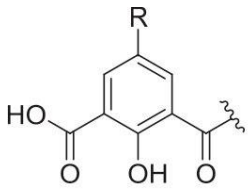
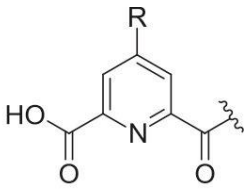
Summary

According to one aspect, there is provided a luminescent lanthanide nanoparticle, having at the same time a brightness greater than 10^4 $M^{-1}.cm^{-1}$ and a lifetime of the excited-state longer than 3 ms, comprising a lanthanide ion nanoparticle including terbium, and several molecules of chromophore ligand that are bonded to the surface of the lanthanide ion nanoparticle, characterized in that:

- said lanthanide ion nanoparticle comprises terbium ions and ions of at least a second lanthanide selected from the group consisting of: cerium, praseodymium, neodymium, samarium, europium, dysprosium, holmium, erbium, thulium and ytterbium;
- said ligand is an organic molecule comprising at least one chromophore radical of formula I or of formula II:



I



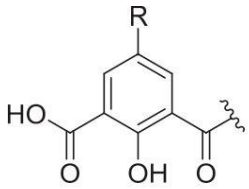
II

wherein R is selected from H, CN group or COOH group, and
wherein said ligand further comprises a grafting function able to be covalently linked to a carrier molecule of analytical interest.

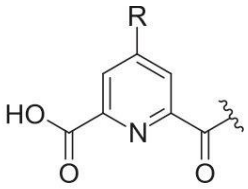
CLAIMS

1. Luminescent lanthanide nanoparticle, having at the same time a brightness greater than 10^4 $M^{-1}.cm^{-1}$ and a lifetime of the excited-state longer than 3ms, comprising a lanthanide ion nanoparticle including terbium, and several molecules of chromophore ligand that are bonded to the surface of the lanthanide ion nanoparticle, characterized in that:

- said lanthanide ion nanoparticle comprises terbium ions and ions of at least a second lanthanide selected from the group consisting of: cerium, praseodymium, neodymium, samarium, europium, dysprosium, holmium, erbium, thulium and ytterbium;
- said ligand is an organic molecule comprising at least one chromophore radical of formula I or of formula II:



I



II

wherein R is selected from H, CN group or COOH group, and
wherein said ligand further comprises a grafting function able to be covalently linked to a carrier molecule of analytical interest.

2. Luminescent nanoparticle according to claim 1 characterized in that the second lanthanide is selected from europium, samarium, dysprosium and ytterbium, and is preferentially europium.

3. Luminescent nanoparticle according to any one of the preceding claims characterized in that said lanthanide ion nanoparticle further comprises ions of a third lanthanide selected from lanthanum, lutetium and gadolinium, and being preferentially lanthanum.

4. Luminescent nanoparticle according to any one of the preceding claims characterized in that said lanthanide ion nanoparticle contains between 10 and 99.9 mol. %, preferentially between 50 and 99.9 mol. %, and even more preferentially between 75 and 99.9 mol. % of terbium ions, and between 0.1

and 90 mol. %, preferentially between 0.1 and 50 mol. %, and even more preferentially between 0.1 and 25 mol. % of ions of the second lanthanide.

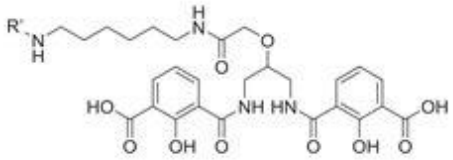
5. Luminescent nanoparticle according to claim 3 characterized in that said lanthanide ion nanoparticle contains between 1 and 98.9 mol. %, preferentially between 10 and 98 mol. %, and even more preferentially between 40 and 98 mol. % of terbium ions, between 0.1 and 20 mol. %, preferentially between 0.5 and 10 mol. %, and even more preferentially between 1 and 5 mol. % of ions of the second lanthanide, and between 1 and 90.9 mol. %, preferentially between 10 and 80 mol. %, and even more preferentially between 10 and 20 mol. % of ions of the third lanthanide.

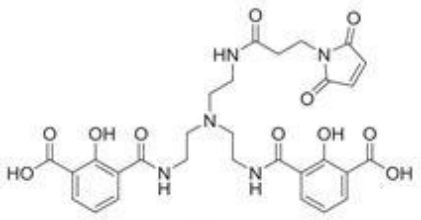
6. Luminescent nanoparticle according to any one of the preceding claims characterized in that said ligand comprises n chromophore radicals and a spacer group, wherein the spacer group is a heteroatom containing carbon chain that links together the chromophore radicals and wherein n is an integer from 1 to 10, preferentially from 2 to 6 and more preferentially from 2 to 3.

7. Luminescent nanoparticle according to any one of the preceding claims characterized in that the luminescent nanoparticle further comprises a carrier molecule of analytical interest covalently attached to at least one ligand molecule.

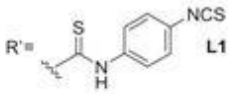
8. Luminescent nanoparticle according to and one of the preceding claims characterized in that the carrier molecule of analytical interest is selected from the group consisting of: peptides, proteins, antibodies, antibody moieties, small molecules of molecular weight lower than 2000 $g.mol^{-1}$, biotin, desthiobiotin, streptavidin and Matuzumab antibody.

9. Luminescent nanoparticle according to any one of the preceding claims characterized in that said ligand is selected from molecules having a structure according to formula L1, L2, L3, L4 and L5:





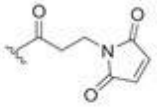
L4



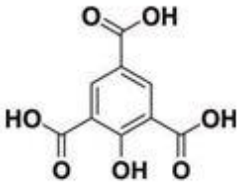
L1



L2



L3



L5

10. Luminescent nanoparticle according to any one of the preceding claims characterized in that the luminescent nanoparticle has a brightness and an excited-state lifetime that are simultaneously superior to 3 ms and 10^4 $M^{-1}.cm^{-1}$ respectively, preferentially simultaneously superior to 5 ms and 10^5 $M^{-1}.cm^{-1}$ respectively, and even more preferentially simultaneously superior to 7 ms and 10^6 $M^{-1}.cm^{-1}$ respectively,

wherein the brightness is calculated as the product of the molar absorption coefficient at the excitation wavelength by the luminescence quantum yield and wherein the excited-state lifetime is the longest measured excited-state lifetime corresponding to an emission of europium ions at $\lambda_{emission}$ = 695 nm after an excitation at $\lambda_{excitation}$ = 330 nm.