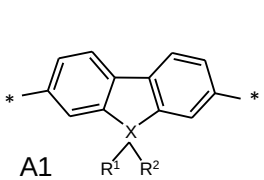
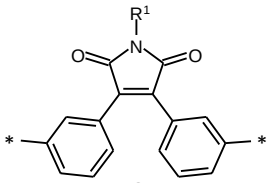
Claims

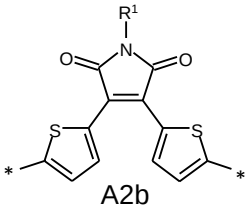
1. Conjugated polymer comprising monomer units A chosen from the monomer units of formulas A3a, A3b, A1a' or A1a'':



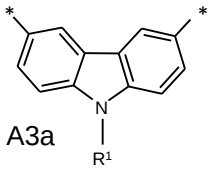
A1



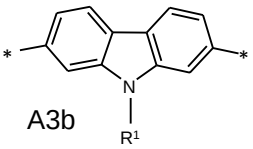
A2a



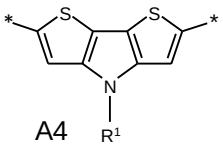
A2b



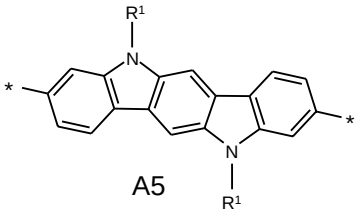
A3a



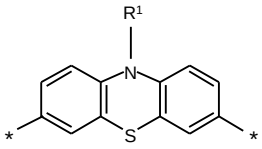
A3b



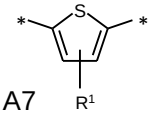
A4



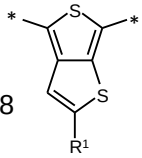
A5



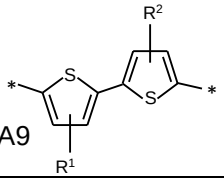
A6



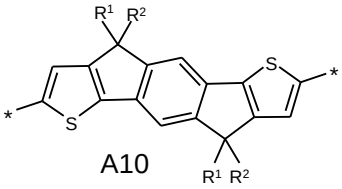
A7



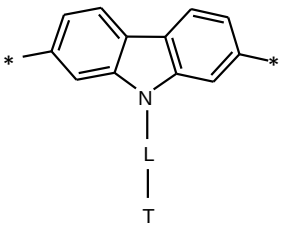
A8



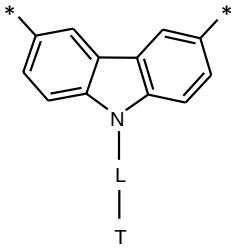
A9



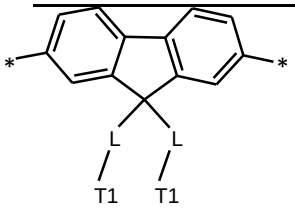
A10



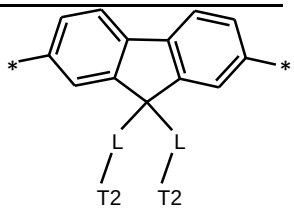
A3a



A3b



A1a'

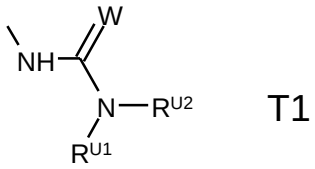


A1a''

~~where X denotes a carbon, silicon or germanium atom,~~

~~R^1 and R^2, identical or different when they are present in the same monomer unit, are monovalent groups containing at least one group T chosen from the groups oxime, iminodiacetic acid or one of the salts thereof, a macrocyclic group including from 9 to 36 atoms of which at least 3 heteroatoms chosen from oxygen, nitrogen and the combinations thereof, or~~

where L denotes a divalent group, T comprises at least one oxime function, T2 includes an iminodiacetic acid group or one of the salts thereof connected via the nitrogen atom thereof, and T1 is a group of formula ~~T1~~:

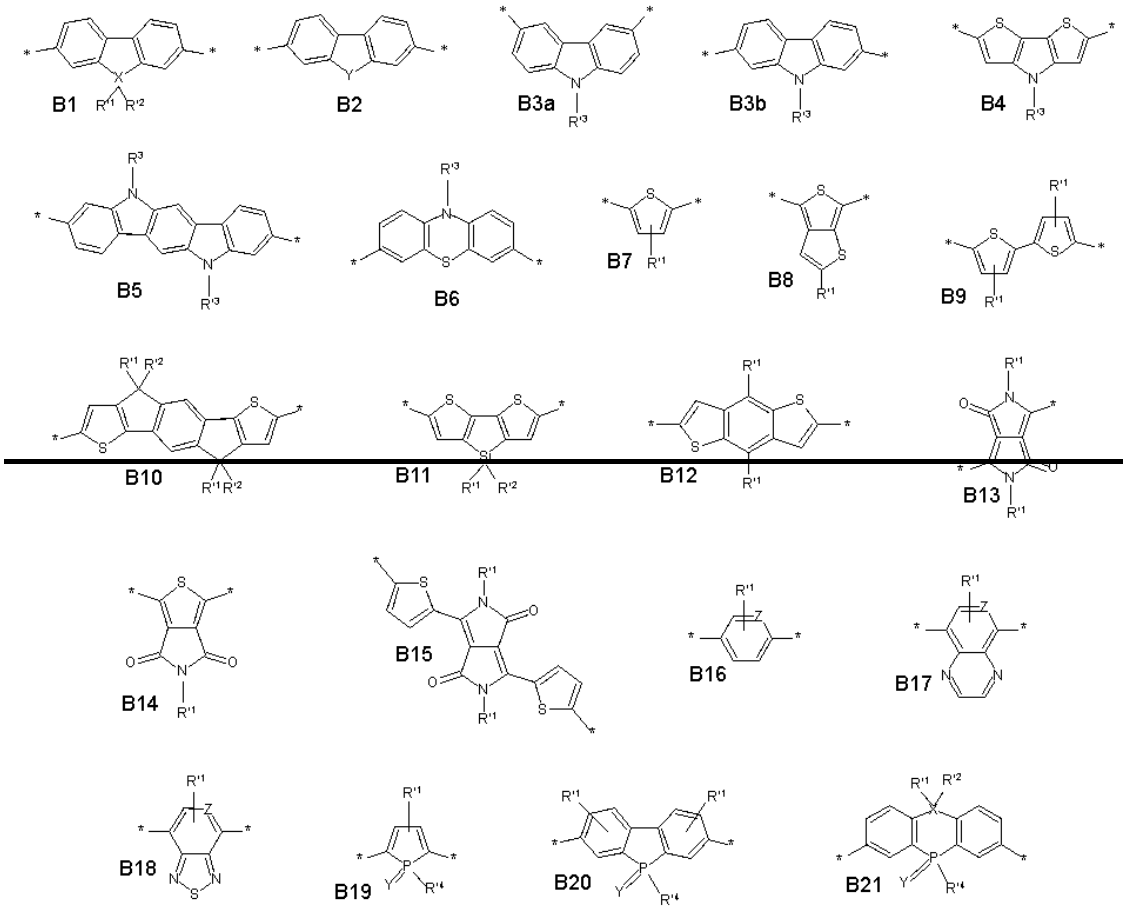


T1

where W denotes a sulphur or oxygen atom, R^{U1} and R^{U2} denote independently a hydrogen atom, an optionally substituted alkyl group or an aryl group,

—— * denotes the attachment point of the monomer unit to the polymer chain, the carbon atoms of the monomer units A being optionally substituted.

