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(54) Title: CERIUM (IV) COMPLEXES AND THEIR USE IN ORGANIC ELECTRONICS

(57) Abstract: The present invention relates to an electronic component comprising a cerium IV complex, a doped semi-conductor matrix material comprising the cerium IV complex and at least one electron donor, the use of the cerium IV complex, especially as an organic semi-conductor, as a dopant in organic semiconductor matrix materials and as a charge injector in a charge injection layer, and new cerium IV complexes.



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Cerium (IV) complexes and their use in organic electronics

The present invention relates to electronically doped semiconductor materials and an electronic component comprising cerium (IV) complexes. A further object of the invention is the use of the cerium (IV) complexes as electron acceptors, especially as p-dopants and electron transport materials in organic electronic components. Another object of the invention are new cerium (IV) complexes.

BACKGROUND OF THE INVENTION

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Organic electronics focuses on the development, characterization and application of new materials, both based on small organic molecules and polymers with certain desired electronic properties for the production of electronic components. These comprise e.g. organic field effect transistors (OFETs) such as organic thin film transistors (OTFTs), organic electroluminescent devices such as organic light emitting diodes (OLEDs), organic solar cells (OSCs), e.g. exciton solar cells, dye-sensitized solar cells (DSSCs) or perovskite solar cells, electrophotography, e.g. photoconductive materials in organic photoconductors (OPCs), organic optical detectors, organic photoreceptors, light-emitting electrochemical cells (LECs) and organic laser diodes.

20

It is known that organic semiconductor matrices can be heavily influenced regarding their electrical conductivity by doping. Such organic semiconductive matrix materials can be formed by either from compounds with good electron donor properties (p-conductor) or from compounds with good electron acceptor properties (n-conductor). In contrast to inorganic semiconductors, organic semiconductors have a very low intrinsic charge carrier concentration. Organic semiconductor matrix materials are therefore usually doped in order to achieve good semiconductor properties. For n-doping strong electron donors (n dopants) are used, which transfer an electron to the LUMO of the semiconductor matrix (n-doping), resulting in a free electron on the matrix (SOMO). For p-doping strong electron acceptors (p-dopants) are used, which remove an electron from the HOMO of the semiconductor matrix (p-doping), resulting in a hole. In other words, for p-doping the LUMO of the dopant must be below the HOMO-energy of the matrix. The dopant acts as an acceptor and leaves a mobile hole (SOMO) in the matrix.

30

Known p-dopants for electron donor materials are electron acceptors such as tetracyanoquinone methane (TCNQ), 2,3,5,6-tetrafluorotetracyano-1,4-benzoquinone methane (F4TCNQ), trinaphthylenes (HATNA), metal oxides such as MoO_3 or WO_3 , or radicalene compounds as e.g. described in EP 2180029. The acceptor molecules generate so-called

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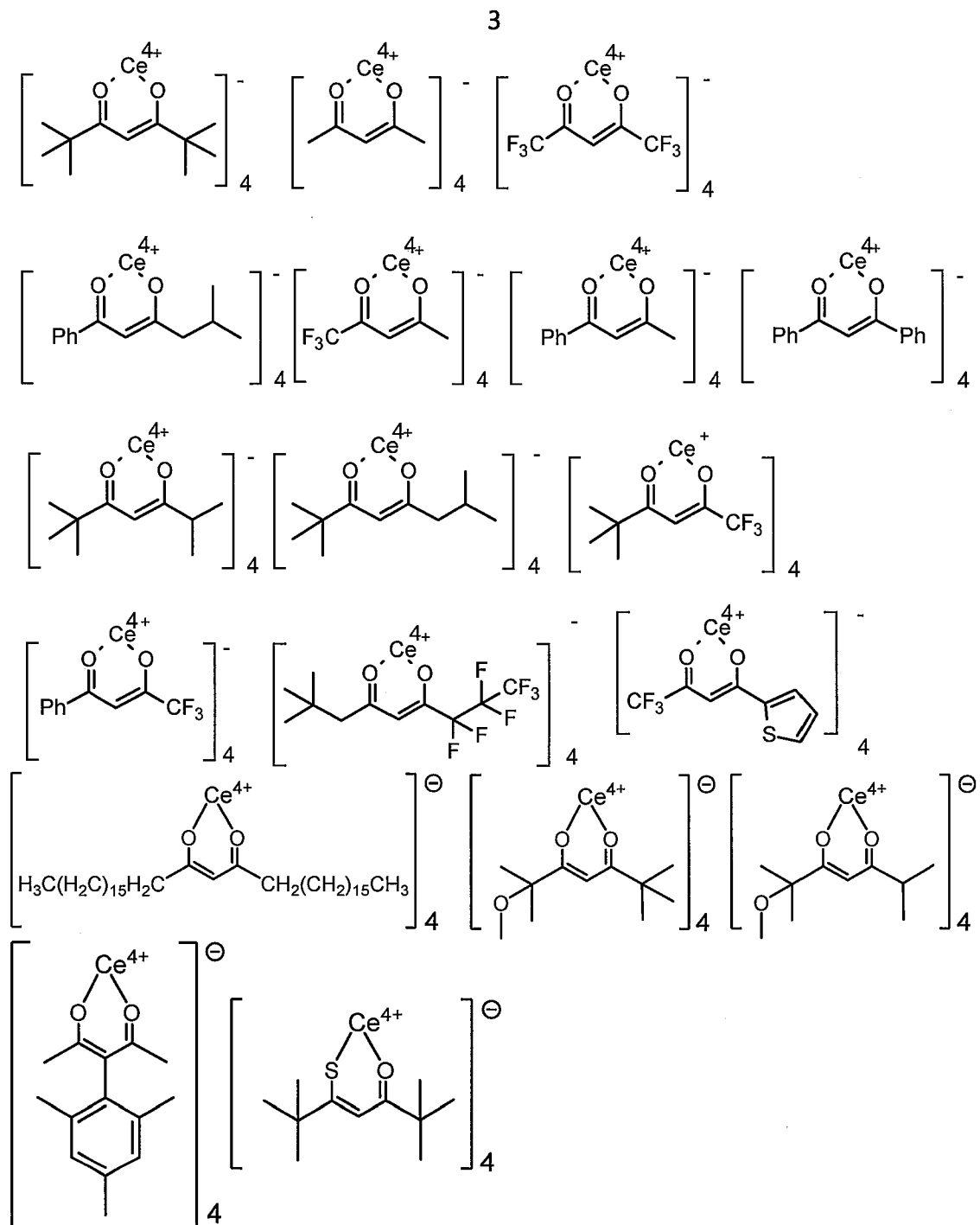
holes in the semiconductor matrix materials (hole transport materials) by electron transfer processes, and the conductivity of the semiconductor matrix material (hole transport material) is more or less changed depending on the number and mobility of the holes.

- 5 However, the previously described compounds or compound classes have disadvantages for a technical use in the production of doped semiconductors or of corresponding electronic components with such doped layers. The compounds or compound classes mentioned are, for example, too volatile, have a too high absorption coefficient, have an unstable evaporation rate and/or show low thermostability. In addition, some of
10 these compounds have very high production costs.

Thus, there is still a demand for compounds, which are easily available or producible, are suitable for doping electron donor materials and do not have the disadvantages described above.

15

Only a few cerium (IV) complexes of the class of diketonates are known. A few β -diketonate complexes of cerium (IV) are described in the literature. M. Ciampolini et al., J.C.S. Dalton, 1977, 1325; T. J. Pinnaviaia et al., Contribution from the department of Chemistry, Cornell University, Ithaca, New York, 1965, 233; I. Baxter et al., J. Chem. Cryst, Vol. 28, No
20 4, 1998, 267; N. A. Piro et al., Coord. Chem. Review, 260, 2014, 21, M. Delarosa et al., J. Coord. Chem., 55(7), 2002, 781; Jahr et al., Zeitschrift für Chemie, Bd. 15, 1975, S 280-281; Snezhko et al. Material Science and Engineering, Vol. 18, 1993, S. 230-231; Brill et al., Liebigs Annalen der Chemie, 1979, S. 803-810 and WO02/018394 describe the following cerium (IV) complexes:



- 5 WO02/018394 relates to precursor source reagent metal-organic compositions. The formation of cerium doped (Ca, Sr)Ga₂S₂ films with thio-containing solvent systems and deposition in the presence of hydrogen sulfide gas is described.

- 10 Kunkely et al., Journal of Photochemistry and Photobiology A, Vol 146, No 1-2, p. 63-66 describes cerium (IV) 2,2,6,6-tetramethyl-3,5-heptane-dionate anion. It is further described that this complex has luminescent properties and is also photoactive. These properties are irrelevant for a p-dopant or for redox doping pairs of transport layers.

US 2010/0038632 describes a variety of complexes including cerium (IV) complexes. On the one hand explicit cerium (IV) complexes according to the invention are not mentioned. On the other hand, the large band gaps in cerium complexes mentioned in this document are not relevant for a p-dopant.

5

Until now, it was unknown to use cerium (IV) complexes in organic semiconductor materials. In particular, it has not yet been described to use cerium (IV) complexes as p-dopants, as electron transport materials or as electron acceptors.

10 Surprisingly, it has now been found that cerium (IV) complexes can be advantageously used as p-dopants. Furthermore, it has been found that cerium (IV) complexes can be used as electron transport materials (ETM) in organic electronic components such as organic light emitting diodes (OLED), photovoltaic cells, organic solar cells (OPV), organic diodes or organic transistors.

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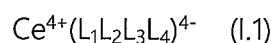
Furthermore, many cerium (IV) diketonates can be evaporated very well under vacuum and occasionally exhibit high thermostability. Thus, they are basically suitable for both variants of processing of organic-electronic components, the vacuum coating (vapour deposition) and the solvent-based processing (solution processing).

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SUMMARY OF THE INVENTION

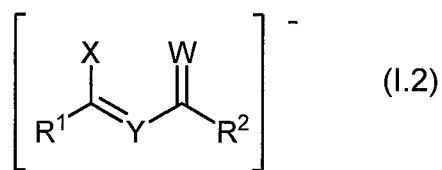
A first object of the invention is an electronic component comprising a compound of the general formula (I.1)

25



or a mixture of at least two different compounds of the general formula (I.1), wherein L_1 , L_2 , L_3 ; and L_4 are independently from each other selected from a bidentate ligand having the general formula (I.2)

30



, wherein

X and W independently from each other represent O, S or NR^6 ;

35 Y represents N or CR^3 ;

5 R^1, R^2 independently from each other represent CN, C_1 - C_6 -alkyl, C_1 - C_6 -haloalkyl, C_1 - C_6 -alkoxy, C_1 - C_6 -haloalkoxy, C_1 - C_6 -alkylsulfanyl, C_1 - C_6 -haloalkylsulfanyl, $NR^{4a}R^{4b}$, C_6 - C_{14} -aryl or hetaryl having 4 to 13 carbon atoms, wherein hetaryl has 1, 2 or 3 identical or different heteroatoms or heteroatom-containing groups as ring members, selected from N, NR^7 , O, S, SO and SO_2 , wherein aryl and hetaryl are unsubstituted or substituted by 1, 2, 3, 4 or 5 identical or different radicals R^8 ;

10 R^3 represents hydrogen, CN, nitro, halogen, C_1 - C_6 -alkyl, C_1 - C_6 -haloalkyl, C_1 - C_6 -alkoxy, C_1 - C_6 -haloalkoxy, C_1 - C_6 -alkylsulfanyl, C_1 - C_6 -haloalkylsulfanyl, $NR^{4a}R^{4b}$, C_6 - C_{14} -aryl or hetaryl having 4 to 13 carbon atoms, wherein hetaryl has 1, 2 or 3 identical or different heteroatoms or heteroatom-containing groups as ring members, selected from N, NR^7 , O, S, SO and SO_2 , wherein aryl and hetaryl are unsubstituted or substituted by 1, 2, 3, 4 or 5 identical or different radicals R^5 ;

15 $R^{4a}R^{4b}$ independently from each other represent hydrogen, C_1 - C_6 -alkyl or C_6 - C_{14} -aryl, wherein aryl is unsubstituted or substituted by 1, 2, 3, 4 or 5 identical or different radicals R^5 ;

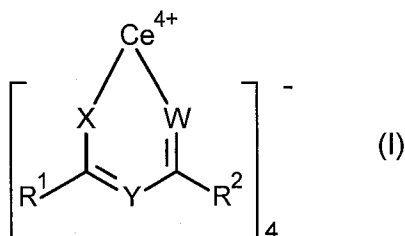
20 R^5 represents CN, halogen, C_1 - C_4 -alkyl or C_1 - C_4 -haloalkyl;

25 R^6 represents hydrogen, C_1 - C_6 -alkyl, C_1 - C_6 -haloalkyl, C_6 - C_{14} -aryl or hetaryl having 4 to 13 carbon atoms, wherein hetaryl has 1, 2 or 3 identical or different heteroatoms or heteroatom-containing groups as ring members, selected from N, NR^7 , O, S, SO and SO_2 , wherein aryl and hetaryl are unsubstituted or substituted by 1, 2, 3, 4 or 5 identical or different radicals R^5 ;

R^7 represents hydrogen, C_1 - C_6 -alkyl, C_1 - C_6 -haloalkyl or C_6 - C_{14} -aryl, wherein aryl is unsubstituted or substituted by 1, 2, 3, 4 or 5 identical or different radicals R^5 ;

30 R^8 represents CN, halogen, C_1 - C_4 -alkyl, C_1 - C_4 -haloalkyl or C_6 - C_{14} -aryl, which is unsubstituted or substituted by 1, 2 or 3 identical or different radicals selected from C_1 - C_4 -alkyl and C_1 - C_4 -haloalkyl.

35 A further object of the invention is an electronic component comprising a compound of the general formula (I)



or a mixtures thereof, wherein

5 X and W independently from each other represent O, S or NR⁶;

Y represents N or CR³;

10 R¹, R² independently from each other represent CN, C₁-C₆-alkyl, C₁-C₆-haloalkyl, C₁-C₆-alkoxy, C₁-C₆-haloalkoxy, C₁-C₆-alkylsulfanyl, C₁-C₆-haloalkylsulfanyl, NR^{4a}R^{4b}, C₆-C₁₄-aryl or hetaryl having 4 to 13 carbon atoms, wherein hetaryl has 1, 2 or 3 identical or different heteroatoms or heteroatom-containing groups as ring members, selected from N, NR⁷, O, S, SO and SO₂, wherein aryl and hetaryl are unsubstituted or substituted by 1, 2, 3, 4 or 5 identical or different radicals R⁸;

15 R³ represents hydrogen, CN, nitro, halogen, C₁-C₆-alkyl, C₁-C₆-haloalkyl, C₁-C₆-alkoxy, C₁-C₆-haloalkoxy, C₁-C₆-alkylsulfanyl, C₁-C₆-haloalkylsulfanyl, NR^{4a}R^{4b}, C₆-C₁₄-aryl or hetaryl having 4 to 13 carbon atoms, wherein hetaryl has 1, 2 or 3 identical or different heteroatoms or heteroatom-containing groups as ring members, selected from N, NR⁷, O, S, SO and SO₂, wherein aryl and hetaryl are unsubstituted or substituted by 1, 2, 3, 4 or 5 identical or different radicals R⁵;

20 R^{4a}R^{4b} independently from each other represent hydrogen, C₁-C₆-alkyl or C₆-C₁₄-aryl, wherein aryl is unsubstituted or substituted by 1, 2, 3, 4 or 5 identical or different radicals R⁵;

25 R⁵ represents CN, halogen, C₁-C₄-alkyl or C₁-C₄-haloalkyl;

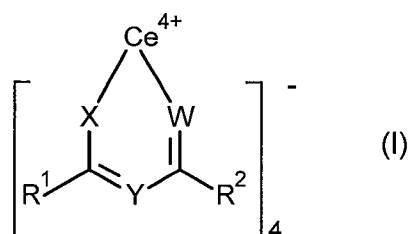
30 R⁶ represents hydrogen, C₁-C₆-alkyl, C₁-C₆-haloalkyl, C₆-C₁₄-aryl or hetaryl having 4 to 13 carbon atoms, wherein hetaryl has 1, 2 or 3 identical or different heteroatoms or heteroatom-containing groups as ring members, selected

from N, NR⁷, O, S, SO and SO₂, wherein aryl and hetaryl are unsubstituted or substituted by 1, 2, 3, 4 or 5 identical or different radicals R⁵;

5 R⁷ represents hydrogen, C₁-C₆-alkyl, C₁-C₆-haloalkyl or C₆-C₁₄-aryl, wherein aryl is unsubstituted or substituted by 1, 2, 3, 4 or 5 identical or different radicals R⁵;

10 R⁸ represents CN, halogen, C₁-C₄-alkyl, C₁-C₄-haloalkyl or C₆-C₁₄-aryl, which is unsubstituted or substituted by 1, 2 or 3 identical or different radicals selected from C₁-C₄-alkyl and C₁-C₄-haloalkyl.

A further object of the invention is an electronic component comprising a compound of the general formula (I)



15 or mixtures thereof, wherein

X and W independently from each other represent O, S or NR⁶;

20 Y represents N or CR³;

25 R¹, R² independently from each other represent CN, C₁-C₆-alkyl, C₁-C₆-haloalkyl, C₁-C₆-alkoxy, C₁-C₆-haloalkoxy, C₁-C₆-alkylsulfanyl, C₁-C₆-haloalkylsulfanyl, NR^{4a}R^{4b}, C₆-C₁₄-aryl or hetaryl having 4 to 13 carbon atoms, wherein hetaryl has 1, 2 or 3 identical or different heteroatoms or heteroatom-containing groups as ring members, selected from N, NR⁷, O, S, SO and SO₂, wherein aryl and hetaryl are unsubstituted or substituted by 1, 2, 3, 4 or 5 identical or different radicals R⁵;

30 R³ represents hydrogen, CN, nitro, halogen, C₁-C₆-alkyl, C₁-C₆-haloalkyl, C₁-C₆-alkoxy, C₁-C₆-haloalkoxy, C₁-C₆-alkylsulfanyl, C₁-C₆-haloalkylsulfanyl, NR^{4a}R^{4b}, C₆-C₁₄-aryl or hetaryl having 4 to 13 carbon atoms, wherein hetaryl has 1, 2 or 3 identical or different heteroatoms or heteroatom-containing groups as

ring members, selected from N, NR⁷, O, S, SO and SO₂, wherein aryl and hetaryl are unsubstituted or substituted by 1, 2, 3, 4 or 5 identical or different radicals R⁵;

5 R^{4a}R^{4b} independently from each other represent hydrogen, C₁-C₆-alkyl or C₆-C₁₄-aryl, wherein aryl is unsubstituted or substituted by 1, 2, 3, 4 or 5 identical or different radicals R⁵;

10 R⁵ represents CN, halogen, C₁-C₄-alkyl or C₁-C₄-haloalkyl;

R⁶ represents hydrogen, C₁-C₆-alkyl, C₁-C₆-haloalkyl, C₆-C₁₄-aryl or hetaryl having 4 to 13 carbon atoms, wherein hetaryl has 1, 2 or 3 identical or different heteroatoms or heteroatom-containing groups as ring members, selected from N, NR⁷, O, S, SO and SO₂, wherein aryl and hetaryl are unsubstituted or substituted by 1, 2, 3, 4 or 5 identical or different radicals R⁵;

15 R⁷ represents hydrogen, C₁-C₆-alkyl, C₁-C₆-haloalkyl or C₆-C₁₄-aryl, wherein aryl is unsubstituted or substituted by 1, 2, 3, 4 or 5 identical or different radicals R⁵.

20

A further object of the invention is a doped semiconductor matrix material comprising at least one electron donor and at least one compound of formula (I.1) or (I), wherein the radicals X, W, Y, R¹ and R² have the meanings given above and as defined below.

25 Another object of the invention is the use of a compound (I.1) or mixtures thereof or compound (I) or mixtures thereof, wherein the radicals X, W, Y, R¹ and R² have the meanings defined before and as defined below,

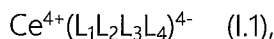
- as organic semiconductor,
- 30 - as doping agent in organic semiconductor matrix materials, especially as p-dopant in hole transport layers,
- as charge injector in a charge injection layer,
- as cathode material in organic batteries,
- as electrochromic material.

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A further object of the invention is the use of Ce(III)-complex anions obtained by reduction of a compound (I.1) or (I) as defined above and below or of charge transfer complexes of a compound (I.1) or (I), as defined above and below, with electron donors as organic conductor, as electrochromic material or as ferrimagnets.

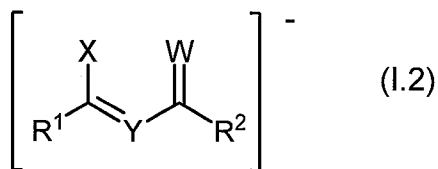
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A further object of the invention is a compound of the general formula (I.1)



5 and mixtures thereof, wherein

L_1 , L_2 , L_3 ; and L_4 are independently from each other a bidentate ligand having the general formula (I.2)



10

, wherein

X and W independently from each other represent O, S or NR^6 ;

Y represents N or CR^3 ;

15

R^1 , R^2 independently from each other represent CN, C_1 - C_6 -alkyl, C_1 - C_6 -haloalkyl, C_1 - C_6 -alkoxy, C_1 - C_6 -haloalkoxy, C_1 - C_6 -alkylsulfanyl, C_1 - C_6 -haloalkylsulfanyl, $\text{NR}^{4a}\text{R}^{4b}$, C_6 - C_{14} -aryl or hetaryl having 4 to 13 carbon atoms, wherein hetaryl has 1, 2 or 3 identical or different heteroatoms or heteroatom-containing groups as ring members, selected from N, NR^7 , O, S, SO and SO_2 , wherein aryl and hetaryl are unsubstituted or substituted by 1, 2, 3, 4 or 5 identical or different radicals R^8 ;

20

R^3 represents hydrogen, CN, nitro, halogen, C_1 - C_6 -alkyl, C_1 - C_6 -haloalkyl, C_1 - C_6 -alkoxy, C_1 - C_6 -haloalkoxy, C_1 - C_6 -alkylsulfanyl, C_1 - C_6 -haloalkylsulfanyl, $\text{NR}^{4a}\text{R}^{4b}$, C_6 - C_{14} -aryl or hetaryl having 4 to 13 carbon atoms, wherein hetaryl has 1, 2 or 3 identical or different heteroatoms or heteroatom-containing groups as ring members, selected from N, NR^7 , O, S, SO and SO_2 , wherein aryl and hetaryl are unsubstituted or substituted by 1, 2, 3, 4 or 5 identical or different radicals R^5 ;

25

$\text{R}^{4a}\text{R}^{4b}$ independently from each other represent hydrogen, C_1 - C_6 -alkyl or C_6 - C_{14} -aryl, wherein aryl is unsubstituted or substituted by 1, 2, 3, 4 or 5 identical or different radicals R^5 ;

30

R^5 represents CN, halogen, C_1 - C_4 -alkyl or C_1 - C_4 -haloalkyl;

35

R^6 represents hydrogen, C_1 - C_6 -alkyl, C_1 - C_6 -haloalkyl, C_6 - C_{14} -aryl or hetaryl having 4 to 13 carbon atoms, wherein hetaryl has 1, 2 or 3 identical or different heteroatoms or

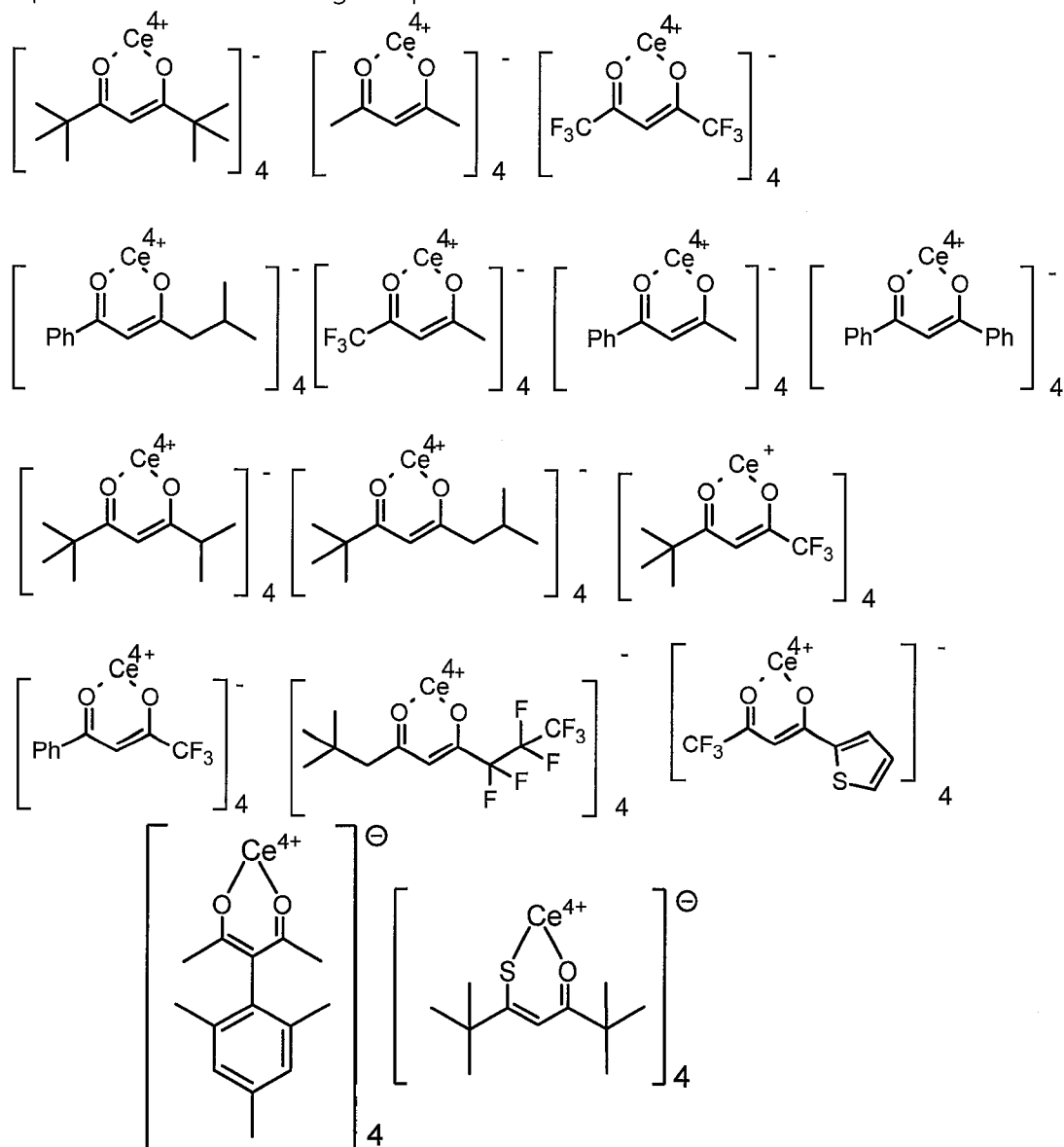
heteroatom-containing groups as ring members, selected from N, NR⁷, O, S, SO and SO₂, wherein aryl and hetaryl are unsubstituted or substituted by 1, 2, 3, 4 or 5 identical or different radicals R⁵;

5 R⁷ represents hydrogen, C₁-C₆-alkyl, C₁-C₆-haloalkyl or C₆-C₁₄-aryl, wherein aryl is unsubstituted or substituted by 1, 2, 3, 4 or 5 identical or different radicals R⁵;

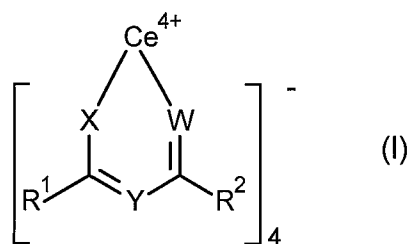
R⁸ represents CN, halogen, C₁-C₄-alkyl, C₁-C₄-haloalkyl or C₆-C₁₄-aryl, which is unsubstituted or substituted by 1, 2 or 3 identical or different radicals selected from C₁-C₄-alkyl and C₁-C₄-haloalkyl;

10

with the proviso that the following compounds are excluded:



A further object of the invention are compounds of the general formula (I)



5

and their charge transfer complexes, their reduction products and mixtures thereof, wherein

10 X and W independently from each other represent O, S or NR⁶;

Y represents N or CR³;

15 R¹, R² independently from each other represent CN, C₁-C₆-alkyl, C₁-C₆-haloalkyl, C₁-C₆-alkoxy, C₁-C₆-haloalkoxy, C₁-C₆-alkylsulfanyl, C₁-C₆-haloalkylsulfanyl, NR^{4a}R^{4b}, C₆-C₁₄-aryl or hetaryl having 4 to 13 carbon atoms, wherein hetaryl has 1, 2 or 3 identical or different heteroatoms or heteroatom-containing groups as ring members, selected from N, NR⁷, O, S, SO and SO₂, wherein aryl and hetaryl are unsubstituted or substituted by 1, 2, 3, 4 or 5 identical or different radicals R⁸;

20 R³ represents hydrogen, CN, nitro, halogen, C₁-C₆-alkyl, C₁-C₆-haloalkyl, C₁-C₆-alkoxy, C₁-C₆-haloalkoxy, C₁-C₆-alkylsulfanyl, C₁-C₆-haloalkylsulfanyl, NR^{4a}R^{4b}, C₆-C₁₄-aryl or hetaryl having 4 to 13 carbon atoms, wherein hetaryl has 1, 2 or 3 identical or different heteroatoms or heteroatom-containing groups as ring members, selected from N, NR⁷, O, S, SO and SO₂, wherein aryl and hetaryl are unsubstituted or substituted by 1, 2, 3, 4 or 5 identical or different radicals R⁵;

25 R^{4a}R^{4b} independently from each other represent hydrogen, C₁-C₆-alkyl or C₆-C₁₄-aryl, wherein aryl is unsubstituted or substituted by 1, 2, 3, 4 or 5 identical or different radicals R⁵;

30

R⁵ represents CN, halogen, C₁-C₄-alkyl or C₁-C₄-haloalkyl;

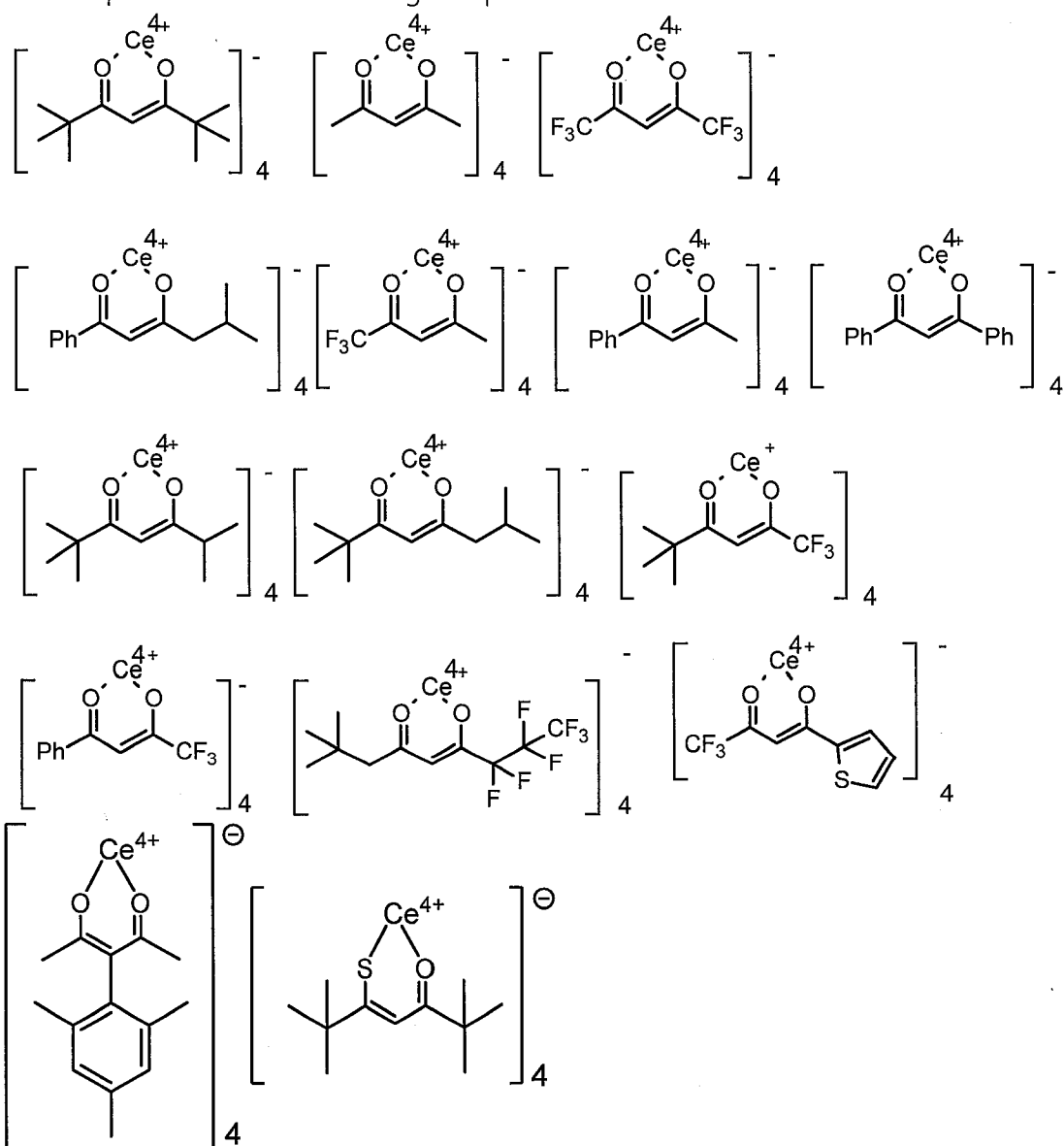
R⁶ represents hydrogen, C₁-C₆-alkyl, C₁-C₆-haloalkyl, C₆-C₁₄-aryl or hetaryl having 4 to 13 carbon atoms, wherein hetaryl has 1, 2 or 3 identical or different heteroatoms or

heteroatom-containing groups as ring members, selected from N, NR⁷, O, S, SO and SO₂, wherein aryl and hetaryl are unsubstituted or substituted by 1, 2, 3, 4 or 5 identical or different radicals R⁵;

