nm, preferably when present in a solution of THF/H_2O, wherein the volume ratio of THF and H_2O is in the range from about 9:1 to about 1:9.

6. The polymeric nanoparticles of any one of claims 1 to 5, wherein the polymeric nanoparticles exhibit aggregation-induced emission (AIE) properties.

7. A device for the detection of nitro compounds, comprising polymeric nanoparticles of any one of claims 1 to 6.

8. The device of claim 7, wherein the device further comprises paper.

9. The device of claim 7 or 8, wherein the polymeric nanoparticles are located on the surface of the device.

10. The device of claim 9, wherein the surface concentration of the polymeric nanoparticles is in the range from about 0.1 $\mu g/cm^2$ to about 5 $\mu g/cm^2$, preferably from about 0.5 $\mu g/cm^2$ to about 2 $\mu g/cm^2$, more preferably from about 0.8 $\mu g/cm^2$ to about 1.5 $\mu g/cm^2$.

11. The device of any one of claims 7 to 10, wherein the mean particle size of the polymeric nanoparticles is in the range from about 50 nm to about 1500 nm, preferably from about 100 nm to about 1300 nm, more preferably from about 200 nm to about 1200 nm.

12. A method for fabricating a device of any one of claims 7 to 11, comprising the steps of:
    a) preparing a dispersion of polymeric nanoparticles of any one of claims 1 to 6 in a mixture of THF/H_2O;
    b) applying the dispersion of step a) to a support; and
    c) drying of the support obtained in step b).

13. The method of claim 12, wherein the concentration of polymeric nanoparticles in the solution prepared in step a) is in the range from about 50 μg/ml to about 200 μg/ml.

14. The method of claim 12 or 13, wherein, in step a), the volume ratio of THF and H_2O is in the range from about 9:1 to about 1:9.

15. The method of any one of claims 12 to 14, wherein the applying of step b) is performed by drop coating, spin coating, dip coating, spray coating or vapor deposition.

16. The method of any one of claims 12 to 15, wherein the support of step b) is paper.

17. The method of any one of claims 12 to 16, wherein the drying of step c) is performed by natural air drying, indirect drying, vacuum drying, or application of hot air.

18. A method for the detection of nitro compounds, comprising the steps of:
    a) contacting the device of any one of claims 7 to 11 with a sample;
    b) exposing the sample contaminated device obtained in step a) to UV radiation; and
    c) determining the presence of nitro compounds in the sample by observing fluorescence quenching on the device.

19. The method of claim 18, wherein the contacting of step a) is exposure of the device to sample vapor, direct application of sample onto the surface of the device or dipping of the device into a solution of the sample.

20. The method of claim 18 or 19, wherein the duration of contacting of step a) is in the range from about 1 sec to about 45 min, preferably from about 30 sec to about 30 min, more preferably from about 1 min to about 10 min.

21. The method of any one of claims 18 to 20, wherein the concentration of the nitro compounds in the sample is at least 2 ppb.

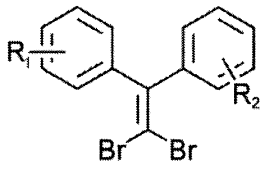
22. The method of any one of claims 18 to 21, wherein the method further comprises the step of d) comparing the fluorescence quenching on the sample contaminated device with a suitable non-contaminated control.

23. The method of any one of claims 18 to 22, wherein the nitro compounds to be detected comprise nitrotoluene, dinitrotoluene, trinitrotoluene, picric acid, styphnic acid, or combinations thereof.

24. Use of polymeric nanoparticles of any one of claims 1 to 6 for the detection of nitro compounds.

25. The use of claim 24, wherein the nitro compounds comprise nitrotoluene, dinitrotoluene, trinitrotoluene, picric acid, styphnic acid, and combinations thereof.

26. A method for preparing the polymeric nanoparticles of any one of claims 1 to 6, comprising reacting a compound of formula (II)

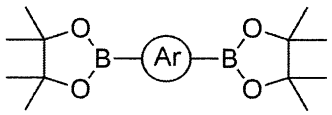


(II)

with a compound of formula (III)

$(OH)_2B$--$B(OH)_2$ (III)

or formula (IIIa)



(IIIa)

wherein R_1, R_2 and  are defined as in claim 1 above

in a Suzuki coupling reaction in the presence of (i) a base, preferably K_2CO_3 or Cs_2CO_3, and (ii) a palladium catalyst, preferably $Pd(PPh_3)_4$.