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(54) **Title:** COMPOSITION

(57) **Abstract:** The present invention relates to a stacked layer preferably being a protection layer for an optical device, comprising at least; (A) an organic layer, and (B) an inorganic layer placed over the organic layer. The stacked layer may be used to make semiconductor device/display device application, for example semiconductor chip, or a liquid crystal, quantum dot, µLED and OLED display fabricated on a substrate controlled by semiconductors.

# Composition

## Field of the invention

The present invention relates to a stacked layer, preferably being a protection layer for an optical device, comprising at least an organic layer and an inorganic layer; use of a composition for fabricating an organic layer of a stacked layer comprising at least an organic layer and an inorganic layer; method for fabricating a stacked layer; and a device comprising at least a stacked layer.

## Background Art

Electronic devices, especially organic electronic devices have become thinner and thinner over the years. These devices are generally encapsulated with optically transparent insulating materials.

US 9944818 B2 discloses a two component mass polymerizable composition which is capable of tailoring to the desirable refractive index and is suitable as a filler and a protective coating material.

US 11230624 B2 discloses a polycycloolefin monomers and catalyst activated by compound capable of generating photoacid as 3d printing materials.

## Patent Literature

1. US 9944818 B2
2. US 11230624 B2

## Summary of the invention

However, the inventors newly have found that there are still one or more of considerable problems for which improvement is desired, as listed below: realziing higher transparency of an obtained stacked layer at visible light wavelength, lower haze value of an obtained stacked layer, lower dielectric constant of a composition and an obtained film (stacked layer), lower permittivity of a composition and an obtained film (stacked layer), improved touch sensitivity of a touch-screen separated from an OLED device by a stacked layer according to this invention, higher refractive index, improved mechanical properties of an obtained stacked layer against mechanical stress such as folding and bending; realizing improved Hardness (N/mm$^2$) value of an obtained stacked layer, improved Module value (Mpa) of an obtained stacked layer, good curing ratio of an composition, and/or good thermal properties. Here, said staked layer contains at least an (A) organic layer, and (B) an inorganic layer placed over the organic layer, preferably said inorganic layer is directly attached onto said organic layer. Preferably said stacked layer consists of inorganic layer/organic layer/inorganic layer.

The inventors aimed to solve one or more of the above-mentioned problems.

The present inventors have surprisingly found that one or more of the above described technical problems can be solved by the features as defined in the claims.

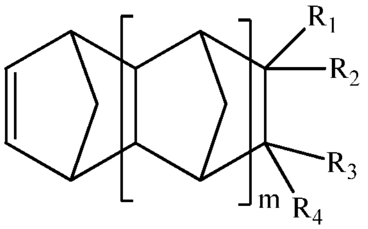
Namely, in one aspect of the present invention, it was found a novel stacked layer, preferably being a protection layer for an optical device, comprising at least;
(A) an organic layer, and
(B) an inorganic layer placed over the organic layer, preferably said inorganic layer is directly attached onto said organic layer,
wherein the haze value of the stacked layer is less than 5, preferably less than 1.

In another aspect of the present invention, it relates to a stacked layer, preferably being a protection layer for an optical device, comprising at least;
(A) an organic layer, and

(B) an inorganic layer placed over the organic layer, preferably said inorganic layer is directly attached onto said organic layer,

wherein said organic layer is obtained from a composition comprising at least:

a) a chemical compound of formula (I):



(I)

wherein:

m is an integer 0, 1 or 2;

$R_1$, $R_2$, $R_3$ and $R_4$ are the same or different and each independently selected from the group consisting of hydrogen, halogen, methyl, ethyl, linear or branched $(C_3\text{-}C_{16})$alkyl, perfluoro$(C_1\text{-}C_{12})$alkyl, hydroxy$(C_1\text{-}C_{16})$alkyl, $(C_3\text{-}C_{12})$cycloalkyl, $(C_6\text{-}C_{12})$bicycloalkyl, $(C_7\text{-}C_{14})$tricycloalkyl, $(C_6\text{-}C_{10})$aryl, $(C_6\text{-}C_{10})$aryl$(C_1\text{-}C_6)$alkyl, perfluoro$(C_6\text{-}C_{10})$aryl, perfluoro$(C_6\text{-}C_{10})$aryl$(C_1\text{-}C_6)$alkyl, tri$(C_1\text{-}C_6)$alkoxysilyl and a group of formula (A):

$$-Z^1\text{-Aryl} \quad (A)$$

wherein:

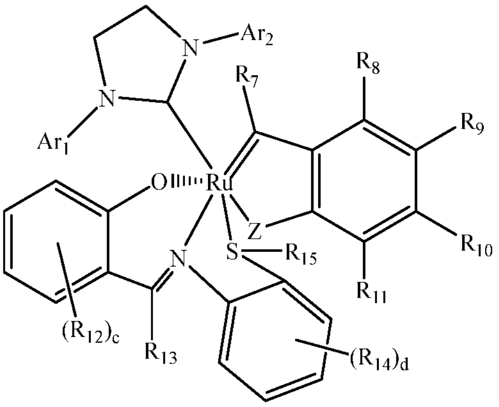
$Z^1$ is a connecting bond or a group selected from the group consisting of: $(CR_5R_6)_a$, $O(CR_5R_6)_a$, $(CR_5R_6)_aO$, $(CR_5R_6)_a\text{-}O\text{-}(CR_5R_6)_b$, $(CR_5R_6)_a\text{-}O\text{-}(SiR_5R_6)_b$, $(CR_5R_6)_a\text{-}(CO)O\text{-}(CR_5R_6)_b$, $(CR_5R_6)_a\text{-}O(CO)\text{-}(CR_5R_6)_b$, $(CR_5R_6)_a\text{-}(CO)\text{-}(CR_5R_6)_b$, where a and b are integers which may be the same or different and each independently is 1 to 12;

$R_5$ and $R_6$ are the same or different and each independently selected from the group consisting of hydrogen, methyl, ethyl, linear or branched $(C_3\text{-}C_6)$alkyl, hydroxy, methoxy, ethoxy, linear or branched $(C_3\text{-}C_6)$alkyloxy, acetoxy, $(C_2\text{-}C_6)$acyl, hydroxymethyl, hydroxyethyl, linear or branched hydroxy$(C_3\text{-}C_6)$alkyl, phenyl and phenoxy;

Aryl is phenyl or phenyl substituted with one or more of groups selected from the group consisting of methyl, ethyl, linear or branched ($C_3$-$C_6$)alkyl, hydroxy, methoxy, ethoxy, linear or branched ($C_3$-$C_6$)alkyloxy, acetoxy, ($C_2$-$C_6$)acyl, hydroxymethyl, hydroxyethyl, linear or branched hydroxy($C_3$-$C_6$)alkyl, phenyl and phenoxy;

wherein at least one of $R_1$, $R_2$, $R_3$ and $R_4$ is not hydrogen when m is 0, wherein at least two of $R_1$, $R_2$, $R_3$ and $R_4$ may form a ring;

b) an organo-transition metal catalyst comprising a metal selected from ruthenium or osmium, preferably it is an organo-ruthenium compound, more preferably it is represented by formula (II):



(II)

wherein

c and d are integers from 0 to 5;

Z is oxygen or sulfur;

$R_7$ is selected from the group consisting of hydrogen, ($C_1$-$C_{20}$)alkyl, ($C_2$-$C_{20}$)alkenyl, ($C_2$-$C_{20}$)alkynyl and ($C_6$-$C_{10}$)aryl; and

$R_8$, $R_9$, $R_{10}$ and $R_{11}$ are the same or different and each independently selected from the group consisting of hydrogen, halogen, ($C_1$-$C_{16}$)alkyl, ($C_1$-$C_{16}$)alkoxy, ($C_1$-$C_{16}$)perfluoroalkyl, ($C_3$-$C_7$)cycloalkyl, ($C_2$-$C_{16}$)alkenyl, ($C_6$-$C_{14}$)aryl, ($C_6$-$C_{14}$)perfluoroaryl,

($C_3$-$C_{12}$)heterocyclyl, $-OR_{16}$, $-NO_2$, -COOH, $-COOR_{16}$, $-CONR_{16}R_{17}$, $-SO_2NR_{16}R_{17}$, $-SO_2R_{16}$, -CHO, $-COR_{16}$, wherein $R_{16}$ and $R_{17}$ are the same or different and each independently selected from the group consisting of ($C_1$-

$C_6$)alkyl, ($C_1$-$C_6$)perfluoroalkyl, ($C_6$-$C_{14}$)aryl, ($C_6$-$C_{14}$)perfluoroaryl; or wherein

two or more of $R_8$, $R_9$, $R_{10}$ and $R_{11}$ taken together with the carbon atoms to which they are attached to form a substituted or unsubstituted, fused ($C_4$-$C_8$)carbocyclic ring, or a substituted or unsubstituted, fused aromatic ring;

each $R_{12}$, $R_{13}$ and $R_{14}$ may be the same or different and independently of the other selected from the group consisting of hydrogen, halogen, ($C_1$-$C_{16}$)alkyl, ($C_1$-$C_{16}$)alkoxy, ($C_1$-$C_{16}$)perfluoroalkyl, ($C_3$-$C_7$)cycloalkyl, ($C_2$-$C_{16}$)alkenyl, ($C_6$-$C_{14}$)aryl,

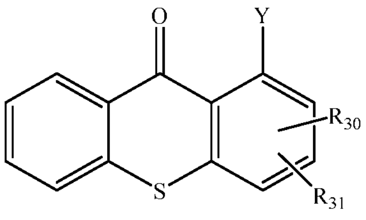
($C_6$-$C_{14}$)perfluoroaryl,($C_3$-$C_{12}$)heterocyclyl, $-OR_{16}$, $-NO_2$,

-COOH, $-COOR_{16}$, $-CONR_{16}R_{17}$, $-SO_2NR_{16}R_{17}$, $-SO_2R_{16}$, -CHO, $-COR_{16}$, wherein $R_{16}$ and $R_{17}$ are the same or different and each independently selected from the group consisting of ($C_1$-$C_6$)alkyl, ($C_1$-$C_6$)perfluoroalkyl, ($C_6$-$C_{14}$)aryl, ($C_6$-$C_{14}$)perfluoroaryl;

$R_{15}$ is selected from the group consisting of ($C_1$-$C_{16}$)alkyl, ($C_1$-$C_{16}$)perfluoroalkyl, ($C_3$-$C_{16}$)cycloalkyl, ($C_6$-$C_{14}$)aryl, ($C_6$-$C_{14}$)perfluoroaryl and ($C_3$-$C_{12}$)heterocyclyl;

$Ar_1$ and $Ar_2$ are the same or different and each independently selected from the group consisting of substituted or unsubstituted phenyl, substituted or unsubstituted biphenyl and substituted or unsubstituted naphthyl, wherein each of said substituents are independently selected from the group consisting of methyl, ethyl and linear or branched ($C_3$-$C_6$)alkyl;

c) a photoactive compound capable of releasing a Bronsted acid when it is subjected to photolytic condition, preferably it is selected from a compound represented by formula (III):



(III)

wherein

Y is halogen; and

$R_{30}$ and $R_{31}$ are the same or different and independently of each other selected from the group consisting of hydrogen, methyl, ethyl, linear or branched ($C_3$-$C_{12}$)alkyl, ($C_3$-$C_{12}$)cycloalkyl, ($C_6$-$C_{12}$)bicycloalkyl, ($C_7$-$C_{14}$)tricycloalkyl, ($C_6$-$C_{10}$)aryl, ($C_6$-$C_{10}$)aryl($C_1$-$C_3$)alkyl, ($C_1$-$C_{12}$)alkoxy, ($C_3$-$C_{12}$)cycloalkoxy, ($C_6$-$C_{12}$)bicycloalkoxy, ($C_7$-$C_{14}$)tricycloalkoxy, ($C_6$-$C_{10}$)aryloxy($C_1$-$C_3$)alkyl and ($C_6$-$C_{10}$)aryloxy.

In another aspect, the present invention furhter relates to use of a composition for fabricating an organic layer of a stacked layer, preferably said stacked layer is being a protection layer for an optical device, wherein said stacked layer comprises at least;

(A) said organic layer, and

(B) an inorganic layer placed over the organic layer.

wherein said composition comprises at least:

a) a chemical compound of formula (I);

b) an organo-transition metal catalyst comprising a metal selected from ruthenium or osmium, preferably it is an organo-ruthenium compound, more preferably it is represented by formula (II); and

c) a photoactive compound capable of releasing a Bronsted acid when it is subjected to photolytic condition, preferably it is selected from a compound represented by formula (III).

In another aspect, the present invention furhter relates to a method for fabricating a stacked layer, preferably said stacked layer is being a protection layer for an optical device, comprising at least the following steps:

($X^{a1}$) providing a composition of onto a substrate, a layer, or an outermost surface of a device to obtain an organic layer,

($X^{a2}$) irradiating the coated layer with light (applying light irradiation) to form a cured film, preferably with light having peak maximum wavelength in the range from 360 to 430 nm, preferably the dose of the light irradiated to the composition is in the range from 1 to 5 J/cm$^2$.

($X^{a3}$) fabricating an inorganic layer over the organic layer to form a stacked layer, preferably said inorganic layer is fabricated by Chemical Vapor Deposition (CVD) or Atomic Layer Deposition (ALD). Preferably said inorganic layer is selected from the group consisting of SiNx,SiOxNy or SiOx.

wherein said composition comprises at least :

a) a chemical compound of formula (I);

b) an organo-transition metal catalyst comprising a metal selected from ruthenium or osmium, preferably it is an organo-ruthenium compound, more preferably it is represented by formula (II); and

c) a photoactive compound capable of releasing a Bronsted acid when it is subjected to photolytic condition, preferably it is selected from a compound represented by formula (III).

In another aspect, the present invention furhter relates to a method for fabricating a stacked layer, preferably said stacked layer is being a protection layer for an optical device, comprising at least the following steps:

($X^{a1}$) providing a substrate having an organic layer,

($X^{a3'}$) fabricating an inorganic layer by Chemical Vapor Deposition (CVD) or Atomic Layer Deposition (ALD) over the organic layer, wherein the chamber pressure in step ($X^{a3}$) is in the range from 0.5 to 3 Torr, preferably 0.8 to 2.4 Torr; and

the power of a radio frequency power supply (RF) used in step ($X^{a3}$) is in the range from 100 to 600W, preferably from 150 to 500W.

In another aspect, the present invention also relates to a stacked layer, preferably it is being a protection layer for an optical device, obtained by the method of the present invention.

In another aspect, the present invention also relates to a device comprising at least the staked layer of the present invention, preferably said device is an optical device, more preferably said device is a display device, preferably said device further comprises a functional module, more preferably said device comprises a functional module selected from OLED, LCD and µLED.

Technical effects of the invention

Present invention provides one or more of the following effects: higher transparency of an obtained stacked layer at visible light wavelength, lower haze value of an obtained stacked layer, lower dielectric constant of a composition and an obtained film (stacked layer), lower permittivity of a composition and an obtained film (stacked layer), improved touch sensitivity of a touch-screen separated from an OLED device by a stacked layer according to this invention, high refractive index, good mechanical properties of an obtained stacked layer against mechanical stress such as folding and bending, improved Hardness (N/mm$^2$) value of an obtained stacked layer, improved Module value (Mpa) of an obtained stacked layer, good curing ratio of an composition, and/or good thermal properties. Here, said staked layer contains at least an (A) organic layer, and (B) an inorganic layer placed over the organic layer, preferably said inorganic layer is directly attached onto said organic layer. Preferably said stacked layer consists of inorganic layer/organic layer/inorganic layer.

## DETAILED DESCRIPTION

The terms as used herein have the following meanings:

As used herein, the articles “a,” “an,” and “the” include plural referents unless otherwise expressly and unequivocally limited to one referent.

Since all numbers, values and/or expressions referring to quantities of ingredients, reaction conditions, etc., used herein and in the claims appended hereto, are subject to the various uncertainties of measurement encountered in obtaining such values, unless otherwise indicated, all are to be understood as modified in all instances by the term “about.”

Where a numerical range is disclosed herein such range is continuous, inclusive of both the minimum and maximum values of the range as well as every value between such minimum and maximum values. Still further, where a range refers to integers, every integer between the minimum and maximum values of such range is included. In addition, where multiple ranges are provided to describe a feature or characteristic, such ranges can be combined. That is to say that, unless otherwise indicated, all ranges disclosed herein are to be understood to encompass any and all sub-ranges subsumed therein.

For example, a stated range of from “1 to 10” should be considered to include any and all sub-ranges between the minimum value of 1 and the maximum value of 10. Exemplary sub-ranges of the range 1 to 10 include, but are not limited to, 1 to 6.1, 3.5 to 7.8, and 5.5 to 10, etc.

As used herein, “hydrocarbyl” refers to a group that contains carbon and hydrogen atoms, non-limiting examples being alkyl, cycloalkyl, aryl, aralkyl, alkaryl, and alkenyl. The term “halohydrocarbyl” refers to a hydrocarbyl group where at least one hydrogen has been replaced by a halogen. The term perhalocarbyl refers to a hydrocarbyl group where all hydrogens have been replaced by a halogen.

As used herein, the expression “alkyl” means a saturated, straight-chain or branched-chain hydrocarbon substituent having the specified number of carbon atoms. Particular alkyl groups are methyl, ethyl, n-propyl, isopropyl, n-butyl, iso-butyl, tert-butyl, and so on. Derived expressions such as “alkoxy,” “thioalkyl,” “alkoxyalkyl,” “hydroxyalkyl,” “alkylcarbonyl,” “alkoxycarbonylalkyl,” “alkoxycarbonyl,” “diphenylalkyl,” “phenylalkyl,” “phenylcarboxyalkyl” and “phenoxyalkyl” are to be construed accordingly.

As used herein, the expression “cycloalkyl” includes all of the known cyclic groups. Representative examples of “cycloalkyl” includes without any limitation cyclopropyl, cyclobutyl, cyclopentyl, cyclohexyl, cycloheptyl, cyclooctyl, and the like. Derived expressions such as “cycloalkoxy,” “cycloalkylalkyl,” “cycloalkylaryl,” “cycloalkylcarbonyl” are to be construed accordingly.

As used herein, the expression “perhaloalkyl” represents the alkyl, as defined above, wherein all of the hydrogen atoms in said alkyl group are replaced with halogen atoms selected from fluorine, chlorine, bromine or iodine. Illustrative examples include trifluoromethyl, trichloromethyl, tribromomethyl, triiodomethyl, pentafluoroethyl, pentachloroethyl, pentabromoethyl, pentaiodoethyl, and straight chained or branched heptafluoropropyl, heptachloropropyl, heptabromopropyl, nonafluorobutyl, nonachlorobutyl, undecafluoropentyl, undecachloropentyl, tridecafluorohexyl, tridecachlorohexyl, and the like. Derived expression, “perhaloalkoxy,” is to be construed accordingly. It should further be noted that certain of the alkyl groups as described herein, such as for example, “alkyl” may partially be fluorinated, that is, only portions of the hydrogen atoms in said alkyl group are replaced with fluorine atoms and shall be construed accordingly.

As used herein the expression “acyl” shall have the same meaning as “alkanoyl,” which can also be represented structurally as “R-CO-,” where R is an “alkyl” as defined herein having the specified number of carbon atoms. Additionally, “alkylcarbonyl” shall mean same as “acyl” as defined herein.

Specifically, “($C_1$-$C_4$)acyl” shall mean formyl, acetyl or ethanoyl, propanoyl, n-butanoyl, etc. Derived expressions such as “acyloxy” and “acyloxyalkyl” are to be construed accordingly.

As used herein, the expression “aryl” means substituted or unsubstituted phenyl or naphthyl. Specific examples of substituted phenyl or naphthyl include o-, p-, m-tolyl, 1,2-, 1,3-, 1,4-xylyl, 1-methylnaphthyl, 2-methylnaphthyl, etc. “Substituted phenyl” or “substituted naphthyl” also include any of the possible substituents as further defined herein or one known in the art.

As used herein, the expression “arylalkyl” means that the aryl as defined herein is further attached to alkyl as defined herein. Representative examples include benzyl, phenylethyl, 2-phenylpropyl, 1-naphthylmethyl, 2-naphthylmethyl and the like.

As used herein, the expression "alkenyl" means a non-cyclic, straight or branched hydrocarbon chain having the specified number of carbon atoms and containing at least one carbon-carbon double bond, and includes ethenyl and straight-chained or branched propenyl, butenyl, pentenyl, hexenyl, and the like. Derived expression, “arylalkenyl” and five membered or six membered “heteroarylalkenyl” is to be construed accordingly. Illustrative examples of such derived expressions include furan-2-ethenyl, phenylethenyl, 4-methoxyphenylethenyl, and the like.

As used herein, the expression “heteroaryl” includes all of the known heteroatom containing aromatic radicals. Representative 5-membered heteroaryl radicals include furanyl, thienyl or thiophenyl, pyrrolyl, isopyrrolyl, pyrazolyl, imidazolyl, oxazolyl, thiazolyl, isothiazolyl, and the like.

Representative 6-membered heteroaryl radicals include pyridinyl, pyridazinyl, pyrimidinyl, pyrazinyl, triazinyl, and the like radicals.

Representative examples of bicyclic heteroaryl radicals include, benzofuranyl, benzothiophenyl, indolyl, quinolinyl, isoquinolinyl, cinnolyl, benzimidazolyl, indazolyl, pyridofuranyl, pyridothienyl, and the like radicals. “Halogen” or “halo” means chloro, fluoro, bromo, and iodo.

In a broad sense, the term “substituted” is contemplated to include all permissible substituents of organic compounds. In a few of the specific embodiments as disclosed herein, the term “substituted” means substituted with one or more substituents independently selected from the group consisting of ($C_1$-$C_6$)alkyl, ($C_2$-$C_6$)alkenyl, ($C_1$-$C_6$)perfluoroalkyl, phenyl, hydroxy, -$CO_2H$, an ester, an amide, ($C_1$-$C_6$)alkoxy, ($C_1$-$C_6$)thioalkyl and ($C_1$-$C_6$)perfluoroalkoxy. However, any of the other suitable substituents known to one skilled in the art can also be used in these embodiments.

It should be noted that any atom with unsatisfied valences in the text, schemes, examples and tables herein is assumed to have the appropriate number of hydrogen atom(s) to satisfy such valences.

By the term “latent organo-transition metal catalyst” is meant organo-transition metal compounds that show little or no catalytic activity at a particular (usually ambient atmospheric conditions) temperature and initiate such activity either upon heat or light or both. Generally the catalytic activity of the catalyst can be kept latent for a prolonged periods of time, which can range from five days or longer especially when it is stored at room temperature or lower in a dark atmosphere. Higher temperatures and/or light may accelerate the catalytic activity.

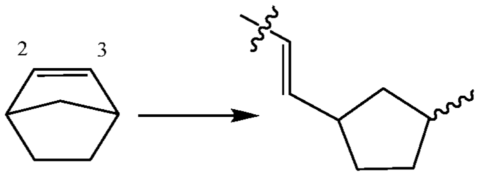
By the term “actinic radiation” or “photolytic conditions” is meant subjecting the compositions of this invention to suitable “electromagnetic radiation,” which can be emitted from a laser, a digital processing (DLP) projector, a lamp, a light emitting diode (LED), a mercury arc lamp, a fiber optic, or liquid crystal display (LCD), and the like.

It will be understood that the terms “dielectric” and “insulating” are used interchangeably herein. Thus reference to an insulating material or layer is inclusive of a dielectric material or layer and *vice versa*. Further, as used herein, the term “organic electronic device” will be understood to be inclusive of the term “organic semiconductor device” and the several specific implementations of such devices used, for example, in electronic, automotive or other industries.

As used herein, the dielectric constant (Dk) of a material is the ratio of the charge stored in an insulating material placed between two metallic plates to the charge that can be stored when the insulating material is replaced by vacuum or air. It is also called as electric permittivity or simply permittivity. And, at times referred as relative permittivity, because it is measured relatively from the permittivity of free space.