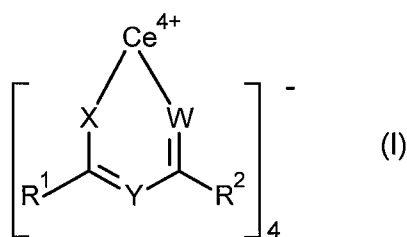
5 R⁷ represents hydrogen, C₁-C₆-alkyl, C₁-C₆-haloalkyl or C₆-C₁₄-aryl, wherein aryl is unsubstituted or substituted by 1, 2, 3, 4 or 5 identical or different radicals R⁵;

R⁸ represents CN, halogen, C₁-C₄-alkyl, C₁-C₄-haloalkyl or C₆-C₁₄-aryl, which is unsubstituted or substituted by 1, 2 or 3 identical or different radicals selected from C₁-C₄-alkyl and C₁-C₄-haloalkyl;

with the proviso that the following compounds are excluded:



A further object of the invention are compounds of general formula (I)



and their charge transfer complexes, their reduction products and mixtures thereof,
5 wherein

X and W independently from each other represent O, S or NR⁶;

Y represents N or CR³;

10 R¹, R² independently from each other represent CN, C₁-C₆-alkyl, C₁-C₆-haloalkyl, C₁-C₆-alkoxy, C₁-C₆-haloalkoxy, C₁-C₆-alkylsulfanyl, C₁-C₆-haloalkylsulfanyl, NR^{4a}R^{4b}, C₆-C₁₄-aryl or hetaryl having 4 to 13 carbon atoms, wherein hetaryl has 1, 2 or 3 identical or different heteroatoms or heteroatom-containing
15 groups as ring members, selected from N, NR⁷, O, S, SO and SO₂, wherein aryl and hetaryl are unsubstituted or substituted by 1, 2, 3, 4 or 5 identical or different radicals R⁵;

20 R³ represents hydrogen, CN, nitro, halogen, C₁-C₆-alkyl, C₁-C₆-haloalkyl, C₁-C₆-alkoxy, C₁-C₆-haloalkoxy, C₁-C₆-alkylsulfanyl, C₁-C₆-haloalkylsulfanyl, NR^{4a}R^{4b}, C₆-C₁₄-aryl or hetaryl having 4 to 13 carbon atoms, wherein hetaryl has 1, 2 or 3 identical or different heteroatoms or heteroatom-containing groups as ring members, selected from N, NR⁷, O, S, SO and SO₂, wherein aryl and he-
25 taryl are unsubstituted or substituted by 1, 2, 3, 4 or 5 identical or different radicals R⁵;

R^{4a}R^{4b} independently from each other represent hydrogen, C₁-C₆-alkyl or C₆-C₁₄-aryl, wherein aryl is unsubstituted or substituted by 1, 2, 3, 4 or 5 identical or
30 different radicals R⁵;

R⁵ represents CN, halogen, C₁-C₄-alkyl or C₁-C₄-haloalkyl;

R⁶ represents hydrogen, C₁-C₆-alkyl, C₁-C₆-haloalkyl, C₆-C₁₄-aryl or hetaryl hav-
ing 4 to 13 carbon atoms, wherein hetaryl has 1, 2 or 3 identical or different

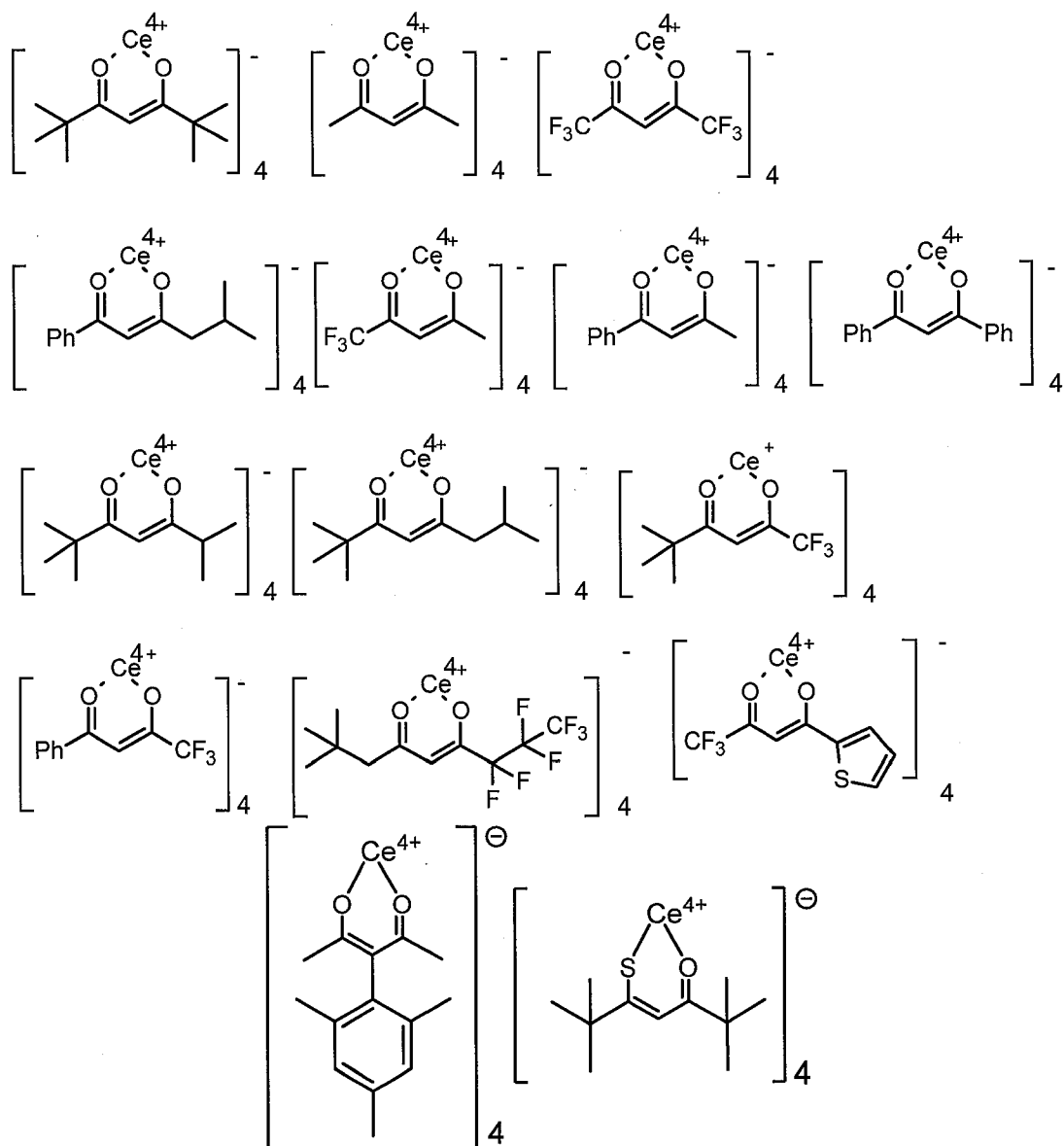
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heteroatoms or heteroatom-containing groups as ring members, selected from N, NR⁷, O, S, SO and SO₂, wherein aryl and hetaryl are unsubstituted or substituted by 1, 2, 3, 4 or 5 identical or different radicals R⁵;

- 5 R⁷ represents hydrogen, C₁-C₆-alkyl, C₁-C₆-haloalkyl or C₆-C₁₄-aryl, wherein aryl is unsubstituted or substituted by 1, 2, 3, 4 or 5 identical or different radicals R⁵;

with the proviso that the following compounds are excluded:

10



DESCRIPTION OF THE INVENTION

15

The invention has the following advantages:

- The cerium-(IV)-complexes according to the invention have only low production costs.
- The cerium-(IV)-complexes according to the invention are advantageously suitable as electron acceptors for use as p-dopants and as electron transport materials in organic-electronic components.
- The cerium-(IV)-complexes according to the invention exhibit better conductivity compared to known electron acceptors.
- The cerium-(IV)-complexes according to the invention show an improved thermostability of the doped layers compared to the state of the art.
- Furthermore, the cerium (IV) complexes according to the invention are characterized by a higher doping efficiency.
- The cerium-(IV)-complexes according to the invention show only a low absorption of the doped layer. Therefore, parasitic absorption and emissions can be reduced or even prevented.
- The cerium-(IV)-complexes according to the invention are suitable for the production of organic and hybrid opto-electronic components, both by means of solvent processing and by vacuum reprocessing.

In the context of the invention, a bidentate ligand (also called didentate) is a ligand, which binds with two atoms to the metal atom (cerium atom).

In the context of the invention, a homoleptic cerium (IV) compound is a complex, wherein all ligands are identical.

In the context of the invention, a heteroleptic cerium (IV) compound is a complex, wherein the meaning of at least one ligand is different to the remaining ligands.

In the context of the invention, the prefix C_n-C_m indicates the number of carbon atoms that a molecule or residue designated thereby may contain.

In the context of the invention, the expression C_1-C_6 -alkyl refers to unbranched or branched saturated hydrocarbon groups having 1 to 6 carbon atoms. C_1-C_6 -alkyl are e.g. methyl, ethyl, propyl, 1-methylethyl, butyl, 1-methylpropyl, 2-methylpropyl, 1,1-dimethylethyl, pentyl, 1-methylbutyl, 2-methylbutyl, 3-methylbutyl, 2,2-dimethylpropyl, 1-ethylpropyl, hexyl, 1,1-dimethylpropyl, 1,2-dimethylpropyl, 1-methylpentyl, 2-methylpentyl, 3-methylpentyl, 4-methylpentyl, 1,1-dimethylbutyl, 1,2-dimethylbutyl, 1,3-dimethylbutyl, 2,2-dimethylbutyl, 2,3-dimethylbutyl, 3,3-dimethylbutyl, 1-ethylbutyl, 2-ethylbutyl, 1,1,2-trimethylpropyl, 1,2,2-trimethylpropyl, 1-ethyl-1-methylpropyl or 1-ethyl-2-

methylpropyl. C₁-C₄-alkyl refers, e.g. to methyl, ethyl, propyl, 1-methylethyl, butyl, 1-methylpropyl, 2-methylpropyl or 1,1-dimethylethyl.

In the context of the invention the expression C₁-C₆-alkoxy refers to an unbranched or
 5 branched saturated C₁-C₆-alkyl group as defined above, which is bound via an oxygen atom. Alkoxy radicals with 1 to 4 carbon atoms are preferred, particularly preferred are 1 or 2 carbon atoms. C₁-C₂-alkoxy is methoxy or ethoxy. C₁-C₄-alkoxy is e.g. methoxy, ethoxy, n-propoxy, 1-methylethoxy (isopropoxy), butoxy, 1-methylpropoxy (sec-butoxy), 2-methylpropoxy (isobutoxy) or 1,1-dimethylethoxy (tert-butoxy). C₁-C₆-alkoxy comprises
 10 the meanings given for C₁-C₄-alkoxy and additionally e.g. pentoxy, 1-methylbutoxy, 2-methylbutoxy, 3-methylbutoxy, 1,1-dimethylpropoxy, 1,2-dimethylpropoxy, 2,2-dimethylpropoxy, 1-ethylpropoxy, hexyloxy, 1-methylpentoxy, 2-methylpentoxy, 3-methylpentoxy, 4-methylpentoxy, 1,1-dimethylbutoxy, 1,2-dimethylbutoxy, 1,3-dimethylbutoxy, 2,2-dimethylbutoxy, 2,3-dimethylbutoxy and 3,3-dimethylbutoxy.

15 In the context of the invention the expression C₁-C₆-alkylsulfanyl refers to an unbranched or branched saturated C₁-C₆-alkyl group as defined above, which is bound via a sulfur atom. Alkylsulfanyl radicals with 1 to 4 carbon atoms are preferred, particularly preferred are 1 or 2 carbon atoms. C₁-C₂-alkylsulfanyl is methylsulfanyl or ethylsulfanyl.
 20 C₁-C₄-alkylsulfanyl is e.g. methylsulfanyl, ethylsulfanyl, n-propylsulfanyl, 1-methylethylsulfanyl (isopropylsulfanyl), butylsulfanyl, 1-methylpropylsulfanyl (sec-butylsulfanyl), 2-methylpropylsulfanyl (isobutylsulfanyl) or 1,1-dimethylethylsulfanyl (tert-butylsulfanyl). C₁-C₆-alkylthio comprises the meanings given for C₁-C₄-alkylsulfanyl and additionally also, e.g., pentylsulfanyl, 1-methylbutylsulfanyl, 2-methylbutylsulfanyl, 3-methylbutylsulfanyl,
 25 1,1-dimethylpropylsulfanyl, 1,2-dimethylpropylsulfanyl, 2,2-dimethylpropylsulfanyl, 1-ethylpropylsulfanyl, hexylsulfanyl, 1-methylpentylsulfanyl, 2-methylpentylsulfanyl, 3-methylpentylsulfanyl, 4-methylpentylsulfanyl, 1,1-dimethylbutylsulfanyl, 1,2-dimethylbutylsulfanyl, 1,3-dimethylbutylsulfanyl, 2,2-dimethylbutylsulfanyl, 2,3-dimethylbutylsulfanyl, 3,3-dimethylbutylsulfanyl, 1-ethylbutylsulfanyl, 2-ethylbutylsulfanyl, 1,1,2-trimethylpropylsulfanyl, 1,2,2-trimethylpropylsulfanyl, 1-ethyl-1-methylpropylsulfanyl or 1-ethyl-2-methylpropylsulfanyl.
 30

In the context of the invention the expressions haloalkyl, haloalkoxy and haloalkylsulfanyl refer to partially or fully halogenated alkyl, alkoxy or alkylsulfanyl. In other words, one or
 35 more hydrogen atoms, for example 1, 2, 3, 4 or 5 hydrogen atoms bonded to one or more carbon atoms of alkyl, alkoxy or alkylsulfanyl are replaced by a halogen atom, in particular by fluorine or chlorine.

The expression "halogen" denotes in each case fluorine, chlorine, bromine or iodine.
 40

The expression "CN" denotes the cyano group ($-C\equiv N$).

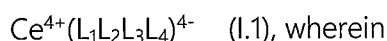
The expression "aryl" comprises in the context of the invention mono- or polynuclear aromatic hydrocarbon radicals with usually 6 to 14, especially preferably 6 to 10 carbon atoms. Examples of aryl are especially phenyl, naphthyl, indenyl, fluorenyl, anthracenyl, phenanthrenyl, naphthacenyl, chrysenyl, pyrenyl, etc. and especially phenyl or naphthyl.

The expression "hetaryl" comprises in the context of the invention mono- or polynuclear aromatic hydrocarbon radicals with 4 to 13 carbon atoms, wherein 1, 2 or 3 carbon atoms have been replaced by 1, 2 or 3 identical or different heteroatoms or heteroatom-containing groups as ring members, said heteroatoms and heteroatom-containing groups, selected from N, NR⁷, O, S, SO and SO₂. The hetaryl group may be attached to the remainder of the molecule via a ring carbon or via a ring nitrogen. Examples of 5- or 6-membered aromatic heterocyclic rings (also called heteroaromatic rings or hetaryl) are 2-furyl, 3-furyl, 2-thienyl, 3-thienyl, 2-pyrrolyl, 3-pyrrolyl, 3-pyrazolyl, 4-pyrazolyl, 5-pyrazolyl, 2-oxazolyl, 4-oxazolyl, 5-oxazolyl, 2-thiazolyl, 4-thiazolyl, 5-thiazolyl, 2-imidazolyl, 4-imidazolyl, 1,3,4-triazol-2-yl, 2-pyridinyl, 3-pyridinyl, 4-pyridinyl, 3-pyridazinyl, 4-pyridazinyl, 2-pyrimidinyl, 4-pyrimidinyl, 5-pyrimidinyl and 2-pyrazinyl. Examples of 8-, 9- or 10-membered aromatic heterobicyclic rings are hetaryl having one of the aforementioned 5- or 6-membered heteroaromatic rings and another aromatic carbocycle or 5- or 6-membered heterocycle fused thereto, for example a fused benzene, thiophen-, furan-, pyrrol-, pyrazol-, imidazol-, pyridin- or pyrimidin-ring. These bicyclic hetarylenes comprises e.g. quinolinyl, isoquinolinyl, cinnolinyl, indolyl, indolizinyl, isoindolyl, indazolyl, benzofuryl, in particular 2-benzofuryl, benzothienyl, in particular 2-benzothienyl, benzo[b]thiazolyl, in particular 2-benzo[b]thiazolyl, benzoxazolyl, in particular 2-benzoxazolyl, benzothiazolyl, in particular 2-benzothiazolyl, benzimidazolyl, in particular 2-benzimidazolyl, imidazo[1,2-a]pyridin-2-yl, thieno[3,2-b]pyridin-5yl, imidazo-[2,1-b]-thiazol-6-yl and 1,2,4-triazolo[1,5-a]pyridin-2-yl.

When # appears in a formula, showing a preferred substructure of a compound of the present invention, it denotes the bond to the rest of the molecule.

Cerium compounds of the formulae (I.1) and (I)

The compound of formula (I.1)



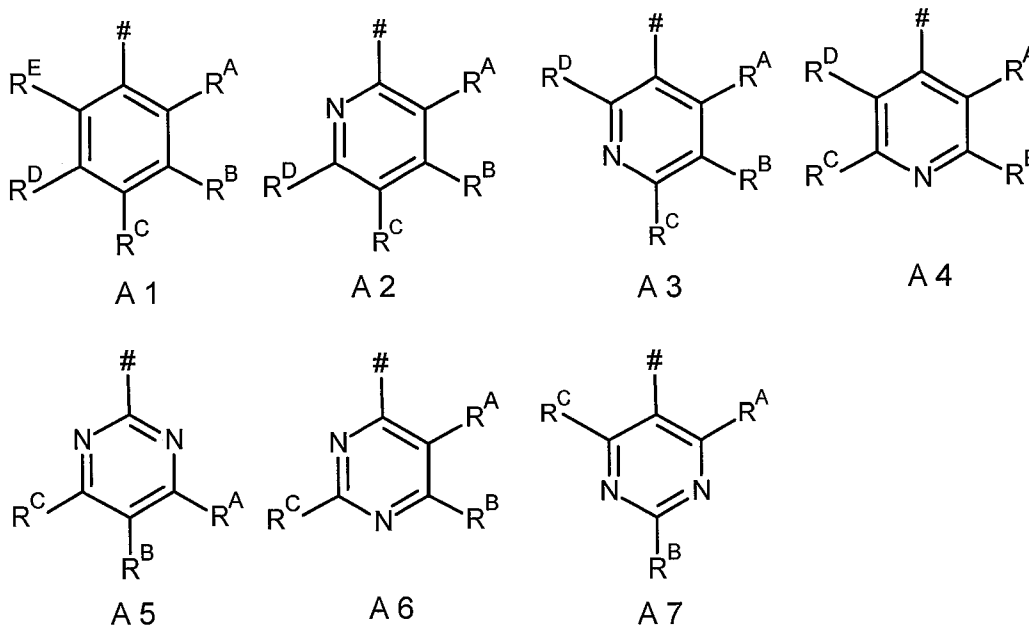
L₁; L₂; L₃; and L₄ are defined above and below, encompasses compounds, wherein
- all four ligands L₁, L₂, L₃ and L₄ have the same meanings,

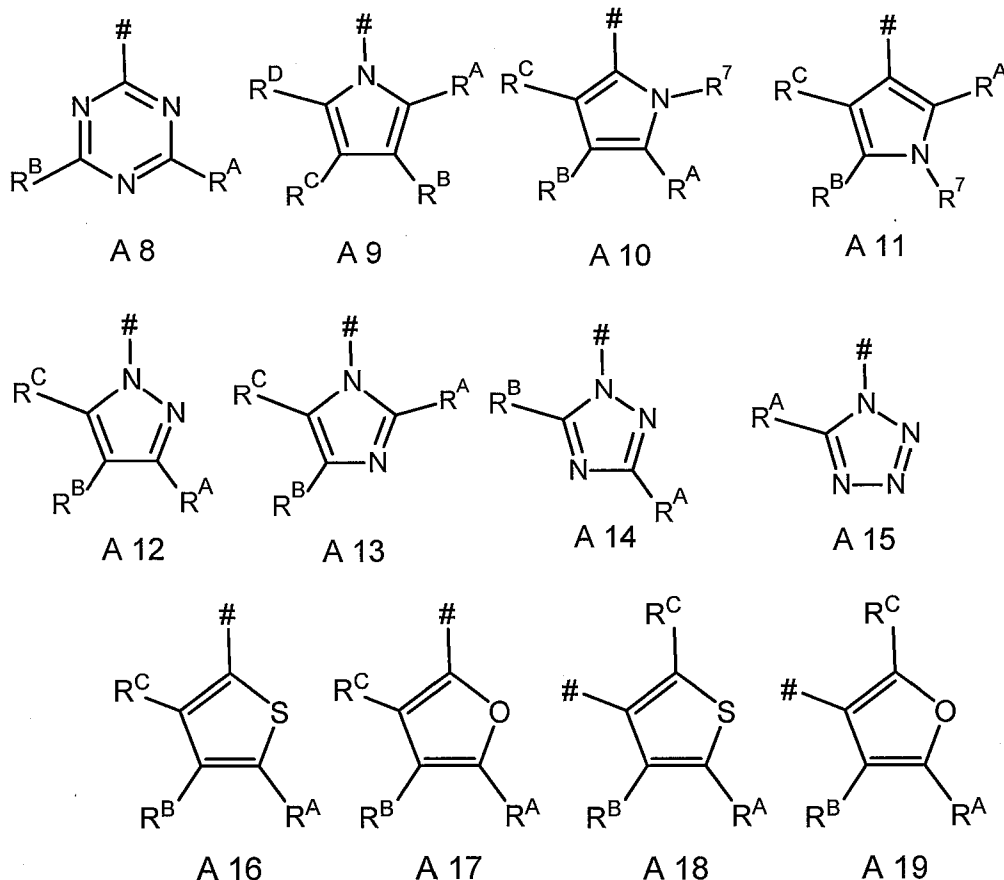
- three of the four ligands have the same meanings,
- two of the four ligands have the same meanings,
- all four ligands L_1 , L_2 , L_3 and L_4 have different meaning.

- 5 Preferred are compounds of formula (I.1) wherein L_1 , L_2 , L_3 and L_4 have the same meanings.

In the cerium compounds of formula (I.1) L_1 , L_2 , L_3 and L_4 are independently from each other selected from bidentate ligands having the general formula (I.2). In the following
 10 preferred embodiments of the compounds (I.1) are directly defined by preferred embodiments of their bidentate ligands (I.2).

- Preferred are compounds of formula (I) and ligands of formula (I.2), wherein R^1 and R^2 are independently selected from CN, C_1 - C_6 -alkyl, C_1 - C_6 -haloalkyl, C_1 - C_6 -alkoxy, C_1 - C_6 -haloalkoxy, C_1 - C_6 -alkylsulfanyl, C_1 - C_6 -haloalkylsulfanyl, $NR^{4a}R^{4b}$ and the group A consisting of A1, A2, A3, A4, A5, A6, A7, A8, A9, A10, A11, A12, A13, A14, A15, A16, A17, A18 and A19
 15





5 where # denotes the bond to the remaining molecule of formula (I) and ligands of formula (I.2),

10 R^A , R^B , R^C , R^D and R^E are independently selected from hydrogen, CN, halogen, C_1 - C_4 -alkyl, C_1 - C_4 -haloalkyl and phenyl, which is unsubstituted or substituted by 1, 2 or 3 identical or different radicals selected from C_1 - C_4 -alkyl and C_1 - C_4 -haloalkyl;

R^{4a} , R^{4b} independently represent hydrogen, C_1 - C_6 -alkyl or C_6 - C_{14} -aryl, wherein aryl is unsubstituted or substituted by 1, 2, 3, 4 or 5 identical or different radicals R^5 ;

15 R^5 represents CN, halogen, C_1 - C_4 -alkyl or C_1 - C_4 -haloalkyl; and

R^7 represents hydrogen, C_1 - C_6 -alkyl, C_1 - C_6 -haloalkyl or C_6 - C_{14} -aryl, wherein aryl is unsubstituted or substituted by 1, 2, 3, 4 or 5 identical or different radicals R^5 .

20 Another preferred embodiment are compounds of formula (I) and ligands of formula (I.2), wherein R^1 and R^2 are independently selected from CN, C_1 - C_6 -alkyl, C_1 - C_6 -haloalkyl, C_1 - C_6 -alkoxy, C_1 - C_6 -haloalkoxy, C_1 - C_6 -alkylsulfanyl, C_1 - C_6 -haloalkylsulfanyl, $NR^{4a}R^{4b}$ and

the group A consisting of A1, A2, A3, A4, A5, A6, A7, A8, A9, A10, A11, A12, A13, A14 and A15, where

5 R^A , R^B , R^C , R^D and R^E are independently selected from hydrogen, CN, halogen, C_1 - C_4 -alkyl and C_1 - C_4 -haloalkyl;

R^{4a} , R^{4b} independently represent hydrogen, C_1 - C_6 -alkyl or C_6 - C_{14} -aryl, wherein aryl is unsubstituted or substituted by 1, 2, 3, 4 or 5 identical or different radicals R^5 ;

10 R^5 represents CN, halogen, C_1 - C_4 -alkyl or C_1 - C_4 -haloalkyl; and

R^7 represents hydrogen, C_1 - C_6 -alkyl, C_1 - C_6 -haloalkyl or C_6 - C_{14} -aryl, wherein aryl is unsubstituted or substituted by 1, 2, 3, 4 or 5 identical or different radicals R^5 .

15 Irrespective of their occurrence the radicals R^A , R^B , R^C , R^D and R^E are preferably selected from hydrogen, CN, fluorine, chlorine, C_1 - C_4 -alkyl, C_1 - C_4 -fluoroalkyl, C_1 - C_4 -chloroalkyl and phenyl, which is unsubstituted or substituted by 1, 2 or 3 identical or different radicals selected from C_1 - C_4 -haloalkyl.

20 Particularly preferred, the radicals R^A , R^B , R^C , R^D and R^E are independently from each other selected from hydrogen, CN, fluorine and chlorine.

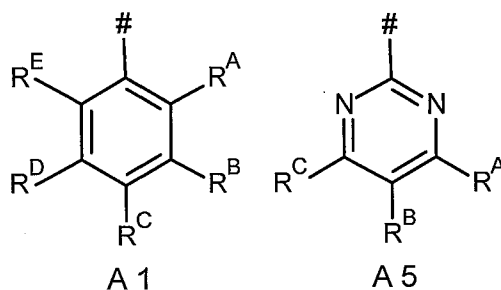
In another particular embodiment the radicals R^A , R^B , R^C , R^D and R^E are independently from each other selected from hydrogen, CN, fluorine, chlorine and phenyl, which is
25 substituted by 1 or 2 identical or different radicals selected from C_1 - C_2 -haloalkyl.

Especially preferred, the radicals R^A , R^B , R^C , R^D and R^E all represent fluorine.

Also especially preferred the radicals R^A , R^B , R^D and R^E are hydrogen and R^C is 3,5-di(tri-
30 fluoromethyl)phenyl.

Preferably in formula (I) and ligands of formula (I.2), R^1 and R^2 are independently selected from C_1 - C_4 -alkyl, C_1 - C_4 -haloalkyl, A1 and A5

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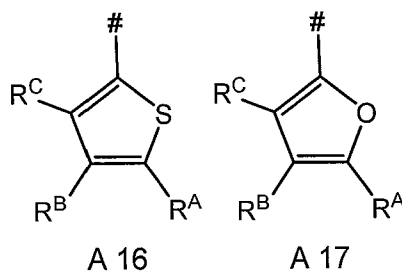


where # denotes the bond to the remaining molecule of formula (I) and ligands of formula (I.2), and wherein

5

R^A , R^B , R^C , R^D and R^E are independently selected from hydrogen, CN, fluorine, chlorine, C_1 - C_4 -alkyl, C_1 - C_4 -fluoroalkyl, C_1 - C_4 -chloroalkyl and phenyl, which is unsubstituted or substituted by 1, 2 or 3 identical or different radicals selected from C_1 - C_4 -haloalkyl.

- 10 In another preferred embodiment in formula (I) and ligands of formula (I.2) R^1 and R^2 are independently selected from A16 und A17

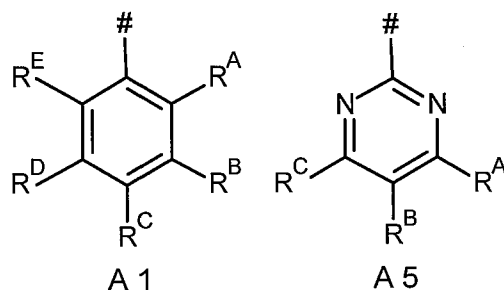


- 15 where # denotes the bond to the remaining molecule of formula (I) and ligands of formula (I.2), and wherein

R^A , R^B and R^C are independently selected from hydrogen, CN, fluorine, chlorine, C_1 - C_4 -alkyl, C_1 - C_4 -fluoroalkyl and C_1 - C_4 -chloroalkyl. Preferably R^A , R^B and R^C are all hydrogen.

20

In a preferred embodiment, in formula (I) and ligands of formula (I.2), R^1 and R^2 are independently selected from A1 and A5



where # denotes the bond to the remaining molecule of formula (I) and ligands of formula (I.2), and wherein

R^A , R^B , R^C , R^D and R^E are independently selected from hydrogen, CN, fluorine, chlorine, C_1 - C_4 -alkyl, C_1 - C_4 -fluoroalkyl, C_1 - C_4 -chloroalkyl and phenyl, which is unsubstituted or substituted by 1, 2 or 3 identical or different radicals selected from C_1 - C_4 -haloalkyl.

In a particularly preferred embodiment in formula (I) and ligands of formula (I.2) R^1 and R^2 are independently selected from A1 and A5, wherein R^A , R^B , R^C , R^D and R^E are independently selected from CN, fluorine and chlorine.