~~2. Conjugated polymer according to any one of the preceding claims, characterised in that it further comprises monomer units B chosen from the monomer units of formulas:~~



~~where X denotes a carbon, silicon or germanium atom; Y denotes a sulphur, oxygen or selenium atom; Z denotes a carbon or nitrogen atom, the carbon atoms of the monomer units B being optionally substituted,~~

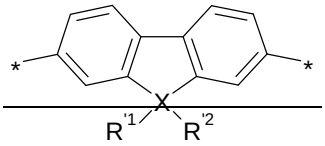
~~—— * denotes the attachment point of the monomer unit to the polymer chain,~~

~~the groups R'1 and R'2, identical or different when they are present in the same monomer unit, represent alkyl or alkoxyl groups comprising from 4 to 20 carbon atoms, linear or branched,~~

~~the group R'3 represents an alkyl group comprising from 4 to 20 carbon atoms, linear or branched, an aryl group substituted by one or a plurality of alkyl groups comprising from 4 to 20 carbon atoms, linear or branched, or an acyl group of formula –C(O)R'5, where R'5 represents an alkyl group comprising from 4 to 20 carbon atoms, linear or branched,~~

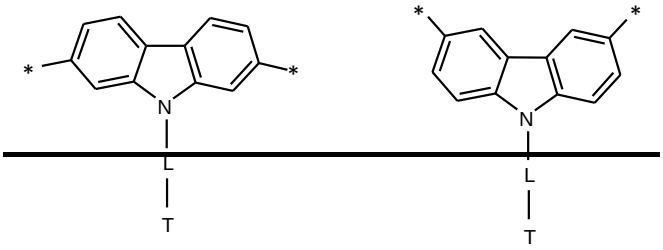
~~the group R'4 represents an aryl group or an alkyl group comprising from 4 to 20 carbon atoms, linear or branched.~~

~~3. Conjugated polymer according to any one of the preceding claims, characterised in that it comprises monomer units of formula B1a, where X, R'1 and R'2 are as defined in claim 2:~~



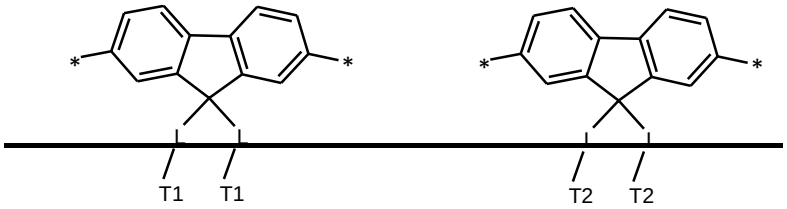
B1a

~~4. Conjugated polymer according to any one of the preceding claims, characterised in that it comprises monomer units of formula A3a or A3b, where L denotes a divalent group and T comprises at least one oxime function:~~



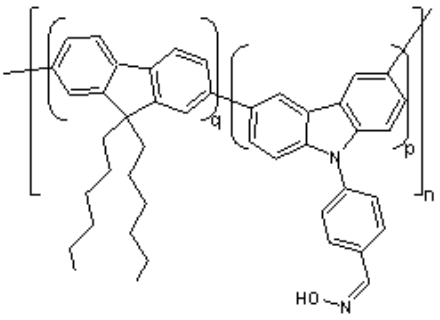
A3a A3b

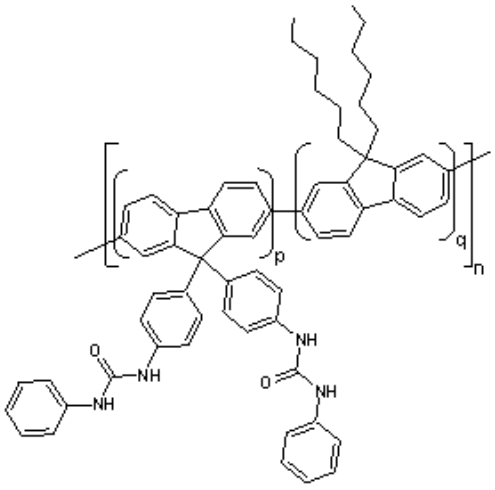
~~5. Conjugated polymer according to any one of the preceding claims, characterised in that it comprises monomer units of formulas A1a' or A1a", where L denotes a divalent group, T1 is as defined in claim 1 and T2 includes an iminodiacetic acid group or one of the salts thereof connected via the nitrogen atom thereof:~~