As used herein, “low-loss” is the dissipation factor (Df), which is a measure of loss-rate of energy of a mode of oscillation (mechanical, electrical, or electromechanical) in a dissipative system. It is the reciprocal of quality factor, which represents the "quality" or durability of oscillation.

By the term "derived" is meant that the polymeric repeating units are polymerized (formed) from, for example, polycyclic norbornene-type monomers in accordance with formulae (I), (V) or (VI) wherein the resulting polymers are ring opened metathesis polymerized (ROMP), for example, the 2,3 double bond of norbornene-type monomers are ring opened and polymerized as shown below:



Accordingly, in accordance with the practice of this invention there is provided a stacked layer, preferably being a protection layer for an optical device,

comprising at least;

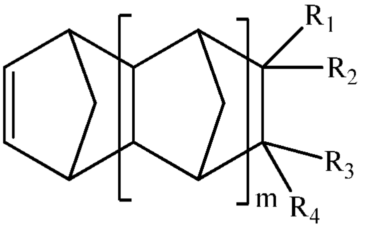
(A) an organic layer, and

(B) an inorganic layer placed over the organic layer, preferably said inorganic layer is directly attached onto said organic layer,

wherein the haze value of the stacked layer is less than 5, preferably less than 1.

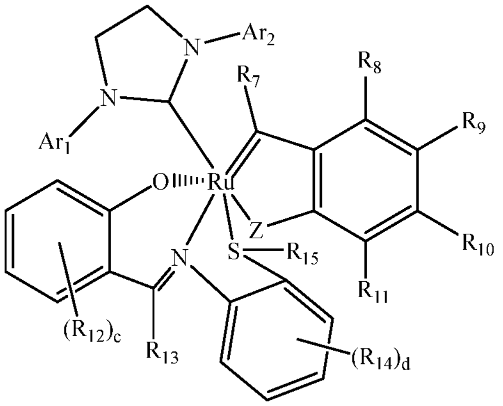
In a preferred embodiment of the present invention, said organic layer of the stacked layer is obtained from a composition comprising at least:

a) a chemical compound of formula (I):



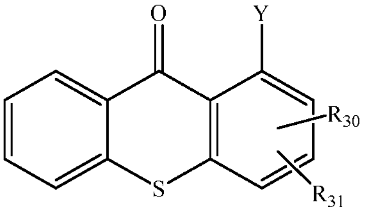
(I);

(b) an organo-transition metal catalyst comprising a metal selected from ruthenium or osmium, preferably it is an organo-ruthenium compound, more preferably it is represented by formula (II);



(II)

(c) a photoactive compound capable of releasing a Bronsted acid when it is subjected to photolytic condition, preferably it is selected from a compound represented by formula (III);



(III).

The definitions of each symbols are described on pages 15-18. Furhter details of a) the chemical compound of formula (I), b) the organo-transition metal catalyst and c) the photoactive compound are also discribed below in the section of **"a) Chemical compound of formula (I)", "b) Organo-transition metal catalyst" and "c) Photoactive compound (photosensitizer) ".**

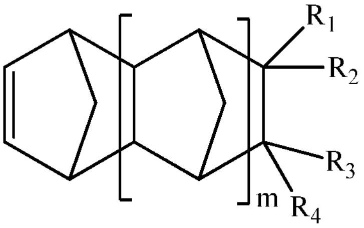
In another aspect, the present invention also relates to stacked layer, preferably being a protection layer for an optical device, comprising at least;

(A) an organic layer, and

(B) an inorganic layer placed over the organic layer, preferably said inorganic layer is directly attached onto said organic layer,

wherein said organic layer is obtained from a composition comprising at least, essentially consisting of or consisting of:

a) a chemical compound of formula (I):



(I)

wherein:

m is an integer 0, 1 or 2;

$R_1$, $R_2$, $R_3$ and $R_4$ are the same or different and each independently selected from the group consisting of hydrogen, halogen, methyl, ethyl, linear or branched ($C_3$-$C_{16}$)alkyl, perfluoro($C_1$-$C_{12}$)alkyl, hydroxy($C_1$-$C_{16}$)alkyl, ($C_3$-$C_{12}$)cycloalkyl, ($C_6$-$C_{12}$)bicycloalkyl, ($C_7$-$C_{14}$)tricycloalkyl, ($C_6$-$C_{10}$)aryl, ($C_6$-$C_{10}$)aryl($C_1$-$C_6$)alkyl, perfluoro($C_6$-$C_{10}$)aryl, perfluoro($C_6$-$C_{10}$)aryl($C_1$-$C_6$)alkyl, tri($C_1$-$C_6$)alkoxysilyl and a group of formula (A):

$$-Z^1\text{-Aryl} \quad (A)$$

wherein:

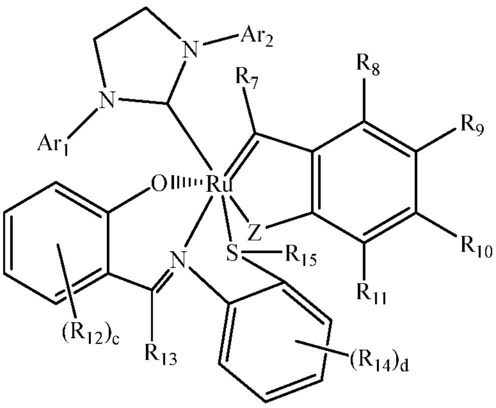
$Z^1$ is a connecting bond or a group selected from the group consisting of: $(CR_5R_6)_a$, $O(CR_5R_6)_a$, $(CR_5R_6)_aO$, $(CR_5R_6)_a$-O-$(CR_5R_6)_b$, $(CR_5R_6)_a$-O-$(SiR_5R_6)_b$, $(CR_5R_6)_a$-(CO)O-$(CR_5R_6)_b$, $(CR_5R_6)_a$-O(CO)-$(CR_5R_6)_b$, $(CR_5R_6)_a$-(CO)-$(CR_5R_6)_b$, where a and b are integers which may be the same or different and each independently is 1 to 12;

$R_5$ and $R_6$ are the same or different and each independently selected from the group consisting of hydrogen, methyl, ethyl, linear or branched ($C_3$-$C_6$)alkyl, hydroxy, methoxy, ethoxy, linear or branched ($C_3$-$C_6$)alkyloxy, acetoxy, ($C_2$-$C_6$)acyl, hydroxymethyl, hydroxyethyl, linear or branched hydroxy($C_3$-$C_6$)alkyl, phenyl and phenoxy;

Aryl is phenyl or phenyl substituted with one or more of groups selected from the group consisting of methyl, ethyl, linear or branched ($C_3$-$C_6$)alkyl, hydroxy, methoxy, ethoxy, linear or branched ($C_3$-$C_6$)alkyloxy, acetoxy, ($C_2$-$C_6$)acyl, hydroxymethyl, hydroxyethyl, linear or branched hydroxy($C_3$-$C_6$)alkyl, phenyl and phenoxy;

wherein at least one of $R_1$, $R_2$, $R_3$ and $R_4$ is not hydrogen when m is 0, wherein at least two of $R_1$, $R_2$, $R_3$ and $R_4$ may form a ring;

b) an organo-transition metal catalyst comprising a metal selected from ruthenium or osmium, preferably it is an organo-ruthenium compound, more preferably it is represented by formula (II):



(II)

wherein

c and d are integers from 0 to 5;

Z is oxygen or sulfur;

$R_7$ is selected from the group consisting of hydrogen, $(C_1\text{-}C_{20})$alkyl, $(C_2\text{-}C_{20})$alkenyl, $(C_2\text{-}C_{20})$alkynyl and $(C_6\text{-}C_{10})$aryl; and

$R_8$, $R_9$, $R_{10}$ and $R_{11}$ are the same or different and each independently selected from the group consisting of hydrogen, halogen, $(C_1\text{-}C_{16})$alkyl, $(C_1\text{-}C_{16})$alkoxy, $(C_1\text{-}C_{16})$perfluoroalkyl, $(C_3\text{-}C_7)$cycloalkyl, $(C_2\text{-}C_{16})$alkenyl, $(C_6\text{-}C_{14})$aryl, $(C_6\text{-}C_{14})$perfluoroaryl,

$(C_3\text{-}C_{12})$heterocyclyl, $-OR_{16}$, $-NO_2$, -COOH, $-COOR_{16}$, $-CONR_{16}R_{17}$, $-SO_2NR_{16}R_{17}$, $-SO_2R_{16}$, -CHO, $-COR_{16}$, wherein $R_{16}$ and $R_{17}$ are the same or different and each independently selected from the group consisting of $(C_1\text{-}C_6)$alkyl, $(C_1\text{-}C_6)$perfluoroalkyl, $(C_6\text{-}C_{14})$aryl, $(C_6\text{-}C_{14})$perfluoroaryl; or wherein

two or more of $R_8$, $R_9$, $R_{10}$ and $R_{11}$ taken together with the carbon atoms to which they are attached to form a substituted or unsubstituted, fused $(C_4\text{-}C_8)$carbocyclic ring, or a substituted or unsubstituted, fused aromatic ring;

each $R_{12}$, $R_{13}$ and $R_{14}$ may be the same or different and independently of the other selected from the group consisting of hydrogen, halogen, $(C_1\text{-}C_{16})$alkyl, $(C_1\text{-}C_{16})$alkoxy, $(C_1\text{-}C_{16})$perfluoroalkyl, $(C_3\text{-}C_7)$cycloalkyl, $(C_2\text{-}C_{16})$alkenyl, $(C_6\text{-}C_{14})$aryl,

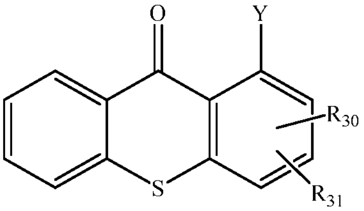
$(C_6\text{-}C_{14})$perfluoroaryl,$(C_3\text{-}C_{12})$heterocyclyl, $-OR_{16}$, $-NO_2$,

-COOH, -COOR$_{16}$, -CONR$_{16}$R$_{17}$, -SO$_2$NR$_{16}$R$_{17}$, -SO$_2$R$_{16}$, -CHO, -COR$_{16}$, wherein R$_{16}$ and R$_{17}$ are the same or different and each independently selected from the group consisting of (C$_1$-C$_6$)alkyl, (C$_1$-C$_6$)perfluoroalkyl, (C$_6$-C$_{14}$)aryl, (C$_6$-C$_{14}$)perfluoroaryl;

R$_{15}$ is selected from the group consisting of (C$_1$-C$_{16}$)alkyl, (C$_1$-C$_{16}$)perfluoroalkyl, (C$_3$-C$_{16}$)cycloalkyl, (C$_6$-C$_{14}$)aryl, (C$_6$-C$_{14}$)perfluoroaryl and (C$_3$-C$_{12}$)heterocyclyl;

Ar$_1$ and Ar$_2$ are the same or different and each independently selected from the group consisting of substituted or unsubstituted phenyl, substituted or unsubstituted biphenyl and substituted or unsubstituted naphthyl, wherein each of said substituents are independently selected from the group consisting of methyl, ethyl and linear or branched (C$_3$-C$_6$)alkyl;

c) a photoactive compound capable of releasing a Bronsted acid when it is subjected to photolytic condition, preferably it is selected from a compound represented by formula (III):



(III)

wherein

Y is halogen; and

R$_{30}$ and R$_{31}$ are the same or different and independently of each other selected from the group consisting of hydrogen, methyl, ethyl, linear or branched (C$_3$-C$_{12}$)alkyl, (C$_3$-C$_{12}$)cycloalkyl, (C$_6$-C$_{12}$)bicycloalkyl, (C$_7$-C$_{14}$)tricycloalkyl, (C$_6$-C$_{10}$)aryl, (C$_6$-C$_{10}$)aryl(C$_1$-C$_3$)alkyl, (C$_1$-C$_{12}$)alkoxy, (C$_3$-C$_{12}$)cycloalkoxy, (C$_6$-C$_{12}$)bicycloalkoxy, (C$_7$-C$_{14}$)tricycloalkoxy, (C$_6$-C$_{10}$)aryloxy(C$_1$-C$_3$)alkyl and (C$_6$-C$_{10}$)aryloxy.

## Composition

The monomers as described herein readily may undergo mass polymerization, i.e., in their neat form without use of any solvents when polymerized under mass ring open metathesis polymerization (ROMP) conditions using certain transition metal catalysts, such as for example, organo-ruthenium and organo-osmium compounds. See for example, R. H. Grubbs et al., *Handbook of Metathesis*, Ed.: Wiley-VCH, Weinheim, Germany, 2003, R. H. Grubbs et al., *Acc. Chem. Res.* 2001, 34, 18-29, R.H. Grubbs et al., Angew. *Chem. Int. Ed.*, 2006, 45, 3760-3765. Also, see US Patent No. 6,838,489, pertinent portions of which are incorporated herein by reference. The term “mass polymerization” as used herein shall have the generally accepted meaning in the art. That is, a polymerization reaction that is generally carried out substantially in the absence of a solvent.

In some cases, however, a small proportion of solvent is present in the reaction medium. For example, such small amounts of solvent may be used to dissolve the latent catalyst and/or the activator or convey the same to the reaction medium. Also, some solvent may be used to reduce the viscosity of the monomer. The amount of solvent that can be used in the reaction medium may be in the range of 0 to 5 weight percent based on the total weight of the monomers employed. Any of the suitable solvents that dissolves the catalyst, activator and/or monomers can be employed in this invention. Examples of such solvents include alkanes, cycloalkane, toluene, THF, dichloromethane, dichloroethane, and the like.

### a) Chemical compound of formula (I)

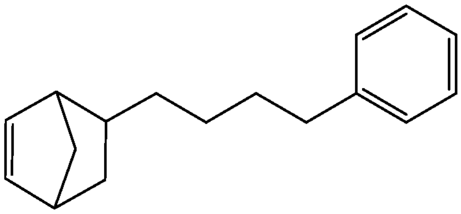
It is believed that the monomer(s) of formula (I) may also serve as high refractive index materials imparting high refractive index to the resulting polymeric film upon mass polymerization at a temperature and/or condition different from the application of the composition onto a desirable substrate.

When the composition of this invention contains two or more monomers, for example, they can be present in any desirable amounts that would bring about intended benefit, including either refractive index modification or viscosity modification or both.

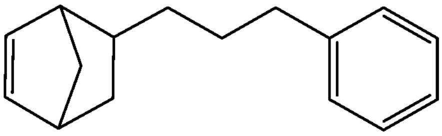
In general, the compositions in accordance with the present invention encompass the above described one or more of the monomer of formula (I) and if needed additional monomers of formula (I) distinct from each other, as it will be seen below, various composition embodiments are selected to provide properties to such embodiments that are appropriate and desirable for the use for which such embodiments are directed, thus such embodiments are tailorable to a variety of specific applications.

For example, as already discussed above, proper combination of distinctive monomers of formula (I) makes it possible to tailor a composition having the desirable refractive index, viscosity and optical transmission properties. In addition, as described further herein it may be desirable to include other polymeric or monomeric materials, such as for example inorganic nanoparticles which are compatible to provide desirable optical properties depending upon the end use application.

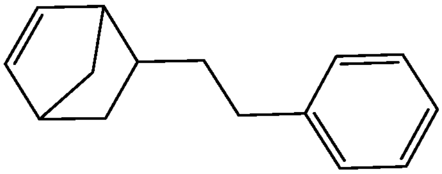
Accordingly, In a preferred embodiment of the present invention, the monomer(s) of formula (I) is selected from the following:



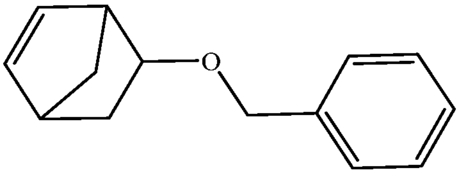
5-(4-phenylbutyl)bicyclo[2.2.1]hept-2-ene;



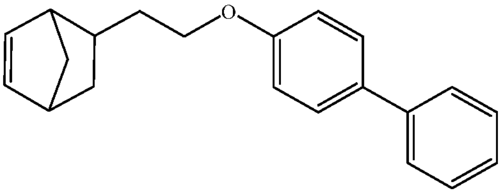
5-(3-phenylpropyl)bicyclo[2.2.1]hept-2-ene;



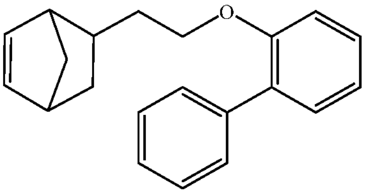
5-phenethylbicyclo[2.2.1]hept-2-ene (PENB);



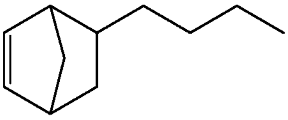
5-(benzyloxy)bicyclo[2.2.1]hept-2-ene;



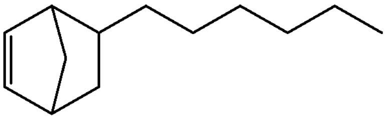
5-(2-([1,1'-biphenyl]-4-yloxy)ethyl)bicyclo[2.2.1]hept-2-ene;



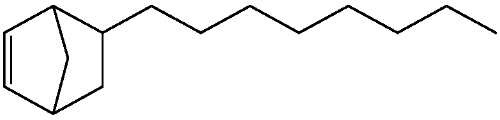
5-(2-([1,1'-biphenyl]-2-yloxy)ethyl)bicyclo[2.2.1]hept-2-ene (NBEtO-2-PhPh);



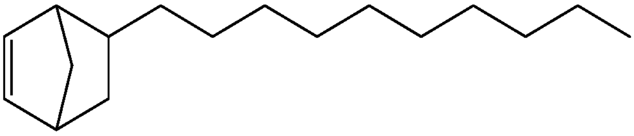
5-butylbicyclo[2.2.1]hept-2-ene (BuNB);



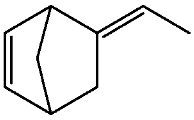
5-hexylbicyclo[2.2.1]hept-2-ene (HexylNB);



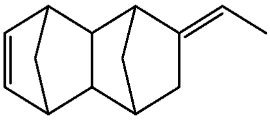
5-octylbicyclo[2.2.1]hept-2-ene (OctNB);



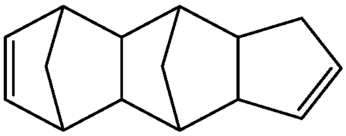
5-decylbicyclo[2.2.1]hept-2-ene (DecNB);



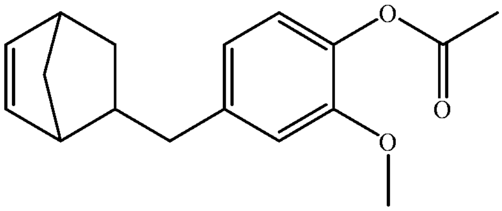
5-ethylidenebicyclo[2.2.1]hept-2-ene;



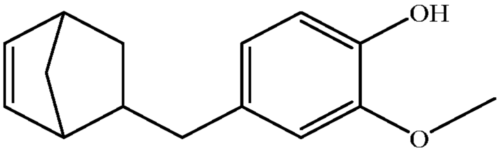
2-ethylidene-1,2,3,4,4a,5,8,8a-octahydro-1,4:5,8-dimethanonaphthalene;



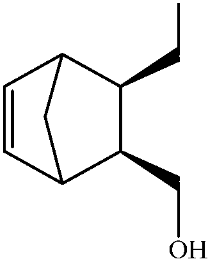
3a,4,4a,5,8,8a,9,9a-octahydro-1H-4,9:5,8-dimethanocyclopenta[b]naphthalene (one of trimers of cyclopentadiene, TCPD1, also known as CPD3);



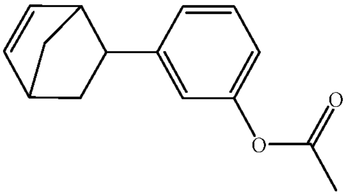
5-norbornenylmethyleugenyl acetate (EuAcNB);



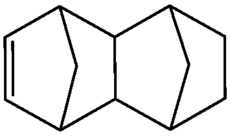
5-norbornenylmethyleugenol (EuOHNB);



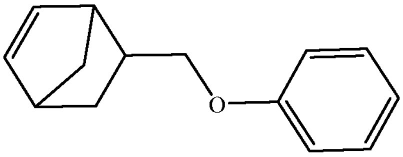
NB(MeOH)2;



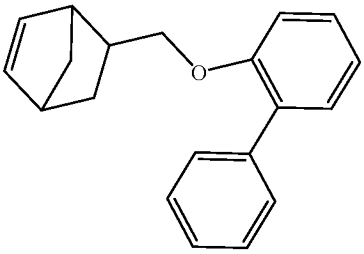
PhAcNB;



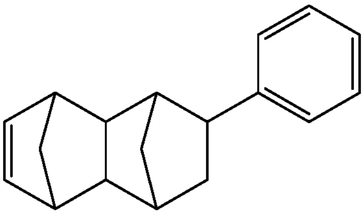
tetracyclododecene (TD);



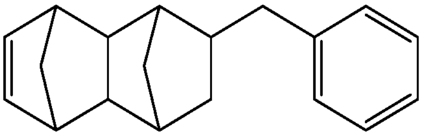
5-(phenoxymethyl)bicyclo[2.2.1]hept-2-ene (NBMeOPh);



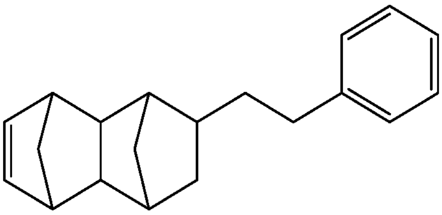
5-(([1,1'-biphenyl]-2-yloxy)methyl)bicyclo[2.2.1]hept-2-ene (NBMeOPhPh);



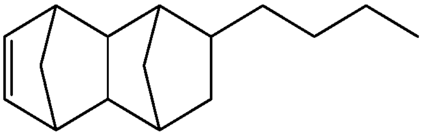
2-phenyl-tetracyclododecene (PhTD);



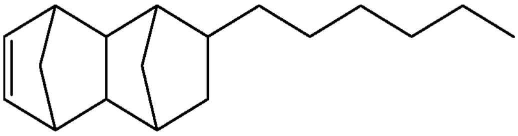
2-benzyl-1,2,3,4,4a,5,8,8a-octahydro-1,4:5,8-dimethanonaphthalene;



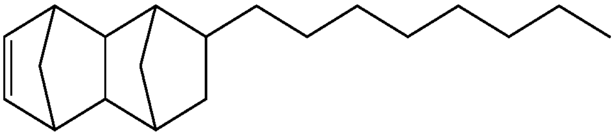
2-phenethyl-1,2,3,4,4a,5,8,8a-octahydro-1,4:5,8-dimethanonaphthalene (PETD);



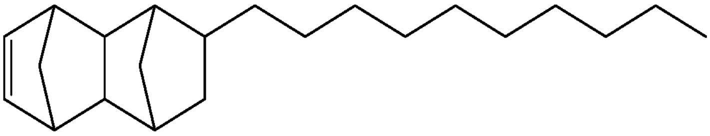
2-butyl-1,2,3,4,4a,5,8,8a-octahydro-1,4:5,8-dimethanonaphthalene (ButylTD);



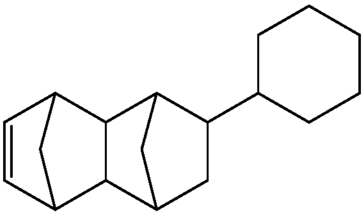
2-hexyl-1,2,3,4,4a,5,8,8a-octahydro-1,4:5,8-dimethanonaphthalene (HexylTD);



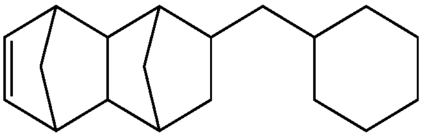
2-octyl-1,2,3,4,4a,5,8,8a-octahydro-1,4:5,8-dimethanonaphthalene (OctylTD);



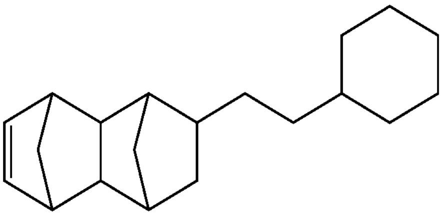
2-decyl-1,2,3,4,4a,5,8,8a-octahydro-1,4:5,8-dimethanonaphthalene (DecylTD);



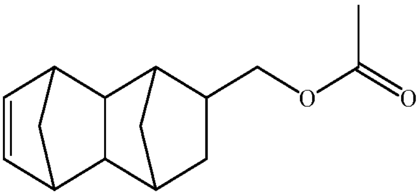
2-cyclohexyl-tetracyclododecene (CyclohexylTD);



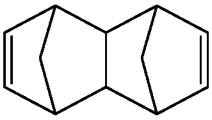
2-cyclohexylmethyl-1,2,3,4,4a,5,8,8a-octahydro-1,4:5,8-dimethanonaphthalene;



2- cyclohexylethyl-1,2,3,4,4a,5,8,8a-octahydro-1,4:5,8-dimethanonaphthalene;



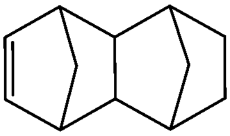
(1,2,3,4,4a,5,8,8a-octahydro-1,4:5,8-dimethanonaphthalen-2-yl)methyl acetate (TDMeOAc); and

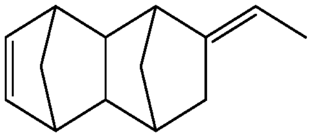


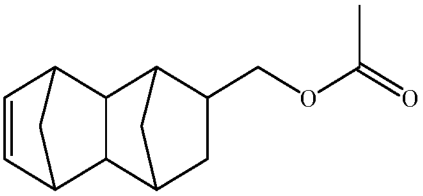
tetracyclododecadiene (TDD).