In another particularly preferred embodiment in formula (I) R^1 and R^2 are independently selected from A1 and A5, wherein R^A , R^B , R^C , R^D and R^E are independently selected from CN, fluorine and chlorine.

In another preferred embodiment in formula (I) and ligands of formula (I.2), R^1 and R^2 are independently selected from C_1 - C_4 -alkyl, C_1 - C_4 -fluoroalkyl, C_1 - C_4 -chloroalkyl and A1, wherein R^A , R^B , R^C , R^D and R^E are independently selected from CN, fluorine and chlorine.

In another preferred embodiment, in formula (I), R^1 and R^2 are independently selected from C_1 - C_4 -alkyl, C_1 - C_4 -fluoroalkyl, C_1 - C_4 -chloroalkyl and A1, wherein R^A , R^B , R^C , R^D and R^E are independently selected from CN, fluorine and chlorine.

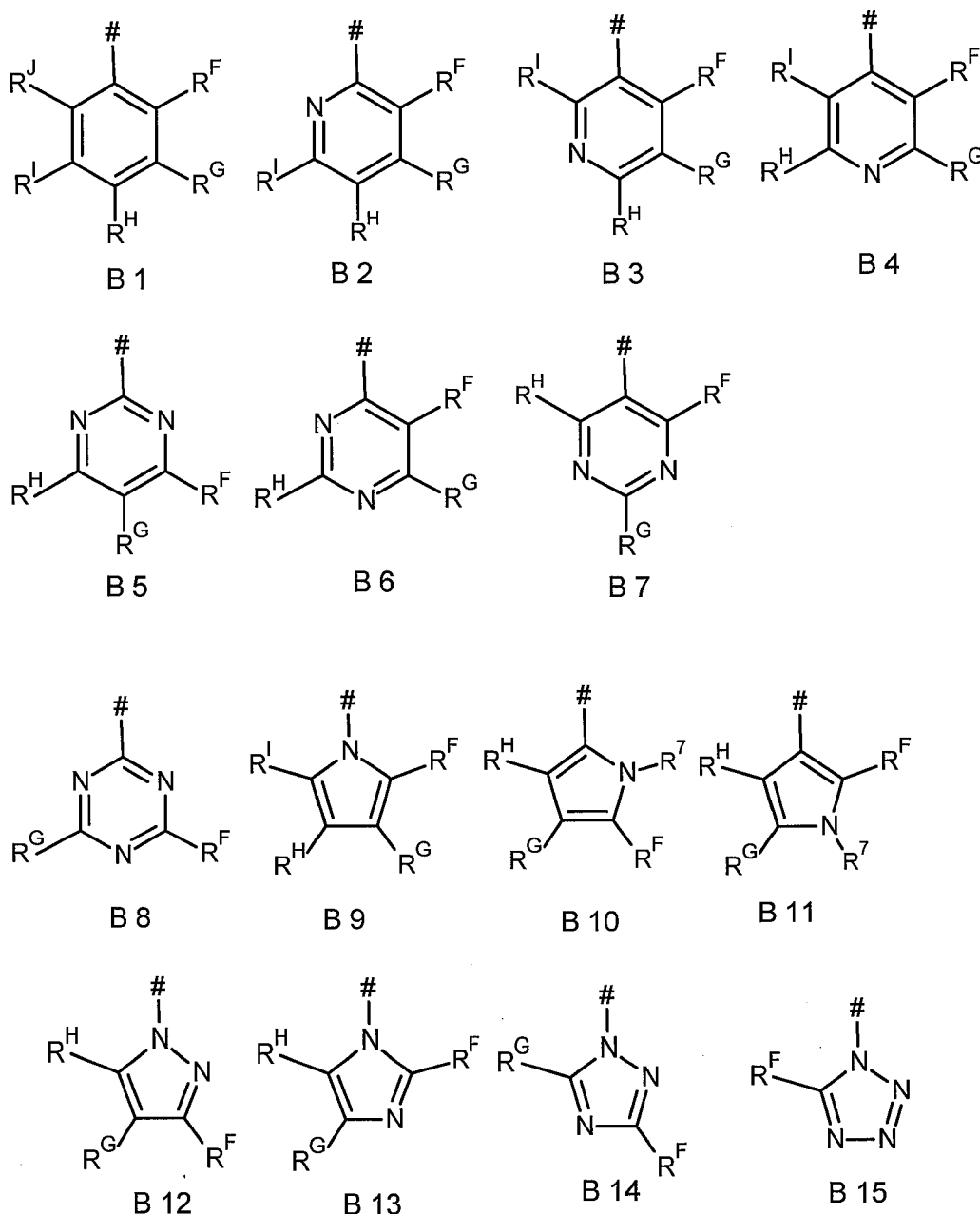
In a particular embodiment, in formula (I) and ligands of formula (I.2), R^1 and R^2 are independently selected from A1 and A5, wherein R^A , R^B , R^C , R^D and R^E are fluorine.

In a particular embodiment, in formula (I), R^1 and R^2 are independently selected from A1 and A5, wherein R^A , R^B , R^C , R^D and R^E are fluorine.

In another preferred embodiment in formula (I) and ligands of formula (I.2), R^1 and R^2 are A1, wherein R^A , R^B , R^D and R^E are hydrogen and R^C is 3,5-di(trifluoromethyl)phenyl.

In another preferred embodiment, in formula (I), R^1 and R^2 are A1, wherein R^A , R^B , R^D and R^E are hydrogen and R^C is 3,5-di(trifluoromethyl)phenyl.

Preferred are compounds of formula (I) and ligands of formula (I.2), wherein Y represents the radical CR^3 and R^3 is selected from hydrogen, CN, nitro, halogen, CF_3 and the group B consisting B1, B2, B3, B4, B5, B6, B7, B8, B9, B10, B11, B12, B13, B14 and B15



where # denotes the bond to the remaining molecule of formula (I) and ligands of formula (I.2),

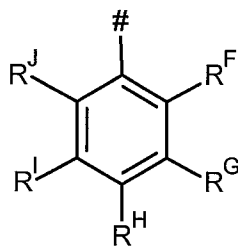
5 R^F , R^G , R^H , R^I and R^J are independently selected from hydrogen, CN, halogen, C_1 - C_4 -alkyl and C_1 - C_4 -haloalkyl; and

R^7 represents hydrogen, C_1 - C_6 -alkyl, C_1 - C_6 -haloalkyl or C_1 - C_{14} -aryl, wherein aryl is unsubstituted or substituted by 1, 2, 3, 4 or 5 identical or different radicals R^5 .

10 Irrespective of their occurrence the radicals R^F , R^G , R^H , R^I and R^J are preferably selected from hydrogen, CN, fluorine, chlorine, C_1 - C_4 -alkyl, C_1 - C_4 -fluoroalkyl and C_1 - C_4 -chloroalkyl.

15 In a preferred embodiment the radicals R^A , R^B , R^C , R^D and R^E represent independently CN, fluorine or chlorine.

In formula (I) and ligands of formula (I.2), Y preferably represents a radical CR^3 , wherein R^3 is selected from hydrogen, CN, nitro, halogen CF_3 and B1



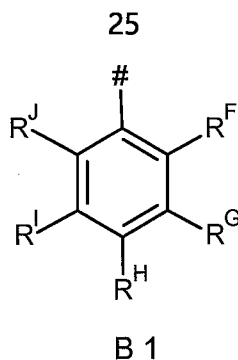
B 1

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where # denotes the bond to the remaining molecule of formula (I) and ligands of formula (I.2), and wherein

25 R^F , R^G , R^H , R^I and R^J are independently selected from hydrogen, CN, fluorine and chlorine.

In formula (I) and ligands of formula (I.2), Y preferably represents a radical CR^3 , wherein R^3 represents B1



where # denotes the bond to the remaining molecule of formula (I) and ligands of formula (I.2), and wherein

- 5 R^F , R^G , R^H , R^I and R^J are independently selected from CN, fluorine and chlorine.

In another preferred embodiment, Y represents a radical CR^3 , wherein R^3 is selected from hydrogen, CN, nitro, fluorine, chlorine and CF_3 .

- 10 Irrespective of their occurrence, the radicals R^{4a} and R^{4b} are preferably selected from hydrogen and C_1 - C_4 -alkyl.

Irrespective of its occurrence, the radical R^5 is preferably selected from CN, fluorine, chlorine, C_1 - C_4 -alkyl and C_1 - C_4 -haloalkyl.

- 15 Irrespective of its occurrence, the radical R^6 is preferably selected from hydrogen and C_1 - C_4 -alkyl.

- 20 Irrespective of its occurrence, the radical R^7 is preferably selected from hydrogen and C_1 - C_4 -alkyl and C_1 - C_4 -haloalkyl.

In a preferred first embodiment A, compounds of formula (I) and ligands of formula (I.2) are preferred, wherein

- 25 X and W represent S or O, in particular O;
 Y represents CR^3 , wherein R^3 is selected from hydrogen, CN, nitro and halogen, in particular fluorine, CN and nitro;
 R^1 and R^2 independently from each other represent CN, C_1 - C_6 -alkyl, C_1 - C_6 -haloalkyl, C_1 - C_6 -alkoxy, C_1 - C_6 -haloalkoxy, C_1 - C_6 -alkylsulfanyl, C_1 - C_6 -haloalkylsulfanyl,
 30 $NR^{4a}R^{4b}$, in particular represents C_1 - C_4 -alkyl or C_1 - C_4 -haloalkyl.

Particular preferred are compounds of formula (I), wherein

- X and W represent S or O, in particular O;
 Y represents CR^3 , wherein R^3 is selected from hydrogen, CN, nitro and halo-
 gen, in particular fluorine, CN and nitro;
 5 R^1 and R^2 independently from each other represent CN, C_1 - C_6 -alkyl, C_1 - C_6 -haloalkyl,
 C_1 - C_6 -alkoxy, C_1 - C_6 -haloalkoxy, C_1 - C_6 -alkylsulfanyl, C_1 - C_6 -haloalkylsulfanyl,
 $NR^{4a}R^{4b}$, in particular represents C_1 - C_4 -alkyl or C_1 - C_4 -haloalkyl.

In a preferred second embodiment B, compounds of formula (I) and ligands of formula
 (I.2) are preferred, wherein

10

- X and W represent S or O, in particular O;
 Y represents CR^3 , wherein R^3 represents B1, B2, B3, B4, B5, B6, B7, B8, B9, B10,
 B11, B12, B13, B14 or B15, in particular represents B1;
 15 R^1 and R^2 independently from each other represent CN, C_1 - C_6 -alkyl, C_1 - C_6 -haloalkyl,
 C_1 - C_6 -alkoxy, C_1 - C_6 -haloalkoxy, C_1 - C_6 -alkylsulfanyl, C_1 - C_6 -haloalkylsulfanyl,
 $NR^{4a}R^{4b}$, in particular represent C_1 - C_4 -alkyl or C_1 - C_4 -haloalkyl.

Particular preferred are compounds of formula (I), wherein

- 20 X and W represent S or O, in particular O;
 Y represents CR^3 , wherein R^3 represents B1, B2, B3, B4, B5, B6, B7, B8, B9, B10,
 B11, B12, B13, B14 or B15, in particular represents B1;
 25 R^1 and R^2 independently from each other represent CN, C_1 - C_6 -alkyl, C_1 - C_6 -haloalkyl,
 C_1 - C_6 -alkoxy, C_1 - C_6 -haloalkoxy, C_1 - C_6 -alkylsulfanyl, C_1 - C_6 -haloalkylsulfanyl,
 $NR^{4a}R^{4b}$, in particular represent C_1 - C_4 -alkyl or C_1 - C_4 -haloalkyl.

In a preferred third embodiment C, compounds of formula (I) and ligands of formula
 (I.2) are preferred, wherein

- 30 X and W represent S or O, in particular O;
 Y represents CR^3 , wherein R^3 represents B1, B2, B3, B4, B5, B6, B7, B8, B9, B10,
 B11, B12, B13, B14 or B15, in particular represents B1;
 35 R^1 and R^2 independently from each other represent A1, A2, A3, A4, A5, A6, A7, A8, A9,
 A10, A11, A12, A13, A14 or A15, in particular represent A1 or A5.

35

Particular preferred are compounds of formula (I), wherein

- X and W represent S or O, in particular O;
 40 Y represents CR^3 , wherein R^3 represents B1, B2, B3, B4, B5, B6, B7, B8, B9, B10,
 B11, B12, B13, B14 or B15, in particular represents B1;

R¹ and R² independently from each other represent A1, A2, A3, A4, A5, A6, A7, A8, A9, A10, A11, A12, A13, A14 or A15, in particular represent A1 or A5.

5 In a preferred fourth embodiment D, compounds of formula (I) and ligands of formula (I.2) are preferred, wherein

X and W represent S or O, in particular O;

Y represents CR³, wherein R³ is selected from hydrogen, CN, nitro and halogen, in particular fluorine, CN and nitro;

10 R¹ and R² independently from each other represent A1, A2, A3, A4, A5, A6, A7, A8, A9, A10, A11, A12, A13, A14 or A15, in particular represent A1 or A5.

Particular preferred are compounds of formula (I), wherein

15 X and W represent S or O, in particular O;

Y represents CR³, wherein R³ is selected from hydrogen, CN, nitro and halogen, in particular fluorine, CN and nitro;

R¹ and R² independently from each other represent A1, A2, A3, A4, A5, A6, A7, A8, A9, A10, A11, A12, A13, A14 or A15, in particular represent A1 or A5.

20

In a preferred fifth embodiment E, compounds of formula (I) and ligands of formula (I.2) are preferred, wherein

X and W represent S or O, in particular O;

25 Y represents CR³, wherein R³ is selected from hydrogen, CN, nitro and halogen, in particular fluorine, CN and nitro;

R¹ represents A1;

R² represents CN, C₁-C₆-alkyl, C₁-C₆-haloalkyl, C₁-C₆-alkoxy, C₁-C₆-haloalkoxy, C₁-C₆-alkylsulfanyl, C₁-C₆-haloalkylsulfanyl, NR^{4a}R^{4b}, in particular represents

30 C₁-C₄-alkyl or C₁-C₄-haloalkyl.

Particular preferred are compounds of formula (I), wherein

X and W represent S or O, in particular O;

35 Y represents CR³, wherein R³ is selected from hydrogen, CN, nitro and halogen, in particular fluorine, CN and nitro;

R¹ represents A1;

R² represents CN, C₁-C₆-alkyl, C₁-C₆-haloalkyl, C₁-C₆-alkoxy, C₁-C₆-haloalkoxy, C₁-C₆-alkylsulfanyl, C₁-C₆-haloalkylsulfanyl, NR^{4a}R^{4b}, in particular represents
40 C₁-C₄-alkyl or C₁-C₄-haloalkyl.

In a preferred sixth embodiment F, compounds of formula (I) and ligands of formula (I.2) are preferred, wherein

- 5 X and W represent S or O, in particular O;
 Y represents CR^3 , wherein R^3 is selected from hydrogen, CN, nitro and halogen, in hydrogen;
 R^1 and R^2 independently from each other represent A16 or A17.

10 Particular preferred are compounds of formula (I), wherein

- X and W represent S or O, in particular O;
 Y represents CR^3 , wherein R^3 is selected from hydrogen, CN, nitro and halogen, in hydrogen;
 15 R^1 and R^2 independently from each other represent A16 or A17.

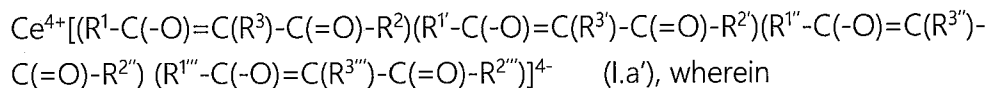
In a preferred seventh embodiment G, compounds of formula (I) and ligands of formula (I.2) are preferred, wherein

- 20 X and W represent S or O, in particular O;
 Y represents CR^3 , wherein R^3 is selected from hydrogen, CN, nitro and halogen, in hydrogen;
 R^1 represents A16 or A17;
 R^2 represents CN, C_1 - C_6 -alkyl, C_1 - C_6 -haloalkyl, C_1 - C_6 -alkoxy, C_1 - C_6 -haloalkoxy,
 25 C_1 - C_6 -alkylsulfanyl, C_1 - C_6 -haloalkylsulfanyl, $NR^{4a}R^{4b}$, in particular represents C_1 - C_4 -alkyl or C_1 - C_4 -haloalkyl.

Particular preferred are compounds of formula (I), wherein

- 30 X and W represent S or O, in particular O;
 Y represents CR^3 , wherein R^3 is selected from hydrogen, CN, nitro and halogen, in hydrogen;
 R^1 represents A16 or A17;
 R^2 represents CN, C_1 - C_6 -alkyl, C_1 - C_6 -haloalkyl, C_1 - C_6 -alkoxy, C_1 - C_6 -haloalkoxy,
 35 C_1 - C_6 -alkylsulfanyl, C_1 - C_6 -haloalkylsulfanyl, $NR^{4a}R^{4b}$, in particular represents C_1 - C_4 -alkyl or C_1 - C_4 -haloalkyl.

Particular preferred are compounds of formula (I.a')



- 5 (R¹, R², R³), (R^{1'}, R^{2'}, R^{3'}), (R^{1''}, R^{2''}, R^{3''}) and (R^{1'''}, R^{2'''}, R^{3'''}) are each selected from the definition given in one line of the following table 1

Table 1:

	R ¹ , R ^{1'} , R ^{1''} , R ^{1'''}	R ² , R ^{2'} , R ^{2''} , R ^{2'''}	R ³ , R ^{3'} , R ^{3''} , R ^{3'''}
1.	methyl	methyl	H
2.	methyl	methyl	CN
3.	methyl	methyl	F
4.	methyl	methyl	Cl
5.	methyl	methyl	NO ₂
6.	methyl	methyl	pentafluorophenyl
7.	methyl	methyl	tetrafluoro-2-(trifluoromethyl)phenyl
8.	methyl	methyl	tetrafluoro-3-(trifluoromethyl)phenyl
9.	methyl	methyl	tetrafluoro-4-(trifluoromethyl)phenyl
10.	methyl	methyl	tetrafluoro-2-pyridyl
11.	methyl	methyl	tetrafluoro-3-pyridyl
12.	methyl	methyl	tetrafluoro-4-pyridyl
13.	methyl	methyl	tetrafluoro-2-benzonitrile
14.	methyl	methyl	tetrafluoro-3-benzonitrile
15.	methyl	methyl	tetrafluoro-4-benzonitrile
16.	trifluoromethyl	trifluoromethyl	H
17.	trifluoromethyl	trifluoromethyl	CN
18.	trifluoromethyl	trifluoromethyl	F
19.	trifluoromethyl	trifluoromethyl	Cl
20.	trifluoromethyl	trifluoromethyl	NO ₂
21.	trifluoromethyl	trifluoromethyl	pentafluorophenyl
22.	trifluoromethyl	trifluoromethyl	tetrafluoro-2-(trifluoromethyl)phenyl
23.	trifluoromethyl	trifluoromethyl	tetrafluoro-3-(trifluoromethyl)phenyl

	R ¹ , R ^{1'} , R ^{1''} , R ^{1'''}	R ² , R ^{2'} , R ^{2''} , R ^{2'''}	R ³ , R ^{3'} , R ^{3''} , R ^{3'''}
24.	trifluoromethyl	trifluoromethyl	tetrafluoro-4-(trifluoromethyl)phenyl
25.	trifluoromethyl	trifluoromethyl	tetrafluoro-2-pyridyl
26.	trifluoromethyl	trifluoromethyl	tetrafluoro-3-pyridyl
27.	trifluoromethyl	trifluoromethyl	tetrafluoro-4-pyridyl
28.	trifluoromethyl	trifluoromethyl	tetrafluoro-2-benzonitrile
29.	trifluoromethyl	trifluoromethyl	tetrafluoro-3-benzonitrile
30.	trifluoromethyl	trifluoromethyl	tetrafluoro-4-benzonitrile
31.	pentafluoroethyl	pentafluoroethyl	H
32.	pentafluoroethyl	pentafluoroethyl	CN
33.	pentafluoroethyl	pentafluoroethyl	F
34.	pentafluoroethyl	pentafluoroethyl	Cl
35.	pentafluoroethyl	pentafluoroethyl	NO ₂
36.	pentafluoroethyl	pentafluoroethyl	pentafluorophenyl
37.	pentafluoroethyl	pentafluoroethyl	tetrafluoro-2-(trifluoromethyl)phenyl
38.	pentafluoroethyl	pentafluoroethyl	tetrafluoro-3-(trifluoromethyl)phenyl
39.	pentafluoroethyl	pentafluoroethyl	tetrafluoro-4-(trifluoromethyl)phenyl
40.	pentafluoroethyl	pentafluoroethyl	tetrafluoro-2-pyridyl
41.	pentafluoroethyl	pentafluoroethyl	tetrafluoro-3-pyridyl
42.	pentafluoroethyl	pentafluoroethyl	tetrafluoro-4-pyridyl
43.	pentafluoroethyl	pentafluoroethyl	tetrafluoro-2-benzonitrile
44.	pentafluoroethyl	pentafluoroethyl	tetrafluoro-3-benzonitrile
45.	pentafluoroethyl	pentafluoroethyl	tetrafluoro-4-benzonitrile
46.	heptafluoro-n-propyl	heptafluoro-n-propyl	H
47.	heptafluoro-n-propyl	heptafluoro-n-propyl	CN
48.	heptafluoro-n-propyl	heptafluoro-n-propyl	F
49.	heptafluoro-n-propyl	heptafluoro-n-propyl	Cl
50.	heptafluoro-n-propyl	heptafluoro-n-propyl	NO ₂
51.	heptafluoro-n-propyl	heptafluoro-n-propyl	pentafluorophenyl

	R ¹ , R ^{1'} , R ^{1''} , R ^{1'''}	R ² , R ^{2'} , R ^{2''} , R ^{2'''}	R ³ , R ^{3'} , R ^{3''} , R ^{3'''}
52.	heptafluoro-n-propyl	heptafluoro-n-propyl	tetrafluoro-2-(trifluoromethyl)phenyl
53.	heptafluoro-n-propyl	heptafluoro-n-propyl	tetrafluoro-3-(trifluoromethyl)phenyl
54.	heptafluoro-n-propyl	heptafluoro-n-propyl	tetrafluoro-4-(trifluoromethyl)phenyl
55.	heptafluoro-n-propyl	heptafluoro-n-propyl	tetrafluoro-2-pyridyl
56.	heptafluoro-n-propyl	heptafluoro-n-propyl	tetrafluoro-3-pyridyl
57.	heptafluoro-n-propyl	heptafluoro-n-propyl	tetrafluoro-4-pyridyl
58.	heptafluoro-n-propyl	heptafluoro-n-propyl	tetrafluoro-2-benzonitrile
59.	heptafluoro-n-propyl	heptafluoro-n-propyl	tetrafluoro-3-benzonitrile
60.	heptafluoro-n-propyl	heptafluoro-n-propyl	tetrafluoro-4-benzonitrile
61.	heptafluoro-isopropyl	heptafluoro-isopropyl	H
62.	heptafluoro-isopropyl	heptafluoro-isopropyl	CN
63.	heptafluoro-isopropyl	heptafluoro-isopropyl	F
64.	heptafluoro-isopropyl	heptafluoro-isopropyl	Cl
65.	heptafluoro-isopropyl	heptafluoro-isopropyl	NO ₂
66.	heptafluor-iso-propyl	heptafluoro-isopropyl	pentafluorophenyl
67.	heptafluor-iso-propyl	heptafluoro-isopropyl	tetrafluoro-2-(trifluoromethyl)phenyl
68.	heptafluoro-isopropyl	heptafluoro-isopropyl	tetrafluoro-3-(trifluoromethyl)phenyl
69.	heptafluoro-isopropyl	heptafluoro-isopropyl	tetrafluoro-4-(trifluoromethyl)phenyl
70.	heptafluoro-isopropyl	heptafluoro-isopropyl	tetrafluoro-2-pyridyl

	R ¹ , R ^{1'} , R ^{1''} , R ^{1'''}	R ² , R ^{2'} , R ^{2''} , R ^{2'''}	R ³ , R ^{3'} , R ^{3''} , R ^{3'''}
71.	heptafluoro-isopropyl	heptafluoro-isopropyl	tetrafluoro-3-pyridyl
72.	heptafluoro-isopropyl	heptafluoro-isopropyl	tetrafluoro-4-pyridyl
73.	heptafluoro-isopropyl	heptafluoro-isopropyl	tetrafluoro-2-benzonitrile
74.	heptafluoro-isopropyl	heptafluoro-isopropyl	tetrafluoro-3-benzonitrile
75.	heptafluoro-isopropyl	heptafluoro-isopropyl	tetrafluoro-4-benzonitrile
76.	tert-butyl	tert-butyl	H
77.	tert-butyl	tert-butyl	CN
78.	tert-butyl	tert-butyl	F
79.	tert-butyl	tert-butyl	Cl
80.	tert-butyl	tert-butyl	NO ₂
81.	tert-butyl	tert-butyl	pentafluorophenyl
82.	tert-butyl	tert-butyl	tetrafluoro-2-(trifluoromethyl)phenyl
83.	tert-butyl	tert-butyl	tetrafluoro-3-(trifluoromethyl)phenyl
84.	tert-butyl	tert-butyl	tetrafluoro-4-(trifluoromethyl)phenyl
85.	tert-butyl	tert-butyl	tetrafluoro-2-pyridyl
86.	tert-butyl	tert-butyl	tetrafluoro-3-pyridyl
87.	tert-butyl	tert-butyl	tetrafluoro-4-pyridyl
88.	tert-butyl	tert-butyl	tetrafluoro-2-benzonitrile
89.	tert-butyl	tert-butyl	tetrafluoro-3-benzonitrile
90.	tert-butyl	tert-butyl	tetrafluoro-4-benzonitrile
91.	nonafluoro-n-butyl	nonafluoro-n-butyl	H
92.	nonafluoro-n-butyl	nonafluoro-n-butyl	CN
93.	nonafluoro-n-butyl	nonafluoro-n-butyl	F
94.	nonafluoro-n-butyl	nonafluoro-n-butyl	Cl
95.	nonafluoro-n-butyl	nonafluoro-n-butyl	NO ₂

	R ¹ , R ^{1'} , R ^{1''} , R ^{1'''}	R ² , R ^{2'} , R ^{2''} , R ^{2'''}	R ³ , R ^{3'} , R ^{3''} , R ^{3'''}
96.	nonafluoro-n-butyl	nonafluoro-n-butyl	pentafluorophenyl
97.	nonafluoro-n-butyl	nonafluoro-n-butyl	tetrafluoro-2-(trifluoromethyl)phenyl
98.	nonafluoro-n-butyl	nonafluoro-n-butyl	tetrafluoro-3-(trifluoromethyl)phenyl
99.	nonafluoro-n-butyl	nonafluoro-n-butyl	tetrafluoro-4-(trifluoromethyl)phenyl
100.	nonafluoro-n-butyl	nonafluoro-n-butyl	tetrafluoro-2-pyridyl
101.	nonafluoro-n-butyl	nonafluoro-n-butyl	tetrafluoro-3-pyridyl
102.	nonafluoro-n-butyl	nonafluoro-n-butyl	tetrafluoro-4-pyridyl
103.	nonafluoro-n-butyl	nonafluoro-n-butyl	tetrafluoro-2-benzonitrile
104.	nonafluoro-n-butyl	nonafluoro-n-butyl	tetrafluoro-3-benzonitrile
105.	nonafluoro-n-butyl	nonafluoro-n-butyl	tetrafluoro-4-benzonitrile
106.	pentafluorophenyl	pentafluorophenyl	H
107.	pentafluorophenyl	pentafluorophenyl	CN
108.	pentafluorophenyl	pentafluorophenyl	F
109.	pentafluorophenyl	pentafluorophenyl	Cl
110.	pentafluorophenyl	pentafluorophenyl	NO ₂
111.	pentafluorophenyl	pentafluorophenyl	pentafluorophenyl
112.	pentafluorophenyl	pentafluorophenyl	tetrafluoro-2-(trifluoromethyl)phenyl
113.	pentafluorophenyl	pentafluorophenyl	tetrafluoro-3-(trifluoromethyl)phenyl
114.	pentafluorophenyl	pentafluorophenyl	tetrafluoro-4-(trifluoromethyl)phenyl

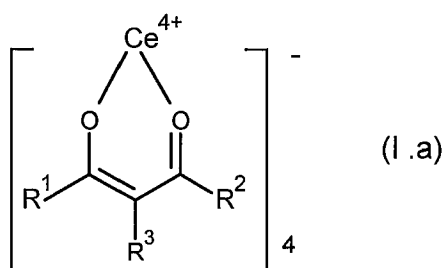
	R ¹ , R ^{1'} , R ^{1''} , R ^{1'''}	R ² , R ^{2'} , R ^{2''} , R ^{2'''}	R ³ , R ^{3'} , R ^{3''} , R ^{3'''}
115.	pentafluorophenyl	pentafluorophenyl	tetrafluoro-2-pyridyl
116.	pentafluorophenyl	pentafluorophenyl	tetrafluoro-3-pyridyl
117.	pentafluorophenyl	pentafluorophenyl	tetrafluoro-4-pyridyl
118.	pentafluorophenyl	pentafluorophenyl	tetrafluoro-2-benzonitrile
119.	pentafluorophenyl	pentafluorophenyl	tetrafluoro-3-benzonitrile
120.	pentafluorophenyl	pentafluorophenyl	tetrafluoro-4-benzonitrile
121.	4-pyrimidyl	4-pyrimidyl	H
122.	4-pyrimidyl	4-pyrimidyl	CN
123.	4-pyrimidyl	4-pyrimidyl	F
124.	4-pyrimidyl	4-pyrimidyl	Cl
125.	4-pyrimidyl	4-pyrimidyl	NO ₂
126.	4-pyrimidyl	4-pyrimidyl	pentafluorophenyl
127.	4-pyrimidyl	4-pyrimidyl	tetrafluoro-2-(trifluoromethyl)phenyl
128.	4-pyrimidyl	4-pyrimidyl	tetrafluoro-3-(trifluoromethyl)phenyl
129.	4-pyrimidyl	4-pyrimidyl	tetrafluoro-4-(trifluoromethyl)phenyl
130.	4-pyrimidyl	4-pyrimidyl	tetrafluoro-2-pyridyl
131.	4-pyrimidyl	4-pyrimidyl	tetrafluoro-3-pyridyl
132.	4-pyrimidyl	4-pyrimidyl	tetrafluoro-4-pyridyl
133.	4-pyrimidyl	4-pyrimidyl	tetrafluoro-2-benzonitrile
134.	4-pyrimidyl	4-pyrimidyl	tetrafluoro-3-benzonitrile
135.	4-pyrimidyl	4-pyrimidyl	tetrafluoro-4-benzonitrile
136.	2-pyrimidyl	2-pyrimidyl	H
137.	2-pyrimidyl	2-pyrimidyl	CN
138.	2-pyrimidyl	2-pyrimidyl	F
139.	2-pyrimidyl	2-pyrimidyl	Cl
140.	2-pyrimidyl	2-pyrimidyl	NO ₂
141.	2-pyrimidyl	2-pyrimidyl	pentafluorophenyl
142.	2-pyrimidyl	2-pyrimidyl	tetrafluoro-2-(trifluoromethyl)phenyl