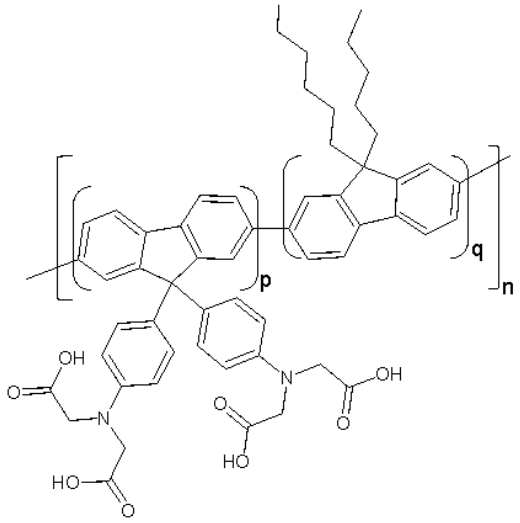


A1a' A1a''

6.2. Conjugated polymer ~~according to any one of the preceding claims~~, characterised in that it complies with one of the following formulas:

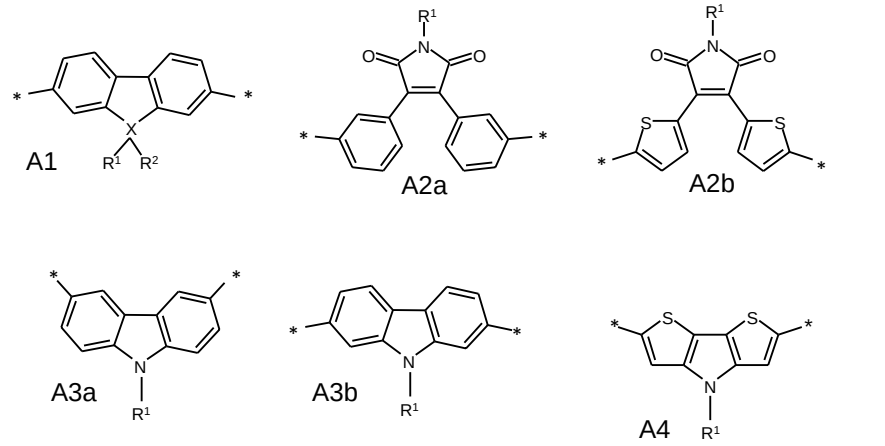






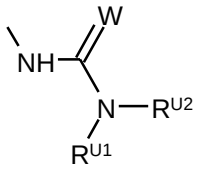
wherein p and q are identical or different integers ranging from 1 to 5 for p and from 0 to 20 for q and n denotes the degree of polymerisation.

~~7. Carbon nanotubes functionalised by at least one conjugated polymer comprising monomer units A chosen from the monomer units of formulas:~~



~~where X denotes a carbon, silicon or germanium atom,~~

~~R^1 and R^2, identical or different when they are present in the same monomer unit, are monovalent groups containing at least one group T chosen from the groups oxime, iminodiacetic acid or one of the salts thereof, a polydentate Lewis base including at least two coordinating nitrogen and/or oxygen atoms, a macrocyclic group including from 9 to 36 atoms of which at least 3 heteroatoms chosen from oxygen, nitrogen and the combinations thereof, or a group of formula T1:~~