As noted, preferably, the monomer of formula (I) is having a refractive index of at least 1.5. The composition is in a clear liquid form at room temperature.

Preferably the following monomer of formula (I) is more suitable:



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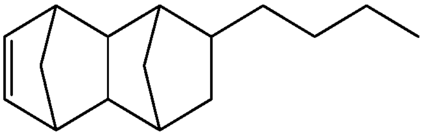
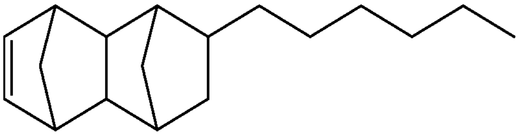
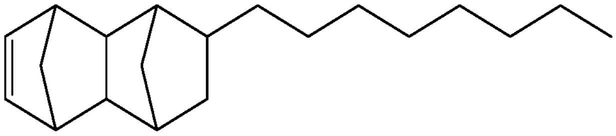
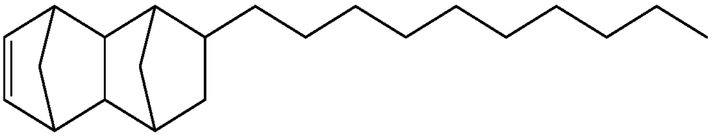
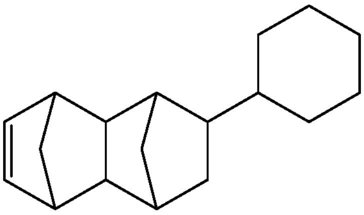
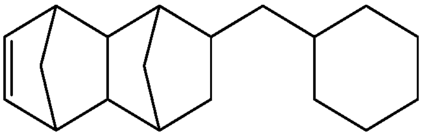


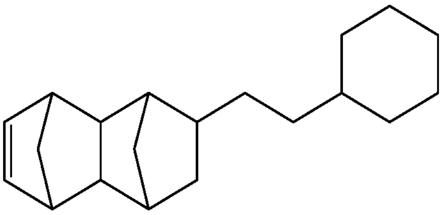


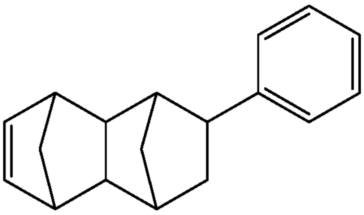


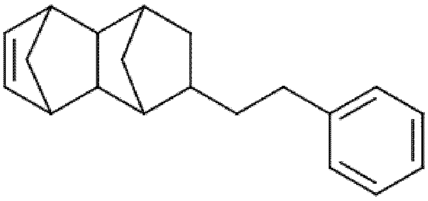


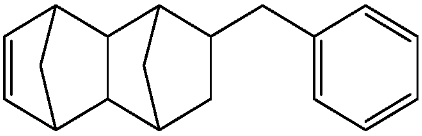


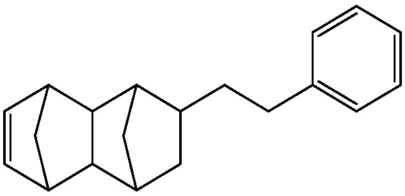












Among them, tetracyclododecene (TD) is particularly suitable.

**b) Organo-transition metal catalyst** (Organo-ruthenium compound)

As noted, the composition of this invention contains at least one an organo-transition metal catalyst comprising a metal selected from ruthenium or osmium, preferably it is an organo-ruthenium compound, more preferably it is represented by formulae (II), that would bring about the mass polymerization as described herein under ROMP conditions when the composition is subjected to suitable actinic radiation. Generally, such an organo-transition metal catalyst comprising a metal selected from ruthenium or osmium, preferably represented by formulae (II), is “latent” and become active only under certain conditions. Again, as used herein the term “latent” means that the organo-transition metal catalyst comprising a metal selected from ruthenium or osmium, used in the composition of this invention remains inactive for a prolonged period of time when the composition of this invention is stored at ambient conditions to temperatures up to 80 °C. Accordingly, in some embodiments the organo-transition metal catalysts remain latent for a period of more than thirty (30) days when stored at temperatures below 80 °C. In some other embodiments, the organo- transition metal catalyst remains latent for a period of forty (40) days to ninety (90) days when stored at temperatures below 50 °C.

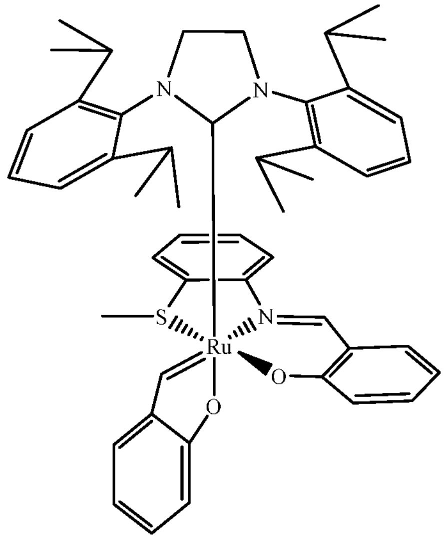
Generally, any of the latent organo- transition metal catalyst, preferably represented by formulae (II), that would bring about ring open metathesis polymerization of the monomers of formulae (I) or (V) or (VI) can be employed in the composition of this invention. Interestingly, it has now been found that organo-ruthenium compounds of formula (II) are very stable at temperatures from about 25 °C (i.e., ambient conditions) up to a temperature of about 80 °C and can be stored as such or in the presence of one or more monomers of formulae (I) or (V) or (VI) for several days even including up to three to six months or even longer. That is, the organo-ruthenium compounds of formula (II) preferably serve as latent catalysts that are stable at or near room temperature to elevated temperatures of up to 80 °C and yet can be readily activated by a variety of conditions, including without any limitation thermal, acid, light and chemical activation only when needed. The chemical activation may include use of thermal acid generator or photo acid generators.

Several of the latent catalysts that are known in the literature are not stable under the conditions specified herein and most of them do not exhibit the required shelf life stability as described herein. See for example, Grubbs, et al., Organometallics, 2011, 30 (24): 6713-6717; Sutar et al., Angew. Chem.

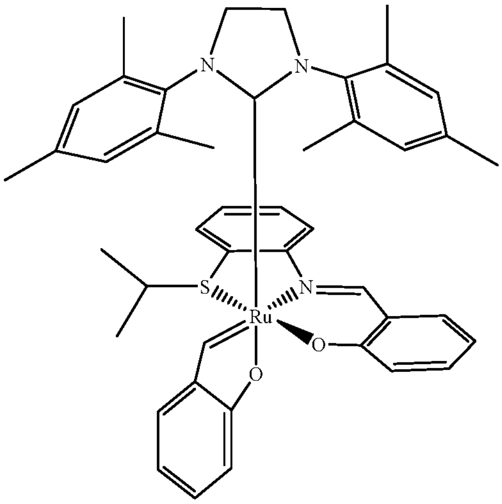
Int. Ed. 2016, 55, 764-767; Leitgeh, et al., Monatsh Chem (2014) 145:1513-1517; van Hensbergen, et al., J. Mater. Chem. C. 2015, 3, 693-702; Grubbs, et al., J. Am. Chem. Soc., 2009, 131, 203802039; Zak, et al., Eur. J. Inorg. Chem., 2014, 1131-1136; Gawin, et al., ACS Catal. 2017, 7, 5443-5449. Further examples of such catalysts can also be found in U. S. Patent No. 9,328,132, pertinent portions of which are incorporated herein by reference. Accordingly, the compositions encompassing the organo-ruthenium compounds of formula (II) provide hitherto unattainable advantages in various applications as described herein.

According to the present invention, such an organo-ruthenium compound can be any publicly available one. The organo-ruthenium compound like described in US 11230624 B2 may also be used. Preferably, it is a compound of formulae (II), wherein:
Z is oxygen;
$R_7$ is hydrogen;
$R_8$, $R_9$, $R_{10}$ and $R_{11}$ are the same or different and each independently selected from the group consisting of hydrogen, methyl, ethyl and $-NO_2$;
$R_{12}$, $R_{13}$ and $R_{14}$ are the same or different and each independently selected from the group consisting of hydrogen, methyl, ethyl and $-NO_2$;
$R_{15}$ is selected from the group consisting of methyl, ethyl and cyclohexyl;
$Ar_1$ and $Ar_2$ are the same or different and each independently selected from the group consisting of phenyl, 2,6-dimethylphenyl, 2,6-diethylphenyl, 2,6-di(isopropyl)phenyl and 2,4,6-trimethylphenyl.

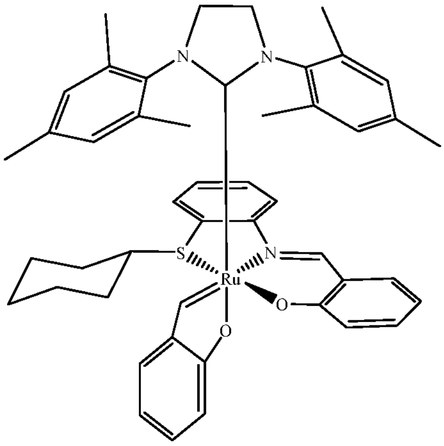
Accordingly, a few of the exemplary latent catalysts, which are within the scope of organo-ruthenium compounds of formula (II), without any limitation maybe selected from the group consisting of:



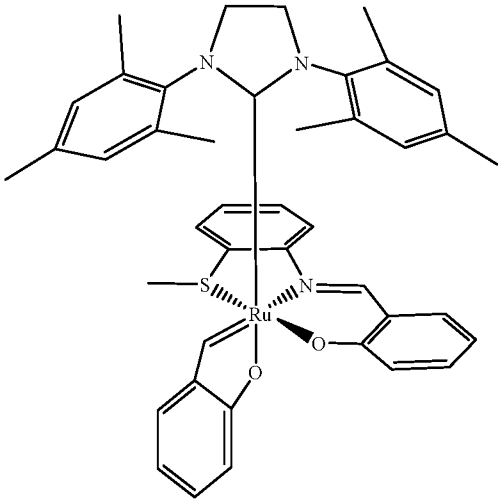
[1,3-bis(2,6-diisopropylphenyl)-2-imidazolidinylidene]{2-[(E)-({2-[methylthio-κS]phenyl}imino-κN)methyl]phenoxido-κO}[2-(oxido-κO)benzylidene-κC]ruthenium(II) (Ru-1);



[1,3-bis(2,4,6-trimethylphenyl)-2-imidazolidinylidene]{2-[(E)-({2-[isopropylthio-κS]phenyl}imino-κN)methyl]phenoxido-κO}[2-(oxido-κO)benzylidene-κC]ruthenium(II) (Ru-2);



[1,3-Bis(2,4,6-trimethylphenyl)-2-imidazolidinylidene]{2-[(E)-({2-[cyclohexylthio-κS]phenyl}imino-κN)methyl]phenoxido-κO}[2-(oxido-κO)benzylidene-κC]ruthenium(II) (Ru-3); and



[1,3-bis(2,4,6-trimethylphenyl)-2-imidazolidinylidene]{2-[(E)-({2-[methylthio-κS]phenyl}imino-κN)methyl]phenoxido-κO}[2-(oxido-κO)benzylidene-κC]ruthenium(II) (Ru-4).

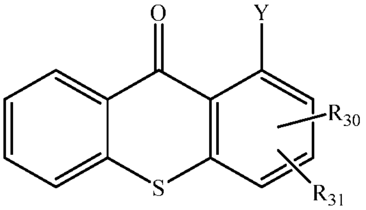
Interestingly, it has now been found that the organo-ruthenium compounds of formula (II) can be activated by certain of the known photoactive compounds (photosensitizer) when subjected to suitable photolytic conditions thereby facilitating mass polymerization of one or more monomers of the formulae (I) or (V) or (VI) contained in the composition of this invention under ROMP conditions as described herein.

The total amount of the organo-ruthenium compound is in the range from 0.001wt% to 1wt% based on the total amount of the chemical compound of formula (I). Preferably it is in the range from 0.005 to 0.5wt%, more preferably from 0.01 to 0.1wt%, even more preferably it is 0.02 to 0.05wt%.

### c) Photoactive compound (photosensitizer)

According to the present invention, the composition contains a photoactive compound capable of releasing a Bronsted acid when it is subjected to photolytic condition, preferably it is configured to bring the organo-ruthenium compound into its active form, preferably it is represented by formula (III).

As the photosensitizer, publicly known photoactive compounds, such as for example, a class of substituted xanthone derivatives, can be used for this purpose. Preferably the photosensitizer is illustrated by structural formula (III):



(III)

wherein

Y is halogen; and

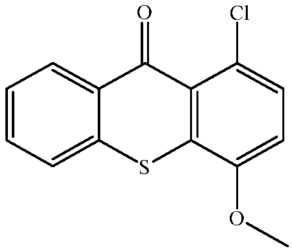
$R_{30}$ and $R_{31}$ are the same or different and independently of each other selected from the group consisting of hydrogen, methyl, ethyl, linear or branched $(C_3-C_{12})$alkyl, $(C_3-C_{12})$cycloalkyl, $(C_6-C_{12})$bicycloalkyl, $(C_7-C_{14})$tricycloalkyl, $(C_6-C_{10})$aryl, $(C_6-C_{10})$aryl$(C_1-C_3)$alkyl, $(C_1-C_{12})$alkoxy, $(C_3-C_{12})$cycloalkoxy, $(C_6-C_{12})$bicycloalkoxy, $(C_7-C_{14})$tricycloalkoxy, $(C_6-C_{10})$aryloxy$(C_1-C_3)$alkyl and $(C_6-C_{10})$aryloxy.

In some embodiments, the compound of formula (III) is having the following:

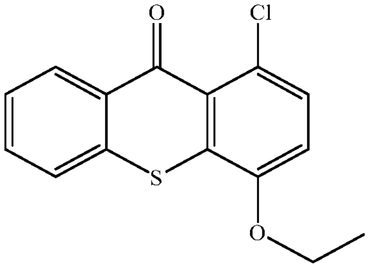
Y is chlorine or bromine; and

$R_{30}$ and $R_{31}$ are the same or different and independently of each other selected from the group consisting of hydrogen, methyl, ethyl, n-propyl, iso-propyl, phenyl, cyclohexyl, methoxy, ethoxy, n- propoxy and phenoxy.

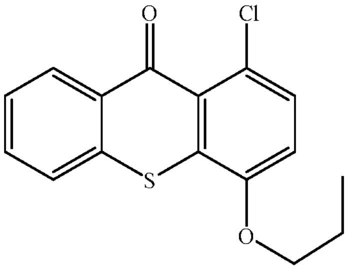
Representative examples of the compounds of formula (VII), without any limitation, may be listed as follows:



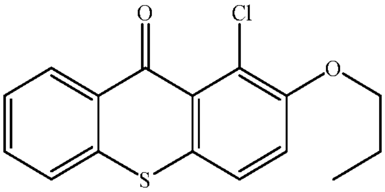
1-chloro-4-methoxy-9H-thioxanthen-9-one;



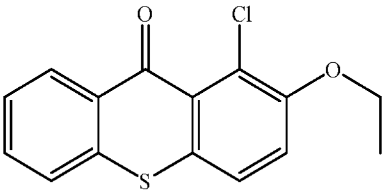
1-chloro-4-ethoxy-9H-thioxanthen-9-one;



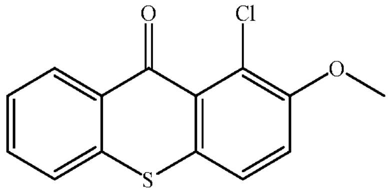
1-chloro-4-propoxy-9H-thioxanthen-9-one (commercially sold under the name CPTX from Lambson);



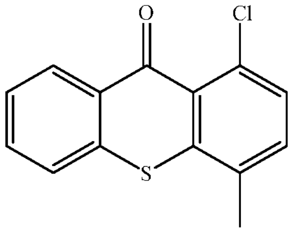
1-chloro-2-propoxy-9H-thioxanthen-9-one;



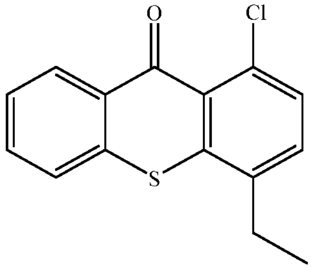
1-chloro-2-ethoxy-9H-thioxanthen-9-one;



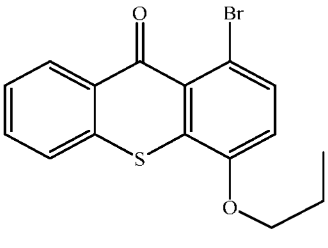
1-chloro-2-methoxy-9H-thioxanthen-9-one;



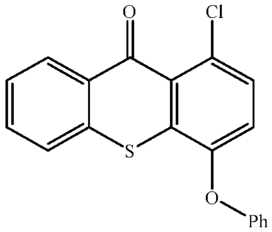
1-chloro-4-methyl-9H-thioxanthen-9-one;



1-chloro-4-ethyl-9H-thioxanthen-9-one;



1-bromo-4-propoxy-9H-thioxanthen-9-one; and



1-chloro-4-phenoxy-9H-thioxanthen-9-one.

It is believed that employing a suitable combination of an organo-ruthenium compound, in combination with one or more of a photosensitizer

(photosensitizer) can trigger the mass polymerization of the monomers when the composition is subjected to a suitable actinic radiation, generally at wavelengths of from about 240 nm to 410 nm, the composition undergoes mass ring open-metathesis polymerization (ROMP) to form a transparent film or an object. For that purpose, the combination of an organo-ruthenium compound of formula (II) and a photosensitizer of formula (III) is especially suitable.

Preferably, the total amount of the photosensitizer (preferably represented by formula (III)) is in the range from 0.01 to 5wt% based on the total amount of the chemical compound of formula (I). More preferably it is from 0.05 to 1wt%, even more preferably from 0.08 to 0.5wt%.

In some embodiments the composition of this invention undergoes mass polymerization when exposed to suitable UV irradiation to form a substantially transparent film. The monomers undergo mass polymerization to form films which are substantially transparent to visible light. That is, most of the visible light is transmitted through the film. In some embodiments such film formed from the composition of this invention exhibits a transmission of equal to or higher than 90 percent of the visible light. In some other embodiments such film formed from the composition of this invention exhibits a transmission of equal to or higher than 95 percent of the visible light.

Accordingly, in some embodiments the compositions of this invention can be mass polymerized to form solid objects, such as transparent films, in less than five seconds after exposure to suitable actinic radiation. In some other embodiments the compositions of this invention can be mass polymerized to form solid objects, such as transparent films, in less than ten seconds after exposure to suitable actinic radiation. In yet some other embodiments the compositions of this invention can be mass polymerized to form solid objects, such as transparent films, in one to ten seconds after exposure to suitable actinic radiation; in two to nine seconds, in three to eight seconds, in four to seven seconds, and so on.

In yet other embodiments the composition of this invention undergoes mass polymerization when exposed to suitable UV irradiation at a temperature from 80 °C to 100 °C to form a substantially transparent film or an object.

In some embodiments the photosensitizer, preferably represented by formula (III), can be activated at certain wavelength of the electromagnetic radiation which can generally range from about 240 nm to 400 nm. Accordingly, any of the compounds which are active in this electromagnetic radiation can be employed in the compositions of this invention. In some embodiments the wavelength of the radiation to activate the photosensitizers, preferably represented by formula (III), is 260 nm. In some other embodiments the wavelength of the radiation to activate the photosensitizer is 310 nm. In yet some other embodiments the wavelength of the radiation to activate the photosensitizer is 395 nm.

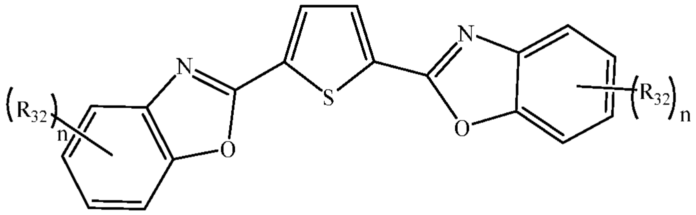
However, any of the other known photosensitizers which can activate the latent organo-ruthenium compound employed herein can also be used in the composition of this invention. All such compounds are part of this invention.

**Ultraviolet (UV) light blockers**

It is believed that incorporation of certain ultraviolet (UV) light blockers imparts further stability to the composition and/or an obtained organic layer of this invention especially when used in the surroundings of UV exposure, such as for example, in the encapsulation of an optical device (e.g. OLED). Even more importantly, it has now been found that incorporation of two or more such UV blocking compounds further provides synergistic effect in that the compositions of this invention can be cured at similar or faster speeds when compared with compositions not employing such two or more UV blocking compounds. It is surprising to note that the incorporation of these two or more UV blockers do not decrease the mass polymerization activity of the compositions of this invention when exposed to suitable actinic radiation, thus providing a synergistic and beneficial effect.

Thus, there is no discernable decrease in activity of the rate of polymerization of the compositions of this invention when subjected to suitable actinic radiation. Furthermore, the films formed from the compositions of this invention exhibit substantially same percent transmission, where a composition of this invention is shown to exhibit better than 90% transmission at wavelengths from 370 nm to 800 nm.