	R ¹ , R ^{1'} , R ^{1''} , R ^{1'''}	R ² , R ^{2'} , R ^{2''} , R ^{2'''}	R ³ , R ^{3'} , R ^{3''} , R ^{3'''}
143.	2-pyrimidyl	2-pyrimidyl	tetrafluoro-3-(trifluoromethyl)phenyl
144.	2-pyrimidyl	2-pyrimidyl	tetrafluoro-4-(trifluoromethyl)phenyl
145.	2-pyrimidyl	2-pyrimidyl	tetrafluoro-2-pyridyl
146.	2-pyrimidyl	2-pyrimidyl	tetrafluoro-3-pyridyl
147.	2-pyrimidyl	2-pyrimidyl	tetrafluoro-4-pyridyl
148.	2-pyrimidyl	2-pyrimidyl	tetrafluoro-2-benzonitrile
149.	2-pyrimidyl	2-pyrimidyl	tetrafluoro-3-benzonitrile
150.	2-pyrimidyl	2-pyrimidyl	tetrafluoro-4-benzonitrile
151.	3,5-bis(trifluoromethyl)-phenyl	3,5-bis(trifluoromethyl)-phenyl	H
152.	3,5-bis(trifluoromethyl)-phenyl	trifluoromethyl	H
153.	phenyl	pentafluoroethyl	H
154.	furan-2-yl	trifluoromethyl	H
155.	furan-2-yl	pentafluoroethyl	H
156.	3,5-bis(trifluoromethyl)-phenyl	pentafluoroethyl	H
157.	3',5'-bis(trifluoromethyl)-[1,1'-biphenyl]-4-yl	pentafluoroethyl	H
158.	3',5'-bis(trifluoromethyl)-[1,1'-biphenyl]-4-yl	trifluoromethyl	H
159.	4-fluoro-3-trifluoromethyl-phenyl	pentafluoroethyl	H
160.	4-fluoro-3-trifluoromethyl-phenyl	3,5-bis(trifluoromethyl)-phenyl	H
161.	3,4,5-trifluorophenyl	3,4,5-trifluorophenyl	H
162.	3,4,5-trifluorophenyl	pentafluoroethyl	H
163.	4-(trifluoromethyl)phenyl	4-(trifluoromethyl)phenyl	H

	R ¹ , R ^{1'} , R ^{1''} , R ^{1'''}	R ² , R ^{2'} , R ^{2''} , R ^{2'''}	R ³ , R ^{3'} , R ^{3''} , R ^{3'''}
164.	4-(trifluoromethyl)phenyl	pentafluoroethyl	H
165.	2,4,6-tris(trifluoromethyl)phenyl	2,4,6-tris(trifluoromethyl)phenyl	H
166.	2,4,6-tris(trifluoromethyl)phenyl	Pentafluoroethyl	H
167.	3,5-bis(trifluoromethyl)-phenyl	3,5-bis(trifluoromethyl)-phenyl	CN
168.	2,4,6-tris(trifluoromethyl)phenyl	2,4,6-tris(trifluoromethyl)phenyl	CN
169.	3,5-bis(trifluoromethyl)-phenyl	pentafluoroethyl	3,5-bis(trifluoromethyl)-phenyl
170.	3,4-bis(trifluoromethyl)-phenyl	3,4-bis(trifluoromethyl)-phenyl	H
171.	3,4-bis(trifluoromethyl)-phenyl	trifluoromethyl	H
172.	3,4-bis(trifluoromethyl)-phenyl	pentafluoroethyl	3,5-bis(trifluoromethyl)-phenyl
173.	3,4-bis(trifluoromethyl)-phenyl	pentafluoroethyl	H
174.	3,4-bis(trifluoromethyl)-phenyl	3,4-bis(trifluoromethyl)-phenyl	CN
175.	4-cyano-3-(trifluoromethyl)-phenyl	3,5-bis(trifluoromethyl)-phenyl	H
176.	4-cyano-3-(trifluoromethyl)-phenyl	pentafluoroethyl	H
177.	3,5-bis(trifluoromethyl)-phenyl	pentafluoroethyl	CN
178.	4-cyano-2,6-bis(trifluoromethyl)-phenyl	4-cyano-2,6-bis(trifluoromethyl)-phenyl	H
179.	4-cyano-2,6-bis(trifluoromethyl)-phenyl	pentafluoroethyl	H
180.	2,4-bis(trifluoromethyl)-phenyl	2,6-bis(trifluoromethyl)-phenyl	H

	R ¹ , R ^{1'} , R ^{1''} , R ^{1'''}	R ² , R ^{2'} , R ^{2''} , R ^{2'''}	R ³ , R ^{3'} , R ^{3''} , R ^{3'''}
181.	2,4-bis(trifluoromethyl)-phenyl	2,6-bis(trifluoromethyl)-phenyl	CN
182.	4-(3',5'-bis(trifluoromethyl)phenyl)-2,6-bis(trifluoromethyl)-phenyl	pentafluoroethyl	H
183.	phenyl	phenyl	CN
184.	3,5-bis(trifluoromethyl)-phenyl	3,5-bis(trifluoromethyl)-phenyl	CF ₃
185.	3,5-bis(trifluoromethyl)-phenyl	trifluoromethyl	CF ₃
186.	phenyl	pentafluoroethyl	CF ₃
187.	3,5-bis(trifluoromethyl)-phenyl	pentafluoroethyl	CF ₃
188.	3,4,5-trifluorophenyl	3,4,5-trifluorophenyl	CF ₃
189.	4-(trifluoromethyl)phenyl	4-(trifluoromethyl)phenyl	CF ₃
190.	phenyl	phenyl	CF ₃

Particularly preferred are the compounds of formula (I.a)



5 wherein R¹, R² and R³ are as defined in table 2:

Table 2:

	R ¹	R ²	R ³
1.	methyl	methyl	H
2.	methyl	methyl	CN
3.	methyl	methyl	F
4.	methyl	methyl	Cl

	R ¹	R ²	R ³
5.	methyl	methyl	NO ₂
6.	methyl	methyl	pentafluorophenyl
7.	methyl	methyl	tetrafluoro-2-(trifluoromethyl)phenyl
8.	methyl	methyl	tetrafluoro-3-(trifluoromethyl)phenyl
9.	methyl	methyl	tetrafluoro-4-(trifluoromethyl)phenyl
10.	methyl	methyl	tetrafluoro-2-pyridyl
11.	methyl	methyl	tetrafluoro-3-pyridyl
12.	methyl	methyl	tetrafluoro-4-pyridyl
13.	methyl	methyl	tetrafluoro-2-benzonitrile
14.	methyl	methyl	tetrafluoro-3-benzonitrile
15.	methyl	methyl	tetrafluoro-4-benzonitrile
16.	trifluoromethyl	trifluoromethyl	H
17.	trifluoromethyl	trifluoromethyl	CN
18.	trifluoromethyl	trifluoromethyl	F
19.	trifluoromethyl	trifluoromethyl	Cl
20.	trifluoromethyl	trifluoromethyl	NO ₂
21.	trifluoromethyl	trifluoromethyl	pentafluorophenyl
22.	trifluoromethyl	trifluoromethyl	tetrafluoro-2-(trifluoromethyl)phenyl
23.	trifluoromethyl	trifluoromethyl	tetrafluoro-3-(trifluoromethyl)phenyl
24.	trifluoromethyl	trifluoromethyl	tetrafluoro-4-(trifluoromethyl)phenyl
25.	trifluoromethyl	trifluoromethyl	tetrafluoro-2-pyridyl
26.	trifluoromethyl	trifluoromethyl	tetrafluoro-3-pyridyl
27.	trifluoromethyl	trifluoromethyl	tetrafluoro-4-pyridyl
28.	trifluoromethyl	trifluoromethyl	tetrafluoro-2-benzonitrile
29.	trifluoromethyl	trifluoromethyl	tetrafluoro-3-benzonitrile
30.	trifluoromethyl	trifluoromethyl	tetrafluoro-4-benzonitrile
31.	pentafluoroethyl	pentafluoroethyl	H
32.	pentafluoroethyl	pentafluoroethyl	CN
33.	pentafluoroethyl	pentafluoroethyl	F
34.	pentafluoroethyl	pentafluoroethyl	Cl

	R ¹	R ²	R ³
35.	pentafluoroethyl	pentafluoroethyl	NO ₂
36.	pentafluoroethyl	pentafluoroethyl	pentafluorophenyl
37.	pentafluoroethyl	pentafluoroethyl	tetrafluoro-2-(trifluoromethyl)phenyl
38.	pentafluoroethyl	pentafluoroethyl	tetrafluoro-3-(trifluoromethyl)phenyl
39.	pentafluoroethyl	pentafluoroethyl	tetrafluoro-4-(trifluoromethyl)phenyl
40.	pentafluoroethyl	pentafluoroethyl	tetrafluoro-2-pyridyl
41.	pentafluoroethyl	pentafluoroethyl	tetrafluoro-3-pyridyl
42.	pentafluoroethyl	pentafluoroethyl	tetrafluoro-4-pyridyl
43.	pentafluoroethyl	pentafluoroethyl	tetrafluoro-2-benzonitrile
44.	pentafluoroethyl	pentafluoroethyl	tetrafluoro-3-benzonitrile
45.	pentafluoroethyl	pentafluoroethyl	tetrafluoro-4-benzonitrile
46.	heptafluoro-n-propyl	heptafluoro-n-propyl	H
47.	heptafluoro-n-propyl	heptafluoro-n-propyl	CN
48.	heptafluoro-n-propyl	heptafluoro-n-propyl	F
49.	heptafluoro-n-propyl	heptafluoro-n-propyl	Cl
50.	heptafluoro-n-propyl	heptafluoro-n-propyl	NO ₂
51.	heptafluoro-n-propyl	heptafluoro-n-propyl	pentafluorophenyl
52.	heptafluoro-n-propyl	heptafluoro-n-propyl	tetrafluoro-2-(trifluoromethyl)phenyl
53.	heptafluoro-n-propyl	heptafluoro-n-propyl	tetrafluoro-3-(trifluoromethyl)phenyl
54.	heptafluoro-n-propyl	heptafluoro-n-propyl	tetrafluoro-4-(trifluoromethyl)phenyl
55.	heptafluoro-n-propyl	heptafluoro-n-propyl	tetrafluoro-2-pyridyl
56.	heptafluoro-n-propyl	heptafluoro-n-propyl	tetrafluoro-3-pyridyl
57.	heptafluoro-n-propyl	heptafluoro-n-propyl	tetrafluoro-4-pyridyl

	R ¹	R ²	R ³
58.	heptafluoro-n-propyl	heptafluoro-n-propyl	tetrafluoro-2-benzonitrile
59.	heptafluoro-n-propyl	heptafluoro-n-propyl	tetrafluoro-3-benzonitrile
60.	heptafluoro-n-propyl	heptafluoro-n-propyl	tetrafluoro-4-benzonitrile
61.	heptafluoro-isopropyl	heptafluoro-isopropyl	H
62.	heptafluoro-isopropyl	heptafluoro-isopropyl	CN
63.	heptafluoro-isopropyl	heptafluoro-isopropyl	F
64.	heptafluoro-isopropyl	heptafluoro-isopropyl	Cl
65.	heptafluoro-isopropyl	heptafluoro-isopropyl	NO ₂
66.	heptafluoro-isopropyl	heptafluoro-isopropyl	pentafluorophenyl
67.	heptafluoro-isopropyl	heptafluoro-isopropyl	tetrafluoro-2-(trifluoromethyl)phenyl
68.	heptafluoro-isopropyl	heptafluoro-isopropyl	tetrafluoro-3-(trifluoromethyl)phenyl
69.	heptafluoro-isopropyl	heptafluoro-isopropyl	tetrafluoro-4-(trifluoromethyl)phenyl
70.	heptafluoro-isopropyl	heptafluoro-isopropyl	tetrafluoro-2-pyridyl
71.	heptafluoro-isopropyl	heptafluoro-isopropyl	tetrafluoro-3-pyridyl
72.	heptafluoro-isopropyl	heptafluoro-isopropyl	tetrafluoro-4-pyridyl
73.	heptafluoro-isopropyl	heptafluoro-isopropyl	tetrafluoro-2-benzonitrile
74.	heptafluoro-isopropyl	heptafluoro-isopropyl	tetrafluoro-3-benzonitrile
75.	heptafluoro-isopropyl	heptafluoro-isopropyl	tetrafluoro-4-benzonitrile
76.	tert-butyl	tert-butyl	H
77.	tert-butyl	tert-butyl	CN

	R ¹	R ²	R ³
78.	tert-butyl	tert-butyl	F
79.	tert-butyl	tert-butyl	Cl
80.	tert-butyl	tert-butyl	NO ₂
81.	tert-butyl	tert-butyl	pentafluorophenyl
82.	tert-butyl	tert-butyl	tetrafluoro-2-(trifluoromethyl)phenyl
83.	tert-butyl	tert-butyl	tetrafluoro-3-(trifluoromethyl)phenyl
84.	tert-butyl	tert-butyl	tetrafluoro-4-(trifluoromethyl)phenyl
85.	tert-butyl	tert-butyl	tetrafluoro-2-pyridyl
86.	tert-butyl	tert-butyl	tetrafluoro-3-pyridyl
87.	tert-butyl	tert-butyl	tetrafluoro-4-pyridyl
88.	tert-butyl	tert-butyl	tetrafluoro-2-benzonitrile
89.	tert-butyl	tert-butyl	tetrafluoro-3-benzonitrile
90.	tert-butyl	tert-butyl	tetrafluoro-4-benzonitrile
91.	nonafluoro-n-butyl	nonafluoro-n-butyl	H
92.	nonafluoro-n-butyl	nonafluoro-n-butyl	CN
93.	nonafluoro-n-butyl	nonafluoro-n-butyl	F
94.	nonafluoro-n-butyl	nonafluoro-n-butyl	Cl
95.	nonafluoro-n-butyl	nonafluoro-n-butyl	NO ₂
96.	nonafluoro-n-butyl	nonafluoro-n-butyl	pentafluorophenyl
97.	nonafluoro-n-butyl	nonafluoro-n-butyl	tetrafluoro-2-(trifluoromethyl)phenyl
98.	nonafluoro-n-butyl	nonafluoro-n-butyl	tetrafluoro-3-(trifluoromethyl)phenyl
99.	nonafluoro-n-butyl	nonafluoro-n-butyl	tetrafluoro-4-(trifluoromethyl)phenyl
100.	nonafluoro-n-butyl	nonafluoro-n-butyl	tetrafluoro-2-pyridyl
101.	nonafluoro-n-butyl	nonafluoro-n-butyl	tetrafluoro-3-pyridyl

	R ¹	R ²	R ³
102.	nonafluoro-n-butyl	nonafluoro-n-butyl	tetrafluoro-4-pyridyl
103.	nonafluoro-n-butyl	nonafluoro-n-butyl	tetrafluoro-2-benzonitrile
104.	nonafluoro-n-butyl	nonafluoro-n-butyl	tetrafluoro-3-benzonitrile
105.	nonafluoro-n-butyl	nonafluoro-n-butyl	tetrafluoro-4-benzonitrile
106.	pentafluorophenyl	pentafluorophenyl	H
107.	pentafluorophenyl	pentafluorophenyl	CN
108.	pentafluorophenyl	pentafluorophenyl	F
109.	pentafluorophenyl	pentafluorophenyl	Cl
110.	pentafluorophenyl	pentafluorophenyl	NO ₂
111.	pentafluorophenyl	pentafluorophenyl	pentafluorophenyl
112.	pentafluorophenyl	pentafluorophenyl	tetrafluoro-2-(trifluoromethyl)phenyl
113.	pentafluorophenyl	pentafluorophenyl	tetrafluoro-3-(trifluoromethyl)phenyl
114.	pentafluorophenyl	pentafluorophenyl	tetrafluoro-4-(trifluoromethyl)phenyl
115.	pentafluorophenyl	pentafluorophenyl	tetrafluoro-2-pyridyl
116.	pentafluorophenyl	pentafluorophenyl	tetrafluoro-3-pyridyl
117.	pentafluorophenyl	pentafluorophenyl	tetrafluoro-4-pyridyl
118.	pentafluorophenyl	pentafluorophenyl	tetrafluoro-2-benzonitrile
119.	pentafluorophenyl	pentafluorophenyl	tetrafluoro-3-benzonitrile
120.	pentafluorophenyl	pentafluorophenyl	tetrafluoro-4-benzonitrile

	R ¹	R ²	R ³
121.	4-pyrimidyl	4-pyrimidyl	H
122.	4-pyrimidyl	4-pyrimidyl	CN
123.	4-pyrimidyl	4-pyrimidyl	F
124.	4-pyrimidyl	4-pyrimidyl	Cl
125.	4-pyrimidyl	4-pyrimidyl	NO ₂
126.	4-pyrimidyl	4-pyrimidyl	pentafluorophenyl
127.	4-pyrimidyl	4-pyrimidyl	tetrafluoro-2-(trifluoromethyl)phenyl
128.	4-pyrimidyl	4-pyrimidyl	tetrafluoro-3-(trifluoromethyl)phenyl
129.	4-pyrimidyl	4-pyrimidyl	tetrafluoro-4-(trifluoromethyl)phenyl
130.	4-pyrimidyl	4-pyrimidyl	tetrafluoro-2-pyridyl
131.	4-pyrimidyl	4-pyrimidyl	tetrafluoro-3-pyridyl
132.	4-pyrimidyl	4-pyrimidyl	tetrafluoro-4-pyridyl
133.	4-pyrimidyl	4-pyrimidyl	tetrafluoro-2-benzonitrile
134.	4-pyrimidyl	4-pyrimidyl	tetrafluoro-3-benzonitrile
135.	4-pyrimidyl	4-pyrimidyl	tetrafluoro-4-benzonitrile
136.	2-pyrimidyl	2-pyrimidyl	H
137.	2-pyrimidyl	2-pyrimidyl	CN
138.	2-pyrimidyl	2-pyrimidyl	F
139.	2-pyrimidyl	2-pyrimidyl	Cl
140.	2-pyrimidyl	2-pyrimidyl	NO ₂
141.	2-pyrimidyl	2-pyrimidyl	pentafluorophenyl
142.	2-pyrimidyl	2-pyrimidyl	tetrafluoro-2-(trifluoromethyl)phenyl
143.	2-pyrimidyl	2-pyrimidyl	tetrafluoro-3-(trifluoromethyl)phenyl
144.	2-pyrimidyl	2-pyrimidyl	tetrafluoro-4-(trifluoromethyl)phenyl
145.	2-pyrimidyl	2-pyrimidyl	tetrafluoro-2-pyridyl
146.	2-pyrimidyl	2-pyrimidyl	tetrafluoro-3-pyridyl
147.	2-pyrimidyl	2-pyrimidyl	tetrafluoro-4-pyridyl
148.	2-pyrimidyl	2-pyrimidyl	tetrafluoro-2-benzonitrile
149.	2-pyrimidyl	2-pyrimidyl	tetrafluoro-3-benzonitrile
150.	2-pyrimidyl	2-pyrimidyl	tetrafluoro-4-benzonitrile
151.	3,5-bis(trifluoromethyl)-phenyl	3,5-bis(trifluoromethyl)-phenyl	H

	R ¹	R ²	R ³
152.	3,5-bis(trifluoromethyl)-phenyl	trifluoromethyl	H
153.	phenyl	pentafluoroethyl	H
154.	furan-2-yl	trifluoromethyl	H
155.	furan-2-yl	pentafluoroethyl	H
156.	3,5-bis(trifluoromethyl)-phenyl	pentafluoroethyl	H
157.	3',5'-bis(trifluoromethyl)-[1,1'-biphenyl]-4-yl	pentafluoroethyl	H
158.	3',5'-bis(trifluoromethyl)-[1,1'-biphenyl]-4-yl	trifluoromethyl	H
159.	4-fluoro-3-trifluoromethyl-phenyl	pentafluoroethyl	H
160.	4-fluoro-3-trifluoromethyl-phenyl	3,5-bis(trifluoromethyl)-phenyl	H
161.	3,4,5-trifluorophenyl	3,4,5-trifluorophenyl	H
162.	3,4,5-trifluorophenyl	pentafluoroethyl	H
163.	4-(trifluoromethyl)phenyl	4-(trifluoromethyl)phenyl	H
164.	4-(trifluoromethyl)phenyl	pentafluoroethyl	H
165.	2,4,6-tris(trifluoromethyl)phenyl	2,4,6-tris(trifluoromethyl)phenyl	H
166.	2,4,6-tris(trifluoromethyl)phenyl	Pentafluoroethyl	H
167.	3,5-bis(trifluoromethyl)-phenyl	3,5-bis(trifluoromethyl)-phenyl	CN
168.	2,4,6-tris(trifluoromethyl)phenyl	2,4,6-tris(trifluoromethyl)phenyl	CN
169.	3,5-bis(trifluoromethyl)-phenyl	pentafluoroethyl	3,5-bis(trifluoromethyl)-phenyl
170.	3,4-bis(trifluoromethyl)-phenyl	3,4-bis(trifluoromethyl)-phenyl	H
171.	3,4-bis(trifluoromethyl)-phenyl	trifluoromethyl	H

	R ¹	R ²	R ³
172.	3,4-bis(trifluoromethyl)-phenyl	pentafluoroethyl	3,5-bis(trifluoromethyl)-phenyl
173.	3,4-bis(trifluoromethyl)-phenyl	pentafluoroethyl	H
174.	3,4-bis(trifluoromethyl)-phenyl	3,4-bis(trifluoromethyl)-phenyl	CN
175.	4-cyano-3-(trifluoromethyl)-phenyl	3,5-bis(trifluoromethyl)-phenyl	H
176.	4-cyano-3-(trifluoromethyl)-phenyl	pentafluoroethyl	H
177.	3,5-bis(trifluoromethyl)-phenyl	pentafluoroethyl	CN
178.	4-cyano-2,6-bis(trifluoromethyl)-phenyl	4-cyano-2,6-bis(trifluoromethyl)-phenyl	H
179.	4-cyano-2,6-bis(trifluoromethyl)-phenyl	pentafluoroethyl	H
180.	2,4-bis(trifluoromethyl)-phenyl	2,6-bis(trifluoromethyl)-phenyl	H
181.	2,4-bis(trifluoromethyl)-phenyl	2,6-bis(trifluoromethyl)-phenyl	CN
182.	4-(3',5'-bis(trifluoromethyl)phenyl)-2,6-bis(trifluoromethyl)-phenyl	pentafluoroethyl	H
183.	phenyl	phenyl	CN
184.	3,5-bis(trifluoromethyl)-phenyl	3,5-bis(trifluoromethyl)-phenyl	CF ₃
185.	3,5-bis(trifluoromethyl)-phenyl	trifluoromethyl	CF ₃
186.	phenyl	pentafluoroethyl	CF ₃
187.	3,5-bis(trifluoromethyl)-phenyl	pentafluoroethyl	CF ₃
188.	3,4,5-trifluorophenyl	3,4,5-trifluorophenyl	CF ₃
189.	4-(trifluoromethyl)phenyl	4-(trifluoromethyl)phenyl	CF ₃
190.	phenyl	phenyl	CF ₃

Especially preferred are the compounds of formula (I.a), wherein R¹, R² and R³ are as defined in table 3:

5 Table 3

	R ¹	R ²	R ³
191.	pentafluorophenyl	pentafluorophenyl	H
192.	phenyl	phenyl	CN
193.	tert-butyl	tert-butyl	H
194.	tert-butyl	tert-butyl	CN
195.	3,5-bis(trifluoromethyl)-phenyl	3,5-bis(trifluoromethyl)-phenyl	H
196.	3,5-bis(trifluoromethyl)-phenyl	trifluoromethyl	H
197.	phenyl	pentafluoroethyl	H
198.	furan-2-yl	trifluoromethyl	H
199.	furan-2-yl	pentafluoroethyl	H
200.	3,5-bis(trifluoromethyl)-phenyl	pentafluoroethyl	H
201.	3',5'-bis(trifluoromethyl)-[1,1'-biphenyl]-4-yl	pentafluoroethyl	H
202.	3',5'-bis(trifluoromethyl)-[1,1'-biphenyl]-4-yl	trifluoromethyl	H
203.	4-fluoro-3-trifluoromethyl-phenyl	pentafluoroethyl	H
204.	4-fluoro-3-trifluoromethyl-phenyl	3,5-bis(trifluoromethyl)-phenyl	H
205.	3,4,5-trifluorophenyl	3,4,5-trifluorophenyl	H
206.	3,4,5-trifluorophenyl	pentafluoroethyl	H
207.	4-(trifluoromethyl)phenyl	4-(trifluoromethyl)phenyl	H
208.	4-(trifluoromethyl)phenyl	pentafluoroethyl	H
209.	2,4,6-tris(trifluoromethyl)phenyl	2,4,6-tris(trifluoromethyl)phenyl	H

	R ¹	R ²	R ³
210.	2,4,6-tris(trifluoromethyl)phenyl	Pentafluoroethyl	H
211.	3,5-bis(trifluoromethyl)-phenyl	3,5-bis(trifluoromethyl)-phenyl	CN
212.	2,4,6-tris(trifluoromethyl)phenyl	2,4,6-tris(trifluoromethyl)phenyl	CN
213.	3,5-bis(trifluoromethyl)-phenyl	pentafluoroethyl	3,5-bis(trifluoromethyl)-phenyl
214.	3,4-bis(trifluoromethyl)-phenyl	3,4-bis(trifluoromethyl)-phenyl	H
215.	3,4-bis(trifluoromethyl)-phenyl	trifluoromethyl	H
216.	3,4-bis(trifluoromethyl)-phenyl	pentafluoroethyl	3,5-bis(trifluoromethyl)-phenyl
217.	3,4-bis(trifluoromethyl)-phenyl	pentafluoroethyl	H
218.	3,4-bis(trifluoromethyl)-phenyl	3,4-bis(trifluoromethyl)-phenyl	CN
219.	4-cyano-3-(trifluoromethyl)-phenyl	3,5-bis(trifluoromethyl)-phenyl	H
220.	4-cyano-3-(trifluoromethyl)-phenyl	pentafluoroethyl	H
221.	3,5-bis(trifluoromethyl)-phenyl	pentafluoroethyl	CN
222.	4-cyano-2,6-bis(trifluoromethyl)-phenyl	4-cyano-2,6-bis(trifluoromethyl)-phenyl	H
223.	4-cyano-2,6-bis(trifluoromethyl)-phenyl	pentafluoroethyl	H
224.	2,4-bis(trifluoromethyl)-phenyl	2,6-bis(trifluoromethyl)-phenyl	H
225.	2,4-bis(trifluoromethyl)-phenyl	2,6-bis(trifluoromethyl)-phenyl	CN
226.	4-(3',5'-bis(trifluoromethyl)phenyl)-2,6-bis(trifluoromethyl)-phenyl	pentafluoroethyl	H

In formula (I.a) the four ligands L_1 , L_2 , L_3 and L_4 bound to the cerium atom have the same meanings.

- 5 The homoleptic compounds of formulae (I.1) and (I) are produced by reacting the β -diketone ligand with a ceric salt. Usually the ceric salt is soluble in the reaction medium. Suitable salts are ceric ammonium nitrate and ceric ammonium sulphate. The β -diketone ligands are either commercial available or they can be prepared by a synthesis known to a skilled person.
- 10 The heteroleptic compounds of formula (I.1) are produced by
- mixing two different homoleptic cerium compounds in a suitable solvent,
 - mixing a homoleptic cerium compound with a ligand or its alkaline/earth alkaline salt different from the ligands of the compound,
 - vapor deposition of two different homoleptic cerium compounds,
 - 15 - vapor deposition (vapor co-condensation) of homoleptic cerium compounds with a ligand different from the ligands of the compound.

Component

- 20 In the context of the invention, an electronic component is understood to be a discrete or integrated electrical component, which uses the properties of compounds of the general formula (I.1) or (I) or semiconductor matrix materials containing a compound of the general formula (I.1) or (I). In a special embodiment, the electronic component has a layer structure comprising in particular 2, 3, 4, 5, 6, 7 or more layers, wherein at least
- 25 one of the layers contains at least one compound of the general formula (I.1) or (I). In particular, the electronic component has a layer structure comprising in particular 2, 3, 4, 5, 6, 7 or more layers, wherein at least one of the layers contains at least one compound of the general formula (I). Each of the layers may also contain inorganic materials, or the component may also comprise layers, which are composed entirely from inorganic materials.
- 30

- Preferably, the electronic component is selected from organic field effect transistors (OFETs), organic electroluminescent devices, organic solar cells (OSCs), devices for electrophotography, organic optical detectors, organic photoreceptors, light-emitting electrochemical cells (LECs) and organic laser diodes. Organic field effect transistors (OFETs)
- 35 are preferably organic thin film transistors (OTFTs). Organic electroluminescent devices are preferably organic light-emitting diodes (OLEDs). Organic solar cells are preferably exciton solar cells, dye sensitized solar cells (DSSCs) or perovskite solar cells. Devices for electrophotography are preferably photoconductive materials in organic photoconductors (OPC).
- 40

Preferably, the electronic component according to the invention is in the form of an organic light-emitting diode, an organic solar cell, a photovoltaic cell, an organic diode or an organic transistor, preferably a field effect transistor or thin-film transistor or a Perovskite solar cell.

The electronic component may be preferably an organic electro-luminescent device, in particular in the form of an organic light-emitting diode (OLED). An organic electroluminescent device comprises a cathode, an anode and at least one emitting layer. In addition to these layers, it may also comprise other layers, e.g. one or more hole injection layers, hole transport layers, hole blocking layers, electron transport layers, electron injection layers, exciton blocking layers, electron blocking layers and/or charge generation layers. Intermediate layers, which have e.g. an exciton-blocking-function can also be inserted between two emitting layers. Not all of these layers must necessarily be present.

A preferred embodiment is an electronic component, in particular in the form of an OLED, wherein the layer comprising the compound of formula (I.1) or (I) is a hole transport layer or a hole injection layer. Especially, the electronic component, in particular in the form of an OLED, wherein the layer comprising the compound of formula (I) is a hole transport layer, a hole injection layer or an electron blocking layer. Generally, a hole injection layer is a layer which facilitates electron injection from the anode into the organic semiconductor matrix material. The hole injection layer can be placed directly adjacent to the anode. A hole transport layer transports the holes from the anode to the emitting layer and is located between a hole injection layer and an emitting layer.

A preferred embodiment is an electronic component in the form of an organic solar cell. Generally organic solar cells are layered and usually comprises at least the following layers: anode, at least one photoactive layer and cathode. These layers are generally applied to a substrate commonly used for this purpose. The photoactive region of the solar cell may comprise two layers, each of which has a homogeneous composition and forms a flat donor-acceptor heterojunction. A photoactive region can also comprise a mixed layer and form a donor-acceptor heterojunction in the form of a donor-acceptor bulk heterojunction. In addition to these layers, the organic solar cell can also comprises other layers, e.g. selected from

- Layers with electron transport layer properties (electron transport layer, ETL),
- Layers comprising a hole-conducting material (hole transport layer, HTL), these do not have to absorb radiation,
- Exciton and hole blocking layers (e.g. EBLs), these must not absorb, and

- Multiplier layers.

Another preferred embodiment is an electronic component in the form of an organic solar cell, wherein the layer, which comprises the compound of formula (I.1) or (I), has electron conductivity properties (electron transport layer, ETL). Especially, the electronic component is in the form of an organic solar cell, wherein the layer, which comprises the compound of formula (I), has electron conductivity properties (electron transport layer, ETL).

A special embodiment is an electronic component, especially in the form of an organic solar cell, wherein the layer, which comprises at least one of the compounds of formula (I.1) or (I) is part of a pn-junction connecting a light absorbing unit to an additional light absorbing unit in a tandem device or in a multi-stacked device and/or a pn-junction connecting a cathode or an anode to a light absorbing unit. In particular, the electronic component is in the form of an organic solar cell, wherein the layer which comprises at least one of the compounds of formula (I) is part of a pn-junction connecting a light absorbing unit to an additional light absorbing unit in a tandem device or in a multi-stacked device and/or a pn-junction connecting a cathode or an anode to a light absorbing unit.