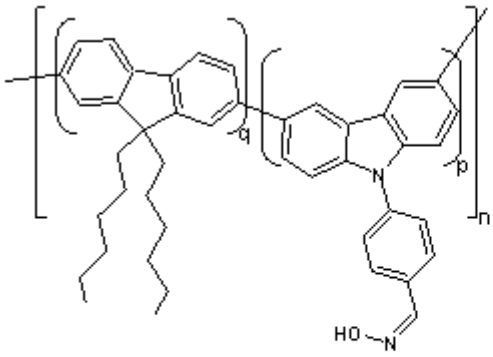


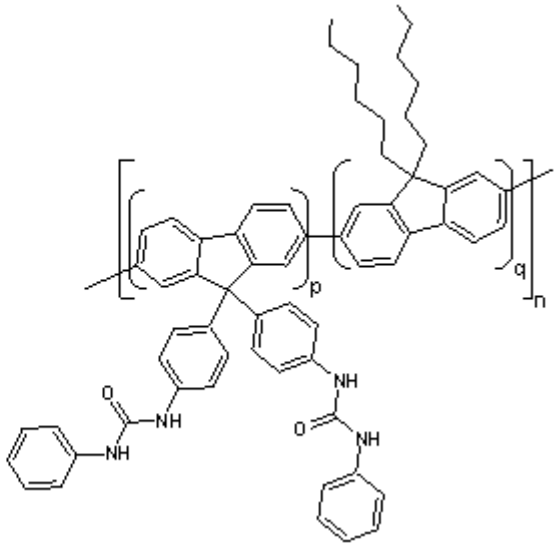
T1

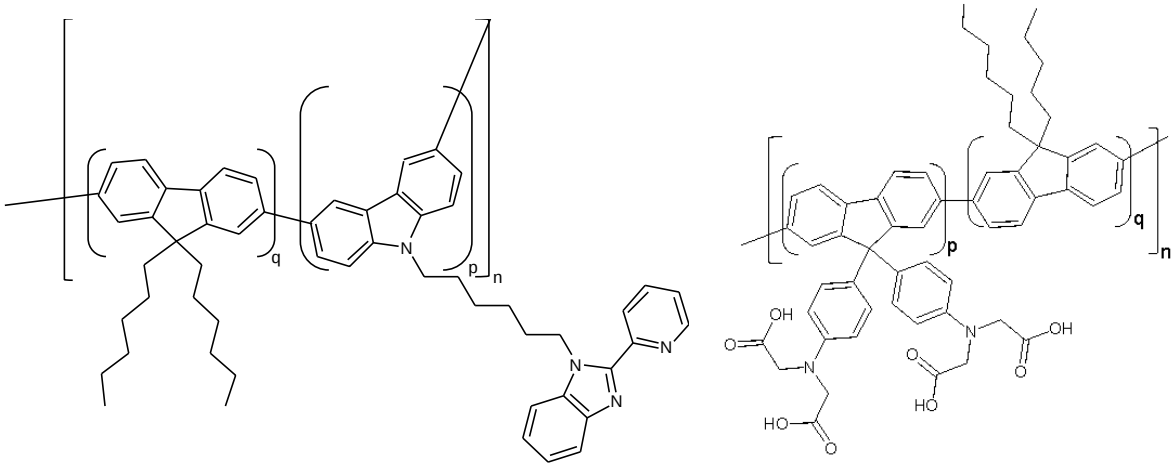
~~where W denotes a sulphur or oxygen atom, R^{U1} and R^{U2} denote independently a hydrogen atom, an optionally substituted alkyl group or an aryl group,~~

~~* denotes the attachment point of the monomer unit to the polymer chain, the carbon atoms of the monomer units A being optionally substituted, the functionalisation being preferably of non-covalent nature.~~

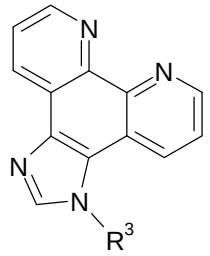
~~8.~~3. Carbon nanotubes <u>functionalised by at least one conjugated polymer</u> ~~according to claim 7~~, characterised in that the conjugated polymer complies with one of the following formulas<u>, the functionalisation being preferably of non-covalent nature</u>:



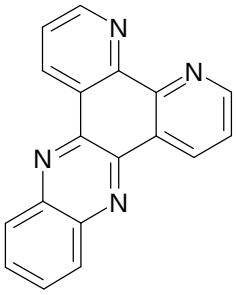




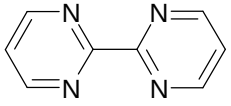
~~9. Carbon nanotubes according to claim 7 or 8, characterised in that the group T is a polydentate Lewis base including at least two coordinating nitrogen atoms chosen from the following groups, optionally substituted: 2,2'-bipyridine (D5), 1,10-phenanthroline (D4), 2,9-dimethyl-1,10-phenanthroline, 1,10-phenanthroline-5,6-dione, imidazo[4,5-f]-1,10-phenanthroline of formula D1, 2,2'-bipyrimidine (D3), 2,2′:6′,2″-terpyridine (D7), dipyrido-[3,2-*a*:2′,3′-*c*]phenazine (D2), a 2,6-bis(2-benzimidazolyl)pyridine of formula D6, a 2-(2-pyridyl)benzimidazole of formula D8, thiabendazole (D9), R^3, R^{3a} in the formulas hereinafter denoting independently from one another a hydrogen atom or an optionally substituted alkyl, optionally substituted alkylene, aryl, or arylene group:~~



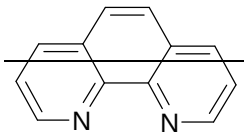
D1



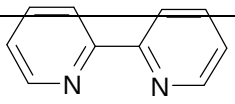
D2



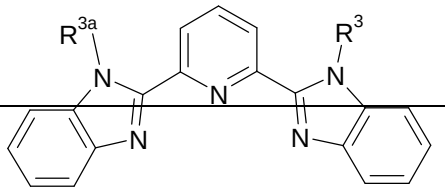
D3



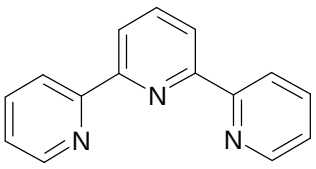
D4



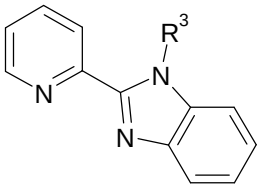
D5



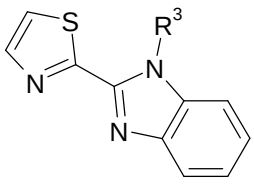
D6



D7



D8



D9

10. System for the detection and/or assay of one or a plurality of ionic chemical species in a fluid, comprising at least one chemical sensor, said chemical sensor comprising a support and at least two electrodes disposed on said support, the support being at least partially coated with a layer of a composition comprising carbon nanotubes functionalised by at least one conjugated polymer as defined in any one of claims 1 to 9, said composition layer ensuring electrical contact between the electrodes and forming the sensitive element of the sensor.

11. System according to claim 10, comprising at least two chemical sensors, for the detection and/or assay of at least two ionic chemical species in a fluid.

12. System according to claim 10 or 11, characterised in that the ionic chemical species is chosen from hypochlorite, chloride, nitrate, phosphate ions, Cu^{+}, Ag^{+}, Ca^{2+}, Mg^{2+}, Pb^{2+}, Hg^{2+}, Cd^{2+}, Cu^{2+}, Fe^{2+}, Ni^{2+}, Co^{2+}, Zn^{2+}, UO_2^{2+}, Fe^{3+}, Cr^{3+} and As^{3+} ions.

13. Method for manufacturing a system according to any one of claims 10 to 12, comprising:

- deposition on a support, whereon are disposed at least two electrodes, of a layer of a composition comprising carbon nanotubes and a conjugated polymer as defined in any one of claims 1 to 9, such that said composition layer ensures electrical contact between the electrodes.

14. Method according to claim 13, characterised in that said deposition is carried out by inkjet printing.

15. Use of a system according to any one of claims 10 to 12, for the detection and/or assay of one or a plurality of ionic chemical species in a fluid, preferably in an aqueous solution.