Accordingly, the composition of this invention may optionally contain at least one compound of formula (VIII):



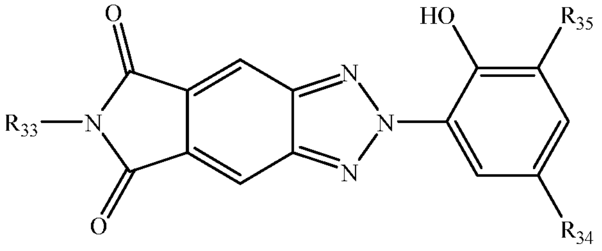
(VIII)

wherein

n is an integer from 0 to 4;

each $R_{32}$ is independently selected from the group consisting of hydrogen, methyl, ethyl, linear or branched $(C_3-C_{12})$alkyl, $(C_3-C_{12})$cycloalkyl, $(C_6-C_{12})$bicycloalkyl, $(C_7-C_{14})$tricycloalkyl, $(C_6-C_{10})$aryl, $(C_6-C_{10})$aryl$(C_1-C_3)$alkyl, $(C_1-C_{12})$alkoxy, $(C_3-C_{12})$cycloalkoxy, $(C_6-C_{12})$bicycloalkoxy, $(C_7-C_{14})$tricycloalkoxy, $(C_6-C_{10})$aryloxy$(C_1-C_3)$alkyl and $(C_6-C_{10})$aryloxy.

In addition, the composition of this invention may optionally contain at least one compound of formula (IX):



(IX);

wherein

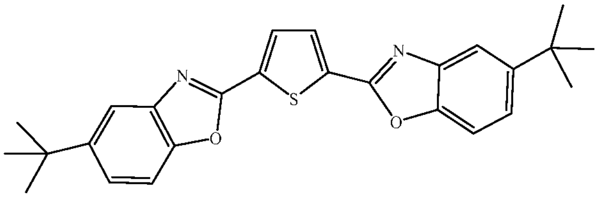
$R_{33}$ is selected from the group consisting of methyl, ethyl, linear or branched $(C_3\text{-}C_{12})$alkyl and $(C_3\text{-}C_{12})$cycloalkyl.

Each of $R_{34}$ and $R_{35}$ may be the same or different and independently selected from the group consisting of $(C_1\text{-}C_{10})$alkyl, $(C_6\text{-}C_{18})$aryl, $(C_6\text{-}C_{12})$aryl$(C_1\text{-}C_5)$alkyl, and $(C_1\text{-}C_5)$alkyl$(C_6\text{-}C_{12})$aryl. In some embodiments, $R_{34}$ and $R_{35}$ is independently selected from the group consisting of $(C_4\text{-}C_8)$alkyl, phenyl, and phenyl$(C_1\text{-}C_3)$alkyl. In some other embodiments, $R_{34}$ and $R_{35}$ is independently selected from the group consisting of $(C_5\text{-}C_8)$alkyl, and phenyl$(C_1\text{-}C_3)$alkyl.

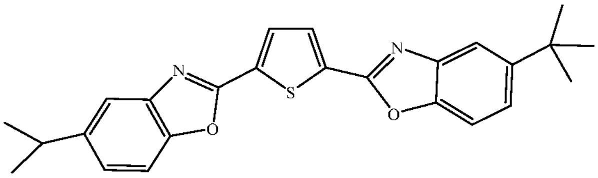
Alkyl portion of $R_{34}$ and $R_{35}$ can be linear or branched. Again, in each occurrence independently selected in whole or part of such alkyl portion being branched. Optionally one or more of methylene of alkyl portion of $R_{34}$ and $R_{35}$ can be replaced with -CO-, -O-, or -COO-. That is, $-CH_2-$ portion of alkyl is replaced with one of -CO-, -O-, or -COO-. In some embodiments one or more of hydrogens on methylene portion of $R_{34}$ and/or $R_{35}$ is replaced with -COO-.

By inclusion of a compound of formula (VIII) and a compound of formula (IX), surprisingly, it is now possible to not only improve the stability of the composition but also improve the optical performance of the articles made therefrom either in fabricating an OLED device or in the fabrication of an 3D article. It is believed that the compounds of formulae (VIII) or (IX) function as UV blockers, among other functions, thereby imparting greater stability to the composition while in peripheral contact with any UV light during the UV exposure of the composition.

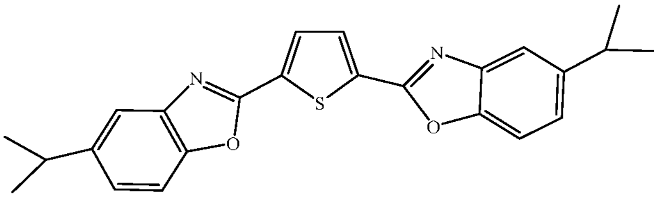
Representative examples of the compounds of formula (VIII), without any limitation, may be listed as follows:



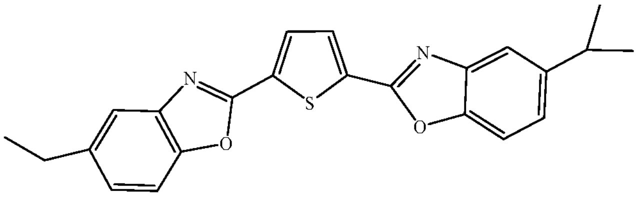
2,5-bis(5-(tert-butyl)benzo[d]oxazol-2-yl)thiophene (BTBBT), available commercially as Benetex OB Plus from Mayzo;



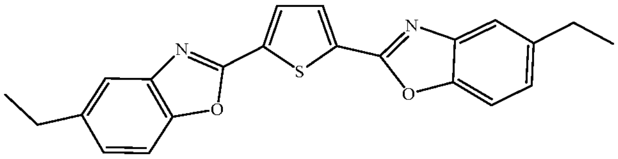
5-(tert-butyl)-2-(5-(5-isopropylbenzo[d]oxazol-2-yl)thiophen-2-yl)benzo[d]oxazole;



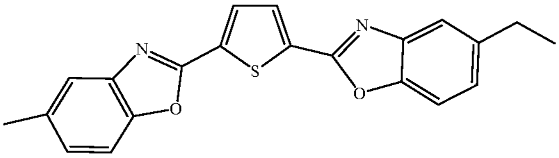
2,5-bis(5-isopropylbenzo[d]oxazol-2-yl)thiophene;



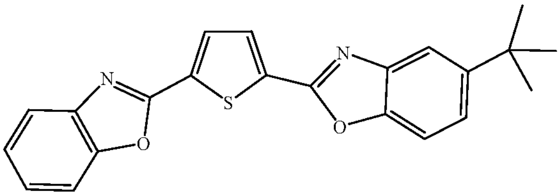
5-ethyl-2-(5-(5-isopropylbenzo[d]oxazol-2-yl)thiophen-2-yl)benzo[d]oxazole;



2,5-bis(5-ethylbenzo[d]oxazol-2-yl)thiophene;

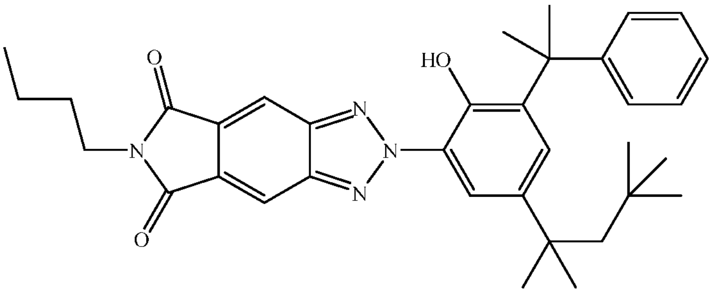


5-ethyl-2-(5-(5-methylbenzo[d]oxazol-2-yl)thiophen-2-yl)benzo[d]oxazole; and

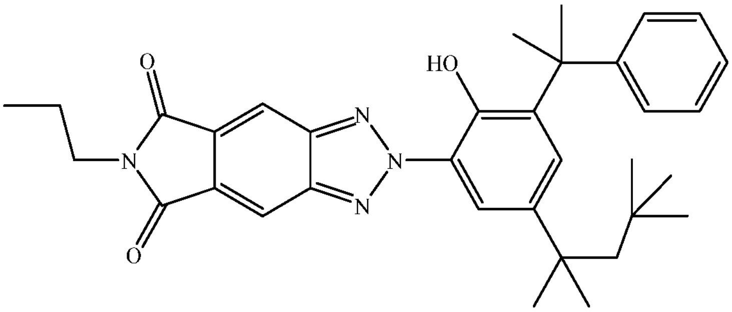


2-(5-(benzo[d]oxazol-2-yl)thiophen-2-yl)-5-(tert-butyl)benzo[d]oxazole.

Representative examples of the compounds of formula (IX), without any limitation, may be listed as follows:

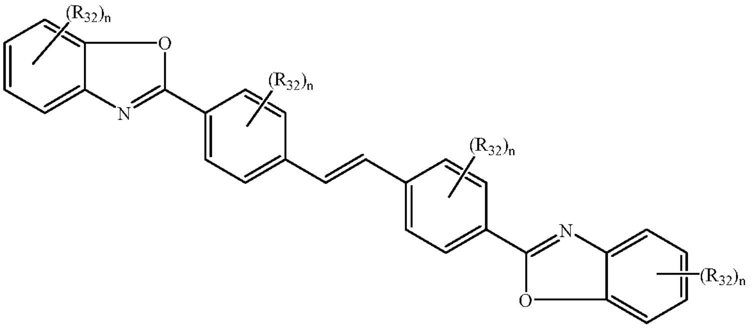


6-butyl-2-(2-hydroxy-3-(2-phenylpropan-2-yl)-5-(2,4,4-trimethylpentan-2-yl)phenyl)-[1,2,3]triazolo[4,5-f]isoindole-5,7(2H,6H)-dione; and

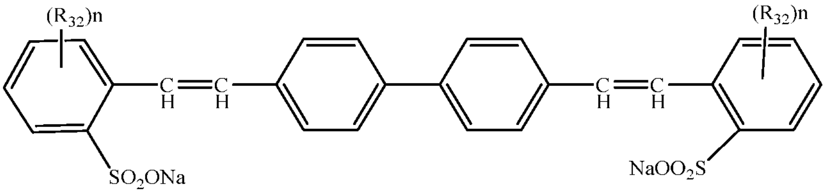


2-(2-hydroxy-3-(2-phenylpropan-2-yl)-5-(2,4,4-trimethylpentan-2-yl)phenyl)-6-propyl-[1,2,3]triazolo[4,5-f]isoindole-5,7(2H,6H)-dione.

Various other UV light blocking compounds and/or UV light absorbers that can be used in the composition of this invention include the following as the UV light blocker:



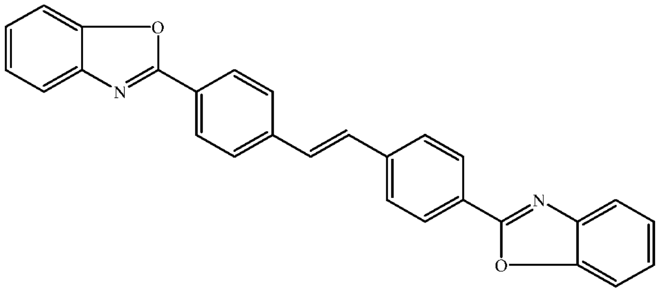
(VIIIa); and



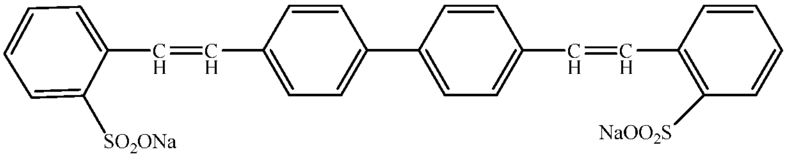
(VIIIb).

Wherein n and $R_{32}$ are same as defined on formula (VIII).

Representative compounds within the scope of compounds of formulae (VIIIa) and (VIIIb) may be represented as follows:



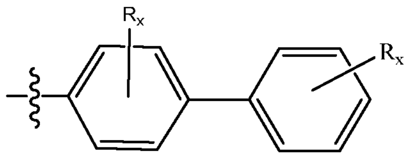
1,2-bis(4-(benzo[d]oxazol-2-yl)phenyl)ethene, available commercially as Benetex OB-1 from Mayzo; and



sodium 2,2'-([1,1'-biphenyl]-4,4'-diylbis(ethene-2,1-diyl))dibenzenesulfonate, available commercially as Benetex OB-M1 from Mayzo.

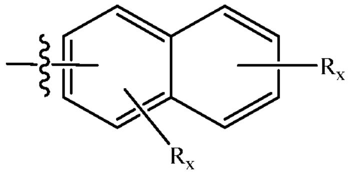
As used herein the Aryl may further include the following:

substituted or unsubstituted biphenyl of formula:



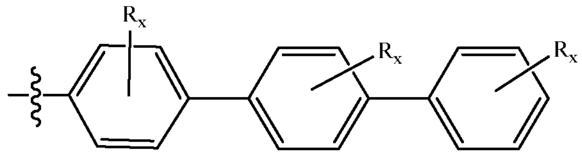
,

substituted or unsubstituted naphthyl of formula:



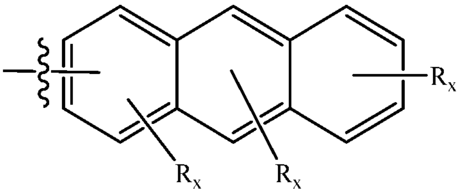
,

substituted or unsubstituted terphenyl of formula:



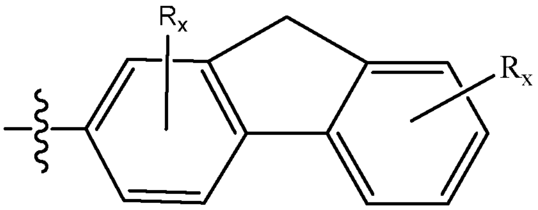
,

substituted or unsubstituted anthracenyl of formula:



,

substituted or unsubstituted fluorenyl of formula:



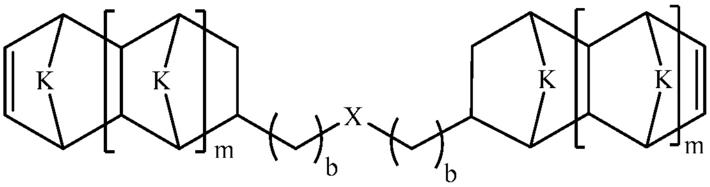
;

where R$_x$ in each occurrence is independently selected from methyl, ethyl, linear or branched (C$_3$-C$_{12}$)alkyl or (C$_6$-C$_{10}$)aryl. On the other hand, the composition of the present invention may not contain any of the Ultraviolet (UV) light blockers.

**Monomeric crosslinking agents (crosslinkers)**

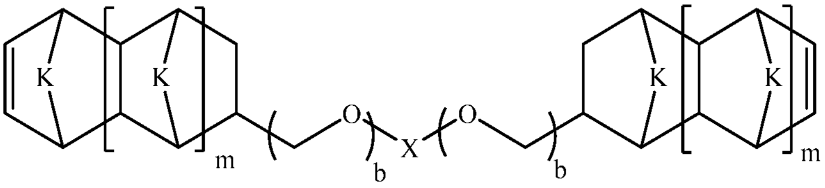
In some embodiment of the present invention, optionally the composition may further employ one or more monomeric crosslinking agents in suitable quantities to dramatically enhance the mechanical properties of the resulting three dimensional objects formed from the compositions of this invention. Representative examples of such suitable monomeric crosslinkers can be selected from one or more member of the group consisting of:

i) a compound of formula (Xa):



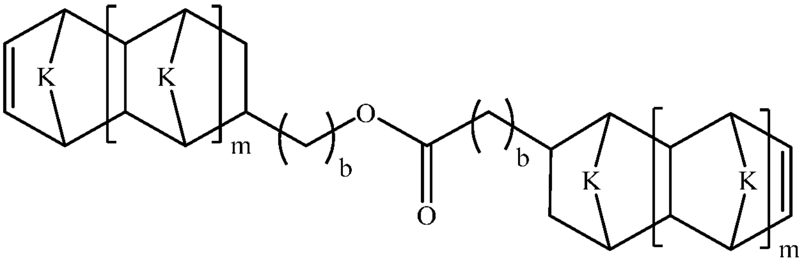
(Xa)

ii) a compound of formula (Xb):



(Xb);

iii) a compound of formula (Xc):



(Xc)

where

m is an integer 0, 1 or 2;

b is an integer from 1 to 10;

K is selected from the group consisting of $CH_2$, $CH_2$-$CH_2$, O and S;

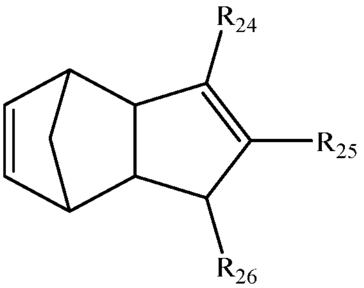
X is a bond or a moiety selected from the group consisting of O, S, $NR_a$, $SiR_bR_c$, $SiR_bR_cO(SiR_bR_cO)_nSiR_bR_c$, $SiR_bR_c(C_6$-$C_{10})arylSiR_bR_c$, -C(O)-, -C(O)O-,

-OC(O)-, -OC(O)-O-, -S-C(O)-, -C(O)-S-, -CH=CH- and -C≡C-;

$R_a$, $R_b$ and $R_c$ are independently of each other selected from the group consisting of hydrogen, methyl, ethyl or a linear or branched $(C_3$-$C_{12})$alkyl, $(C_3$-$C_8)$cycloalkyl, $(C_5$-$C_{12})$bicycloalkyl, $(C_5$-$C_{12})$bicycloalkenyl and $(C_5$-$C_{12})$bicycloalkenyl$(C_1$-$C_3)$alkyl$Si(CH_3)_2$, and such that O, $NR_a$ and/or S atoms are not linked directly to one another; and

n is an integer from 0 to 10.

iv) a compound of formula (Xd):



(Xd)

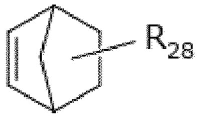
wherein

$R_{24}$ and $R_{25}$ are the same or different and each independently selected from the group consisting of hydrogen, methyl, ethyl, linear or branched ($C_3$-$C_6$)alkyl, methoxy, ethoxy, linear or branched ($C_3$-$C_6$)alkyloxy, acetoxy, ($C_2$-$C_6$)acyl, phenyl and phenoxy; or

$R_{24}$ taken together with $R_{25}$ and the carbon atoms to which they are attached to form a ($C_5$-$C_7$)carbocyclic ring optionally containing one or more double bonds;

$R_{26}$ is hydrogen, halogen, methyl, ethyl, linear or branched ($C_3$-$C_{16}$)alkyl, ($C_6$-$C_{10}$)aryl, ($C_6$-$C_{10}$)aryl($C_1$-$C_6$)alkyl, hydroxy, methoxy, ethoxy, linear or branched ($C_3$-$C_{16}$)alkoxy, ($C_6$-$C_{10}$)aryloxy, ($C_6$-$C_{10}$)aryl($C_1$-$C_6$)alkoxy, -O(CO)$R_{27}$ and -O(CO)O$R_{27}$, where $R_{27}$ is methyl, ethyl, linear or branched ($C_3$-$C_{16}$)alkyl, ($C_6$-$C_{10}$)aryl and ($C_6$-$C_{10}$)aryl($C_1$-$C_6$)alkyl;

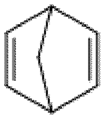
iiv) a compound of formula (Xe):



(Xe)

$R_{28}$ is hydrogen, halogen, methyl, ethyl, linear or branched ($C_3$-$C_{16}$)alkyl, ($C_6$-$C_{10}$)aryl, ($C_6$-$C_{10}$)aryl($C_1$-$C_6$)alkyl, hydroxy, methoxy, ethoxy, linear or branched $(C_3-C_{16})$alkoxy, $(C_6-C_{10})$aryloxy, $(C_6-C_{10})$aryl$(C_1-C_6)$alkoxy, $(C_{2-10})$alkene, preferably $R_{28}$ is $(C_{2-10})$alkene, more preferably it is a vinyl group; and

iiiv)



(norbornadiene).

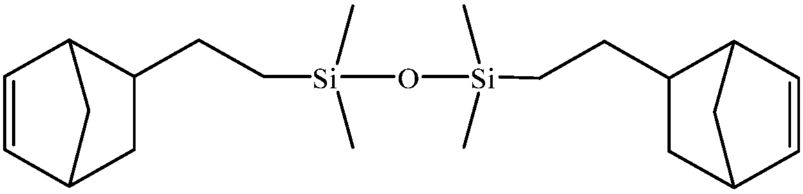
Advantageously, it has now been found that by incorporating one or more compounds of formulae (Xa), (Xb), (Xc), (Xd), (Xe) and norbornadiene, it is possible to tailor the properties of the compositions for the intended purpose. For example, suitable combination of one or more compounds of formulae (Xa), (Xb) or (Xc) with the composition of this invention it is now possible to improve the mechanical properties of the articles formed from the composition of this invention among other properties.

For examples, incorporation of certain siloxane compounds within the scope of compounds of formulae (Xa) or (Xb) improves the impact strength of the products formed therefrom. Any amount of one or more compounds of formula (Xa), (Xb) or (Xc) can be employed that would bring about the intended benefit. In general such amounts may range from 0 to 20 mole percent of one or more compounds of formulae (Xa), (Xb) or (Xc) based upon the total moles of monomers of formula (I), in combination with one or more monomers of formulae (V) or (VI), if employed, and one or more compounds of formulae (Xa), (Xb) or (Xc). In some embodiments such amounts may range from 1 to 15 mole percent, and in some other embodiments such amounts may range from 0.5 to 10 mole percent, and yet in some other embodiments such amounts may range from 0.5 to 5 mole percent.

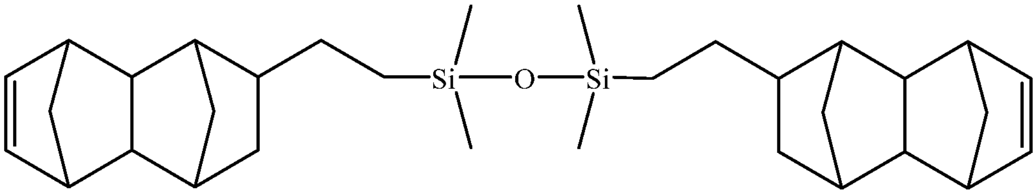
Accordingly, in some embodiments the impact strength of the polymers formed from the composition of this invention is at least 40 J/m. In some other embodiments the impact strength of the polymers formed from the composition of this invention is at least 60 J/m. In yet some other embodiments the impact strength of the polymers formed from the composition of this invention is at least 80 J/m, 100 J/m or higher, 140 J/m or higher or it can be higher than 160 J/m, such as for example higher than 170 J/m, higher than 180 J/m, higher than 200, 220 or 240 J/m, or even higher than 500, 550, 600, 700 or 800 J/m depending upon the types of monomers employed as described herein. In some embodiments the polymers formed from the composition of this invention comprising one or more monomers of formula (I) itself may exhibit such unusual impact strength which can range from 50 to 800 J/m.

In some embodiments the compounds of formulae (Xa), (Xb) or (Xc) are each having m = 0 and K = $CH_2$. In some embodiments the compounds of formulae (Xa), (Xb) or (Xc) are each having m = 1 and K = $CH_2$. In yet some other embodiments the compounds of formulae (Xa), (Xb) or (Xc) are each having m = 2 and K = $CH_2$.