Semiconductor matrix materials

The compounds of formula (I.1) or (I) according to the invention and used according to the invention, as well as their charge transfer complexes, their reduction products, can be used as doping agents in organic semiconductor matrix materials, in particular as p-dopant in hole transport layers. The doped semiconductor matrix material, preferably comprising at least one electron donor and at least one compound of the formula (I.1) or (I), as defined above. The electron donor is preferably selected from

4,4',4''-tris(N-(2-naphthyl)-N-phenyl-amino)triphenylamine (2-TNATA), 4,4',4''-tris(N-3-methylphenyl-N-phenyl-amino)triphenylamine (m-MTDATA), N,N,N',N'-tetrakis(4-methoxy-phenyl)benzidine (MeO-TPD), (2,2',7,7'-tetrakis-(N,N-diphenylamino)-9,9'-spiro-bifluorene (spiro-TTB), N,N'-bis(naphthalen-1-yl)-N,N'-bis(phenyl)-benzidine, N,N'-bis(naphthalen-1-yl)-N,N'-bis(phenyl)-9,9'-spiro-bifluorene, 9,9-bis[4-(N,N-bis(biphenyl-4-yl-amino)phenyl)-9H-fluorene, 2, 2'-bis[N,N-bis(biphenyl-4-yl-amino)-9,9'-spiro-bifluorene, N,N'-((9H-fluorene-9,9-diyl)bis(4,1-phenylene))bis(N-([1,1'-biphenyl]-4-yl)-[1, 1'-biphenyl]-4-amine) (BPAPF), N,N'-bis(phenanthren-9-yl)-N,N'-bis(phenyl)-benzidine, 1,3,5-tris[4-[bis(9,9-dimethyl-fluoren-2-yl)amino]phenyl]benzene, tri(terphenyl-4-yl)amine, diaminoterphenylene, diaminotrimethylphenylindanes, N,N'-bis(9,9-dimethyl-

fluoren-2-yl)-N,N'-diphenyl-benzidine (BF-DPB), N,N'-((9H-fluorene-9,9-diyl)bis(4,1-phenylene))bis(N-([1,1'-biphenyl]-4-yl)-[1,1'-biphenyl]-4-amine) (BPAPF), N₄N₄N₄'N₄'-tetrakis(9,9-dimethyl-9H-fluoren-2-yl)-[1,1'-biphenyl]-4,4'-diamine (TDMFB), N-([1,1'-biphenyl]-2-yl)-N-(9,9-dimethyl-9H-fluoren-2-yl)-9,9'-spirobi[fluoren]-2-amine, (2,7-bis[N,N-bis(4-methoxyphenyl)amino]-9,9'-spirobi[9H-fluorene] (spiro-MeO-TPD), N-([1,1'-biphenyl]-4-yl)-9,9-dimethyl-N-(4-(9-phenyl-9H-carbazol-3-yl)phenyl)-9H-fluoren-2-amine and mixtures thereof.

Suitable diaminoterphenyls are described in DE 102012007795. Diaminotrimethylphenylindanes are described in WO 2018/206769.

In particular, the electron donors are selected from 4,4',4''-tris(N-(2-naphthyl)-N-phenyl-amino)triphenylamine (2-TNATA), 4,4',4''-tris(N-3-methylphenyl-N-phenyl-amino)triphenylamine (m-MTDATA), N,N,N',N'-tetrakis(4-methoxy-phenyl)benzidine (MeO-TPD), (2,2',7,7'-tetrakis-(N,N-diphenylamino)-9,9'-spirobifluorene (spiro-TTB), N,N'-bis(naphthalen-1-yl)-N,N'-bis(phenyl)-benzidine, N,N'-bis(naphthalen-1-yl)-N,N'-bis(phenyl)-9,9'-spiro-bifluorene, 9,9-bis[4-(N,N-bis-biphenyl-4-yl-amino)phenyl]-9H-fluorene, 2,2'-bis[N,N-bis(biphenyl-4-yl)amino]-9,9'-spiro-bifluorene, N,N'-((9H-fluoren-9,9-diyl)bis(4,1-phenylene))bis(N-([1,1'-biphenyl]-4-yl)-[1,1'-biphenyl]-4-amine) (BPAPF), N,N'-bis(phenanthren-9-yl)-N,N'-bis(phenyl)-benzidine, 1,3,5-tris[4-[bis(9,9-dimethyl-fluoren-2-yl)amino]phenyl]benzene, tri(terphenyl-4-yl)amine, N-(4-(6-((9,9-dimethyl-9H-fluoren-2-yl)(6-methoxy-[1,1'-biphenyl]-3-yl)amino)-1,3,3-trimethyl-2,3-dihydro-1H-inden-1-yl)phenyl)-N-(6-methoxy-[1,1'-biphenyl]-3-yl)-9,9-dimethyl-9H-fluoren-2-amine, N-([1,1'-biphenyl]-4-yl)-N-(4-(6-([1,1'-biphenyl]-4-yl(9,9-dimethyl-9H-fluoren-2-yl)amino)-1,3,3-trimethyl-2,3-dihydro-1H-inden-1-yl)phenyl)-9,9-dimethyl-9H-fluoren-2-amine, N,N-di([1,1'-biphenyl]-4-yl)-3-(4-(di([1,1'-biphenyl]-4-yl)amino)phenyl)-1,1,3-trimethyl-2,3-dihydro-1H-inden-5-amine, N-(4-(6-(bis(9,9-dimethyl-9H-fluoren-2-yl)amino)-1,3,3-trimethyl-2,3-dihydro-1H-inden-1-yl)phenyl)-N-(9,9-dimethyl-9H-fluoren-2-yl)-9,9-dimethyl-9H-fluoren-2-amine, N-(4-(6-(9,9'-spirobi[fluoren]-2-yl(9,9-dimethyl-9H-fluoren-2-yl)amino)-1,3,3-trimethyl-2,3-dihydro-1H-inden-1-yl)phenyl)-N-(9,9-dimethyl-9H-fluoren-2-yl)-9,9'-spirobi[fluoren]-2-amine, N-(4-(6-(dibenzo[b,d]furan-2-yl(9,9-dimethyl-9H-fluoren-2-yl)amino)-1,3,3-trimethyl-2,3-dihydro-1H-inden-1-yl)phenyl)-N-(9,9-dimethyl-9H-fluoren-2-yl)dibenzo[b,d]furan-2-amine, 9-(4-(6-(9H-carbazol-9-yl)-1,3,3-trimethyl-2,3-dihydro-1H-inden-1-yl)phenyl)-9H-carbazole, N-([1,1'-biphenyl]-4-yl)-3-(4-([1,1'-biphenyl]-4-yl(4-methoxyphenyl)amino)phenyl)-N-(4-methoxyphenyl)-1,1,3-trimethyl-2,3-dihydro-1H-inden-5-amine, 3-(4-(bis(6-methoxy-[1,1'-biphenyl]-3-yl)amino)phenyl)-N,N-bis(6-methoxy-[1,1'-biphenyl]-3-yl)-1,1,3-trimethyl-2,3-dihydro-1H-inden-5-amine, N1-([1,1'-biphenyl]-4-yl)-N1-(4-(6-([1,1'-biphenyl]-4-yl(4-(diphenylamino)phenyl)amino)-1,3,3-trimethyl-2,3-dihydro-1H-inden-1-yl)phenyl)-N₄N₄-diphenylbenzene-1,4-diamine,

N,N-di([1,1'-biphenyl]-4-yl)-4'-(6-(4-(di([1,1'-biphenyl]-4-yl)amino)phenyl)-1,3,3-trimethyl-2,3-dihydro-1H-inden-1-yl)-[1,1'-biphenyl]-4-amine, N-(4-(5-(bis(9,9-dimethyl-9H-fluoren-2-yl)amino)-1,3,3-trimethyl-2,3-dihydro-1H-inden-1-yl)phenyl)-N-(9,9-dimethyl-9H-fluoren-2-yl)-9,9-dimethyl-9H-fluoren-2-amine, N-(4-(6-(bis(9,9-dimethyl-9H-fluoren-2-yl)amino)-1,3,3-trimethyl-2,3-dihydro-1H-inden-1-yl)phenyl)-N-(9,9-dimethyl-9H-fluoren-2-yl)-9,9-dimethyl-9H-fluoren-2-amine, N,N'-bis(9,9-dimethyl-fluoren-2-yl)-N,N'-diphenyl-benzidine (BF-DPB), N,N'-((9H-fluorene-9,9-diyl)bis(4,1-phenylene))bis(N-([1,1'-biphenyl]-4-yl)-[1,1'-biphenyl]-4-amine) (BPAPF), N4,N4,N4',N4'-tetrakis(9,9-dimethyl-9H-fluoren-2-yl)-[1,1'-biphenyl]-4,4'-diamine (TDMFB), N-([1,1'-biphenyl]-2-yl)-N-(9,9-dimethyl-9H-fluoren-2-yl)-9,9'-spirobi[fluoren]-2-amine, (2,7-bis[N,N-bis(4-methoxyphenyl)amino]-9,9'-spirobi[9H-fluorene] (spiro-MeO-TPD), a mixture of N-(4-(5-(bis(9,9-dimethyl-9H-fluoren-2-yl)amino)-1,3,3-trimethyl-2,3-dihydro-1H-inden-1-yl)phenyl)-N-(9,9-dimethyl-9H-fluoren-2-yl)-9,9-dimethyl-9H-fluoren-2-amine and N-(4-(6-(bis(9,9-dimethyl-9H-fluoren-2-yl)amino)-1,3,3-trimethyl-2,3-dihydro-1H-inden-1-yl)phenyl)-N-(9,9-dimethyl-9H-fluoren-2-yl)-9,9-dimethyl-9H-fluoren-2-amine, N-([1,1'-biphenyl]-4-yl)-9,9-dimethyl-N-(4-(9-phenyl-9H-carbazol-3-yl)phenyl)-9H-fluoren-2-amine and mixtures thereof.

Of course, other suitable organic semiconductor matrix materials, especially hole-conducting materials with semiconducting properties, can also be used.

Doping

The doping can take place in particular in such a manner that the molar ratio of matrix molecule to compounds of formula (I.1) or (I) is 10000 : 1 to 1:1, preferably 1000 : 1 to 2 : 1, especially 5 : 1 to 100 : 1. In particular, the doping can take place in particular in such a manner that the molar ratio of matrix molecule to compounds of formula (I) is 10000 : 1 to 1:1, preferably 1000 : 1 to 2 : 1, especially 5 : 1 to 100 : 1.

Preparation of the doped semiconductor matrix material

The doping of the particular matrix material (in the following also indicated as hole-conducting matrix HT) with the compounds of the general formula (I.1) or (I) according to the invention and used according to the invention can be produced by one or a combination of the following processes:

- a) Mixed evaporation in the vacuum with a source for HT and a source for at least one compound of the general formula (I.1) and (I) in particular at least one compound of the general formula (I).

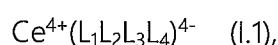
- b) Sequential deposition of HT and at least one compound of the general formula (I.1) or (I), in particular at least one compound of the general formula (I), with subsequent inward diffusion of the doping agent by thermal treatment.
- 5 c) Doping of an HT layer by a solution of at least one compound of the general formula (I.1) or (I), in particular at least one compound of the general formula (I), with subsequent evaporation of the solvent by thermal treatment.
- 10 d) Surface doping of an HT layer by a layer of at least one compound of the general formula (I.1) or (I), in particular at least one compound of the general formula (I), applied on either or both surfaces of the HT layer.
- 15 e) Preparation of a solution of host and at least one compound of the general formula (I.1) or (I), in particular at least one compound of the general formula (I), and forming a film from the solution e.g. by coating, casting or printing techniques or other film preparing techniques known to a person skilled in the art.

Another object of the invention is the use of a compound (I.1) or a mixture thereof or the use of a compound (I) or a mixture thereof, in particular the use of a compound (I) or a mixture thereof as defined above

- as organic semiconductor,
- as doping agent in organic semiconductor matrix materials, especially as p-dopant in hole transport layers,
- 25 - as electron transport material,
- as charge injector in a charge injection layer,
- as cathode material in organic batteries,
- as electrochromic material.

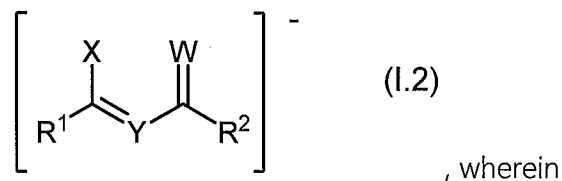
30 A further object of the invention is the use of Ce(III) complex anions obtained by reduction of a compound (I.1) or (I) as defined above or of charge transfer complexes of a compound (I.1) or (I) as defined above with electron donors as organic conductor or as electrochromic material.

35 A further object of the invention are compounds of the general formula (I.1)



and mixtures thereof, wherein

L_1 , L_2 , L_3 ; and L_4 are independently from each other a bidentate ligand having the general formula (I.2)



5

X and W independently from each other represent O, S or NR^6 ;

Y represents N or CR^3 ;

10 R^1 , R^2 independently from each other represent CN, C_1 - C_6 -alkyl, C_1 - C_6 -haloalkyl, C_1 - C_6 -alkoxy, C_1 - C_6 -haloalkoxy, C_1 - C_6 -alkylsulfanyl, C_1 - C_6 -haloalkylsulfanyl, $\text{NR}^{4a}\text{R}^{4b}$, C_6 - C_{14} -aryl or hetaryl having 4 to 13 carbon atoms, wherein hetaryl has 1, 2 or 3 identical or different heteroatoms or heteroatom-containing groups as ring members, selected from N, NR^7 , O, S, SO and SO_2 , wherein aryl and hetaryl are unsubstituted or substituted by 1, 2, 3, 4 or 5 identical or different radicals R^8 ;

15 R^3 represents hydrogen, CN, nitro, halogen, C_1 - C_6 -alkyl, C_1 - C_6 -haloalkyl, C_1 - C_6 -alkoxy, C_1 - C_6 -haloalkoxy, C_1 - C_6 -alkylsulfanyl, C_1 - C_6 -haloalkylsulfanyl, $\text{NR}^{4a}\text{R}^{4b}$, C_6 - C_{14} -aryl or hetaryl having 4 to 13 carbon atoms, wherein hetaryl has 1, 2 or 3 identical or different heteroatoms or heteroatom-containing groups as ring members, selected from N, NR^7 , O, S, SO and SO_2 , wherein aryl and hetaryl are unsubstituted or substituted by 1, 2, 3, 4 or 5 identical or different radicals R^5 ;

20 $\text{R}^{4a}\text{R}^{4b}$ independently from each other represent hydrogen, C_1 - C_6 -alkyl or C_6 - C_{14} -aryl, wherein aryl is unsubstituted or substituted by 1, 2, 3, 4 or 5 identical or different radicals R^5 ;

25 R^5 represents CN, halogen, C_1 - C_4 -alkyl or C_1 - C_4 -haloalkyl;

30 R^6 represents hydrogen, C_1 - C_6 -alkyl, C_1 - C_6 -haloalkyl, C_6 - C_{14} -aryl or hetaryl having 4 to 13 carbon atoms, wherein hetaryl has 1, 2 or 3 identical or different heteroatoms or heteroatom-containing groups as ring members, selected from N, NR^7 , O, S, SO and SO_2 , wherein aryl and hetaryl are unsubstituted or substituted by 1, 2, 3, 4 or 5 identical or different radicals R^5 ;

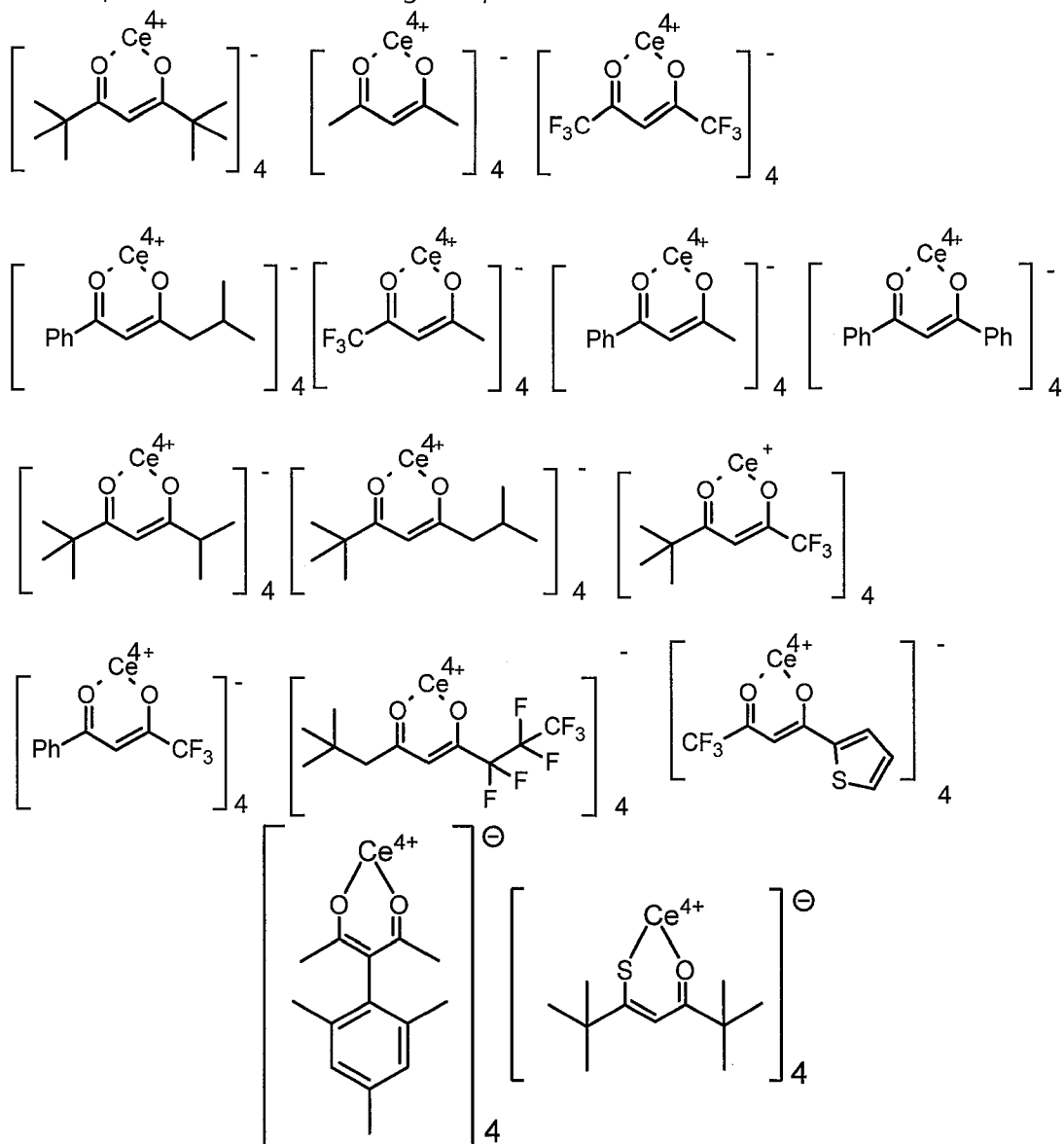
35

R^7 represents hydrogen, C_1 - C_6 -alkyl, C_1 - C_6 -haloalkyl or C_6 - C_{14} -aryl, wherein aryl is unsubstituted or substituted by 1, 2, 3, 4 or 5 identical or different radicals R^5 ;

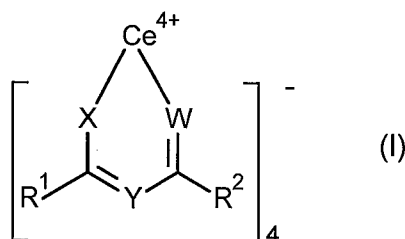
R⁸ represents CN, halogen, C₁-C₄-alkyl, C₁-C₄-haloalkyl or C₆-C₁₄-aryl, which is unsubstituted or substituted by 1, 2 or 3 identical or different radicals selected from C₁-C₄-alkyl and C₁-C₄-haloalkyl;

5

with the proviso that the following compounds are excluded:



10 A further object of the invention are compounds of the general formula (I)



and their charge transfer complexes, their reduction products and mixtures thereof, wherein

5

X and W independently from each other represent O, S or NR⁶;

Y represents N or CR³;

10 R¹, R² independently from each other represent CN, C₁-C₆-alkyl, C₁-C₆-haloalkyl, C₁-C₆-alkoxy, C₁-C₆-haloalkoxy, C₁-C₆-alkylsulfanyl, C₁-C₆-haloalkylsulfanyl, NR^{4a}R^{4b}, C₆-C₁₄-aryl or hetaryl having 4 to 13 carbon atoms, wherein hetaryl has 1, 2 or 3 identical or different heteroatoms or heteroatom-containing groups as ring members, selected from N, NR⁷, O, S, SO and SO₂, wherein aryl and hetaryl are unsubstituted or substituted by 1, 2, 3, 4 or 5 identical or different radicals R⁸;

15 R³ represents hydrogen, CN, nitro, halogen, C₁-C₆-alkyl, C₁-C₆-haloalkyl, C₁-C₆-alkoxy, C₁-C₆-haloalkoxy, C₁-C₆-alkylsulfanyl, C₁-C₆-haloalkylsulfanyl, NR^{4a}R^{4b}, C₆-C₁₄-aryl or hetaryl having 4 to 13 carbon atoms, wherein hetaryl has 1, 2 or 3 identical or different heteroatoms or heteroatom-containing groups as ring members, selected from N, NR⁷, O, S, SO and SO₂, wherein aryl and hetaryl are unsubstituted or substituted by 1, 2, 3, 4 or 5 identical or different radicals R⁵;

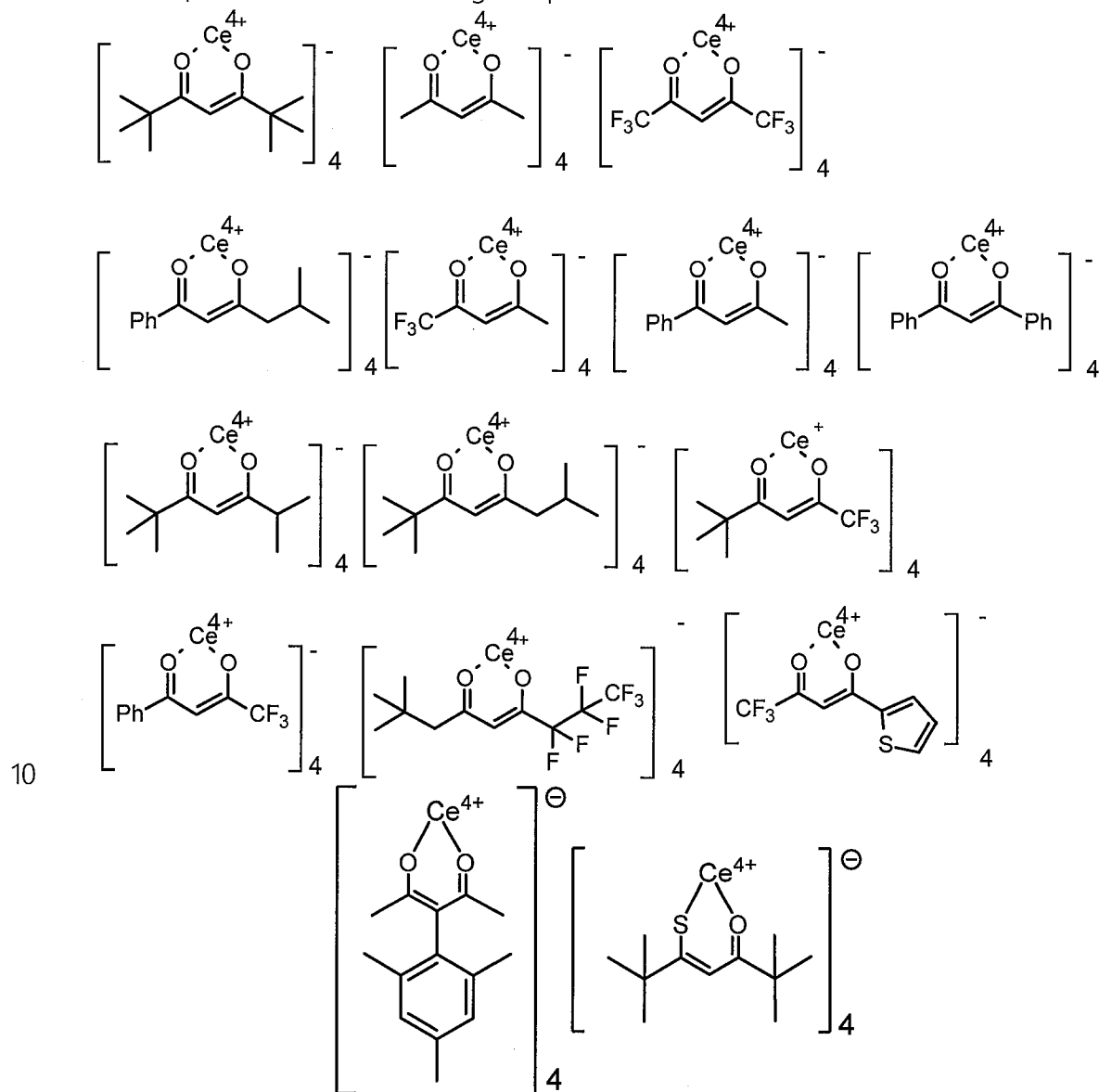
20 R^{4a}R^{4b} independently from each other represent hydrogen, C₁-C₆-alkyl or C₆-C₁₄-aryl, wherein aryl is unsubstituted or substituted by 1, 2, 3, 4 or 5 identical or different radicals R⁵;

25 R⁵ represents CN, halogen, C₁-C₄-alkyl or C₁-C₄-haloalkyl;

30 R⁶ represents hydrogen, C₁-C₆-alkyl, C₁-C₆-haloalkyl, C₆-C₁₄-aryl or hetaryl having 4 to 13 carbon atoms, wherein hetaryl has 1, 2 or 3 identical or different heteroatoms or heteroatom-containing groups as ring members, selected from N, NR⁷, O, S, SO and SO₂, wherein aryl and hetaryl are unsubstituted or substituted by 1, 2, 3, 4 or 5 identical or different radicals R⁵;

- R^7 represents hydrogen, C_1 - C_6 -alkyl, C_1 - C_6 -haloalkyl or C_6 - C_{14} -aryl, wherein aryl is unsubstituted or substituted by 1, 2, 3, 4 or 5 identical or different radicals R^5 ;
- 5 R^8 represents CN, halogen, C_1 - C_4 -alkyl, C_1 - C_4 -haloalkyl or C_6 - C_{14} -aryl, which is unsubstituted or substituted by 1, 2 or 3 identical or different radicals selected from C_1 - C_4 -alkyl and C_1 - C_4 -haloalkyl;

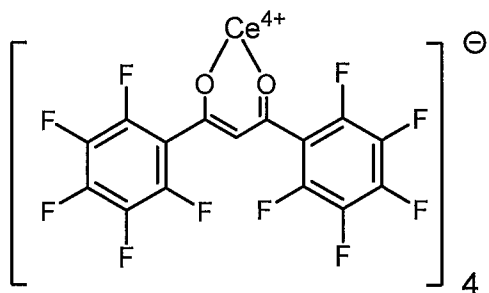
with the proviso that the following compounds are excluded:



The following examples illustrate the invention without limiting it in any way.

15 EXAMPLES

Synthesis of 1:



5

1,3-bis(perfluorophenyl)propane-1,3-dione was prepared according to literature (R. Filler et al., J. Org. Chem. 35(4), 1970, 930).

1,3-Bis(perfluorophenyl)propane-1,3-dione (1.61 g, 4.00 mmol) was dissolved in ethanol (50 ml) and 1M NaOH in ethanol (4 ml, 4 mmol) was added. The solution was stirred for 5 minutes, then ceric (IV) ammonium nitrate (0.55 g, 1 mmol) was added. The dark red solution was stirred for 2 hours. The volatiles were removed in vacuo and the residue suspended in hexane (40 ml). After refluxing for 10 min, the suspension was filtered while hot and the filtrate was allowed to cool to room temperature. Dark red crystals were isolated by vacuum filtration and dried under vacuum. The solid was recrystallized from hexane filtered and dried (0.77 g, 0.43 mmol, 44% yield).

^1H NMR (300 MHz, CDCl_3) δ 6.09.

^{19}F NMR (282 MHz, CDCl_3) δ -139.25, -139.31, -149.63, -149.70, -149.78, -160.69, -160.70, -160.73, -160.78, -160.80, -160.85, -160.88, -160.89.

Melting point: 183 °C

25 Cyclovoltametry in dichloromethane showed the following:

$$E_{1/2} \text{ (vs. Fc/Fc}^+) = +0,13 \text{ V}$$

Cyclovoltametry in acetonitrile showed the following:

30

$$E_{1/2} \text{ (vs. Fc/Fc}^+) = +0,1 \text{ V}$$

Preparation of the samples:

A substrate (laboratory glass 1x1 cm) was cleaned with acetone, ethanol and isopropanol in an ultrasonic bath.

The following solutions/concentrations were used for solvent processing:

1. spiro-MeO-TAD (N2,N2,N2',N2',N7,N7,N7',N7'-octakis(4-methoxyphenyl)-9,9'-spirobi[9H-fluoren]-2,2',7,7'-tetramine) in chlorobenzene: 30 mg/ml
2. Dopant 1 and Spiro-MeO-TAD and in chlorbenzene: 3 mg/ml (dopant 1) and 30 mg/ml Spiro-MeO-TAD

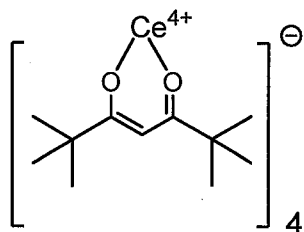
A spincoater from Sawatec AG, Switzerland, was used for the application of the layers. For this purpose, the substrate surface was wetted with solution (a drop was placed in the middle of the substrate). The spin coating was carried out for 60 seconds at 1000 rpm with closed lid and open ventilation slits. Subsequently, gold metal contacts were deposited by evaporation in a vacuum (10^{-7} mbar) (30 nm , 1 Å/s).

Conductivity Spiro-MeO-TAD without dopant: $<1\cdot10^{-9}\text{ S/cm}$

Conductivity Spiro-MeO-TAD with 10 wt% 1 as dopant: $8.4\cdot10^{-5}\text{ S/cm}$

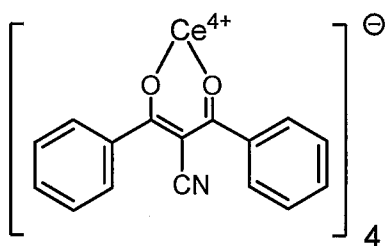
The compound has been solution processed together with the hole transport material CAS [1364603-07-5]. At a doping concentration of 4 mol% a conductivity of $2.6\cdot10^{-6}\text{ S/cm}$ has been achieved.

Synthesis of 2:



Compound 2 is commercially available and was sublimated without decomposition. The sublimation temperature T_{subl} was 130 to 140 °C (pressure; $2\cdot10^{-6}$ mbar).

Synthesis of 3:



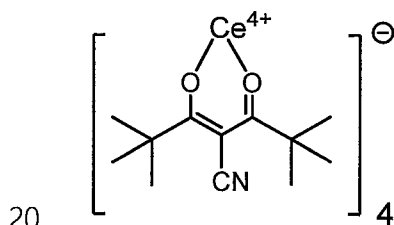
2-Benzoyl-3-oxo-3-phenylpropanenitrile was prepared according to literature (Lava R. Kadel, John R. Kromer, Curtis E. Moore, David M. Eichhorn Polyhedron 125, 2017, 206-218.).

2-Benzoyl-3-oxo-3-phenylpropanenitrile (0,50 g, 2 mmol) was dissolved in ethanol (15 ml), and 1M NaOH in ethanol (2 ml, 2 mmol) was added. The solution was stirred for 5 minutes, then ceric(IV) ammonium nitrate (0,27 g, 0,5 mmol) dissolved in ethanol (5 ml) was added. The dark red solution was stirred for 15 min and after that filtered. The dark solid was washed with water (100ml) and ethanol (10 ml) and dried. 460 mg of a dark red solid were obtained.

Cyclovoltametry in dichloromethane showed the following potential:

$$E_{1/2} \text{ (vs. Fc/Fc}^+) = +0,03 \text{ V}$$

Synthesis of 4:



4,4-Dimethyl-3-oxo-2-pivaloylpentanenitrile was prepared according to literature (C.M. Silvernail et al., Polyhedron 20, 2001, 3113.).

4,4-Dimethyl-3-oxo-2-pivaloylpentanenitril (0,84 g, 4 mmol) was dissolved in ethanol (30 ml), and 1M NaOH in ethanol (4 ml, 4 mmol) was added. The solution was stirred for 5 minutes, then ceric(IV) ammonium nitrate (0,55 g, 1 mmol) dissolved in ethanol (10 ml) was added. The dark red solution was stirred for 15 min. The solvent was removed in vacuo. The residue was extracted with diethylether (50 ml) and filtered. The solvent of the filtrate was removed under vacuum. Dark red solid, 500 mg, 51 % yield.

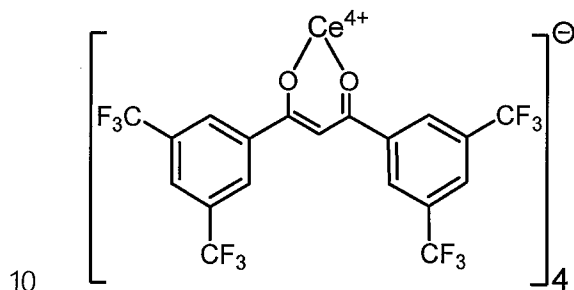
Compound 4 was sublimated. A dark red solid was obtained. The sublimation temperature T_{subl} was 160 °C (pressure; $2 \cdot 10^{-6}$ mbar).

Cyclovoltametry in dichloromethane showed the following potential:

5

$$E_{1/2} \text{ (vs. Fc/Fc}^+) = -0,08 \text{ V}$$

Synthesis of 5



Diisopropylamine (3 g, 30 mmol) was dissolved in 25 mL dry toluene. The solution was cooled to 0°C and n-BuLi (n-butyllithium, 1.6M in hexane, 19 mL, 30 mmol) was added. After 10 min, 3',5'-Bis(trifluoromethyl)acetophenone (7.68 g, 30 mmol) was added. After 15 1 min, 3',5' bis(trifluoromethyl)benzoyl chloride (5.5 g, 20 mmol) was added and the cooling bath was removed. After 2 min, acetic acid conc. (10 mL) was added followed by 20 mL of water and 10 mL of toluene. The two phases were separated, the organic phase was dried over MgSO_4 and rotated off under reduced pressure. The crude diketone was recrystallized from hexane (yield of 1,3-bis(3,5-bis(trifluoromethyl)phenyl)propane-1,3-dione 3.2 g, 6.45 mmol, 33%). 20

1,3-bis(3,5-bis(trifluoromethyl)phenyl)propane-1,3-dione (2.57 g, 5.18 mmol) was dissolved in ethanol (100 ml) and 1M NaOH in ethanol (5.2 ml, 5.2 mmol) was added. The solution was stirred for 5 minutes, then a solution of ceric ammonium nitrate (0.71 g, 25 1.3 mmol) in ethanol (40 ml) was added. The dark red solution was stirred for 15 min and filtered. The volatiles were removed in vacuo and the residue was redissolved in dichloromethane (DCM, 300 ml) and washed with water (100 ml). The organic phase was then dried over MgSO_4 and concentrated under reduced pressure. Hexane (400 mL) was added to yield purple crystals, which were filtered and dried under vacuum (2.5 g, 30 1.17 mmol, 90% yield).

Melting point: 237°C (onset) at 10 K/min, determined with DSC

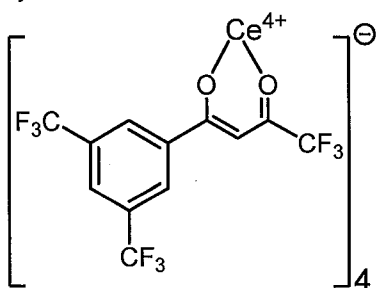
Cyclovoltametry in acetonitrile showed the following potential:

$E_{1/2}$ (vs. Fc/Fc⁺ (MeCN)): = -0.04 V

The compound 5 was co-evaporated with the hole transport material spiro-MeO-TPD (2,7-bis[N,N-bis(4-methoxyphenyl)amino]-9,9-spirobi[9H-fluorene]. At a doping concentration of 3 mol% a conductivity of $8.2 \cdot 10^{-5}$ S/cm has been achieved.

The compound was co-evaporated with the hole transport material MeO-TPD (N,N,N',N'-tetrakis(4-methoxy-phenyl)benzidine). At a doping concentration of 3 mol% a conductivity of $5.2 \cdot 10^{-5}$ S/cm has been achieved.

Synthesis of 6



1-(3,5-bis(trifluoromethyl)phenyl)-4,4,4-trifluorobutane-1,3-dione was prepared according to literature (Liu et al., Molecules 2016, 21, 828.).

1-(3,5-bis(trifluoromethyl)phenyl)-4,4,4-trifluorobutane-1,3-dione (2 g, 5.68 mmol) was dissolved in ethanol (50 ml) and 1M NaOH in ethanol (5.6 ml, 5.6 mmol) was added. The solution was stirred for 5 minutes, then a solution of ceric (IV) ammonium nitrate (0.78 g, 1.42 mmol) in ethanol (20 ml) was added. The dark red solution was stirred for 15 min and filtered. The volatiles were removed in vacuo and the residue redissolved in dichloromethane (300 ml), washed with water (100 ml). The organic phase was then dried over MgSO₄ and concentrated under reduced pressure. Hexane (50 mL) was added to the mixture and the latter was stored at -20°C overnight. The isolated solid was then recrystallized from hot hexane (1 g, 0.64 mmol, 45%).

Melting point: 155°C (peak) at 10 K/min determined with DSC

Cyclovoltametry in acetonitrile showed the following potential:

$E_{1/2}$ (vs. Fc/Fc⁺ (MeCN)): = +0.35 V

The compound 6 was co-evaporated with the hole transport material BF-DPB (N,N'-bis(9,9-dimethyl-fluoren-2-yl)-N,N'-diphenyl-benzidine). With a doping concentration of 6 mol% a conductivity of $7.2 \cdot 10^{-6}$ S/cm has been achieved.

The compound was co-evaporated with the hole transport material MeO-TPD.

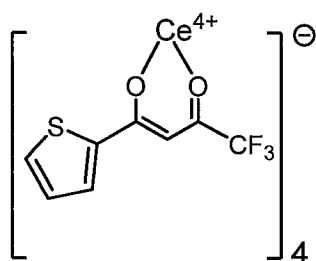
- 5 With a doping concentration of 9 mol% a conductivity of $1.6 \cdot 10^{-4}$ S/cm has been achieved.

The compound was co-evaporated with the hole transport material BPAPF.

With a doping concentration of 13 mol % a conductivity of $3 \cdot 10^{-5}$ S/cm has been achieved.

10

Synthesis of 7



- 15 4,4,4-trifluoro-1-(thiophen-2-yl)butane-1,3-dione is commercial available.

4,4,4-trifluoro-1-(thiophen-2-yl)butane-1,3-dione (1.8 g, 8.1 mmol) was dissolved in ethanol (40 ml) and 1M NaOH in ethanol (8.1 ml, 8.1 mmol) was added. The solution was stirred for 5 minutes, then a solution of ceric (IV) ammonium nitrate (1.11 g, 2 mmol) in ethanol (20 ml) was added. The dark red precipitate was stirred for 15 min and filtered. The solid was rinsed with water (100 ml). The latter was redissolved in dichloromethane (400 ml) and washed with water (2x200 ml). The organic phase was then dried over MgSO₄ and concentrated under reduced pressure. Hexane (300 mL) was added to yield purple crystals, which were filtered, rinsed with hexane (50 ml), pentane (50 ml) and dried under vacuum (1.5 g, 1.46 mmol, 73% yield).

25

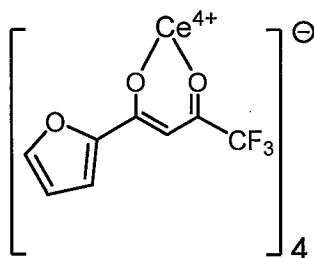
Melting point: 209°C (peak) at 10 K/min determined with DSC

Cyclovoltametry in acetonitrile showed the following potential:

30

$E_{1/2}$ (vs. Fc/Fc⁺ (MeCN)): = +0.20 V

Synthesis of 8



4,4,4-trifluoro-1-(furan-2-yl)butane-1,3-dione is commercial available.

- 5 4,4,4-trifluoro-1-(furan-2-yl)butane-1,3-dione (1.57 g, 7.6 mmol) was dissolved in ethanol (40 ml) and 1M NaOH in ethanol (7.6 ml, 7.6 mmol) was added. The solution was stirred for 5 minutes, then a solution of ceric (IV) ammonium nitrate (1.04 g, 1.9 mmol) in ethanol (20 ml) was added. The dark red precipitate was stirred for 15 min and filtered. The solid was rinsed with water (100 ml). The latter was redissolved in dichloromethane (300 ml) and washed with water (100 ml). The organic phase was then dried over MgSO_4 and concentrated under reduced pressure. Hexane (200 mL) was added to yield to purple crystals, which were filtered, rinsed with pentane (100 ml) and dried under vacuum (yield: 1.2 g, 1.32 mmol, 66%).

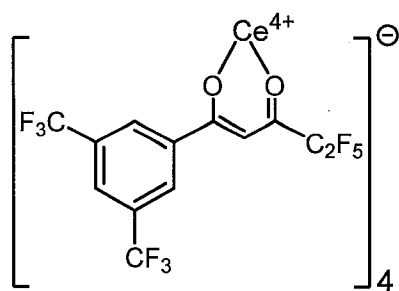
- 15 Melting point: 166°C (peak) at 10 K/min determined with DSC.

Cyclovoltametry in acetonitrile showed the following potential:

$$E_{1/2} \text{ (vs. Fc/Fc}^+ \text{ (MeCN))} = +0.24 \text{ V}$$

20

Synthesis of 9



- 25 3',5' Bis(trifluoromethyl)acetophenone (4.32 g, 16.9 mmol) and ethyl 2,2,3,3,3-pentafluoropropionate (4.86 g, 25.3 mmol) were dissolved in dry methanol (100 ml). MeONa (1.82, 33.8 mmol) in methanol (10 ml) was added and the mixture was refluxed for 2 hours. The resulting solutions was evaporated under reduced pressure. The crude was redissolved in EtOAc (100 ml) and HCl (6 M, 50 ml) was added. The organic phase

was separated, dried over MgSO_4 and rotated off. The red oily diketone was purified by vacuum distillation yielding to a pale yellow oil of 1-(3,5-bis(trifluoromethyl)phenyl)-4,4,5,5,5-pentafluoropentane-1,3-dione (yield: 4.8 g, 12 mmol, 71%).

- 5 1-(3,5-Bis(trifluoromethyl)phenyl)-4,4,5,5,5-pentafluoropentane-1,3-dione (2.22 g, 5.52 mmol) was dissolved in ethanol (50 ml) and 1M NaOH in ethanol (5.5 ml, 5.5 mmol) was added. The solution was stirred for 5 minutes, then a solution of ceric ammonium nitrate (0.76 g, 1.38 mmol) in ethanol (15 ml) was added. The dark red solution was stirred for 15 min and filtered. The solution was evaporated under reduced pressure. The red oil was
 10 extracted with hexane (10 ml) and crystallized upon standing overnight at room temperature. The isolated solid was recrystallized from hot hexane and stored at -20°C (yield 2.02 g, 1.16 mmol, 84%).

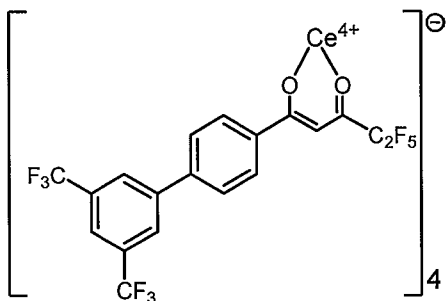
Melting point: 129°C (peak) at 10 K/min determined with DSC

15

Cyclovoltametry in acetonitrile showed the following potential:

$E_{1/2}$ (vs. Fc/Fc^+ (MeCN): = $+0.46\text{ V}$

- 20 Synthesis of 10



- 1-(3',5'-Bis(trifluoromethyl)-[1,1'-biphenyl]-4-yl)ethan-1-one (4 g, 12mmol) was dissolved
 25 in THF (50 mL). The mixture was cooled to 0°C and NaH (1.44g, 60 mmol) was added. The reaction mixture was stirred for 20 min, then ethyl 2,2,3,3,3-pentafluoropropanoate (6.9 g, 36 mmol) was added. The cold bath was removed and the mixture was stirred overnight. The solution was concentrated under reduced pressure, water (20 mL) was added followed by HCl (6M, 15 mL). The mixture was extracted with ethyl acetate (300
 30 mL). The organic phase was washed with water (50 mL) and brine (50 mL), dried over MgSO_4 and rotated off. The crude material was purified by filtration over silica (DCM as eluent), yielding a pale red solid of 1-(3',5'-bis(trifluoromethyl)-[1,1'-biphenyl]-4-yl)-4,4,4-trifluorobutane-1,3-dione (yield: 3.2 g, 62 %).

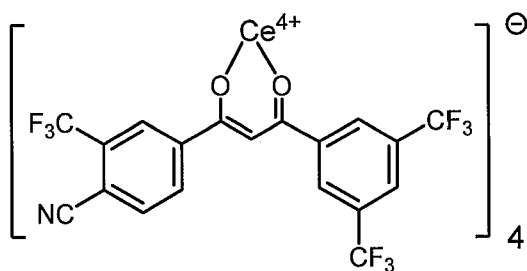
1-(3',5'-bis(trifluoromethyl)-[1,1'-biphenyl]-4-yl)-4,4,5,5,5-pentafluoropentane-1,3-dione (1.52 g, 3.17 mmol) was dissolved in ethanol (50 ml) and 1M NaOH in ethanol (3.2 ml, 3.2 mmol) was added. The solution was stirred for 5 minutes, then a solution of ceric (IV) ammonium nitrate (0.43 g, 0.79 mmol) in ethanol (20 ml) was added. The dark red solution was stirred for 15 min and filtered. The volatiles were removed in vacuo and the residue was redissolved in DCM (250 ml) and washed with water (100 ml). The organic phase was dried over MgSO_4 and rotated off under reduced pressure. The mixture was redissolved in DCM (50 mL) and hexane (200 mL) was added. The solution was concentrated under reduced pressure and stored at -20°C yielding dark red crystals, which were filtered and dried under vacuum (yield 0.6 g, 0.3 mmol, 37%).

Melting point: 214°C (peak) at 10 K/min determined with DSC

Cyclovoltametry in acetonitrile showed the following potential:

$E_{1/2}$ (vs. Fc/Fc^+): = +0.43 V

Synthesis of 11



Methyl 4-cyano-3-(trifluoromethyl)benzoate (2.09 g, 9.12 mmol) was dissolved in THF (50 mL). The mixture was cooled to 0°C and NaH (706 mg, 29.4 mmol) was added. The reaction mixture was stirred for 20 min, then 1-(3,5-bis(trifluoromethyl)phenyl)ethan-1-one (1.95 g, 7.6 mmol) was added. The cold bath was removed and the mixture was stirred overnight. The solution was concentrated under reduced pressure, water (10 mL) was added followed by HCl (6M, 10 mL). The mixture was extracted with ethyl acetate (40 mL). The organic phase was washed with water (50 mL) and brine (50 mL), dried over MgSO_4 and rotated off. The crude material was purified by recrystallization from hot EtOH, yielding a colorless microcrystalline solid (1.32 g, 39 %).

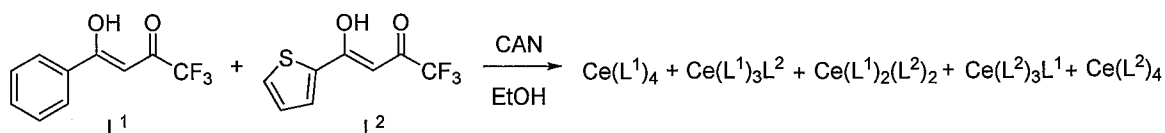
Complex :

4-(3-(3,5-bis(trifluoromethyl)phenyl)-3-oxopropanoyl)-2-(trifluoromethyl)benzonitrile (1.32 g, 2.91 mmol) was dissolved in EtOH (50 ml) and 1M NaOH in EtOH (2.9 ml, 2.9 mmol)

was added. The solution was stirred for 5 minutes, then a solution of ceric ammonium nitrate (0.4 g, 0.73 mmol) in EtOH (20 ml) was added. The dark red solution was stirred for 15 min and concentrated under reduced pressure. The dark red precipitate was filtered and rinsed with water (50 mL), EtOH (5 mL) and hexanes (15 mL). The isolated solid was dried under vacuum (1.06 g, 1.16 mmol, 75%).

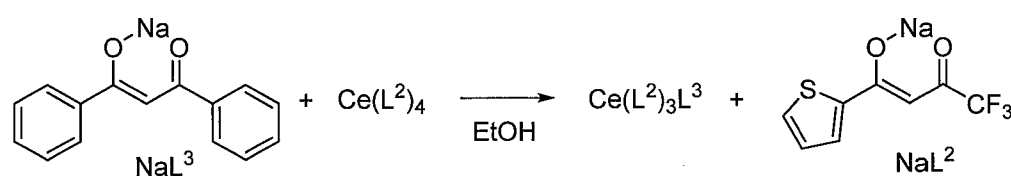
Potential measured in acetonitrile +0,10V vs. Fc/Fc⁺.

Synthesis of 12 (mixture of homoleptic and heteroleptic cer-complexes)



A mixture of the ligands L¹ (1.00 g) and L² (1.02 g) with the molar ratio of 1:1) has been dissolved in 10 ml of EtOH. 9.2 ml of a 1M-solution of NaOH in EtOH was added in one portion while stirring. 1.26 g of ceric ammonium nitrate (CAN) dissolved in 10 ml of EtOH were added dropwise. The red precipitated was filtered off and washed two times with water. After drying the red powder was analyzed by mass spectrometry (Atmospheric Pressure Chemical Ionization APCI-, Advion ASAP Mass Spectrometer). The mass spectrum indicated formation of the two homoleptic complexes Ce(L¹)₄ and Ce(L²)₄ as well as all possible heteroleptic complexes as depicted above.

Synthesis of 13: (heteroleptic cer-complex)



52 mg of ligand salt NaL³ were dissolved in 10 ml EtOH and 216 mg of the complex Ce(L²)₄ were added. To the resulting suspension, 5 ml of THF were added and a homogeneous red solution was formed. Mass spectrometric analysis (Atmospheric Pressure Chemical Ionization APCI-, Advion ASAP Mass Spectrometer) of that solution showed partial formation of the new complex Ce(L²)₃L³.

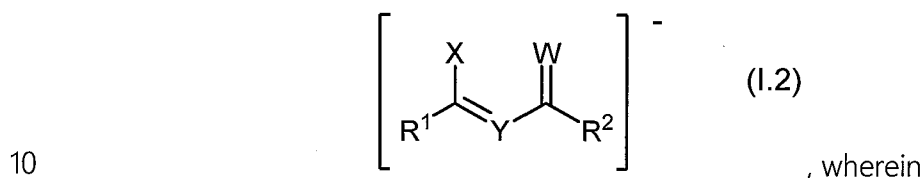
Claims

1. Electronic component comprising at least one compound of the general formula (I.1)



or mixtures thereof, wherein

L_1 ; L_2 ; L_3 ; and L_4 are independently from each other selected from a bidentate ligand having the general formula (I.2)



X and W independently from each other represent O, S or NR^6 ;

Y represents N or CR^3 ;

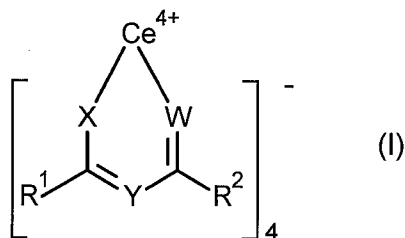
15 R^1 , R^2 independently from each other represent CN, C_1 - C_6 -alkyl, C_1 - C_6 -haloalkyl, C_1 - C_6 -alkoxy, C_1 - C_6 -haloalkoxy, C_1 - C_6 -alkylsulfanyl, C_1 - C_6 -haloalkylsulfanyl, $\text{NR}^{4a}\text{R}^{4b}$, C_6 - C_{14} -aryl or hetaryl having 4 to 13 carbon atoms, wherein hetaryl has 1, 2 or 3 identical or different heteroatoms or heteroatom-containing groups as ring members, selected from N, NR^7 , O, S, SO and SO_2 , wherein aryl and hetaryl are unsubstituted or substituted by 1, 2, 3, 4 or 5 identical or different radicals R^8 ;

25 R^3 represents hydrogen, CN, nitro, halogen, C_1 - C_6 -alkyl, C_1 - C_6 -haloalkyl, C_1 - C_6 -alkoxy, C_1 - C_6 -haloalkoxy, C_1 - C_6 -alkylsulfanyl, C_1 - C_6 -haloalkylsulfanyl, $\text{NR}^{4a}\text{R}^{4b}$, C_6 - C_{14} -aryl or hetaryl having 4 to 13 carbon atoms, wherein hetaryl has 1, 2 or 3 identical or different heteroatoms or heteroatom-containing groups as ring members, selected from N, NR^7 , O, S, SO and SO_2 , wherein aryl and hetaryl are unsubstituted or substituted by 1, 2, 3, 4 or 5 identical or different radicals R^5 ;

30 $\text{R}^{4a}\text{R}^{4b}$ independently from each other represent hydrogen, C_1 - C_6 -alkyl or C_6 - C_{14} -aryl, wherein aryl is unsubstituted or substituted by 1, 2, 3, 4 or 5 identical or different radicals R^5 ;

35

- 5 R^5 represents CN, halogen, C_1 - C_4 -alkyl or C_1 - C_4 -haloalkyl;
- 10 R^6 represents hydrogen, C_1 - C_6 -alkyl, C_1 - C_6 -haloalkyl, C_6 - C_{14} -aryl or hetaryl having 4 to 13 carbon atoms, wherein hetaryl has 1, 2 or 3 identical or different heteroatoms or heteroatom-containing groups as ring members, selected from N, NR^7 , O, S, SO and SO_2 , wherein aryl and hetaryl are unsubstituted or substituted by 1, 2, 3, 4 or 5 identical or different radicals R^5 ;
- 15 R^7 represents hydrogen, C_1 - C_6 -alkyl, C_1 - C_6 -haloalkyl or C_6 - C_{14} -aryl, wherein aryl is unsubstituted or substituted by 1, 2, 3, 4 or 5 identical or different radicals R^5 ;
- 20 R^8 represents CN, halogen, C_1 - C_4 -alkyl, C_1 - C_4 -haloalkyl or C_6 - C_{14} -aryl, which is unsubstituted or substituted by 1, 2 or 3 identical or different radicals selected from C_1 - C_4 -alkyl and C_1 - C_4 -haloalkyl.
2. Electronic component according to claim 1 comprising at least one compound of the general formula (I)



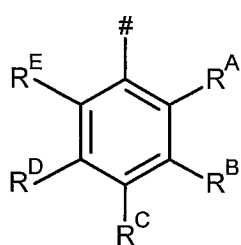
or mixtures thereof, wherein

- 25 X and W independently from each other represent O, S or NR^6 ;
- Y represents N or CR^3 ;
- 30 R^1 , R^2 independently from each other represent CN, C_1 - C_6 -alkyl, C_1 - C_6 -haloalkyl, C_1 - C_6 -alkoxy, C_1 - C_6 -haloalkoxy, C_1 - C_6 -alkylsulfanyl, C_1 - C_6 -haloalkylsulfanyl, $NR^{4a}R^{4b}$, C_6 - C_{14} -aryl or hetaryl having 4 to 13 carbon atoms, wherein hetaryl has 1, 2 or 3 identical or different heteroatoms or heteroatom-containing groups as ring members, selected from N, NR^7 , O, S, SO and SO_2 , wherein aryl and hetaryl

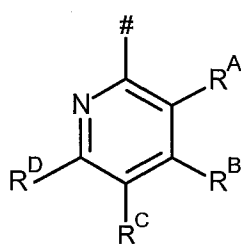
are unsubstituted or substituted by 1, 2, 3, 4 or 5 identical or different radicals R⁸;

- 5 R³ represents hydrogen, CN, nitro, halogen, C₁-C₆-alkyl, C₁-C₆-haloalkyl, C₁-C₆-alkoxy, C₁-C₆-haloalkoxy, C₁-C₆-alkylsulfanyl, C₁-C₆-haloalkylsulfanyl, NR^{4a}R^{4b}, C₆-C₁₄-aryl or hetaryl having 4 to 13 carbon atoms, wherein hetaryl has 1, 2 or 3 identical or different heteroatoms or heteroatom-containing groups as ring members, selected from N, NR⁷, O, S, SO and SO₂, wherein aryl and hetaryl are unsubstituted or substituted by 1, 2, 3, 4 or 5 identical or different radicals R⁵;
- 10
- 15 R^{4a}R^{4b} independently from each other represent hydrogen, C₁-C₆-alkyl or C₆-C₁₄-aryl, wherein aryl is unsubstituted or substituted by 1, 2, 3, 4 or 5 identical or different radicals R⁵;
- 20 R⁵ represents CN, halogen, C₁-C₄-alkyl or C₁-C₄-haloalkyl;
- 25 R⁶ represents hydrogen, C₁-C₆-alkyl, C₁-C₆-haloalkyl, C₆-C₁₄-aryl or hetaryl having 4 to 13 carbon atoms, wherein hetaryl has 1, 2 or 3 identical or different heteroatoms or heteroatom-containing groups as ring members, selected from N, NR⁷, O, S, SO and SO₂, wherein aryl and hetaryl are unsubstituted or substituted by 1, 2, 3, 4 or 5 identical or different radicals R⁵;
- 30 R⁷ represents hydrogen, C₁-C₆-alkyl, C₁-C₆-haloalkyl or C₆-C₁₄-aryl, wherein aryl is unsubstituted or substituted by 1, 2, 3, 4 or 5 identical or different radicals R⁵;
- 35 R⁸ represents CN, halogen, C₁-C₄-alkyl, C₁-C₄-haloalkyl or C₆-C₁₄-aryl, which is unsubstituted or substituted by 1, 2 or 3 identical or different radicals selected from C₁-C₄-alkyl and C₁-C₄-haloalkyl.
- 40 3. Electronic component according to claim 1 or 2, wherein R¹ and R² in formula (I) and ligands of formula (I.2) are independently selected from CN, C₁-C₆-alkyl, C₁-C₆-haloalkyl, C₁-C₆-alkoxy, C₁-C₆-haloalkoxy, C₁-C₆-alkylsulfanyl, C₁-C₆-haloalkylsulfanyl, NR^{4a}R^{4b} and the group A consisting of A1, A2, A3, A4, A5, A6, A7, A8, A9, A10, A11, A12, A13, A14, A15, A16, A17, A18 and A19

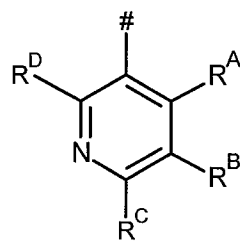
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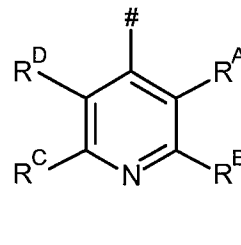
A 1



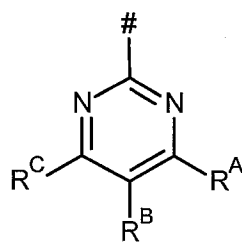
A 2



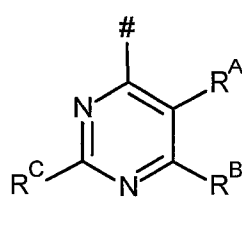
A 3



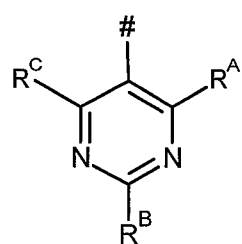
A 4



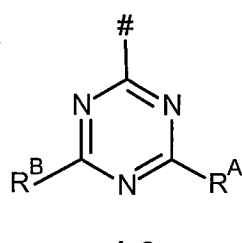
A 5



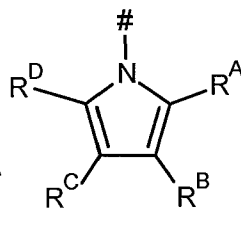
A 6



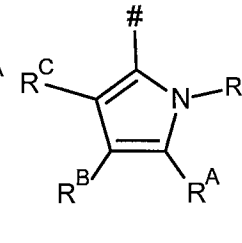
A 7



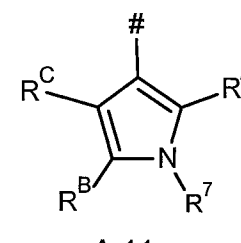
A 8



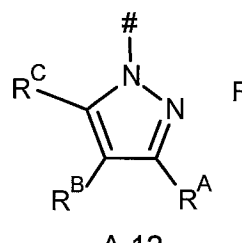
A 9



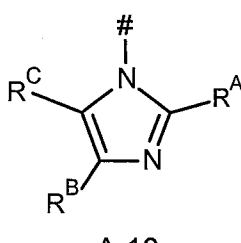
A 10



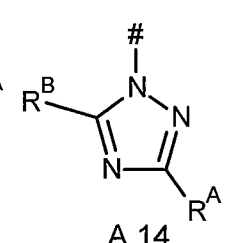
A 11



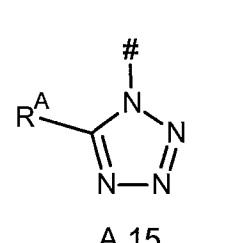
A 12



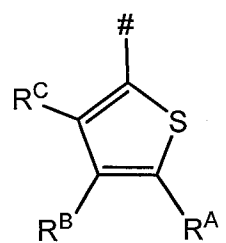
A 13



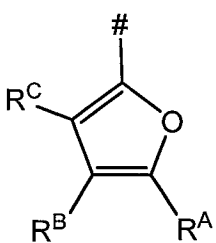
A 14



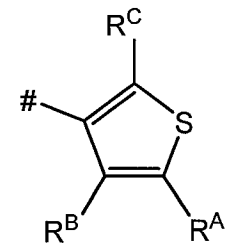
A 15



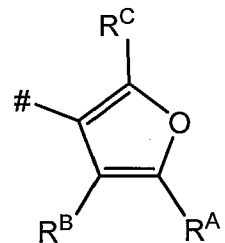
A 16



A 17



A 18



A 19

where # denotes the bond to the remaining molecule of formulae (I.2) and (I),

R^A , R^B , R^C , R^D and R^E are independently selected from hydrogen, CN, halogen, C_1 - C_4 -alkyl, C_1 - C_4 -haloalkyl and phenyl, which is unsubstituted or substituted by 1, 2 or 3 identical or different radicals selected from C_1 - C_4 -alkyl and C_1 - C_4 -haloalkyl;

5

R^{4a} , R^{4b} independently represent hydrogen, C_1 - C_6 -alkyl or C_6 - C_{14} -aryl, wherein aryl is unsubstituted or substituted by 1, 2, 3, 4 or 5 identical or different radicals R^5 ;

10

R^5 represents CN, halogen, C_1 - C_4 -alkyl or C_1 - C_4 -haloalkyl; and

R^7 represents hydrogen, C_1 - C_6 -alkyl, C_1 - C_6 -haloalkyl or C_6 - C_{14} -aryl, wherein aryl is unsubstituted or substituted by 1, 2, 3, 4 or 5 identical or different radicals R^5 .

15

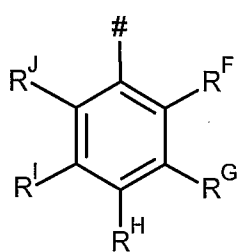
4. Electronic component according to claim 3, wherein in A1, A2, A3, A4, A5, A6, A7, A8, A9, A10, A11, A12, A13, A14 and A15 the radicals R^A , R^B , R^C , R^D and R^E are independently from another selected from hydrogen, CN, fluorine, chlorine, C_1 - C_4 -alkyl, C_1 - C_4 -fluoroalkyl, C_1 - C_4 -chloroalkyl and phenyl, which is unsubstituted or substituted by 1, 2 or 3 identical or different radicals selected from C_1 - C_4 -haloalkyl.