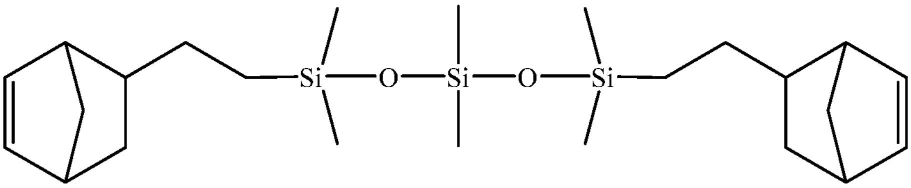
Representative examples of compounds within the scope of formulae (Xa) or (Xb) without any limitation includes the following:



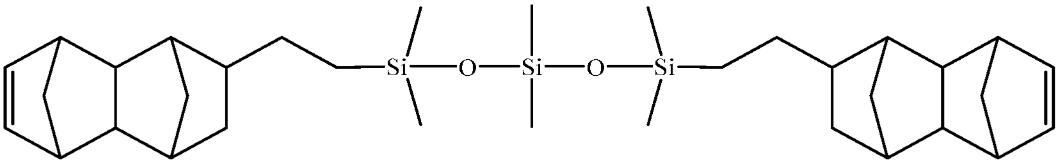
1,3-bis(2-(bicyclo[2.2.1]hept-5-en-2-yl)ethyl)-1,1,3,3-tetramethyldisiloxane (BisENBTMDS);



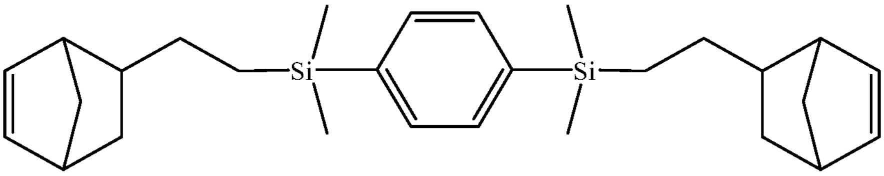
1,1,3,3-tetramethyl-1,3-bis(2-(1,2,3,4,4a,5,8,8a-octahydro-1,4:5,8-dimethanonaphthalen-2-yl)ethyl)disiloxane;



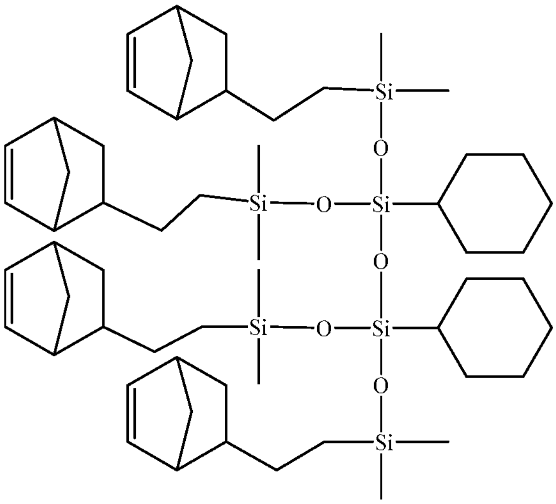
1,5-bis(2-(bicyclo[2.2.1]hept-5-en-2-yl)ethyl)-1,1,3,3,5,5-hexamethyltrisiloxane (BisENBHMTS);



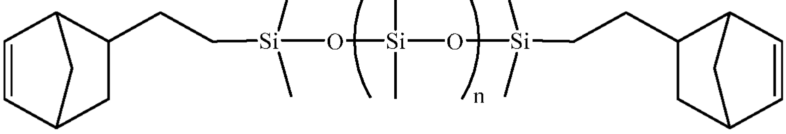
1,1,3,3,5,5-hexamethyl-1,5-bis(2-(1,2,3,4,4a,5,8,8a-octahydro-1,4:5,8-dimethanonaphthalen-2-yl)ethyl)trisiloxane;



1,4-bis((2-(bicyclo[2.2.1]hept-5-en-2-yl)ethyl)dimethylsilyl)benzene;

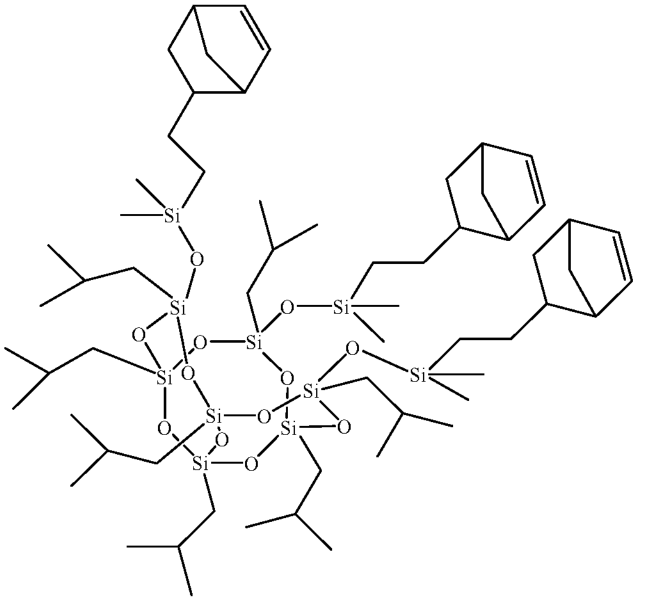


3,3'-oxybis(1,5-bis(2-(bicyclo[2.2.1]hept-5-en-2-yl)ethyl)-3-cyclohexyl-1,1,5,5-tetramethyltrisiloxane) (TeTENBOMSS);



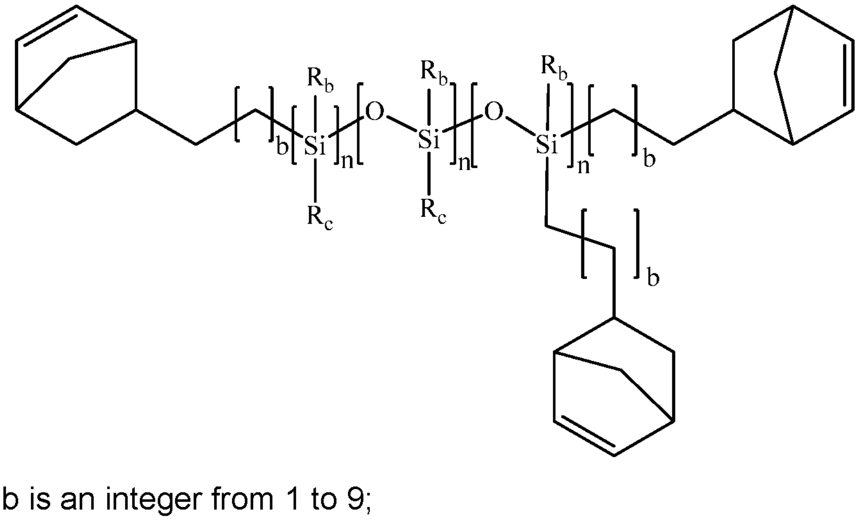
(bicycloheptenyl)ethyl terminated polydimethylsiloxane, where n is 2 to 4;

and



3,7,14-tris(((2-(bicyclo[2.2.1]hept-5-en-2-yl)ethyl)dimethylsilyl)oxy)-1,3,5,7,9,11,14-heptaisobutyl-2,4,6,8,10,12,13,15,16-nonaoxa-1,3,5,7,9,11,14-heptasilatricyclo[7.3.3.15,11]hexadecane (trisnorbornenylisobutyl POSS).

In addition, various other oligomeric or polymeric polysiloxanes with multi-functional cycloolefinic pendent groups are suitable as crosslinking molecules in the composition of this invention which may or may not be within the scope of compound of formula (XIa). Such examples include an oligomeric siloxane of the formula:

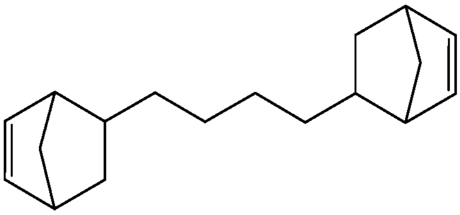


Where b is an integer from 1 to 9;

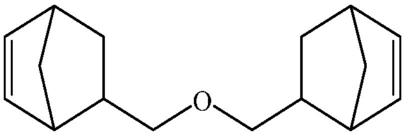
n is an integer from 1 to 10; and

$R_b$ and $R_c$ are independently selected from the group consisting of methyl, ethyl, n-propyl, iso-propyl, n-butyl, isobutyl and phenyl.

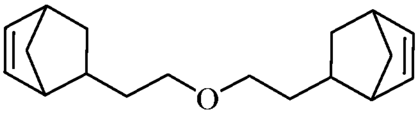
Various other non-limiting examples of the compounds of formulae (Xa), (Xb) or (Xc) maybe selected from the group consisting of:



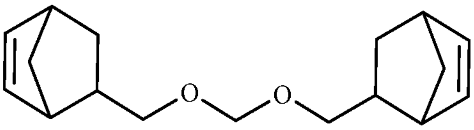
1,4-di(bicyclo[2.2.1]hept-5-en-2-yl)butane;



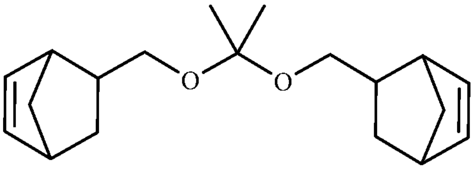
5,5'-(oxybis(methylene))bis(bicyclo[2.2.1]hept-2-ene);



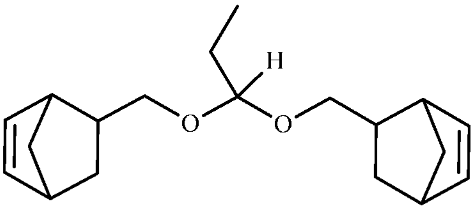
5,5'-(oxybis(ethane-2,1-diyl))bis(bicyclo[2.2.1]hept-2-ene);



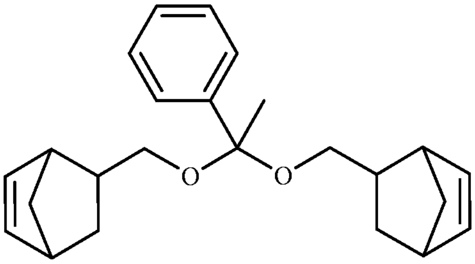
bis(bicyclo[2.2.1]hept-5-en-2-ylmethoxy)methane;



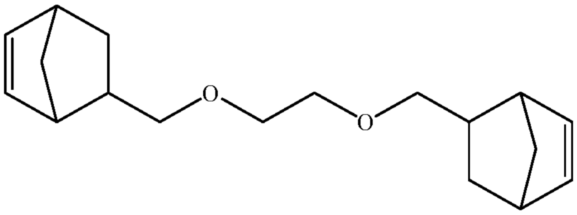
5,5'-((propane-2,2-diylbis(oxy))bis(methylene))bis(bicyclo[2.2.1]hept-2-ene);



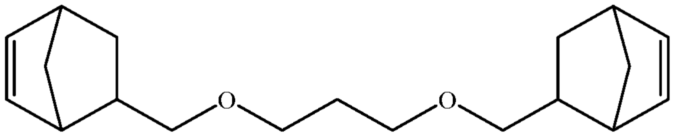
5,5'-((propane-1,1-diylbis(oxy))bis(methylene))bis(bicyclo[2.2.1]hept-2-ene);



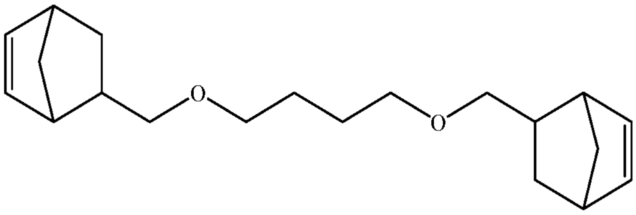
5,5'-(((1-phenylethane-1,1-diyl)bis(oxy))bis(methylene))bis(bicyclo[2.2.1]hept-2-ene);



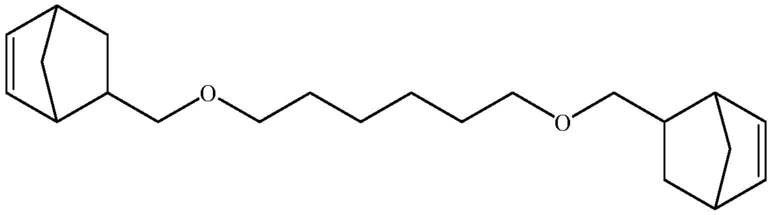
1,2-bis(bicyclo[2.2.1]hept-5-en-2-ylmethoxy)ethane;



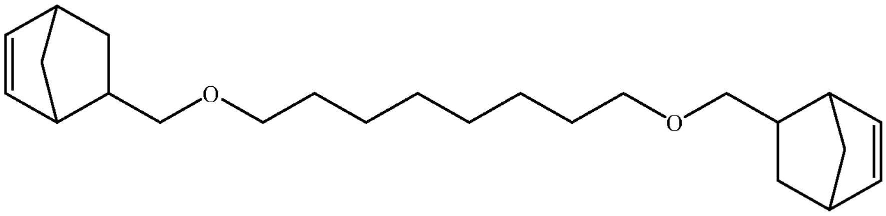
1,3-bis(bicyclo[2.2.1]hept-5-en-2-ylmethoxy)propane;



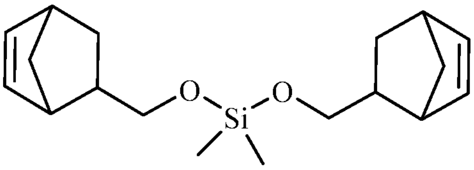
1,4-bis(bicyclo[2.2.1]hept-5-en-2-ylmethoxy)butane;



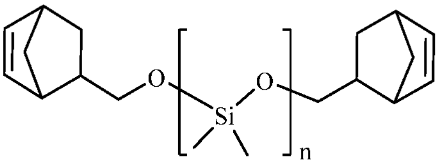
1,6-bis(bicyclo[2.2.1]hept-5-en-2-ylmethoxy)hexane;



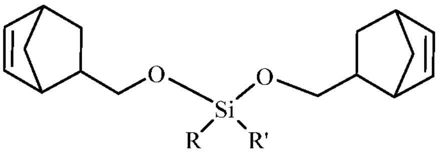
1,8-bis(bicyclo[2.2.1]hept-5-en-2-ylmethoxy)octane;



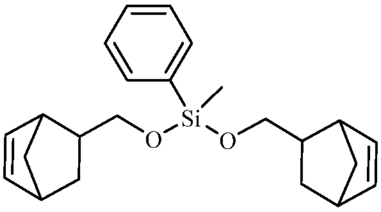
bis(bicyclo[2.2.1]hept-5-en-2-ylmethoxy)dimethylsilane;



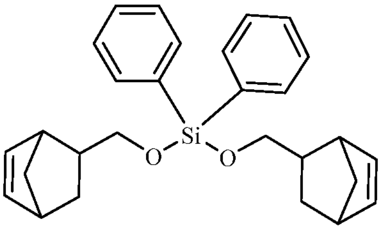
where n is 2 to 4;



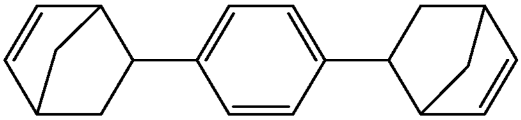
Where R and R’ are independently selected from ($C_1$-$C_{12}$alkyl), ($C_6$-$C_{10}$aryl) and ($C_6$-$C_{10}$aryl)($C_1$-$C_{12}$alkyl);



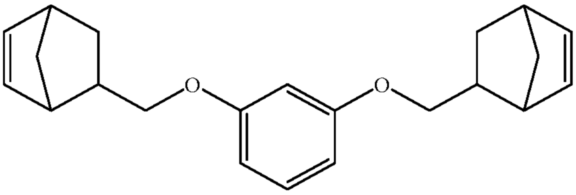
bis(bicyclo[2.2.1]hept-5-en-2-ylmethoxy)(methyl)(phenyl)silane;



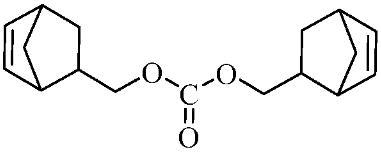
bis(bicyclo[2.2.1]hept-5-en-2-ylmethoxy)diphenylsilane;



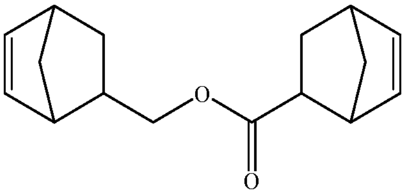
1,4-di(bicyclo[2.2.1]hept-5-en-2-yl)benzene;



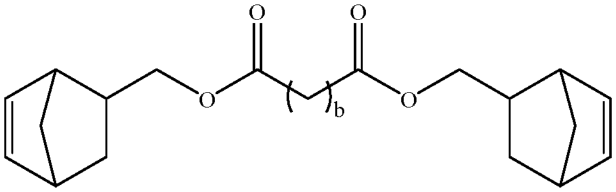
1,3-bis(bicyclo[2.2.1]hept-5-en-2-ylmethoxy)benzene;



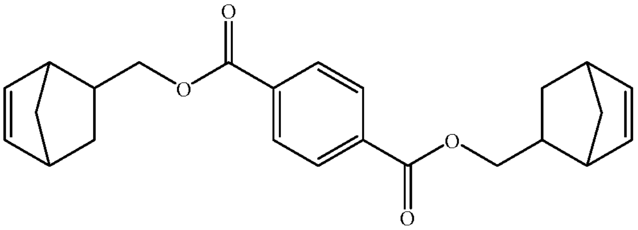
bis(bicyclo[2.2.1]hept-5-en-2-ylmethyl) carbonate;



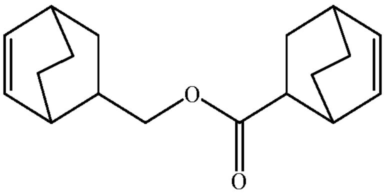
bicyclo[2.2.1]hept-5-en-2-ylmethyl bicyclo[2.2.1]hept-5-ene-2-carboxylate;



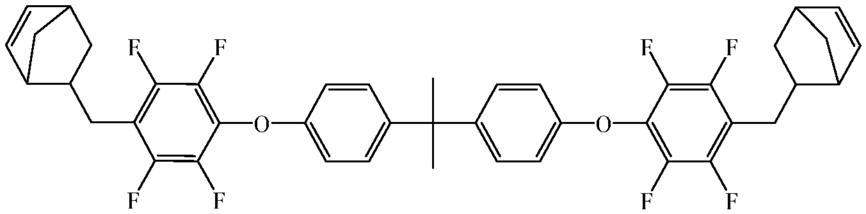
Where b is an integer form 1 to 6;



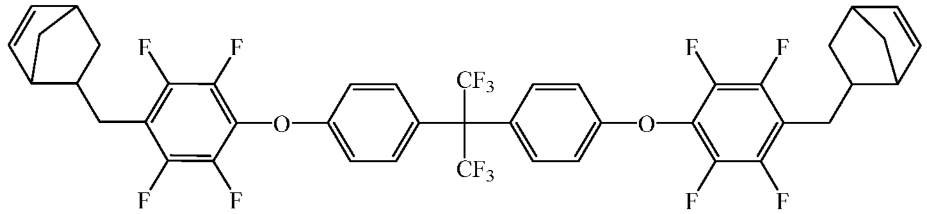
bis(bicyclo[2.2.1]hept-5-en-2-ylmethyl) terephthalate;



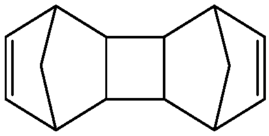
bicyclo[2.2.2]oct-5-en-2-ylmethyl bicyclo[2.2.2]oct-5-ene-2-carboxylate;



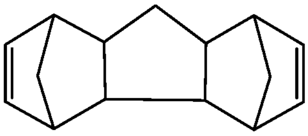
5,5'-((((propane-2,2-diylbis(4,1-phenylene))bis(oxy))bis(2,3,5,6-tetrafluoro-4,1-phenylene))bis(methylene))bis(bicyclo[2.2.1]hept-2-ene);



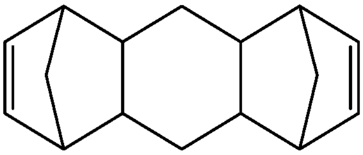
5,5'-(((((perfluoropropane-2,2-diyl)bis(4,1-phenylene))bis(oxy))bis(2,3,5,6-tetrafluoro-4,1-phenylene))bis(methylene))bis(bicyclo[2.2.1]hept-2-ene)



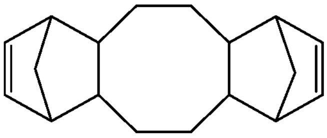
1,4,4a,4b,5,8,8a,8b-octahydro-1,4:5,8-dimethanobiphenylene;



4,4a,4b,5,8,8a,9,9a-octahydro-1H-1,4:5,8-dimethanofluorene;

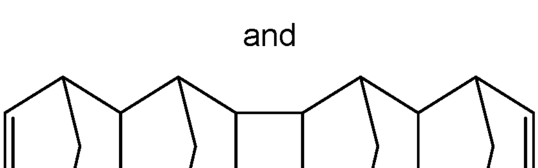


1,4,4a,5,8,8a,9,9a,10,10a-decahydro-1,4:5,8-dimethanoanthracene;



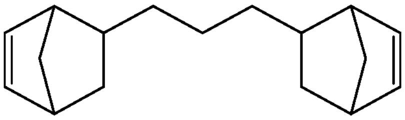
1,4,4a,5,6,6a,7,10,10a,11,12,12a-dodecahydro-1,4:7,10-dimethanodibenzo[a,e][8]annulene;

and

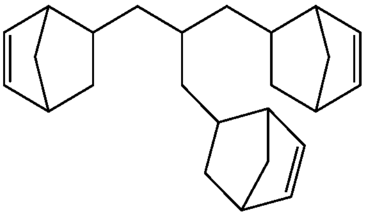


1,4,4a,5,5a,5b,6,6a,7,10,10a,11,11a,11b,12,12a-hexadecahydro-1,4:5,12:6,11:7,10-tetramethanodibenzo[b,h]biphenylene.

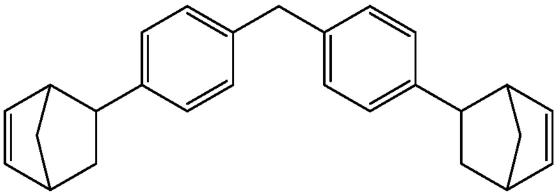
Various other non-limiting examples within the scope of the compounds of formula (Xa), (Xb) or (Xc) maybe enumerated as follows:



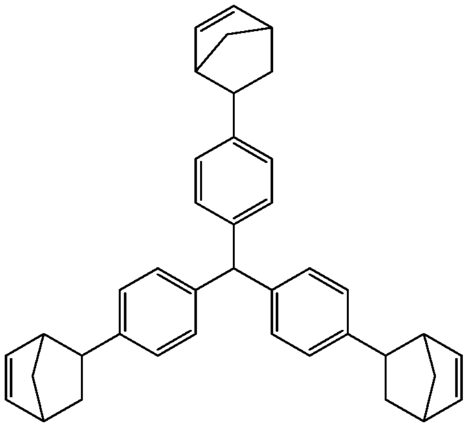
1,3-di(bicyclo[2.2.1]hept-5-en-2-yl)propane;



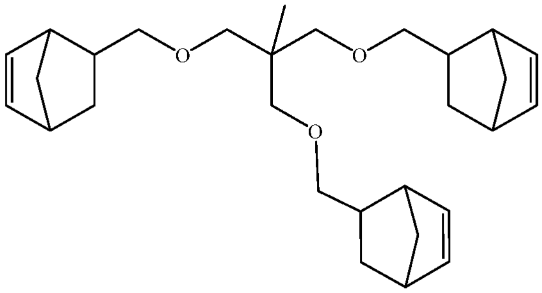
5,5'-(2-(bicyclo[2.2.1]hept-5-en-2-ylmethyl)propane-1,3-diyl)bis(bicyclo[2.2.1]hept-2-ene);



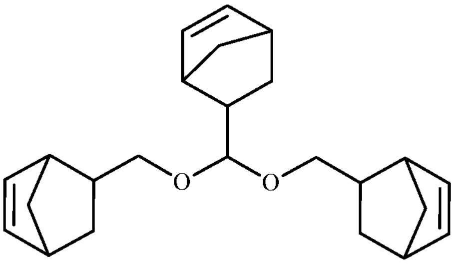
bis(4-(bicyclo[2.2.1]hept-5-en-2-yl)phenyl)methane;



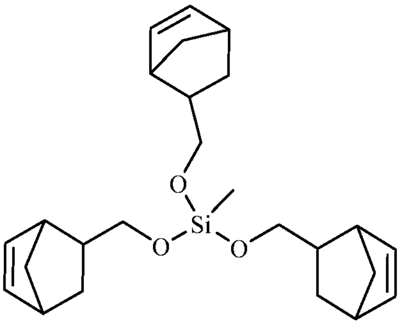
tris(4-(bicyclo[2.2.1]hept-5-en-2-yl)phenyl)methane;



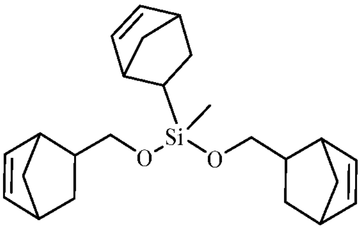
5,5'-(((2-((bicyclo[2.2.1]hept-5-en-2-ylmethoxy)methyl)-2-methylpropane-1,3-diyl)bis(oxy))bis(methylene))bis(bicyclo[2.2.1]hept-2-ene);



5,5'-(((bicyclo[2.2.1]hept-5-en-2-ylmethylene)bis(oxy))bis(methylene))bis(bicyclo[2.2.1]hept-2-ene);



tris(bicyclo[2.2.1]hept-5-en-2-ylmethoxy)(methyl)silane; and



bicyclo[2.2.1]hept-5-en-2-ylbis(bicyclo[2.2.1]hept-5-en-2-ylmethoxy)(methyl)silane.