20

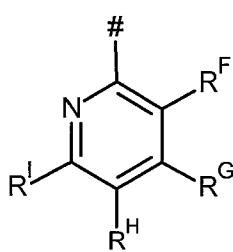
5. Electronic component according to any one of the preceding claims, wherein in formula(I) and ligands of formula (I.2) Y represents the radical CR^3 , wherein R^3 is selected from hydrogen, CN, nitro, halogen, CF_3 and the group B consisting B1, B2, B3, B4, B5, B6, B7, B8, B9, B10, B11, B12, B13, B14 and B15

25

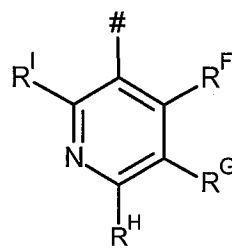
73



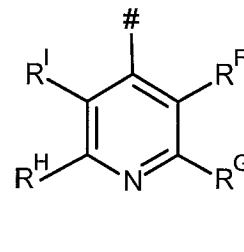
B 1



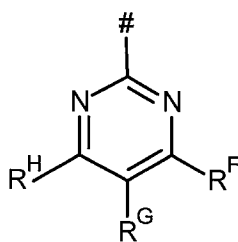
B 2



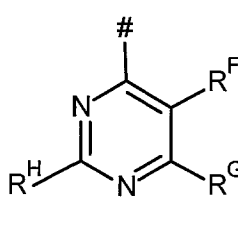
B 3



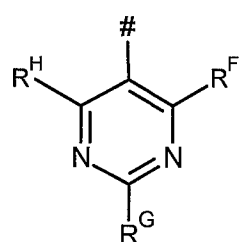
B 4



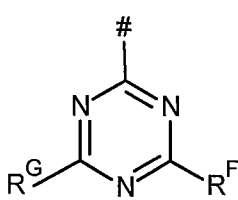
B 5



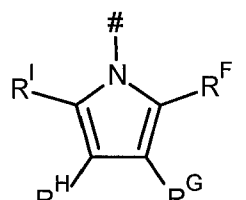
B 6



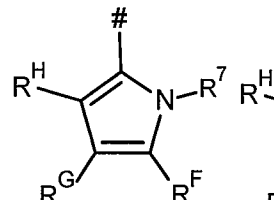
B 7



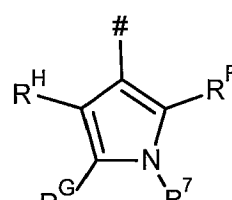
B 8



B 9

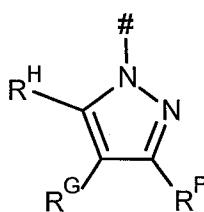


B 10

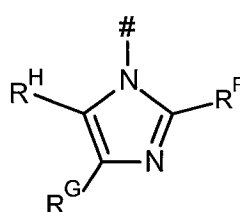


B 11

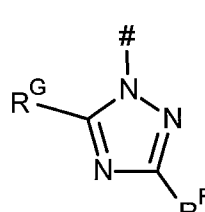
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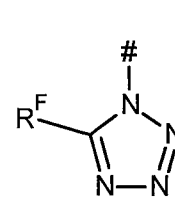
B 12



B 13



B 14



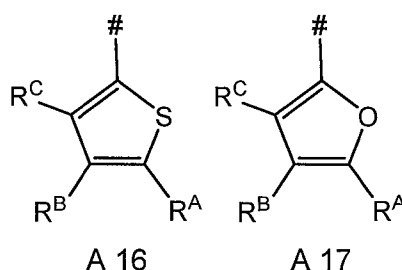
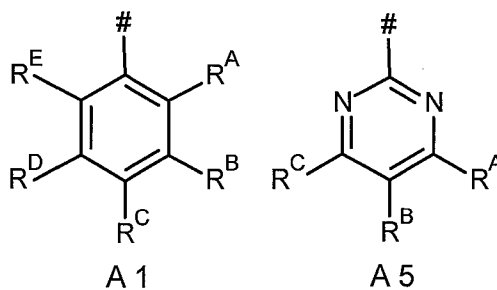
B 15

where # denotes the bond to the remaining molecule of formulae (I.2) and (I),

10 R^F , R^G , R^H , R^I and R^J are independently selected from hydrogen, CN, halogen, C_1 - C_4 -alkyl and C_1 - C_4 -haloalkyl; and

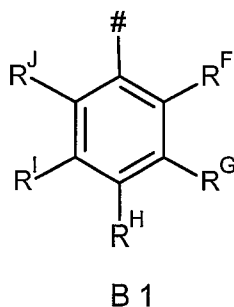
R^7 represents hydrogen, C_1 - C_6 -alkyl, C_1 - C_6 -haloalkyl or C_1 - C_{14} -aryl, wherein aryl is
15 unsubstituted or substituted by 1, 2, 3, 4 or 5 identical or different radicals R^5 .

6. Electronic component according to any one of the preceding claims, wherein in formula (I) and ligands of formula (I.2) R^1 and R^2 are independently selected from C_1 - C_4 -alkyl, C_1 - C_4 -haloalkyl, A1, A5, A16 and A17



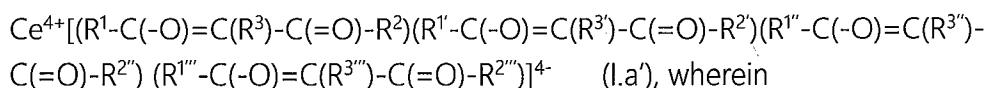
where # denotes the bond to the remaining molecule of formulae (I.2) and (I), and wherein R^A , R^B , R^C , R^D and R^E are independently selected from hydrogen, CN, fluorine, chlorine, C_1 - C_4 -alkyl, C_1 - C_4 -fluoroalkyl, C_1 - C_4 -chloroalkyl and phenyl, which is unsubstituted or substituted by 1, 2 or 3 identical or different radicals selected from C_1 - C_4 -haloalkyl.

7. Electronic component according to any one of the preceding claims, wherein in formula (I) and ligands of formula (I.2) Y represents a radical CR^3 and wherein R^3 is selected from hydrogen, CN, nitro, halogen, CF_3 and B1



where # denotes the bond to the remaining molecule of formulae (I.2) and (I), and wherein R^F , R^G , R^H , R^I and R^J are independently selected from hydrogen, CN, fluorine and chlorine.

- 5 8. Electronic component according to claims 1 or 2, wherein the compounds of formula (I.1) or (I) are selected from compounds of formula (I.a')



10

(R^1 , R^2 , R^3), ($R^{1'}$, $R^{2'}$, $R^{3'}$), ($R^{1''}$, $R^{2''}$, $R^{3''}$) and ($R^{1'''}$, $R^{2'''}$, $R^{3'''}$) are each selected from the definition given in one line of the following table

$R^1, R^{1'}, R^{1''}, R^{1'''}$	$R^2, R^{2'}, R^{2''}, R^{2'''}$	$R^3, R^{3'}, R^{3''}, R^{3'''}$
methyl	methyl	H
methyl	methyl	CN
methyl	methyl	F
methyl	methyl	Cl
methyl	methyl	NO ₂
methyl	methyl	pentafluorophenyl
methyl	methyl	tetrafluoro-2-(trifluoromethyl)phenyl
methyl	methyl	tetrafluoro-3-(trifluoromethyl)phenyl
methyl	methyl	tetrafluoro-4-(trifluoromethyl)phenyl
methyl	methyl	tetrafluoro-2-pyridyl
methyl	methyl	tetrafluoro-3-pyridyl
methyl	methyl	tetrafluoro-4-pyridyl
methyl	methyl	tetrafluoro-2-benzonitrile
methyl	methyl	tetrafluoro-3-benzonitrile
methyl	methyl	tetrafluoro-4-benzonitrile
trifluoromethyl	trifluoromethyl	H
trifluoromethyl	trifluoromethyl	CN
trifluoromethyl	trifluoromethyl	F
trifluoromethyl	trifluoromethyl	Cl
trifluoromethyl	trifluoromethyl	NO ₂
trifluoromethyl	trifluoromethyl	pentafluorophenyl
trifluoromethyl	trifluoromethyl	tetrafluoro-2-(trifluoromethyl)phenyl
trifluoromethyl	trifluoromethyl	tetrafluoro-3-(trifluoromethyl)phenyl
trifluoromethyl	trifluoromethyl	tetrafluoro-4-(trifluoromethyl)phenyl

R ¹ , R ^{1'} , R ^{1''} , R ^{1'''}	R ² , R ^{2'} , R ^{2''} , R ^{2'''}	R ³ , R ^{3'} , R ^{3''} , R ^{3'''}
trifluoromethyl	trifluoromethyl	tetrafluoro-2-pyridyl
trifluoromethyl	trifluoromethyl	tetrafluoro-3-pyridyl
trifluoromethyl	trifluoromethyl	tetrafluoro-4-pyridyl
trifluoromethyl	trifluoromethyl	tetrafluoro-2-benzonitrile
trifluoromethyl	trifluoromethyl	tetrafluoro-3-benzonitrile
trifluoromethyl	trifluoromethyl	tetrafluoro-4-benzonitrile
pentafluoroethyl	pentafluoroethyl	H
pentafluoroethyl	pentafluoroethyl	CN
pentafluoroethyl	pentafluoroethyl	F
pentafluoroethyl	pentafluoroethyl	Cl
pentafluoroethyl	pentafluoroethyl	NO ₂
pentafluoroethyl	pentafluoroethyl	pentafluorophenyl
pentafluoroethyl	pentafluoroethyl	tetrafluoro-2-(trifluoromethyl)phenyl
pentafluoroethyl	pentafluoroethyl	tetrafluoro-3-(trifluoromethyl)phenyl
pentafluoroethyl	pentafluoroethyl	tetrafluoro-4-(trifluoromethyl)phenyl
pentafluoroethyl	pentafluoroethyl	tetrafluoro-2-pyridyl
pentafluoroethyl	pentafluoroethyl	tetrafluoro-3-pyridyl
pentafluoroethyl	pentafluoroethyl	tetrafluoro-4-pyridyl
pentafluoroethyl	pentafluoroethyl	tetrafluoro-2-benzonitrile
pentafluoroethyl	pentafluoroethyl	tetrafluoro-3-benzonitrile
pentafluoroethyl	pentafluoroethyl	tetrafluoro-4-benzonitrile
heptafluoro-n-propyl	heptafluoro-n-propyl	H
heptafluoro-n-propyl	heptafluoro-n-propyl	CN
heptafluoro-n-propyl	heptafluoro-n-propyl	F
heptafluoro-n-propyl	heptafluoro-n-propyl	Cl
heptafluoro-n-propyl	heptafluoro-n-propyl	NO ₂
heptafluoro-n-propyl	heptafluoro-n-propyl	pentafluorophenyl
heptafluoro-n-propyl	heptafluoro-n-propyl	tetrafluoro-2-(trifluoromethyl)phenyl
heptafluoro-n-propyl	heptafluoro-n-propyl	tetrafluoro-3-(trifluoromethyl)phenyl

R ¹ , R ^{1'} , R ^{1''} , R ^{1'''}	R ² , R ^{2'} , R ^{2''} , R ^{2'''}	R ³ , R ^{3'} , R ^{3''} , R ^{3'''}
heptafluoro-n-propyl	heptafluoro-n-propyl	tetrafluoro-4-(trifluoromethyl)phenyl
heptafluoro-n-propyl	heptafluoro-n-propyl	tetrafluoro-2-pyridyl
heptafluoro-n-propyl	heptafluoro-n-propyl	tetrafluoro-3-pyridyl
heptafluoro-n-propyl	heptafluoro-n-propyl	tetrafluoro-4-pyridyl
heptafluoro-n-propyl	heptafluoro-n-propyl	tetrafluoro-2-benzonitrile
heptafluoro-n-propyl	heptafluoro-n-propyl	tetrafluoro-3-benzonitrile
heptafluoro-n-propyl	heptafluoro-n-propyl	tetrafluoro-4-benzonitrile
heptafluoro-isopropyl	heptafluoro-isopropyl	H
heptafluoro-isopropyl	heptafluoro-isopropyl	CN
heptafluoro-isopropyl	heptafluoro-isopropyl	F
heptafluoro-isopropyl	heptafluoro-isopropyl	Cl
heptafluoro-isopropyl	heptafluoro-isopropyl	NO ₂
heptafluor-iso-propyl	heptafluoro-isopropyl	pentafluorophenyl
heptafluor-iso-propyl	heptafluoro-isopropyl	tetrafluoro-2-(trifluoromethyl)phenyl
heptafluoro-isopropyl	heptafluoro-isopropyl	tetrafluoro-3-(trifluoromethyl)phenyl
heptafluoro-isopropyl	heptafluoro-isopropyl	tetrafluoro-4-(trifluoromethyl)phenyl
heptafluoro-isopropyl	heptafluoro-isopropyl	tetrafluoro-2-pyridyl
heptafluoro-isopropyl	heptafluoro-isopropyl	tetrafluoro-3-pyridyl
heptafluoro-isopropyl	heptafluoro-isopropyl	tetrafluoro-4-pyridyl

R ¹ , R ^{1'} , R ^{1''} , R ^{1'''}	R ² , R ^{2'} , R ^{2''} , R ^{2'''}	R ³ , R ^{3'} , R ^{3''} , R ^{3'''}
heptafluoro-isopropyl	heptafluoro-isopropyl	tetrafluoro-2-benzonitrile
heptafluoro-isopropyl	heptafluoro-isopropyl	tetrafluoro-3-benzonitrile
heptafluoro-isopropyl	heptafluoro-isopropyl	tetrafluoro-4-benzonitrile
tert-butyl	tert-butyl	H
tert-butyl	tert-butyl	CN
tert-butyl	tert-butyl	F
tert-butyl	tert-butyl	Cl
tert-butyl	tert-butyl	NO ₂
tert-butyl	tert-butyl	pentafluorophenyl
tert-butyl	tert-butyl	tetrafluoro-2-(trifluoromethyl)phenyl
tert-butyl	tert-butyl	tetrafluoro-3-(trifluoromethyl)phenyl
tert-butyl	tert-butyl	tetrafluoro-4-(trifluoromethyl)phenyl
tert-butyl	tert-butyl	tetrafluoro-2-pyridyl
tert-butyl	tert-butyl	tetrafluoro-3-pyridyl
tert-butyl	tert-butyl	tetrafluoro-4-pyridyl
tert-butyl	tert-butyl	tetrafluoro-2-benzonitrile
tert-butyl	tert-butyl	tetrafluoro-3-benzonitrile
tert-butyl	tert-butyl	tetrafluoro-4-benzonitrile
nonafluoro-n-butyl	nonafluoro-n-butyl	H
nonafluoro-n-butyl	nonafluoro-n-butyl	CN
nonafluoro-n-butyl	nonafluoro-n-butyl	F
nonafluoro-n-butyl	nonafluoro-n-butyl	Cl
nonafluoro-n-butyl	nonafluoro-n-butyl	NO ₂
nonafluoro-n-butyl	nonafluoro-n-butyl	pentafluorophenyl
nonafluoro-n-butyl	nonafluoro-n-butyl	tetrafluoro-2-(trifluoromethyl)phenyl
nonafluoro-n-butyl	nonafluoro-n-butyl	tetrafluoro-3-(trifluoromethyl)phenyl
nonafluoro-n-butyl	nonafluoro-n-butyl	tetrafluoro-4-(trifluoromethyl)phenyl
nonafluoro-n-butyl	nonafluoro-n-butyl	tetrafluoro-2-pyridyl
nonafluoro-n-butyl	nonafluoro-n-butyl	tetrafluoro-3-pyridyl
nonafluoro-n-butyl	nonafluoro-n-butyl	tetrafluoro-4-pyridyl
nonafluoro-n-butyl	nonafluoro-n-butyl	tetrafluoro-2-benzonitrile
nonafluoro-n-butyl	nonafluoro-n-butyl	tetrafluoro-3-benzonitrile
nonafluoro-n-butyl	nonafluoro-n-butyl	tetrafluoro-4-benzonitrile
pentafluorophenyl	pentafluorophenyl	H

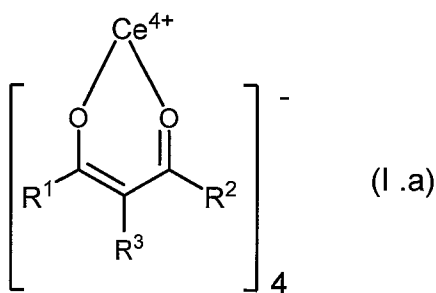
R ¹ , R ^{1'} , R ^{1''} , R ^{1'''}	R ² , R ^{2'} , R ^{2''} , R ^{2'''}	R ³ , R ^{3'} , R ^{3''} , R ^{3'''}
pentafluorophenyl	pentafluorophenyl	CN
pentafluorophenyl	pentafluorophenyl	F
pentafluorophenyl	pentafluorophenyl	Cl
pentafluorophenyl	pentafluorophenyl	NO ₂
pentafluorophenyl	pentafluorophenyl	pentafluorophenyl
pentafluorophenyl	pentafluorophenyl	tetrafluoro-2-(trifluoromethyl)phenyl
pentafluorophenyl	pentafluorophenyl	tetrafluoro-3-(trifluoromethyl)phenyl
pentafluorophenyl	pentafluorophenyl	tetrafluoro-4-(trifluoromethyl)phenyl
pentafluorophenyl	pentafluorophenyl	tetrafluoro-2-pyridyl
pentafluorophenyl	pentafluorophenyl	tetrafluoro-3-pyridyl
pentafluorophenyl	pentafluorophenyl	tetrafluoro-4-pyridyl
pentafluorophenyl	pentafluorophenyl	tetrafluoro-2-benzonitrile
pentafluorophenyl	pentafluorophenyl	tetrafluoro-3-benzonitrile
pentafluorophenyl	pentafluorophenyl	tetrafluoro-4-benzonitrile
4-pyrimidyl	4-pyrimidyl	H
4-pyrimidyl	4-pyrimidyl	CN
4-pyrimidyl	4-pyrimidyl	F
4-pyrimidyl	4-pyrimidyl	Cl
4-pyrimidyl	4-pyrimidyl	NO ₂
4-pyrimidyl	4-pyrimidyl	pentafluorophenyl
4-pyrimidyl	4-pyrimidyl	tetrafluoro-2-(trifluoromethyl)phenyl
4-pyrimidyl	4-pyrimidyl	tetrafluoro-3-(trifluoromethyl)phenyl
4-pyrimidyl	4-pyrimidyl	tetrafluoro-4-(trifluoromethyl)phenyl
4-pyrimidyl	4-pyrimidyl	tetrafluoro-2-pyridyl
4-pyrimidyl	4-pyrimidyl	tetrafluoro-3-pyridyl
4-pyrimidyl	4-pyrimidyl	tetrafluoro-4-pyridyl
4-pyrimidyl	4-pyrimidyl	tetrafluoro-2-benzonitrile
4-pyrimidyl	4-pyrimidyl	tetrafluoro-3-benzonitrile
4-pyrimidyl	4-pyrimidyl	tetrafluoro-4-benzonitrile
2-pyrimidyl	2-pyrimidyl	H
2-pyrimidyl	2-pyrimidyl	CN
2-pyrimidyl	2-pyrimidyl	F
2-pyrimidyl	2-pyrimidyl	Cl
2-pyrimidyl	2-pyrimidyl	NO ₂
2-pyrimidyl	2-pyrimidyl	pentafluorophenyl
2-pyrimidyl	2-pyrimidyl	tetrafluoro-2-(trifluoromethyl)phenyl
2-pyrimidyl	2-pyrimidyl	tetrafluoro-3-(trifluoromethyl)phenyl

R ¹ , R ^{1'} , R ^{1''} , R ^{1'''}	R ² , R ^{2'} , R ^{2''} , R ^{2'''}	R ³ , R ^{3'} , R ^{3''} , R ^{3'''}
2-pyrimidyl	2-pyrimidyl	tetrafluoro-4-(trifluoromethyl)phenyl
2-pyrimidyl	2-pyrimidyl	tetrafluoro-2-pyridyl
2-pyrimidyl	2-pyrimidyl	tetrafluoro-3-pyridyl
2-pyrimidyl	2-pyrimidyl	tetrafluoro-4-pyridyl
2-pyrimidyl	2-pyrimidyl	tetrafluoro-2-benzonitrile
2-pyrimidyl	2-pyrimidyl	tetrafluoro-3-benzonitrile
2-pyrimidyl	2-pyrimidyl	tetrafluoro-4-benzonitrile
3,5-bis(trifluoromethyl)-phenyl	3,5-bis(trifluoromethyl)-phenyl	H
3,5-bis(trifluoromethyl)-phenyl	trifluoromethyl	H
phenyl	pentafluoroethyl	H
furan-2-yl	trifluoromethyl	H
furan-2-yl	pentafluoroethyl	H
3,5-bis(trifluoromethyl)-phenyl	pentafluoroethyl	H
3',5'-bis(trifluoromethyl)-[1,1'-biphenyl]-4-yl	pentafluoroethyl	H
3',5'-bis(trifluoromethyl)-[1,1'-biphenyl]-4-yl	trifluoromethyl	H
4-fluoro-3-trifluoromethyl-phenyl	pentafluoroethyl	H
4-fluoro-3-trifluoromethyl-phenyl	3,5-bis(trifluoromethyl)-phenyl	H
3,4,5-trifluorophenyl	3,4,5-trifluorophenyl	H
3,4,5-trifluorophenyl	pentafluoroethyl	H
4-(trifluoromethyl)phenyl	4-(trifluoromethyl)phenyl	H
4-(trifluoromethyl)phenyl	pentafluoroethyl	H
2,4,6-tris(trifluoromethyl)phenyl	2,4,6-tris(trifluoromethyl)phenyl	H
2,4,6-tris(trifluoromethyl)phenyl	Pentafluoroethyl	H
3,5-bis(trifluoromethyl)-phenyl	3,5-bis(trifluoromethyl)-phenyl	CN

R ¹ , R ^{1'} , R ^{1''} , R ^{1'''}	R ² , R ^{2'} , R ^{2''} , R ^{2'''}	R ³ , R ^{3'} , R ^{3''} , R ^{3'''}
2,4,6-tris(trifluoromethyl)phenyl	2,4,6-tris(trifluoromethyl)phenyl	CN
3,5-bis(trifluoromethyl)-phenyl	pentafluoroethyl	3,5-bis(trifluoromethyl)-phenyl
3,4-bis(trifluoromethyl)-phenyl	3,4-bis(trifluoromethyl)-phenyl	H
3,4-bis(trifluoromethyl)-phenyl	trifluoromethyl	H
3,4-bis(trifluoromethyl)-phenyl	pentafluoroethyl	3,5-bis(trifluoromethyl)-phenyl
3,4-bis(trifluoromethyl)-phenyl	pentafluoroethyl	H
3,4-bis(trifluoromethyl)-phenyl	3,4-bis(trifluoromethyl)-phenyl	CN
4-cyano-3-(trifluoromethyl)-phenyl	3,5-bis(trifluoromethyl)-phenyl	H
4-cyano-3-(trifluoromethyl)-phenyl	pentafluoroethyl	H
3,5-bis(trifluoromethyl)-phenyl	pentafluoroethyl	CN
4-cyano-2,6-bis(trifluoromethyl)-phenyl	4-cyano-2,6-bis(trifluoromethyl)-phenyl	H
4-cyano-2,6-bis(trifluoromethyl)-phenyl	pentafluoroethyl	H
2,4-bis(trifluoromethyl)-phenyl	2,6-bis(trifluoromethyl)-phenyl	H
2,4-bis(trifluoromethyl)-phenyl	2,6-bis(trifluoromethyl)-phenyl	CN
4-(3',5'-bis(trifluoromethyl)phenyl)-2,6-bis(trifluoromethyl)-phenyl	pentafluoroethyl	H
phenyl	phenyl	CN
3,5-bis(trifluoromethyl)-phenyl	3,5-bis(trifluoromethyl)-phenyl	CF ₃
3,5-bis(trifluoromethyl)-phenyl	trifluoromethyl	CF ₃
phenyl	pentafluoroethyl	CF ₃

R ¹ , R ^{1'} , R ^{1''} , R ^{1'''}	R ² , R ^{2'} , R ^{2''} , R ^{2'''}	R ³ , R ^{3'} , R ^{3''} , R ^{3'''}
3,5-bis(trifluoromethyl)-phenyl	pentafluoroethyl	CF ₃
3,4,5-trifluorophenyl	3,4,5-trifluorophenyl	CF ₃
4-(trifluoromethyl)phenyl	4-(trifluoromethyl)phenyl	CF ₃
phenyl	phenyl	CF ₃

9. Electronic component according to claims 1, 2 or 8, wherein the compounds of formula (I.1) or (I) are selected from compounds of formula (I.a)



5

wherein R¹, R² and R³ are selected from

R ¹	R ²	R ³
methyl	methyl	H
methyl	methyl	CN
methyl	methyl	F
methyl	methyl	Cl
methyl	methyl	NO ₂
methyl	methyl	pentafluorophenyl
methyl	methyl	tetrafluoro-2-(trifluoromethyl)phenyl
methyl	methyl	tetrafluoro-3-(trifluoromethyl)phenyl
methyl	methyl	tetrafluoro-4-(trifluoromethyl)phenyl
methyl	methyl	tetrafluoro-2-pyridyl
methyl	methyl	tetrafluoro-3-pyridyl
methyl	methyl	tetrafluoro-4-pyridyl
methyl	methyl	tetrafluoro-2-benzonitrile
methyl	methyl	tetrafluoro-3-benzonitrile
methyl	methyl	tetrafluoro-4-benzonitrile
trifluoromethyl	trifluoromethyl	H

R ¹	R ²	R ³
trifluoromethyl	trifluoromethyl	CN
trifluoromethyl	trifluoromethyl	F
trifluoromethyl	trifluoromethyl	Cl
trifluoromethyl	trifluoromethyl	NO ₂
trifluoromethyl	trifluoromethyl	pentafluorophenyl
trifluoromethyl	trifluoromethyl	tetrafluoro-2-(trifluoromethyl)phenyl
trifluoromethyl	trifluoromethyl	tetrafluoro-3-(trifluoromethyl)phenyl
trifluoromethyl	trifluoromethyl	tetrafluoro-4-(trifluoromethyl)phenyl
trifluoromethyl	trifluoromethyl	tetrafluoro-2-pyridyl
trifluoromethyl	trifluoromethyl	tetrafluoro-3-pyridyl
trifluoromethyl	trifluoromethyl	tetrafluoro-4-pyridyl
trifluoromethyl	trifluoromethyl	tetrafluoro-2-benzonitrile
trifluoromethyl	trifluoromethyl	tetrafluoro-3-benzonitrile
trifluoromethyl	trifluoromethyl	tetrafluoro-4-benzonitrile
pentafluoroethyl	pentafluoroethyl	H
pentafluoroethyl	pentafluoroethyl	CN
pentafluoroethyl	pentafluoroethyl	F
pentafluoroethyl	pentafluoroethyl	Cl
pentafluoroethyl	pentafluoroethyl	NO ₂
pentafluoroethyl	pentafluoroethyl	pentafluorophenyl
pentafluoroethyl	pentafluoroethyl	tetrafluoro-2-(trifluoromethyl)phenyl
pentafluoroethyl	pentafluoroethyl	tetrafluoro-3-(trifluoromethyl)phenyl
pentafluoroethyl	pentafluoroethyl	tetrafluoro-4-(trifluoromethyl)phenyl
pentafluoroethyl	pentafluoroethyl	tetrafluoro-2-pyridyl
pentafluoroethyl	pentafluoroethyl	tetrafluoro-3-pyridyl
pentafluoroethyl	pentafluoroethyl	tetrafluoro-4-pyridyl
pentafluoroethyl	pentafluoroethyl	tetrafluoro-2-benzonitrile
pentafluoroethyl	pentafluoroethyl	tetrafluoro-3-benzonitrile
pentafluoroethyl	pentafluoroethyl	tetrafluoro-4-benzonitrile
heptafluoro-n-propyl	heptafluoro-n-propyl	H
heptafluoro-n-propyl	heptafluoro-n-propyl	CN
heptafluoro-n-propyl	heptafluoro-n-propyl	F
heptafluoro-n-propyl	heptafluoro-n-propyl	Cl

R ¹	R ²	R ³
heptafluoro-n-propyl	heptafluoro-n-propyl	NO ₂
heptafluoro-n-propyl	heptafluoro-n-propyl	pentafluorophenyl
heptafluoro-n-propyl	heptafluoro-n-propyl	tetrafluoro-2-(trifluoromethyl)phenyl
heptafluoro-n-propyl	heptafluoro-n-propyl	tetrafluoro-3-(trifluoromethyl)phenyl
heptafluoro-n-propyl	heptafluoro-n-propyl	tetrafluoro-4-(trifluoromethyl)phenyl
heptafluoro-n-propyl	heptafluoro-n-propyl	tetrafluoro-2-pyridyl
heptafluoro-n-propyl	heptafluoro-n-propyl	tetrafluoro-3-pyridyl
heptafluoro-n-propyl	heptafluoro-n-propyl	tetrafluoro-4-pyridyl
heptafluoro-n-propyl	heptafluoro-n-propyl	tetrafluoro-2-benzonitrile
heptafluoro-n-propyl	heptafluoro-n-propyl	tetrafluoro-3-benzonitrile
heptafluoro-n-propyl	heptafluoro-n-propyl	tetrafluoro-4-benzonitrile
heptafluoro-isopropyl	heptafluoro-isopropyl	H
heptafluoro-isopropyl	heptafluoro-isopropyl	CN
heptafluoro-isopropyl	heptafluoro-isopropyl	F
heptafluoro-isopropyl	heptafluoro-isopropyl	Cl
heptafluoro-isopropyl	heptafluoro-isopropyl	NO ₂
heptafluoro-iso-propyl	heptafluoro-isopropyl	pentafluorophenyl
heptafluoro-iso-propyl	heptafluoro-isopropyl	tetrafluoro-2-(trifluoromethyl)phenyl
heptafluoro-isopropyl	heptafluoro-isopropyl	tetrafluoro-3-(trifluoromethyl)phenyl

R ¹	R ²	R ³
heptafluoro-isopropyl	heptafluoro-isopropyl	tetrafluoro-4-(trifluoromethyl)phenyl
heptafluoro-isopropyl	heptafluoro-isopropyl	tetrafluoro-2-pyridyl
heptafluoro-isopropyl	heptafluoro-isopropyl	tetrafluoro-3-pyridyl
heptafluoro-isopropyl	heptafluoro-isopropyl	tetrafluoro-4-pyridyl
heptafluoro-isopropyl	heptafluoro-isopropyl	tetrafluoro-2-benzonitrile
heptafluoro-isopropyl	heptafluoro-isopropyl	tetrafluoro-3-benzonitrile
heptafluoro-isopropyl	heptafluoro-isopropyl	tetrafluoro-4-benzonitrile
tert-butyl	tert-butyl	H
tert-butyl	tert-butyl	CN
tert-butyl	tert-butyl	F
tert-butyl	tert-butyl	Cl
tert-butyl	tert-butyl	NO ₂
tert-butyl	tert-butyl	pentafluorophenyl
tert-butyl	tert-butyl	tetrafluoro-2-(trifluoromethyl)phenyl
tert-butyl	tert-butyl	tetrafluoro-3-(trifluoromethyl)phenyl
tert-butyl	tert-butyl	tetrafluoro-4-(trifluoromethyl)phenyl
tert-butyl	tert-butyl	tetrafluoro-2-pyridyl
tert-butyl	tert-butyl	tetrafluoro-3-pyridyl
tert-butyl	tert-butyl	tetrafluoro-4-pyridyl
tert-butyl	tert-butyl	tetrafluoro-2-benzonitrile
tert-butyl	tert-butyl	tetrafluoro-3-benzonitrile
tert-butyl	tert-butyl	tetrafluoro-4-benzonitrile
nonafluoro-n-butyl	nonafluoro-n-butyl	H
nonafluoro-n-butyl	nonafluoro-n-butyl	CN
nonafluoro-n-butyl	nonafluoro-n-butyl	F
nonafluoro-n-butyl	nonafluoro-n-butyl	Cl
nonafluoro-n-butyl	nonafluoro-n-butyl	NO ₂
nonafluoro-n-butyl	nonafluoro-n-butyl	pentafluorophenyl
nonafluoro-n-butyl	nonafluoro-n-butyl	tetrafluoro-2-(trifluoromethyl)phenyl
nonafluoro-n-butyl	nonafluoro-n-butyl	tetrafluoro-3-(trifluoromethyl)phenyl
nonafluoro-n-butyl	nonafluoro-n-butyl	tetrafluoro-4-(trifluoromethyl)phenyl

R ¹	R ²	R ³
nonafluoro-n-butyl	nonafluoro-n-butyl	tetrafluoro-2-pyridyl
nonafluoro-n-butyl	nonafluoro-n-butyl	tetrafluoro-3-pyridyl
nonafluoro-n-butyl	nonafluoro-n-butyl	tetrafluoro-4-pyridyl
nonafluoro-n-butyl	nonafluoro-n-butyl	tetrafluoro-2-benzonitrile
nonafluoro-n-butyl	nonafluoro-n-butyl	tetrafluoro-3-benzonitrile
nonafluoro-n-butyl	nonafluoro-n-butyl	tetrafluoro-4-benzonitrile
pentafluorophenyl	pentafluorophenyl	H
pentafluorophenyl	pentafluorophenyl	CN
pentafluorophenyl	pentafluorophenyl	F
pentafluorophenyl	pentafluorophenyl	Cl
pentafluorophenyl	pentafluorophenyl	NO ₂
pentafluorophenyl	pentafluorophenyl	pentafluorophenyl
pentafluorophenyl	pentafluorophenyl	tetrafluoro-2-(trifluoromethyl)phenyl
pentafluorophenyl	pentafluorophenyl	tetrafluoro-3-(trifluoromethyl)phenyl
pentafluorophenyl	pentafluorophenyl	tetrafluoro-4-(trifluoromethyl)phenyl
pentafluorophenyl	pentafluorophenyl	tetrafluoro-2-pyridyl
pentafluorophenyl	pentafluorophenyl	tetrafluoro-3-pyridyl
pentafluorophenyl	pentafluorophenyl	tetrafluoro-4-pyridyl
pentafluorophenyl	pentafluorophenyl	tetrafluoro-2-benzonitrile
pentafluorophenyl	pentafluorophenyl	tetrafluoro-3-benzonitrile
pentafluorophenyl	pentafluorophenyl	tetrafluoro-4-benzonitrile
4-pyrimidyl	4-pyrimidyl	H
4-pyrimidyl	4-pyrimidyl	CN
4-pyrimidyl	4-pyrimidyl	F
4-pyrimidyl	4-pyrimidyl	Cl
4-pyrimidyl	4-pyrimidyl	NO ₂
4-pyrimidyl	4-pyrimidyl	pentafluorophenyl
4-pyrimidyl	4-pyrimidyl	tetrafluoro-2-(trifluoromethyl)phenyl
4-pyrimidyl	4-pyrimidyl	tetrafluoro-3-(trifluoromethyl)phenyl
4-pyrimidyl	4-pyrimidyl	tetrafluoro-4-(trifluoromethyl)phenyl
4-pyrimidyl	4-pyrimidyl	tetrafluoro-2-pyridyl
4-pyrimidyl	4-pyrimidyl	tetrafluoro-3-pyridyl
4-pyrimidyl	4-pyrimidyl	tetrafluoro-4-pyridyl
4-pyrimidyl	4-pyrimidyl	tetrafluoro-2-benzonitrile
4-pyrimidyl	4-pyrimidyl	tetrafluoro-3-benzonitrile
4-pyrimidyl	4-pyrimidyl	tetrafluoro-4-benzonitrile
2-pyrimidyl	2-pyrimidyl	H

R ¹	R ²	R ³
2-pyrimidyl	2-pyrimidyl	CN
2-pyrimidyl	2-pyrimidyl	F
2-pyrimidyl	2-pyrimidyl	Cl
2-pyrimidyl	2-pyrimidyl	NO ₂
2-pyrimidyl	2-pyrimidyl	pentafluorophenyl
2-pyrimidyl	2-pyrimidyl	tetrafluoro-2-(trifluoromethyl)phenyl
2-pyrimidyl	2-pyrimidyl	tetrafluoro-3-(trifluoromethyl)phenyl
2-pyrimidyl	2-pyrimidyl	tetrafluoro-4-(trifluoromethyl)phenyl
2-pyrimidyl	2-pyrimidyl	tetrafluoro-2-pyridyl
2-pyrimidyl	2-pyrimidyl	tetrafluoro-3-pyridyl
2-pyrimidyl	2-pyrimidyl	tetrafluoro-4-pyridyl
2-pyrimidyl	2-pyrimidyl	tetrafluoro-2-benzonitrile
2-pyrimidyl	2-pyrimidyl	tetrafluoro-3-benzonitrile
2-pyrimidyl	2-pyrimidyl	tetrafluoro-4-benzonitrile
3,5-bis(trifluoromethyl)-phenyl	3,5-bis(trifluoromethyl)-phenyl	H
3,5-bis(trifluoromethyl)-phenyl	trifluoromethyl	H
phenyl	pentafluoroethyl	H
furan-2-yl	trifluoromethyl	H
furan-2-yl	pentafluoroethyl	H
3,5-bis(trifluoromethyl)-phenyl	pentafluoroethyl	H
3',5'-bis(trifluoromethyl)-[1,1'-biphenyl]-4-yl	pentafluoroethyl	H
3',5'-bis(trifluoromethyl)-[1,1'-biphenyl]-4-yl	trifluoromethyl	H
4-fluoro-3-trifluoromethyl-phenyl	pentafluoroethyl	H
4-fluoro-3-trifluoromethyl-phenyl	3,5-bis(trifluoromethyl)-phenyl	H
3,4,5-trifluorophenyl	3,4,5-trifluorophenyl	H
3,4,5-trifluorophenyl	pentafluoroethyl	H
4-(trifluoromethyl)phenyl	4-(trifluoromethyl)phenyl	H

R ¹	R ²	R ³
4-(trifluoromethyl)phenyl	pentafluoroethyl	H
2,4,6-tris(trifluoromethyl)phenyl	2,4,6-tris(trifluoromethyl)phenyl	H
2,4,6-tris(trifluoromethyl)phenyl	Pentafluoroethyl	H
3,5-bis(trifluoromethyl)-phenyl	3,5-bis(trifluoromethyl)-phenyl	CN
2,4,6-tris(trifluoromethyl)phenyl	2,4,6-tris(trifluoromethyl)phenyl	CN
3,5-bis(trifluoromethyl)-phenyl	pentafluoroethyl	3,5-bis(trifluoromethyl)-phenyl
3,4-bis(trifluoromethyl)-phenyl	3,4-bis(trifluoromethyl)-phenyl	H
3,4-bis(trifluoromethyl)-phenyl	trifluoromethyl	H
3,4-bis(trifluoromethyl)-phenyl	pentafluoroethyl	3,5-bis(trifluoromethyl)-phenyl
3,4-bis(trifluoromethyl)-phenyl	pentafluoroethyl	H
3,4-bis(trifluoromethyl)-phenyl	3,4-bis(trifluoromethyl)-phenyl	CN
4-cyano-3-(trifluoromethyl)-phenyl	3,5-bis(trifluoromethyl)-phenyl	H
4-cyano-3-(trifluoromethyl)-phenyl	pentafluoroethyl	H
3,5-bis(trifluoromethyl)-phenyl	pentafluoroethyl	CN
4-cyano-2,6-bis(trifluoromethyl)-phenyl	4-cyano-2,6-bis(trifluoromethyl)-phenyl	H
4-cyano-2,6-bis(trifluoromethyl)-phenyl	pentafluoroethyl	H
2,4-bis(trifluoromethyl)-phenyl	2,6-bis(trifluoromethyl)-phenyl	H
2,4-bis(trifluoromethyl)-phenyl	2,6-bis(trifluoromethyl)-phenyl	CN
4-(3',5'-bis(trifluoromethyl)phenyl)-2,6-	pentafluoroethyl	H

R ¹	R ²	R ³
bis(trifluoromethyl)-phenyl		
phenyl	phenyl	CN
3,5-bis(trifluoromethyl)-phenyl	3,5-bis(trifluoromethyl)-phenyl	CF ₃
3,5-bis(trifluoromethyl)-phenyl	trifluoromethyl	CF ₃
phenyl	pentafluoroethyl	CF ₃
3,5-bis(trifluoromethyl)-phenyl	pentafluoroethyl	CF ₃
3,4,5-trifluorophenyl	3,4,5-trifluorophenyl	CF ₃
4-(trifluoromethyl)phenyl	4-(trifluoromethyl)phenyl	CF ₃
phenyl	phenyl	CF ₃

10. Electronic component according to any one of the preceding claims, wherein L₁, L₂, L₃ and L₄ have the same meanings.
- 5 11. Electronic component according to any one of the preceding claims in form of an organic light-emitting diode, an organic solar cell, a photovoltaic cell, an organic diode or an organic transistor, preferably in form of a thin-film transistor, a Perovskite solar cell.
- 10 12. Electronic component according to any one of the preceding claims, having a layer structure, which comprises 2, 3, 4, 5, 6, 7 or more layers.
- 15 13. Electronic component according to any one of the preceding claims, comprising an hole transport layer and/or a hole injection layer, which comprises at least of the compound of formula (I.1) or (I).
- 20 14. Electronic component according to any one of the preceding claims, comprising an electron transport layer, which comprises at least of the compound of formula (I.1) or (I).
15. Doped semiconductor matrix material comprising at least one electron donor and at least one compound of the formula (I.1) or (I) as defined in any one of claims 1 to 10, wherein the electron donor is preferably selected from 4,4',4"-tris(N-(2-naphthyl)-N-phenyl-amino)triphenylamine (2-TNATA), 4,4',4"-tris(N-3-methylphenyl-N-

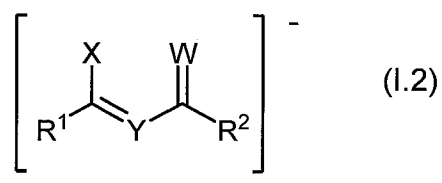
phenyl-amino)triphenylamine (m-MTDATA), N,N,N',N'-tetrakis(4-methoxy-phenyl)benzidine (MeO-TPD), (2,2',7,7'-tetrakis-(N,N-diphenylamino)-9,9'-spirobifluorene (spiro-TTB), N,N'-bis(naphthalen-1-yl)-N,N'-bis(phenyl)-benzidine, N,N'-bis(naphthalen-1-yl)-N,N'-bis(phenyl)-9,9'-spiro-bifluorene, 9,9-bis[4-(N,N-bis(biphenyl-4-yl-amino)phenyl]-9H-fluorene, 2,2'-bis[N,N-bis(biphenyl-4-yl-amino)-9,9'-spiro-bifluorene, N,N'-((9H-fluoren-9,9-diyl)bis(4,1-phenylene))bis(N-([1,1'-biphenyl]-4-yl)-[1,1'-biphenyl]-4-amine) (BPAPF), N,N'-bis(phenanthren-9-yl)-N,N'-bis(phenyl)-benzidine, 1,3,5-tris[4-[bis(9,9-dimethyl-fluoren-2-yl)amino]phenyl]benzene, tri(terphenyl-4-yl)amine, N-(4-(6-((9,9-dimethyl-9H-fluoren-2-yl)(6-methoxy-[1,1'-biphenyl]-3-yl)amino)-1,3,3-trimethyl-2,3-dihydro-1H-inden-1-yl)phenyl)-N-(6-methoxy-[1,1'-biphenyl]-3-yl)-9,9-dimethyl-9H-fluoren-2-amine, N-([1,1'-biphenyl]-4-yl)-N-(4-(6-([1,1'-biphenyl]-4-yl(9,9-dimethyl-9H-fluoren-2-yl)amino)-1,3,3-trimethyl-2,3-dihydro-1H-inden-1-yl)phenyl)-9,9-dimethyl-9H-fluoren-2-amine, N,N-di([1,1'-biphenyl]-4-yl)-3-(4-(di([1,1'-biphenyl]-4-yl)amino)phenyl)-1,1,3-trimethyl-2,3-dihydro-1H-inden-5-amine, N-(4-(6-(bis(9,9-dimethyl-9H-fluoren-2-yl)amino)-1,3,3-trimethyl-2,3-dihydro-1H-inden-1-yl)phenyl)-N-(9,9-dimethyl-9H-fluoren-2-yl)-9,9-dimethyl-9H-fluoren-2-amine, N-(4-(6-(9,9'-spirobi[fluoren]-2-yl(9,9-dimethyl-9H-fluoren-2-yl)amino)-1,3,3-trimethyl-2,3-dihydro-1H-inden-1-yl)phenyl)-N-(9,9-dimethyl-9H-fluoren-2-yl)-9,9'-spirobi[fluoren]-2-amine, N-(4-(6-(dibenzo[b,d]furan-2-yl(9,9-dimethyl-9H-fluoren-2-yl)amino)-1,3,3-trimethyl-2,3-dihydro-1H-inden-1-yl)phenyl)-N-(9,9-dimethyl-9H-fluoren-2-yl)dibenzo[b,d]furan-2-amine, 9-(4-(6-(9H-carbazol-9-yl)-1,3,3-trimethyl-2,3-dihydro-1H-inden-1-yl)phenyl)-9H-carbazole, N-([1,1'-biphenyl]-4-yl)-3-(4-([1,1'-biphenyl]-4-yl(4-methoxyphenyl)amino)phenyl)-N-(4-methoxyphenyl)-1,1,3-trimethyl-2,3-dihydro-1H-inden-5-amine, 3-(4-(bis(6-methoxy-[1,1'-biphenyl]-3-yl)amino)phenyl)-N,N-bis(6-methoxy-[1,1'-biphenyl]-3-yl)-1,1,3-trimethyl-2,3-dihydro-1H-inden-5-amine, N1-([1,1'-biphenyl]-4-yl)-N1-(4-(6-([1,1'-biphenyl]-4-yl(4-(diphenylamino)phenyl)amino)-1,3,3-trimethyl-2,3-dihydro-1H-inden-1-yl)phenyl)-N4,N4-diphenylbenzene-1,4-diamine, N,N-di([1,1'-biphenyl]-4-yl)-4'-(6-(4-(di([1,1'-biphenyl]-4-yl)amino)phenyl)-1,3,3-trimethyl-2,3-dihydro-1H-inden-1-yl)-[1,1'-biphenyl]-4-amine, N-(4-(5-(bis(9,9-dimethyl-9H-fluoren-2-yl)amino)-1,3,3-trimethyl-2,3-dihydro-1H-inden-1-yl)phenyl)-N-(9,9-dimethyl-9H-fluoren-2-yl)-9,9-dimethyl-9H-fluoren-2-amine, N-(4-(6-(bis(9,9-dimethyl-9H-fluoren-2-yl)amino)-1,3,3-trimethyl-2,3-dihydro-1H-inden-1-yl)phenyl)-N-(9,9-dimethyl-9H-fluoren-2-yl)-9,9-dimethyl-9H-fluoren-2-amine, N,N'-bis(9,9-dimethyl-fluoren-2-yl)-N,N'-diphenyl-benzidine (BF-DPB), N,N'-((9H-fluorene-9,9-diyl)bis(4,1-phenylene))bis(N-([1,1'-biphenyl]-4-yl)-[1,1'-biphenyl]-4-amine) (BPAPF), N4,N4,N4',N4'-tetrakis(9,9-dimethyl-9H-fluoren-2-yl)-[1,1'-biphenyl]-4,4'-diamine (TDMFB), N-([1,1'-biphenyl]-2-yl)-N-(9,9-dimethyl-9H-fluoren-2-yl)-9,9'-spirobi[fluoren]-2-amine, (2,7-bis[N,N-bis(4-methoxyphenyl)amino]-9,9-spi-

robi[9H-fluorene] (spiro-MeO-TPD), a mixture of N-(4-(5-(bis(9,9-dimethyl-9H-fluoren-2-yl)amino)-1,3,3-trimethyl-2,3-dihydro-1H-inden-1-yl)phenyl)-N-(9,9-dimethyl-9H-fluoren-2-yl)-9,9-dimethyl-9H-fluoren-2-amine and N-(4-(6-(bis(9,9-dimethyl-9H-fluoren-2-yl)amino)-1,3,3-trimethyl-2,3-dihydro-1H-inden-1-yl)phenyl)-N-(9,9-dimethyl-9H-fluoren-2-yl)-9,9-dimethyl-9H-fluoren-2-amine, N-([1,1'-bi-phenyl]-4-yl)-9,9-dimethyl-N-(4-(9-phenyl-9H-carbazol-3-yl)phenyl)-9H-fluoren-2-amine and mixtures thereof.

16. Use of a compound (I.1) or mixtures thereof or of a compound (I) or mixtures thereof, as defined in any one of claims 1 to 10
- as organic semiconductor,
 - as doping agent in organic semiconductor matrix materials, especially as p-dopant in hole transport layers,
 - as electron transport material,
 - as charge injector in a charge injection layer,
 - as cathode material in organic batteries,
 - as electrochromic material.
17. Use of Ce(III) complex anions obtained by reduction of a compound (I.1) or (I) as defined in any one of claims 1 to 10 or of charge transfer complexes of a compound (I.1) or (I) as defined in any one of claims 1 to 10 with electron donors as organic conductor or as electrochromic material.
18. Compound of the general formula (I.1)



L_1 ; L_2 ; L_3 ; and L_4 are independently from each other a bidentate ligand having the general formula (I.2)



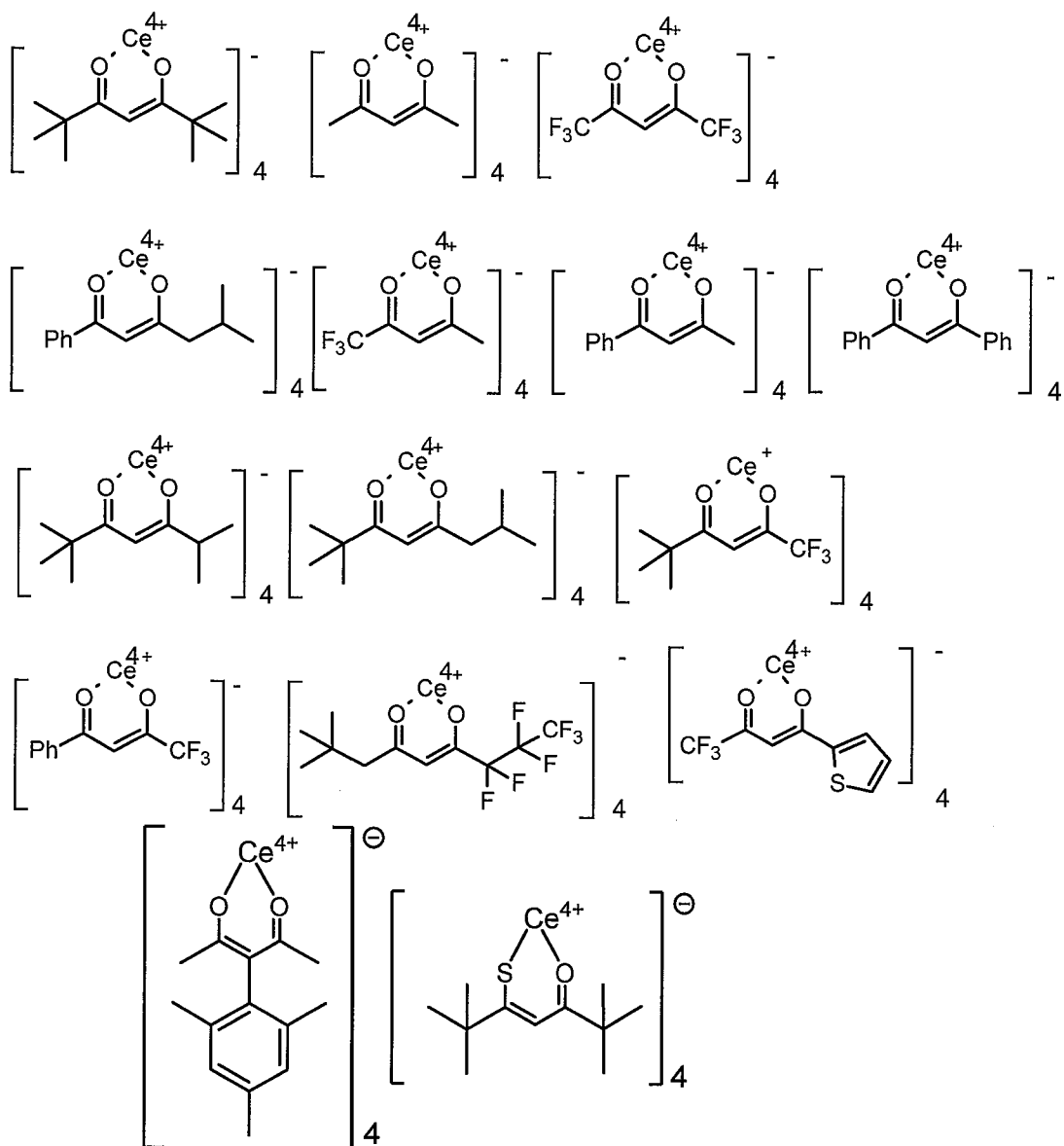
, wherein

X and W independently from each other represent O, S or NR^6 ;

Y represents N or CR^3 ;

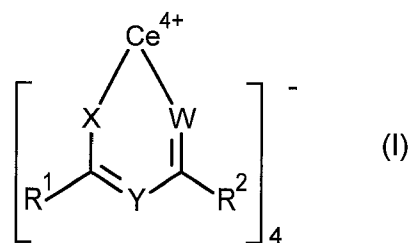
- 5 R^1, R^2 independently from each other represent CN, C_1 - C_6 -alkyl, C_1 - C_6 -haloalkyl, C_1 - C_6 -alkoxy, C_1 - C_6 -haloalkoxy, C_1 - C_6 -alkylsulfanyl, C_1 - C_6 -haloalkylsulfanyl, $NR^{4a}R^{4b}$, C_6 - C_{14} -aryl or hetaryl having 4 to 13 carbon atoms, wherein hetaryl has 1, 2 or 3 identical or different heteroatoms or heteroatom-containing groups as ring members, selected from N, NR^7 , O, S, SO and SO_2 , wherein aryl and hetaryl are unsubstituted or substituted by 1, 2, 3, 4 or 5 identical or different radicals R^8 ;
- 10 R^3 represents hydrogen, CN, nitro, halogen, C_1 - C_6 -alkyl, C_1 - C_6 -haloalkyl, C_1 - C_6 -alkoxy, C_1 - C_6 -haloalkoxy, C_1 - C_6 -alkylsulfanyl, C_1 - C_6 -haloalkylsulfanyl, $NR^{4a}R^{4b}$, C_6 - C_{14} -aryl or hetaryl having 4 to 13 carbon atoms, wherein hetaryl has 1, 2 or 3 identical or different heteroatoms or heteroatom-containing groups as ring members, selected from N, NR^7 , O, S, SO and SO_2 , wherein aryl and hetaryl are unsubstituted or substituted by 1, 2, 3, 4 or 5 identical or different radicals R^5 ;
- 15 $R^{4a}R^{4b}$ independently from each other represent hydrogen, C_1 - C_6 -alkyl or C_6 - C_{14} -aryl, wherein aryl is unsubstituted or substituted by 1, 2, 3, 4 or 5 identical or different radicals R^5 ;
- 20 R^5 represents CN, halogen, C_1 - C_4 -alkyl or C_1 - C_4 -haloalkyl;
- 25 R^6 represents hydrogen, C_1 - C_6 -alkyl, C_1 - C_6 -haloalkyl, C_6 - C_{14} -aryl or hetaryl having 4 to 13 carbon atoms, wherein hetaryl has 1, 2 or 3 identical or different heteroatoms or heteroatom-containing groups as ring members, selected from N, NR^7 , O, S, SO and SO_2 , wherein aryl and hetaryl are unsubstituted or substituted by 1, 2, 3, 4 or 5 identical or different radicals R^5 ;
- 30 R^7 represents hydrogen, C_1 - C_6 -alkyl, C_1 - C_6 -haloalkyl or C_6 - C_{14} -aryl, wherein aryl is unsubstituted or substituted by 1, 2, 3, 4 or 5 identical or different radicals R^5 ;
- 35 R^8 represents CN, halogen, C_1 - C_4 -alkyl, C_1 - C_4 -haloalkyl or C_6 - C_{14} -aryl, which is unsubstituted or substituted by 1, 2 or 3 identical or different radicals selected from C_1 - C_4 -alkyl and C_1 - C_4 -haloalkyl;
- 40 with the proviso that the following compounds are excluded:

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19. Compound according to claim 18 having the general formula (I)

5



and their charge transfer complexes, their reduction products and mixtures thereof, wherein

10

X and W independently from each other represent O, S or NR⁶;

Y represents N or CR³;

5 R¹, R² independently from each other represent CN, C₁-C₆-alkyl, C₁-C₆-haloalkyl, C₁-C₆-alkoxy, C₁-C₆-haloalkoxy, C₁-C₆-alkylsulfanyl, C₁-C₆-haloalkylsulfanyl, NR^{4a}R^{4b}, C₆-C₁₄-aryl or hetaryl having 4 to 13 carbon atoms, wherein hetaryl has 1, 2 or 3 identical or different heteroatoms or heteroatom-containing groups as ring members, selected from N, NR⁷, O, S, SO and SO₂, wherein
10 aryl and hetaryl are unsubstituted or substituted by 1, 2, 3, 4 or 5 identical or different radicals R⁸;

R³ represents hydrogen, CN, nitro, halogen, C₁-C₆-alkyl, C₁-C₆-haloalkyl, C₁-C₆-alkoxy, C₁-C₆-haloalkoxy, C₁-C₆-alkylsulfanyl, C₁-C₆-haloalkylsulfanyl, NR^{4a}R^{4b},
15 C₆-C₁₄-aryl or hetaryl having 4 to 13 carbon atoms, wherein hetaryl has 1, 2 or 3 identical or different heteroatoms or heteroatom-containing groups as ring members, selected from N, NR⁷, O, S, SO and SO₂, wherein aryl and hetaryl are unsubstituted or substituted by 1, 2, 3, 4 or 5 identical or different radicals R⁵;

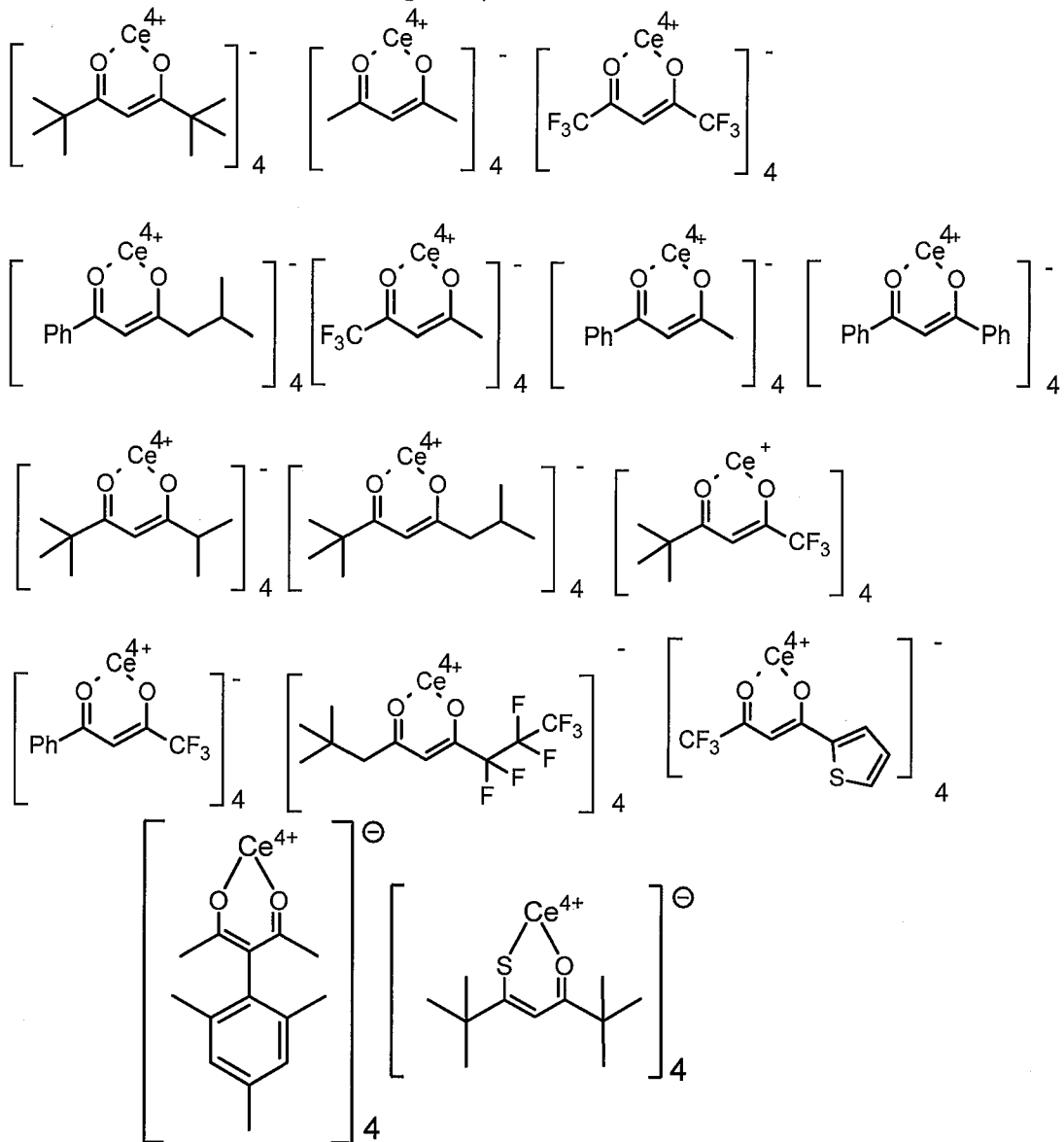
20 R^{4a}R^{4b} independently from each other represent hydrogen, C₁-C₆-alkyl or C₆-C₁₄-aryl, wherein aryl is unsubstituted or substituted by 1, 2, 3, 4 or 5 identical or different radicals R⁵;

25 R⁵ represents CN, halogen, C₁-C₄-alkyl or C₁-C₄-haloalkyl;

R⁶ represents hydrogen, C₁-C₆-alkyl, C₁-C₆-haloalkyl, C₆-C₁₄-aryl or hetaryl having 4 to 13 carbon atoms, wherein hetaryl has 1, 2 or 3 identical or different heteroatoms or heteroatom-containing groups as ring members, selected
30 from N, NR⁷, O, S, SO and SO₂, wherein aryl and hetaryl are unsubstituted or substituted by 1, 2, 3, 4 or 5 identical or different radicals R⁵;

R⁷ represents hydrogen, C₁-C₆-alkyl, C₁-C₆-haloalkyl or C₆-C₁₄-aryl, wherein aryl is unsubstituted or substituted by 1, 2, 3, 4 or 5 identical or different radicals R⁵;
35

R⁸ represents CN, halogen, C₁-C₄-alkyl, C₁-C₄-haloalkyl or C₆-C₁₄-aryl, which is unsubstituted or substituted by 1, 2 or 3 identical or different radicals selected from C₁-C₄-alkyl and C₁-C₄-haloalkyl;
40



INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2020/074918

A. CLASSIFICATION OF SUBJECT MATTER
INV. H01L51/54 C07F5/00 H01L51/46
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H01L C07F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6 605 317 B1 (KATHIRGAMANATHAN POOPATHY [GB]) 12 August 2003 (2003-08-12) column 4, line 7 - line 13; claims 1-5 -----	1-19
X	US 7 183 008 B1 (KATHIRGAMANATHAN POOPATHY [GB]) 27 February 2007 (2007-02-27) column 2, line 44 - line 45; claims 1-4 -----	1-19
A	US 2006/105197 A1 (KATHIRGAMANATHAN POOPATHY [GB] ET AL) 18 May 2006 (2006-05-18) the whole document ----- -/-	1-19



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

26 November 2020

Date of mailing of the international search report

04/12/2020

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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2020/074918

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DANIEL WERNER ET AL: "Facile Reversible Benzophenone Insertion into Rare-Earth Metal Pyrazolate Complexes", EUROPEAN JOURNAL OF INORGANIC CHEMISTRY, vol. 2017, no. 28, 31 July 2017 (2017-07-31), pages 3419-3428, XP055751040, DE ISSN: 1434-1948, DOI: 10.1002/ejic.201700635 Scheme 1; page 3420; compound 4 -----	1-19

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2020/074918

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