In some embodiments of this invention the composition of this invention may additionally contain other photosensitizer compounds which can activate the organo-ruthenium compounds of formulae (II) in order to facilitate the mass polymerization of the monomers of formula (I). For this purpose, any suitable sensitizer compound can be employed in the compositions of the present invention. Such suitable sensitizer compounds include, photosensitizers, such as, anthracenes, phenanthrenes, chrysenes, benzpyrenes, fluoranthenes, rubrenes, pyrenes, xanthones, indanthrenes, and mixtures thereof.

In some exemplary embodiments, suitable sensitizer components include mixtures thereof. Generally, the photosensitizers absorb energy from the radiated light source and transfers that energy to the desirable substrate/reactant employed in the composition of this invention.

On the other hand, the compound of the present invention may not contain any of the Ultraviolet (UV) light blockers.

- **Additional monomers (additive)**

According to the present invention, said composition may further optionally comprise an additive of formula (I) with the proviso that said additive is different from a) the chemical compound of formula (I) as a co-monomer. On the other hand, the composition of the present invention may not contain any of the addtional monomers described here.

Preferably symbol m of the formula is 1, more preferably said additive is selected from the group consisting of:

| | |
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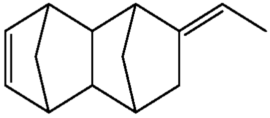
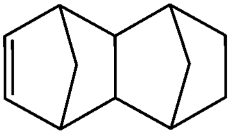
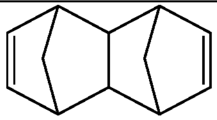
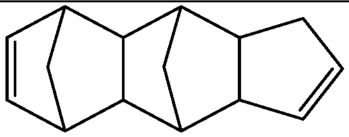
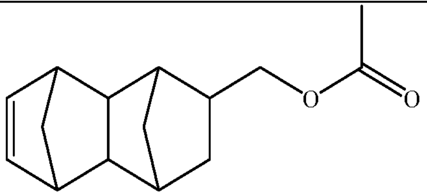
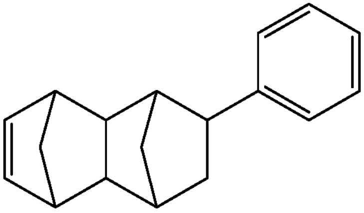
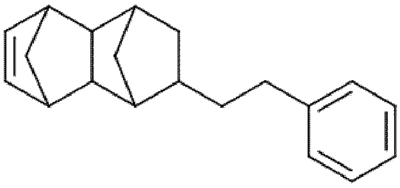
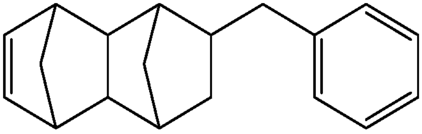
|  |  |
|  |  |
|  |  |
|  |  |

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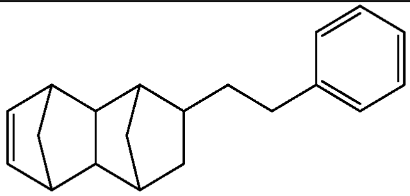
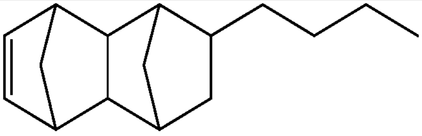
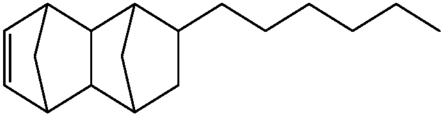
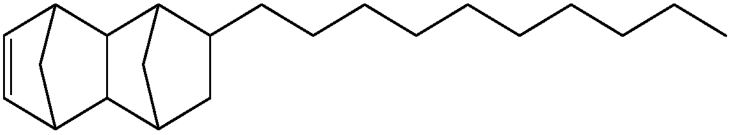
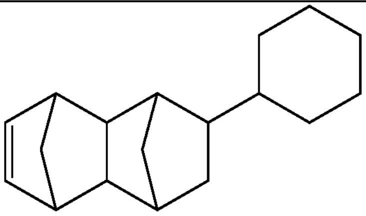
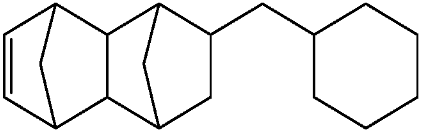
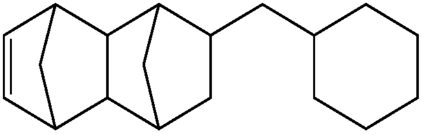
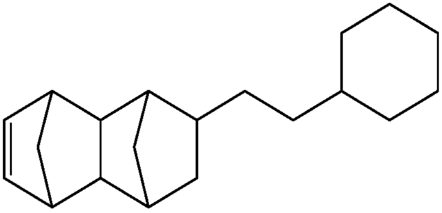
|  |  |
|  |  |
|  |  |
|  |  |

It is believed that said additive as co-monomer realizes improved high Tg and/or improved high E properties of the obtained organic layer.

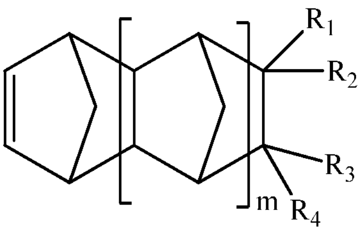
In another aspect, the present invention further relates to use of a composition for fabricating an organic layer of a stacked layer, preferably said stacked layer is being a protection layer for an optical device, wherein said stacked layer comprises at least;

(A) said organic layer, and

(B) an inorganic layer placed over the organic layer.

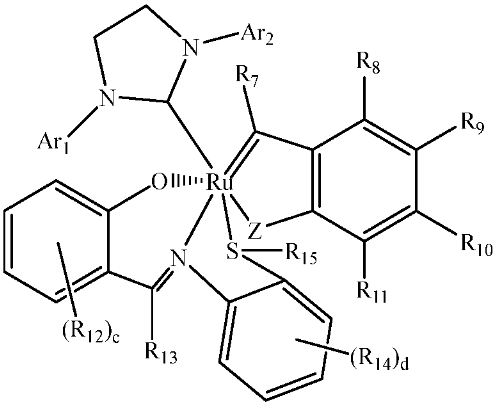
wherein said composition comprises at least:

a) a chemical compound of formula (I):



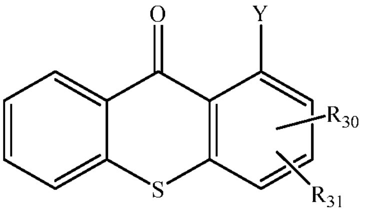
(I)

b) an organo-transition metal catalyst comprising a metal selected from ruthenium or osmium, preferably it is an organo-ruthenium compound, more preferably it is represented by formula (II);



(II)

c) a photoactive compound capable of releasing a Bronsted acid when it is subjected to photolytic condition, preferably it is selected from a compound represented by formula (III);



(III).

The definitions of each symbols are the same as already described above in pages 15-18. Furhter details of a) the chemical compound of formula (I), b) the organo-transition metal catalyst and c) the photoactive compound are already discribed in above in the section of **“a) Chemical compound of formula (I)”, “b) Organo-transition metal catalyst” and “c) Photoactive compound (photosensitizer) ”.**

### (B) Inorganic layer

According to the present invention, said (B) Inorganic layer is fabricated over the (A) organic layer by Chemical Vapor Deposition (CVD) or Atomic Layer Deposition (ALD). Preferably said inorganic layer is selected from the group consisting of SiNx,SiOxNy or SiOx.

- **Method for fabricating a stacked layer**

In another aspect, the present invention further relates to a method for fabricating a stacked layer, preferably said stacked layer is being a protection layer for an optical device, comprising at least or consisting of the following steps:

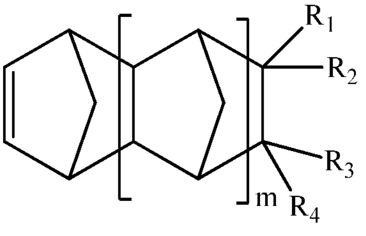
($X^{a1}$) providing a composition of onto a substrate, a layer, or an outermost surface of a device to obtain an organic layer,

($X^{a2}$) irradiating the coated layer with light (applying light irradiation) to form a cured film, preferably with light having peak maximum wavelength in the range from 360 to 430 nm, preferably the dose of the light irradiated to the composition is in the range from 1 to 5 J/cm$^2$.Preferably the peak maximum wavelength of light is in the range from 365nm to 405nm.

($X^{a3}$) fabricating an inorganic layer over the organic layer to form a stacked layer, preferably said inorganic layer is fabricated by Chemical Vapor Deposition (CVD) or Atomic Layer Deposition (ALD). Preferably said inorganic layer is selected from the group consisting of SiNx,SiOxNy or SiOx.

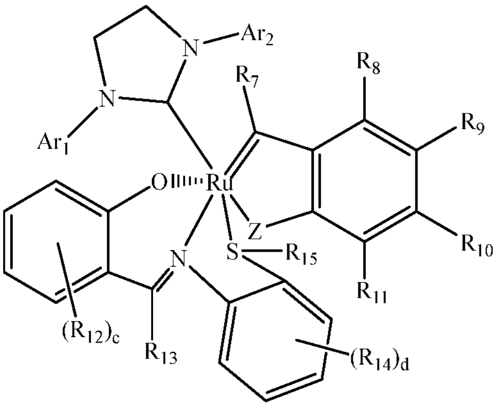
wherein said composition comprises at least, essentially consisting of or consisting of :

a) a chemical compound of formula (I):



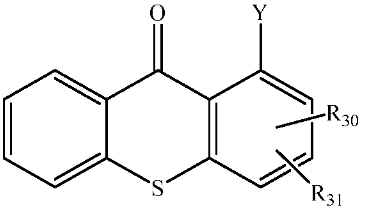
(I);

(b) an organo-transition metal catalyst comprising a metal selected from ruthenium or osmium, preferably it is an organo-ruthenium compound, more preferably it is represented by formula (II);



(II)

(c) a photoactive compound capable of releasing a Bronsted acid when it is subjected to photolytic condition, preferably it is selected from a compound represented by formula (III);



(III).

The definitions of each symbols are the same as already described above in pages 14-17. Furhter details of a) the chemical compound of formula (I), b) the organo-transition metal catalyst and c) the photoactive compound are already discribed in above in the section of **"a) Chemical compound of formula (I)", "b) Organo-transition metal catalyst" and "c) Photoactive compound (photosensitizer) ".**

- **Solvent**

According to the present invention, in a preferred embodiment, said composition comprises a solvent 10wt% or less based on the total amount of the composition, more preferably it is 5wt% or less, more preferably it is a solvent free composition, preferably said solvent is one or more members of the group consisting of ethylene glycol monoalkyl ethers, preferably ethylene glycol monomethyl ether, ethylene glycol monoethyl ether, ethylene glycol monopropyl ether, and ethylene glycol monobutyl ether; diethylene glycol dialkyl ethers, preferably diethylene glycol dimethyl ether, diethylene glycol diethyl ether, diethylene glycol dipropyl ether, and diethylene glycol dibutyl ether; propylene glycol monoalkyl ethers, preferably propylene glycol monomethyl ether(PGME), propylene glycol monoethyl ether, and propylene glycol monopropyl ether; ethylene glycol alkyl ether acetates, preferably methyl cellosolve acetate and ethyl cellosolve acetate; propylene glycol alkyl ether acetates, preferably propylene glycol monomethyl ether acetate (PGMEA), propylene glycol monoethyl ether acetate, and propylene glycol monopropyl ether acetate; ketones, preferably methyl ethyl ketone, acetone, methyl amyl ketone, methyl isobutyl ketone, and cyclohexanone; alcohols, preferably ethanol, propanol, butanol, hexanol, cyclo hexanol, ethylene glycol, triethylene glycol and glycerin; esters, preferably ethyl 3-ethoxypropionate, methyl 3-methoxypropionate and ethyl lactate; and cyclic esters, preferably gamma-butyrolactone; chlorinated hydrocarbons, preferably chloroform, dichloromethane, chlorobenzene, alkyl- and cycloalkylbenzenes preferably 1,3,5-trimethylbenzene, 1,2,4-trimethyl benzene, 1,2,3-trimethyl benzene, docecylbenzene, cyclohexylbenzene, 1,2,3,4-tetramethylbenzene, 1,2,3,5-tetramethylbenzene, 3-isopropylbiphenyl, 3-methylbiphenyl, 4-methylbiphenyl and dichlorobenzene.

In another aspect, the composition of this invention undergoes mass polymerization when subjected to suitable radiation for a sufficient length of time to form a polymeric film or a solid object.

That is to say that the composition of this invention is poured onto a surface or onto a substrate which needs to be encapsulated, and exposed to suitable radiation in order for the monomers to undergo polymerization to form a solid transparent polymer which could be in the form of a transparent film or a solid object.

Generally, as already noted above, such polymerization can take place when exposed to actinic radiation at wavelengths ranging from about 240 nm to

410 nm. The compositions can also be subjected simultaneously to suitable radiation and heat to cause mass polymerization. By practice of this invention it is now possible to obtain polymeric films on such substrates which are substantially transparent film or solid objects depending on the method of fabrication employed.

The “substantially transparent film” as used herein means that the films formed from the composition of this invention are optically clear in the visible light. Accordingly, in some embodiments of this invention such films are having at least 90 percent of visible light transmission, in some other embodiments the films formed from the composition of this invention exhibit at least 95 percent of visible light transmission.

The coating of the desired substrate to form a film with the composition of this invention can be performed by any of the coating or printing procedures as described herein and/or known to one skilled in the art, such as by spin coating. Other suitable coating methods include without any limitation spraying, doctor blading, meniscus coating, ink jet coating and slot coating. The composition can also be inkjet printed onto the substrate as is known in the art. The mixture can also be poured onto a substrate to form a film. Suitable substrate includes any appropriate substrate as is, or may be used for electrical, electronic or optoelectronic devices, for example, a semiconductor substrate, a ceramic substrate, a glass substrate.

Next, the coated substrate is exposed to suitable actinic radiation, i.e., exposed to radiation of wavelength ranging from 240 nm to 410 nm as described herein to facilitate the mass polymerization. In some embodiments the substrate is exposed to radiation and baked at a temperature of from about 40°C to about 90°C for about 2 minutes to 30 minutes. In some other embodiments the substrate is exposed to radiation and baked at a temperature of from about 60°C to about 90°C for 5 minutes to 20 minutes.

The films thus formed are then evaluated for their optical properties using any of the methods known in the art. For example, the refractive index of the film across the visible spectrum can be measured by ellipsometry. The optical quality of the film can be determined by visual observation. Quantitatively the percent transparency can be measured by visible spectroscopy. Generally, the films formed according to this invention exhibit excellent optical transparent properties and can be tailored to desirable refractive index as described herein.

The compositions of this invention are also useful as protective layers in a variety of electronic or optoelectronic devices, particularly organic electronic devices, which are sensitive to environmental conditions, especially to oxygen and moisture. The compositions of this invention serve as such protective layers providing much needed protection against environmental conditions. Generally, in such applications, for example, an organic light emitting diode (OLED) devices, a plurality of layers of OLED or an OLED stack is formed on a suitable substrate, which is then encapsulated by the compositions of this invention.

The encapsulation of the OLED stack can be carried out by any of the known methods including but not limited to dip coating, inkjet coating, spin coating, and the like methods. Then the coated OLED stack is subjected to suitable actinic radiation so as to form a transparent polymeric layer on the OLED stack via ROMP. Before or after the transparent polymeric layer formation, a conducting layer is deposited on to the polymeric layer. Such conducting layers can be deposited by any of the known methods, such as for example, chemical vapor deposition (CVD) methods, among others. The polymeric layers formed from the compositions of this invention are stable to such CVD methods and retain their properties especially the transparent property, among other properties as described herein. Finally, the OLED device may optionally be protected by forming another polymeric layer by coating with the composition of this invention as described above and subjecting to suitable actinic radiation. Such stacking process can take plural processes of the transparent polymeric layer formation and/or the conducting layer deposition.

In another aspect, the present invention further relates to a method for fabricating a stacked layer, preferably said stacked layer is being a protection layer for an optical device, comprising at least the following steps or consisting of the following steps:

($X^{a1}$) providing a substrate having an organic layer,

($X^{a3'}$) fabricating an inorganic layer by Chemical Vapor Deposition (CVD) or Atomic Layer Deposition (ALD) over the organic layer, wherein the chamber pressure in step ($X^{a3}$) is in the range from 0.2 to 3 Torr, preferably 0.5 to 2 Torr; and the power of a radio frequency power supply (RF) used in step ($X^{a3}$) is in the range from 10 to 600W, preferably from 15 to 500W.

More preferably, in step ($X^{a3'}$), chamber pressure is 0.2 to 1.5 Torr when CVD is applied. Furhter preferably it is from 0.5 to 1.0 Torr; and RF power in step ($X^{a3'}$) is 10 to 70W when CVD is used. Furhter preferably it is from 15 to 35W. When ALD is used, then chamber pressure is preferably from 0.5 to 2 Torr, more preferably from 0.8 to 1.5 Torr; and RF power in step ($X^{a3'}$) is from 80 to 500W, more preferably from 100 to 250W.

In a preferred embodiment of the present invention, the process time in ($X^{a3'}$) is in the range from 1h to 20h in case ALD is applied, more preferably from 4h to 15h, even more preferably from 6 to 12h; and the process time is in the range from 1min-60min in case CVD is applied, more preferably from 2 to 30min, even more preferably from 3 to 10min.

In a preferably embodiment of the present invention, the frequency of the radio frequency power supply (RF) in step ($X^{a3'}$) is in the range from

3khz to 20Mhz, more preferably from 4khz to 16MHz, even more preferably it is from 4khz to 13.6MHz.

It is believed that these process conditions are especially suitable to reduce or avoid process damage of the organic layer and to realize improved lower haze value.

In another aspect, the present invention further relates to a stacked layer, preferably it is being a protection layer for an optical device, obtained by the method of the present invention. Preferably the average layer thickness of the inorganic layer of the stacked layer obtained by the method is in the range from 0.05 to 1µm, preferably from 0.1 to 0.5µm, even more preferably from 0.2 to 0.3µm when it is made by ALD and it is in the range from 1 to 15µm, preferably from 4 to 12µm, even more preferably from 5 to 9µm when it is made by CVD.

It is believed that such layer thickness is suitable to realize lower haze value, improved flexibility, e.g. for flexible devices.
In a preferred embodiment of the present invention, the stacked layer may optionally contains (C) another inorganic layer under (A) the organic layer which is opposite side of (B) the inorganic layer, like (C) another inorganic layer / (A) the organic layer / (B) inorganic layer. Said another inorganic layer (C) may preferably fabricated by ALD or CVD. The process conditions for fabricating said another inorganic layer (C) and the average layer thickness of said another inorganic layer (C) can be the same to (B) the inorganic layer as described above.

In a preferred embodiment of the present invention, the total layer thickness of the stacked layer is in the range from 0.01 to 100 µm, preferably from 1 to 20µm, more preferably from 8 to 12.

And In a preferred embodiment of the present invention, the layer thickness of said organic layer of the stacked layer is in the range from 1 to 75µm, preferably from 3 to 50µm, more preferably from 4 to 20µm, even more preferably from 5 to 15µm; wherein the layer thickness of said inorganic layer is in the range from 0.01 to 10µm, preferably from 0.1 to 5µm, even more preferably from 0.2 to 1.5µm, furthermore preferably from 0.5 to 1 µm.

In a preferred embodiment of the present invention, the stacked layer has the permittivity value $\varepsilon<2.5$, preferably $1.5\leq\varepsilon<2.5$, more preferably $2.0\leq\varepsilon\leq2.4$.

In a preferred embodiment of the present invention, the film has the haze value 5 or less, preferably it is in the range from 5 to 0.1.

According to the present invention, said Haze value is measured at room temperature in air following the procedure described in ASTM D1003-21. The measurement can be performed using a commercial haze meter like e.g. the BYK Gardner Haze-Gard plus 4725.

In a preferred embodiment of the present invention, the stacked layer has Martens Hardness value in the range from 40 to 120 N/mm$^2$, preferably from 60 to 110 N/mm$^2$, more preferably from 70 to 95 N/mm$^2$.

In a preferred embodiment of the present invention, the stacked layer has Young's modulus value in the range from 2,000 to 5,000 Mpa, preferably 2,500 to 4,000 Mpa, more preferably from 3,000 to 3,500 Mpa.

Young's modulus value and Martens Hardness value are measured as described in with using Fischerscope HM2000S based on https://www.asmec.de/en/information.php?seite=0&useite=21, DIN ISO 14577 1–3.

In a preferred embodiment of the present invention, the inorganic layer is selected from SiNx, SiOxNy or SiOx. Namely SiN, SiON, SiO or $SiO_2$.

In another aspect, the present invention further relates to a device comprising at least the stacked layer of the present invention. Preferably said device is an optical device, more preferably said device is a display device, preferably said device further comprises a functional module, more preferably said device comprises a functional module selected from OLED, LCD and μLED.

Preferable embodiments

1. A stacked layer, preferably being a protection layer for an optical device, comprising at least;

(A) an organic layer, and

(B) an inorganic layer placed over the organic layer, preferably said inorganic layer is directly attached onto said organic layer,

wherein the haze value of the stacked layer is less than 5, preferably less than 1.

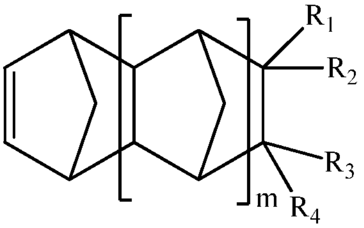
2. A stacked layer, preferably being a protection layer for an optical device, comprising at least;

(A) an organic layer, and

(B) an inorganic layer placed over the organic layer, preferably said inorganic layer is directly attached onto said organic layer,

wherein said organic layer is obtained from a composition comprising at least:

a) a chemical compound of formula (I):



(I)

wherein:

m is an integer 0, 1 or 2;

$R_1$, $R_2$, $R_3$ and $R_4$ are the same or different and each independently selected from the group consisting of hydrogen, halogen, methyl, ethyl, linear or branched ($C_3$-$C_{16}$)alkyl, perfluoro($C_1$-$C_{12}$)alkyl, hydroxy($C_1$-$C_{16}$)alkyl, ($C_3$-$C_{12}$)cycloalkyl, ($C_6$-$C_{12}$)bicycloalkyl, ($C_7$-$C_{14}$)tricycloalkyl, ($C_6$-$C_{10}$)aryl, ($C_6$-$C_{10}$)aryl($C_1$-$C_6$)alkyl, perfluoro($C_6$-$C_{10}$)aryl, perfluoro($C_6$-$C_{10}$)aryl($C_1$-$C_6$)alkyl, tri($C_1$-$C_6$)alkoxysilyl and a group of formula (A):

$$-Z^1\text{-Aryl} \quad (A)$$

wherein:

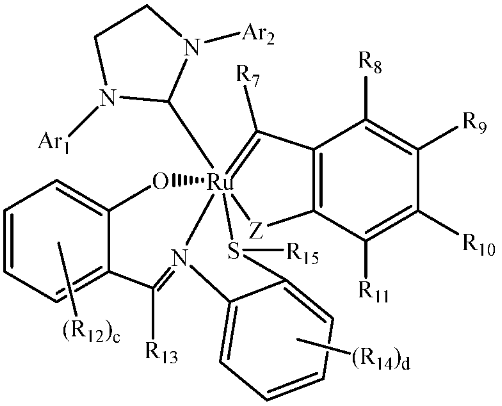
$Z^1$ is a connecting bond or a group selected from the group consisting of: $(CR_5R_6)_a$, $O(CR_5R_6)_a$, $(CR_5R_6)_aO$, $(CR_5R_6)_a$-O-$(CR_5R_6)_b$, $(CR_5R_6)_a$-O-$(SiR_5R_6)_b$, $(CR_5R_6)_a$-(CO)O-$(CR_5R_6)_b$, $(CR_5R_6)_a$-O(CO)-$(CR_5R_6)_b$, $(CR_5R_6)_a$-(CO)-$(CR_5R_6)_b$, where a and b are integers which may be the same or different and each independently is 1 to 12;

$R_5$ and $R_6$ are the same or different and each independently selected from the group consisting of hydrogen, methyl, ethyl, linear or branched ($C_3$-$C_6$)alkyl, hydroxy, methoxy, ethoxy, linear or branched ($C_3$-$C_6$)alkyloxy, acetoxy, ($C_2$-$C_6$)acyl, hydroxymethyl, hydroxyethyl, linear or branched hydroxy($C_3$-$C_6$)alkyl, phenyl and phenoxy;

Aryl is phenyl or phenyl substituted with one or more of groups selected from the group consisting of methyl, ethyl, linear or branched ($C_3$-$C_6$)alkyl, hydroxy, methoxy, ethoxy, linear or branched ($C_3$-$C_6$)alkyloxy, acetoxy, ($C_2$-$C_6$)acyl, hydroxymethyl, hydroxyethyl, linear or branched hydroxy($C_3$-$C_6$)alkyl, phenyl and phenoxy;

wherein at least one of $R_1$, $R_2$, $R_3$ and $R_4$ is not hydrogen when m is 0, wherein at least two of $R_1$, $R_2$, $R_3$ and $R_4$ may form a ring;

b) an organo-transition metal catalyst comprising a metal selected from ruthenium or osmium, preferably it is an organo-ruthenium compound, more preferably it is represented by formula (II):



(II)

wherein

c and d are integers from 0 to 5;

Z is oxygen or sulfur;

$R_7$ is selected from the group consisting of hydrogen, $(C_1\text{-}C_{20})$alkyl, $(C_2\text{-}C_{20})$alkenyl, $(C_2\text{-}C_{20})$alkynyl and $(C_6\text{-}C_{10})$aryl; and

$R_8$, $R_9$, $R_{10}$ and $R_{11}$ are the same or different and each independently selected from the group consisting of hydrogen, halogen, $(C_1\text{-}C_{16})$alkyl, $(C_1\text{-}C_{16})$alkoxy, $(C_1\text{-}C_{16})$perfluoroalkyl, $(C_3\text{-}C_7)$cycloalkyl, $(C_2\text{-}C_{16})$alkenyl, $(C_6\text{-}C_{14})$aryl, $(C_6\text{-}C_{14})$perfluoroaryl, $(C_3\text{-}C_{12})$heterocyclyl, $-OR_{16}$, $-NO_2$, -COOH, $-COOR_{16}$, $-CONR_{16}R_{17}$, $-SO_2NR_{16}R_{17}$, $-SO_2R_{16}$, -CHO, $-COR_{16}$, wherein $R_{16}$ and $R_{17}$ are the same or different and each independently selected from the group consisting of $(C_1\text{-}C_6)$alkyl, $(C_1\text{-}C_6)$perfluoroalkyl, $(C_6\text{-}C_{14})$aryl, $(C_6\text{-}C_{14})$perfluoroaryl; or wherein

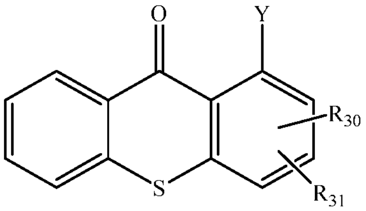
two or more of $R_8$, $R_9$, $R_{10}$ and $R_{11}$ taken together with the carbon atoms to which they are attached to form a substituted or unsubstituted, fused $(C_4\text{-}C_8)$carbocyclic ring, or a substituted or unsubstituted, fused aromatic ring;

each $R_{12}$, $R_{13}$ and $R_{14}$ may be the same or different and independently of the other selected from the group consisting of hydrogen, halogen, ($C_1$-$C_{16}$)alkyl, ($C_1$-$C_{16}$)alkoxy, ($C_1$-$C_{16}$)perfluoroalkyl, ($C_3$-$C_7$)cycloalkyl, ($C_2$-$C_{16}$)alkenyl, ($C_6$-$C_{14}$)aryl, ($C_6$-$C_{14}$)perfluoroaryl,($C_3$-$C_{12}$)heterocyclyl, -$OR_{16}$, -$NO_2$, -COOH, -$COOR_{16}$, -$CONR_{16}R_{17}$, -$SO_2NR_{16}R_{17}$, -$SO_2R_{16}$, -CHO, -$COR_{16}$, wherein $R_{16}$ and $R_{17}$ are the same or different and each independently selected from the group consisting of ($C_1$-$C_6$)alkyl, ($C_1$-$C_6$)perfluoroalkyl, ($C_6$-$C_{14}$)aryl, ($C_6$-$C_{14}$)perfluoroaryl;

$R_{15}$ is selected from the group consisting of ($C_1$-$C_{16}$)alkyl, ($C_1$-$C_{16}$)perfluoroalkyl, ($C_3$-$C_{16}$)cycloalkyl, ($C_6$-$C_{14}$)aryl, ($C_6$-$C_{14}$)perfluoroaryl and ($C_3$-$C_{12}$)heterocyclyl;

$Ar_1$ and $Ar_2$ are the same or different and each independently selected from the group consisting of substituted or unsubstituted phenyl, substituted or unsubstituted biphenyl and substituted or unsubstituted naphthyl, wherein each of said substituents are independently selected from the group consisting of methyl, ethyl and linear or branched ($C_3$-$C_6$)alkyl;

c) a photoactive compound capable of releasing a Bronsted acid when it is subjected to photolytic condition, preferably it is selected from a compound represented by formula (III):



(III)

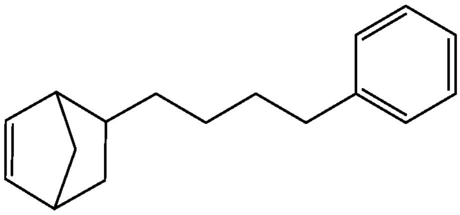
wherein

Y is halogen; and

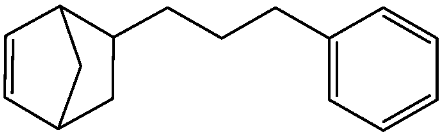
$R_{30}$ and $R_{31}$ are the same or different and independently of each other selected from the group consisting of hydrogen, methyl, ethyl, linear or branched ($C_3$-$C_{12}$)alkyl, ($C_3$-$C_{12}$)cycloalkyl, ($C_6$-$C_{12}$)bicycloalkyl, ($C_7$-$C_{14}$)tricycloalkyl, ($C_6$-$C_{10}$)aryl, ($C_6$-$C_{10}$)aryl($C_1$-$C_3$)alkyl, ($C_1$-$C_{12}$)alkoxy,

($C_3$-$C_{12}$)cycloalkoxy, ($C_6$-$C_{12}$)bicycloalkoxy, ($C_7$-$C_{14}$)tricycloalkoxy, ($C_6$-$C_{10}$)aryloxy($C_1$-$C_3$)alkyl and ($C_6$-$C_{10}$)aryloxy.

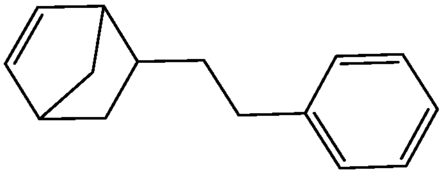
3. The layer of embodiment 2, wherein the monomer of formula (I) of the composition is selected from the group consisting of:



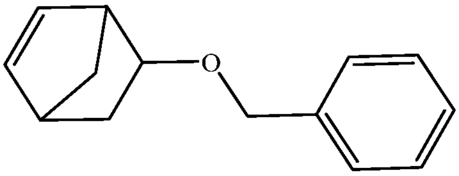
5-(4-phenylbutyl)bicyclo[2.2.1]hept-2-ene;



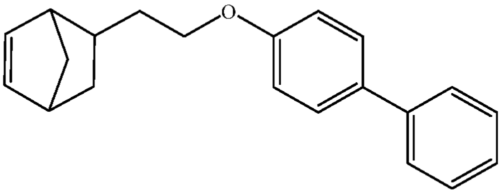
5-(3-phenylpropyl)bicyclo[2.2.1]hept-2-ene;



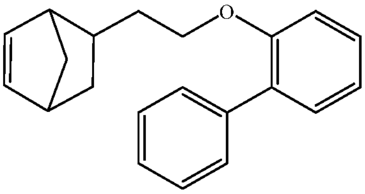
5-phenethylbicyclo[2.2.1]hept-2-ene (PENB);



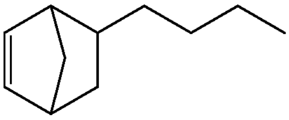
5-(benzyloxy)bicyclo[2.2.1]hept-2-ene;



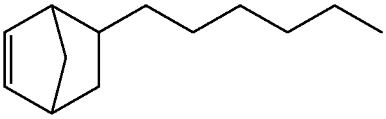
5-(2-([1,1'-biphenyl]-4-yloxy)ethyl)bicyclo[2.2.1]hept-2-ene;



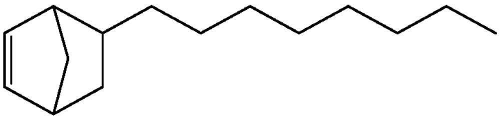
5-(2-([1,1'-biphenyl]-2-yloxy)ethyl)bicyclo[2.2.1]hept-2-ene (NBEtO-2-PhPh);



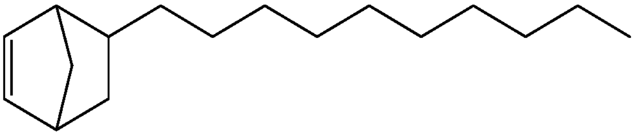
5-butylbicyclo[2.2.1]hept-2-ene (BuNB);



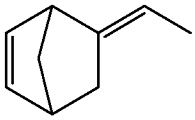
5-hexylbicyclo[2.2.1]hept-2-ene (HexylNB);



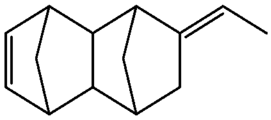
5-octylbicyclo[2.2.1]hept-2-ene (OctNB);



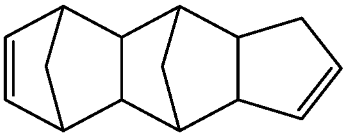
5-decylbicyclo[2.2.1]hept-2-ene (DecNB);



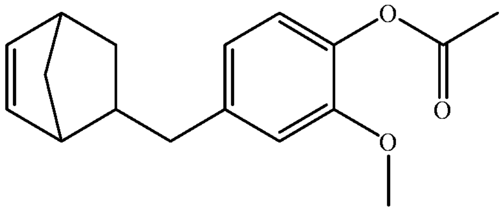
5-ethylidenebicyclo[2.2.1]hept-2-ene;



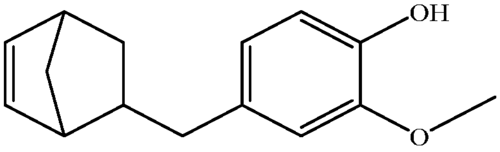
2-ethylidene-1,2,3,4,4a,5,8,8a-octahydro-1,4:5,8-dimethanonaphthalene;



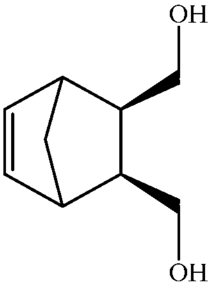
3a,4,4a,5,8,8a,9,9a-octahydro-1H-4,9:5,8-dimethanocyclopenta[b]naphthalene (one of trimers of cyclopentadiene, TCPD1, also known as CPD3);



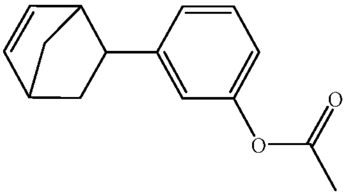
5-norbornenylmethyleugenyl acetate (EuAcNB);



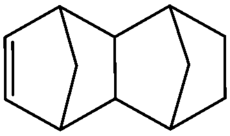
5-norbornenylmethyleugenol (EuOHNB);



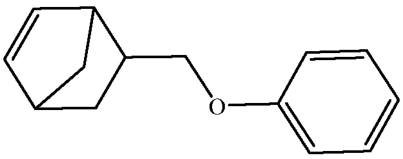
NB(MeOH)2;



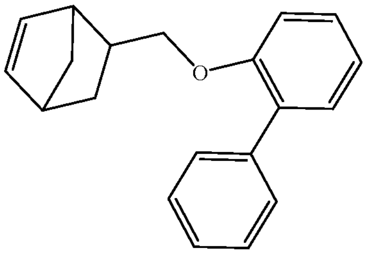
PhAcNB;



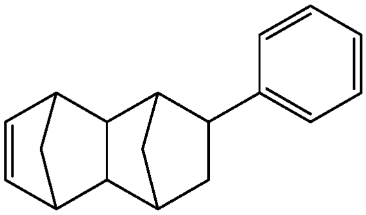
tetracyclododecene (TD);



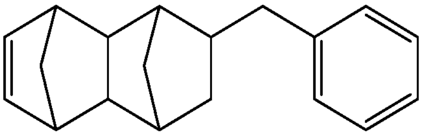
5-(phenoxymethyl)bicyclo[2.2.1]hept-2-ene (NBMeOPh);



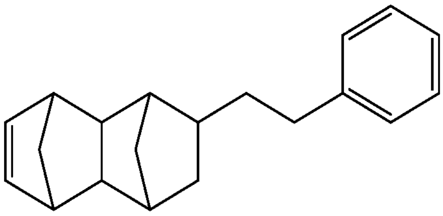
5-(([1,1'-biphenyl]-2-yloxy)methyl)bicyclo[2.2.1]hept-2-ene (NBMeOPhPh);



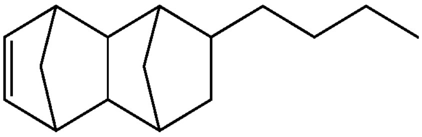
2-phenyl-tetracyclododecene (PhTD);



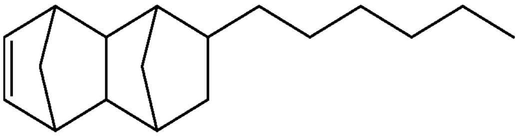
2-benzyl-1,2,3,4,4a,5,8,8a-octahydro-1,4:5,8-dimethanonaphthalene;



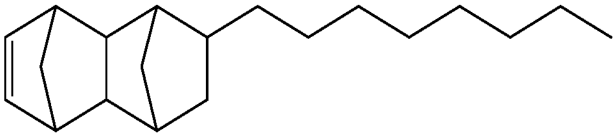
2-phenethyl-1,2,3,4,4a,5,8,8a-octahydro-1,4:5,8-dimethanonaphthalene (PETD);



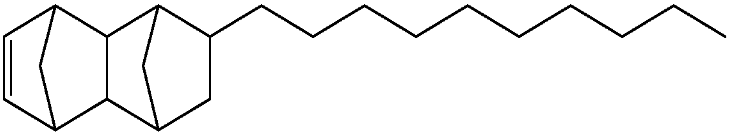
2-butyl-1,2,3,4,4a,5,8,8a-octahydro-1,4:5,8-dimethanonaphthalene (ButylTD);



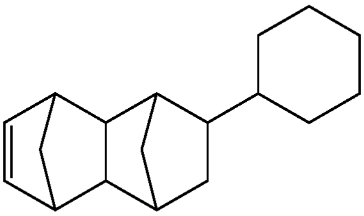
2-hexyl-1,2,3,4,4a,5,8,8a-octahydro-1,4:5,8-dimethanonaphthalene (HexylTD);



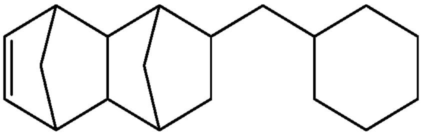
2-octyl-1,2,3,4,4a,5,8,8a-octahydro-1,4:5,8-dimethanonaphthalene (OctylTD);



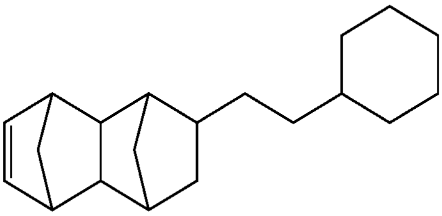
2-decyl-1,2,3,4,4a,5,8,8a-octahydro-1,4:5,8-dimethanonaphthalene (DecylTD);



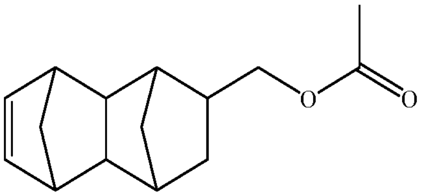
2-cyclohexyl-tetracyclododecene (CyclohexylTD);



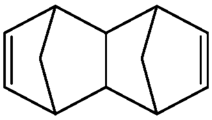
2-cyclohexylmethyl-1,2,3,4,4a,5,8,8a-octahydro-1,4:5,8-dimethanonaphthalene;



2- cyclohexylethyl-1,2,3,4,4a,5,8,8a-octahydro-1,4:5,8-dimethanonaphthalene;



(1,2,3,4,4a,5,8,8a-octahydro-1,4:5,8-dimethanonaphthalen-2-yl)methyl acetate (TDMeOAc); and



tetracyclododecadiene (TDD).

4. The layer of embodiment 2 or 3, wherein:

Z is oxygen;

$R_7$ is hydrogen;

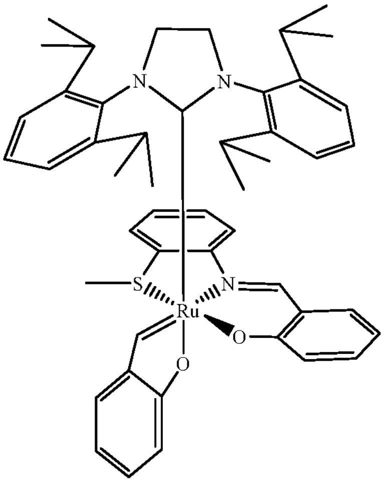
$R_8$, $R_9$, $R_{10}$ and $R_{11}$ are the same or different and each independently selected from the group consisting of hydrogen, methyl, ethyl and -$NO_2$;

$R_{12}$, $R_{13}$ and $R_{14}$ are the same or different and each independently selected from the group consisting of hydrogen, methyl, ethyl and -$NO_2$;

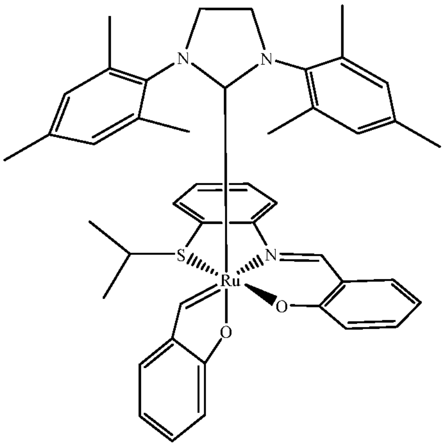
$R_{15}$ is selected from the group consisting of methyl, ethyl and cyclohexyl;

$Ar_1$ and $Ar_2$ are the same or different and each independently selected from the group consisting of phenyl, 2,6-dimethylphenyl, 2,6-diethylphenyl, 2,6-di(isopropyl)phenyl and 2,4,6-trimethylphenyl.

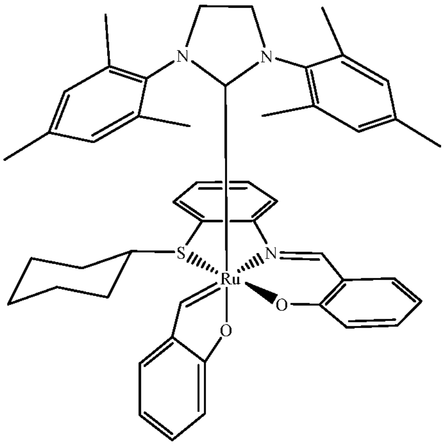
5. The layer of any one of embodiments 2 to 4, wherein the organo-ruthenium compound is represented by formula (II) selected from the group consisting of:



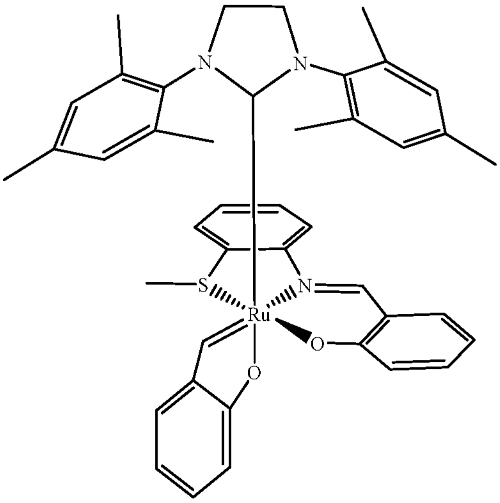
[1,3-Bis(2,6-diisopropylphenyl)-2-imidazolidinylidene]{2-[(E)-({2-[methylthio-κS]phenyl}imino-κN)methyl]phenoxido-κO}[2-(oxido-κO)benzylidene-κC]ruthenium(II) (Ru-1);



[1,3-Bis(2,4,6-trimethylphenyl)-2-imidazolidinylidene]{2-[(E)-({2-[isopropylthio-κS]phenyl}imino-κN)methyl]phenoxido-κO}[2-(oxido-κO)benzylidene-κC]ruthenium(II);



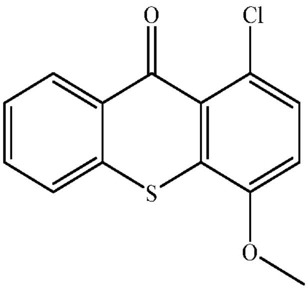
[1,3-Bis(2,4,6-trimethylphenyl)-2-imidazolidinylidene]{2-[(E)-({2-[cyclohexylthio-κS]phenyl}imino-κN)methyl]phenoxido-κO}[2-(oxido-κO)benzylidene-κC]ruthenium(II); and



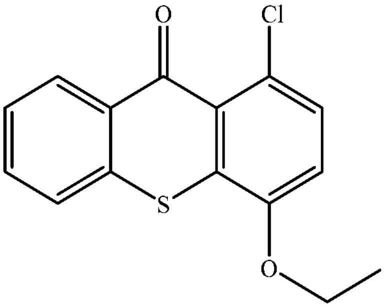
[1,3-Bis(2,4,6-trimethylphenyl)-2-imidazolidinylidene]{2-[(E)-({2-[methylthio-κS]phenyl}imino-κN)methyl]phenoxido-κO}[2-(oxido-κO)benzylidene-κC]ruthenium(II).

6. The layer of any one of embodiments 2 to 5, wherein:
Y is chlorine or bromine; and
$R_{30}$ and $R_{31}$ are the same or different and independently of each other selected from the group consisting of hydrogen, methyl, ethyl, n-propyl, iso-propyl, phenyl, cyclohexyl, methoxy, ethoxy, n- propoxy and phenoxy.

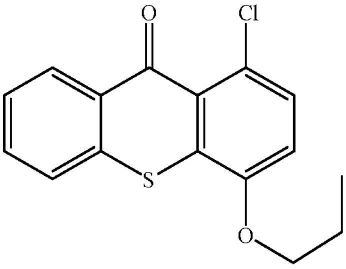
7. The layer of any one of embodiments 2 to 6, wherein the compound of formula (III) is selected from the group consisting of:



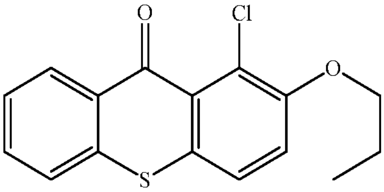
1-chloro-4-methoxy-9H-thioxanthen-9-one;



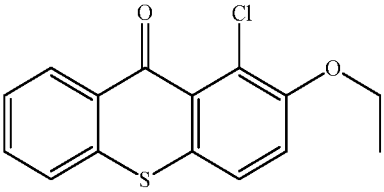
1-chloro-4-ethoxy-9H-thioxanthen-9-one;



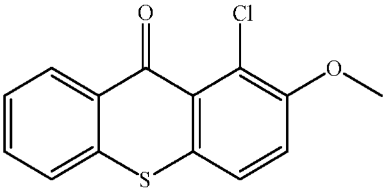
1-chloro-4-propoxy-9H-thioxanthen-9-one;



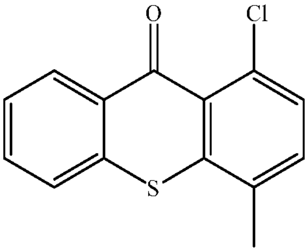
1-chloro-2-propoxy-9H-thioxanthen-9-one;



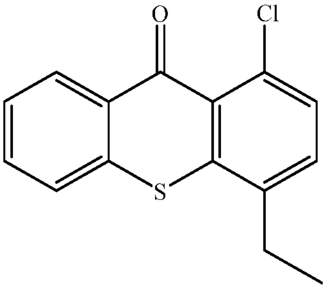
1-chloro-2-ethoxy-9H-thioxanthen-9-one;



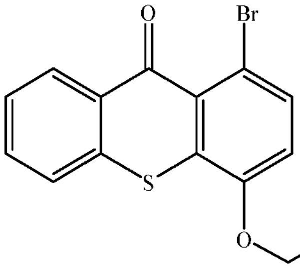
1-chloro-2-methoxy-9H-thioxanthen-9-one;



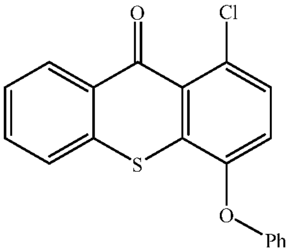
1-chloro-4-methyl-9H-thioxanthen-9-one;



1-chloro-4-ethyl-9H-thioxanthen-9-one;



1-bromo-4-propoxy-9H-thioxanthen-9-one; and



1-chloro-4-phenoxy-9H-thioxanthen-9-one.

8.The layer of any one of embodiments 2 to 7, wherein said composition further comprises a UV light blocker and/or a crosslinker.

9. The layer of any one of embodiments 1 to 8, wherein said composition further comprises an additive of formula (I) with the proviso that said additive is different from a) the chemical compound of formula (I).

Preferably symbol m of the formula is 1, more preferably said additive is selected from the group consisting of:

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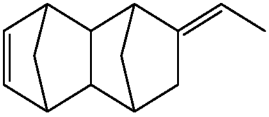
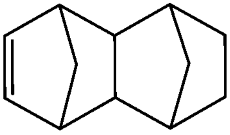
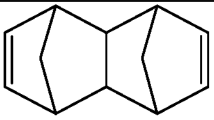
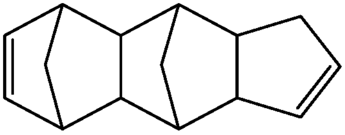
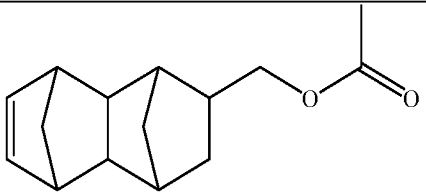
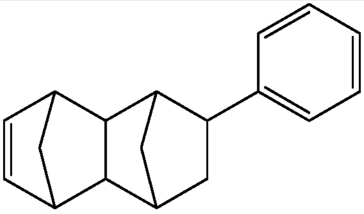
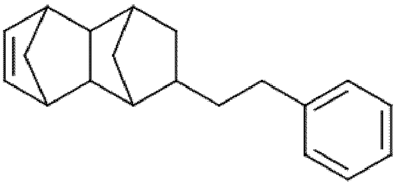
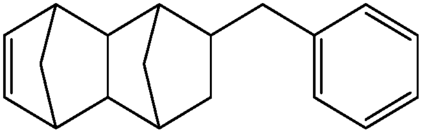
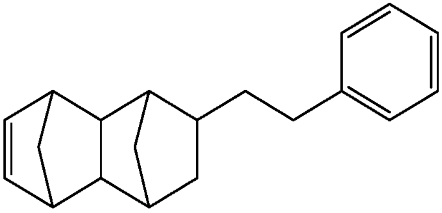
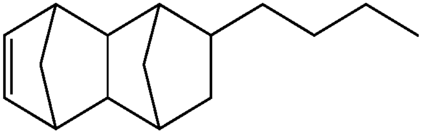
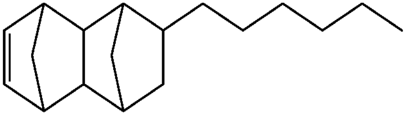
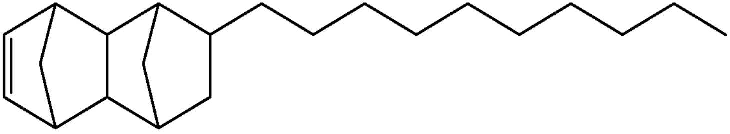
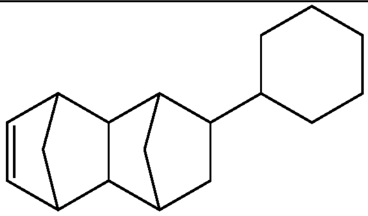
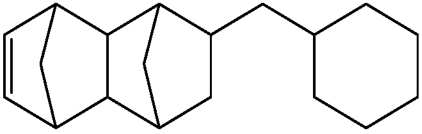
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

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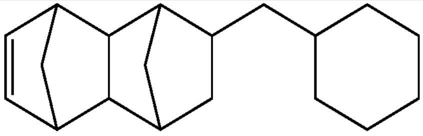
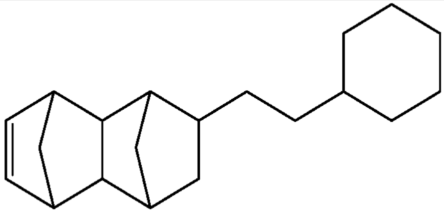
|  |  |

10. The layer of any one of preceding embodiments, wherein said composition comprises a solvent 10wt% or less based on the total amount of the composition, more preferably it is 5wt% or less, more preferably it is a solvent free composition, preferably said solvent is one or more members of the group consisting of ethylene glycol monoalkyl ethers, preferably ethylene glycol monomethyl ether, ethylene glycol monoethyl ether, ethylene glycol monopropyl ether, and ethylene glycol monobutyl ether; diethylene glycol dialkyl ethers, preferably diethylene glycol dimethyl ether, diethylene glycol diethyl ether, diethylene glycol dipropyl ether, and diethylene glycol dibutyl ether; propylene glycol monoalkyl ethers, preferably propylene glycol monomethyl ether(PGME), propylene glycol monoethyl ether, and propylene glycol monopropyl ether; ethylene glycol alkyl ether acetates, preferably methyl cellosolve acetate and ethyl cellosolve acetate; propylene glycol alkyl ether acetates, preferably propylene glycol monomethyl ether acetate (PGMEA), propylene glycol monoethyl ether acetate, and propylene glycol monopropyl ether acetate; ketones, preferably methyl ethyl ketone, acetone, methyl amyl ketone, methyl isobutyl ketone, and cyclohexanone; alcohols, preferably ethanol, propanol, butanol, hexanol, cyclo hexanol, ethylene glycol, triethylene glycol and glycerin; esters, preferably ethyl 3-ethoxypropionate, methyl 3-methoxypropionate and ethyl lactate; and cyclic esters, preferably gamma-butyrolactone; chlorinated hydrocarbons, preferably chloroform, dichloromethane, chlorobenzene, alkyl- and cycloalkylbenzenes preferably 1,3,5-trimethylbenzene, 1,2,4-trimethyl benzene, 1,2,3-trimethyl benzene, docecylbenzene, cyclohexylbenzene, 1,2,3,4-tetramethylbenzene, 1,2,3,5-

tetramethylbenzene, 3-isopropylbiphenyl, 3-methylbiphenyl, 4-methylbiphenyl and dichlorobenzene.

11. Use of a composition for fabricating an organic layer of a stacked layer, preferably said stacked layer is being a protection layer for an optical device,

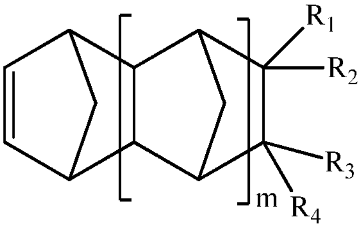
wherein said stacked layer comprises at least;

(A) said organic layer, and

(B) an inorganic layer placed over the organic layer.

wherein said composition comprises at least:

a) a chemical compound of formula (I):



(I)

wherein:

m is an integer 0, 1 or 2;

$R_1$, $R_2$, $R_3$ and $R_4$ are the same or different and each independently selected from the group consisting of hydrogen, halogen, methyl, ethyl, linear or branched $(C_3\text{-}C_{16})$alkyl, perfluoro$(C_1\text{-}C_{12})$alkyl, hydroxy$(C_1\text{-}C_{16})$alkyl, $(C_3\text{-}C_{12})$cycloalkyl, $(C_6\text{-}C_{12})$bicycloalkyl, $(C_7\text{-}C_{14})$tricycloalkyl, $(C_6\text{-}C_{10})$aryl, $(C_6\text{-}C_{10})$aryl$(C_1\text{-}C_6)$alkyl, perfluoro$(C_6\text{-}C_{10})$aryl, perfluoro$(C_6\text{-}C_{10})$aryl$(C_1\text{-}C_6)$alkyl, tri$(C_1\text{-}C_6)$alkoxysilyl and a group of formula (A):

$$-Z^1\text{-Aryl}\ (A)$$

wherein:

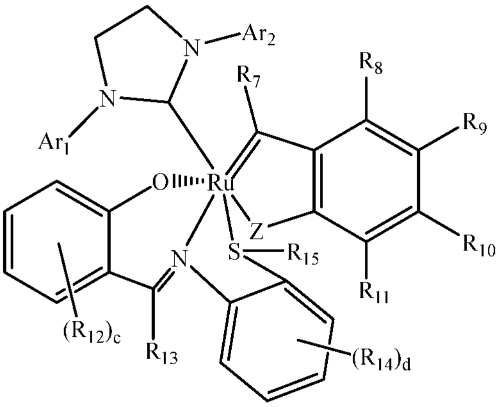
$Z^1$ is a connecting bond or a group selected from the group consisting of: $(CR_5R_6)_a$, $O(CR_5R_6)_a$, $(CR_5R_6)_aO$, $(CR_5R_6)_a\text{-O-}(CR_5R_6)_b$, $(CR_5R_6)_a\text{-O-}(SiR_5R_6)_b$, $(CR_5R_6)_a\text{-(CO)O-}(CR_5R_6)_b$, $(CR_5R_6)_a\text{-O(CO)-}(CR_5R_6)_b$, $(CR_5R_6)_a\text{-(CO)-}(CR_5R_6)_b$, where a and b are integers which may be the same or different and each independently is 1 to 12;

$R_5$ and $R_6$ are the same or different and each independently selected from the group consisting of hydrogen, methyl, ethyl, linear or branched ($C_3$-$C_6$)alkyl, hydroxy, methoxy, ethoxy, linear or branched ($C_3$-$C_6$)alkyloxy, acetoxy, ($C_2$-$C_6$)acyl, hydroxymethyl, hydroxyethyl, linear or branched hydroxy($C_3$-$C_6$)alkyl, phenyl and phenoxy;

Aryl is phenyl or phenyl substituted with one or more of groups selected from the group consisting of methyl, ethyl, linear or branched ($C_3$-$C_6$)alkyl, hydroxy, methoxy, ethoxy, linear or branched ($C_3$-$C_6$)alkyloxy, acetoxy, ($C_2$-$C_6$)acyl, hydroxymethyl, hydroxyethyl, linear or branched hydroxy($C_3$-$C_6$)alkyl, phenyl and phenoxy;

wherein at least one of $R_1$, $R_2$, $R_3$ and $R_4$ is not hydrogen when m is 0, wherein at least two of $R_1$, $R_2$, $R_3$ and $R_4$ may form a ring;

b) an organo-transition metal catalyst comprising a metal selected from ruthenium or osmium, preferably it is an organo-ruthenium compound, more preferably it is represented by formula (II):



(II)

wherein

c and d are integers from 0 to 5;

Z is oxygen or sulfur;

$R_7$ is selected from the group consisting of hydrogen, ($C_1$-$C_{20}$)alkyl, ($C_2$-$C_{20}$)alkenyl, ($C_2$-$C_{20}$)alkynyl and ($C_6$-$C_{10}$)aryl; and

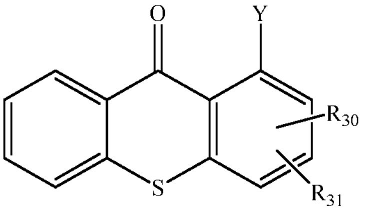
$R_8$, $R_9$, $R_{10}$ and $R_{11}$ are the same or different and each independently selected from the group consisting of hydrogen, halogen, ($C_1$-$C_{16}$)alkyl, ($C_1$-$C_{16}$)alkoxy, ($C_1$-$C_{16}$)perfluoroalkyl, ($C_3$-$C_7$)cycloalkyl, ($C_2$-$C_{16}$)alkenyl, ($C_6$-$C_{14}$)aryl, ($C_6$-$C_{14}$)perfluoroaryl, ($C_3$-$C_{12}$)heterocyclyl, $-OR_{16}$, $-NO_2$, -COOH, $-COOR_{16}$, $-CONR_{16}R_{17}$, $-SO_2NR_{16}R_{17}$, $-SO_2R_{16}$, -CHO, $-COR_{16}$, wherein $R_{16}$ and $R_{17}$ are the same or different and each independently selected from the group consisting of ($C_1$-$C_6$)alkyl, ($C_1$-$C_6$)perfluoroalkyl, ($C_6$-$C_{14}$)aryl, ($C_6$-$C_{14}$)perfluoroaryl; or wherein two or more of $R_8$, $R_9$, $R_{10}$ and $R_{11}$ taken together with the carbon atoms to which they are attached to form a substituted or unsubstituted, fused ($C_4$-$C_8$)carbocyclic ring, or a substituted or unsubstituted, fused aromatic ring;

each $R_{12}$, $R_{13}$ and $R_{14}$ may be the same or different and independently of the other selected from the group consisting of hydrogen, halogen, ($C_1$-$C_{16}$)alkyl, ($C_1$-$C_{16}$)alkoxy, ($C_1$-$C_{16}$)perfluoroalkyl, ($C_3$-$C_7$)cycloalkyl, ($C_2$-$C_{16}$)alkenyl, ($C_6$-$C_{14}$)aryl, ($C_6$-$C_{14}$)perfluoroaryl,($C_3$-$C_{12}$)heterocyclyl, $-OR_{16}$, $-NO_2$, -COOH, $-COOR_{16}$, $-CONR_{16}R_{17}$, $-SO_2NR_{16}R_{17}$, $-SO_2R_{16}$, -CHO, $-COR_{16}$, wherein $R_{16}$ and $R_{17}$ are the same or different and each independently selected from the group consisting of ($C_1$-$C_6$)alkyl, ($C_1$-$C_6$)perfluoroalkyl, ($C_6$-$C_{14}$)aryl, ($C_6$-$C_{14}$)perfluoroaryl;

$R_{15}$ is selected from the group consisting of ($C_1$-$C_{16}$)alkyl, ($C_1$-$C_{16}$)perfluoroalkyl, ($C_3$-$C_{16}$)cycloalkyl, ($C_6$-$C_{14}$)aryl, ($C_6$-$C_{14}$)perfluoroaryl and ($C_3$-$C_{12}$)heterocyclyl;

$Ar_1$ and $Ar_2$ are the same or different and each independently selected from the group consisting of substituted or unsubstituted phenyl, substituted or unsubstituted biphenyl and substituted or unsubstituted naphthyl, wherein each of said substituents are independently selected from the group consisting of methyl, ethyl and linear or branched ($C_3$-$C_6$)alkyl;

c) a photoactive compound capable of releasing a Bronsted acid when it is subjected to photolytic condition, preferably it is selected from a compound represented by formula (III):



(III)

wherein

Y is halogen; and

$R_{30}$ and $R_{31}$ are the same or different and independently of each other selected from the group consisting of hydrogen, methyl, ethyl, linear or branched $(C_3\text{-}C_{12})$alkyl, $(C_3\text{-}C_{12})$cycloalkyl, $(C_6\text{-}C_{12})$bicycloalkyl, $(C_7\text{-}C_{14})$tricycloalkyl, $(C_6\text{-}C_{10})$aryl, $(C_6\text{-}C_{10})$aryl$(C_1\text{-}C_3)$alkyl, $(C_1\text{-}C_{12})$alkoxy, $(C_3\text{-}C_{12})$cycloalkoxy, $(C_6\text{-}C_{12})$bicycloalkoxy, $(C_7\text{-}C_{14})$tricycloalkoxy, $(C_6\text{-}C_{10})$aryloxy$(C_1\text{-}C_3)$alkyl and $(C_6\text{-}C_{10})$aryloxy.

12. A method for fabricating a stacked layer, preferably said stacked layer is being a protection layer for an optical device, comprising at least the following steps:

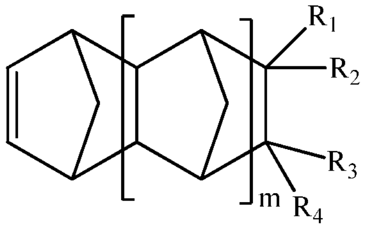
($X^{a1}$) providing a composition of onto a substrate, a layer, or an outermost surface of a device to obtain an organic layer,

($X^{a2}$) irradiating the coated layer with light (applying light irradiation) to form a cured film, preferably with light having peak maximum wavelength in the range from 360 to 430 nm, preferably the dose of the light irradiated to the composition is in the range from 1 to 5 J/cm$^2$.

($X^{a3}$) fabricating an inorganic layer over the organic layer to form a stacked layer, preferably said inorganic layer is fabricated by Chemical Vapor Deposition (CVD) or Atomic Layer Deposition (ALD). Preferably said inorganic layer is selected from the group consisting of SiNx,SiOxNy or SiOx.

wherein said composition comprises at least :

a) a chemical compound of formula (I):



(I)

wherein:

m is an integer 0, 1 or 2;

$R_1$, $R_2$, $R_3$ and $R_4$ are the same or different and each independently selected from the group consisting of hydrogen, halogen, methyl, ethyl, linear or branched $(C_3\text{-}C_{16})$alkyl, perfluoro$(C_1\text{-}C_{12})$alkyl, hydroxy$(C_1\text{-}C_{16})$alkyl, $(C_3\text{-}C_{12})$cycloalkyl, $(C_6\text{-}C_{12})$bicycloalkyl, $(C_7\text{-}C_{14})$tricycloalkyl, $(C_6\text{-}C_{10})$aryl, $(C_6\text{-}C_{10})$aryl$(C_1\text{-}C_6)$alkyl, perfluoro$(C_6\text{-}C_{10})$aryl, perfluoro$(C_6\text{-}C_{10})$aryl$(C_1\text{-}C_6)$alkyl, tri$(C_1\text{-}C_6)$alkoxysilyl and a group of formula (A):

$$-Z^1\text{-Aryl (A)}$$

wherein:

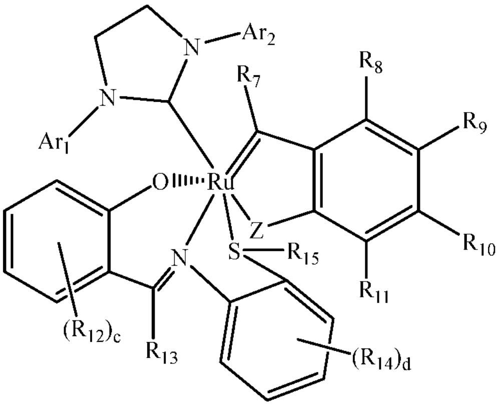
$Z^1$ is a connecting bond or a group selected from the group consisting of: $(CR_5R_6)_a$, $O(CR_5R_6)_a$, $(CR_5R_6)_aO$, $(CR_5R_6)_a\text{-}O\text{-}(CR_5R_6)_b$, $(CR_5R_6)_a\text{-}O\text{-}(SiR_5R_6)_b$, $(CR_5R_6)_a\text{-}(CO)O\text{-}(CR_5R_6)_b$, $(CR_5R_6)_a\text{-}O(CO)\text{-}(CR_5R_6)_b$, $(CR_5R_6)_a\text{-}(CO)\text{-}(CR_5R_6)_b$, where a and b are integers which may be the same or different and each independently is 1 to 12;

$R_5$ and $R_6$ are the same or different and each independently selected from the group consisting of hydrogen, methyl, ethyl, linear or branched $(C_3\text{-}C_6)$alkyl, hydroxy, methoxy, ethoxy, linear or branched $(C_3\text{-}C_6)$alkyloxy, acetoxy, $(C_2\text{-}C_6)$acyl, hydroxymethyl, hydroxyethyl, linear or branched hydroxy$(C_3\text{-}C_6)$alkyl, phenyl and phenoxy;

Aryl is phenyl or phenyl substituted with one or more of groups selected from the group consisting of methyl, ethyl, linear or branched $(C_3\text{-}C_6)$alkyl, hydroxy, methoxy, ethoxy, linear or branched $(C_3\text{-}C_6)$alkyloxy, acetoxy, $(C_2\text{-}$

$C_6$)acyl, hydroxymethyl, hydroxyethyl, linear or branched hydroxy($C_3$-$C_6$)alkyl, phenyl and phenoxy;
wherein at least one of $R_1$, $R_2$, $R_3$ and $R_4$ is not hydrogen when m is 0,
wherein at least two of $R_1$, $R_2$, $R_3$ and $R_4$ may form a ring;

b) an organo-transition metal catalyst comprising a metal selected from ruthenium or osmium, preferably it is an organo-ruthenium compound, more preferably it is represented by formula (II):



(II)

wherein
c and d are integers from 0 to 5;
Z is oxygen or sulfur;
$R_7$ is selected from the group consisting of hydrogen, ($C_1$-$C_{20}$)alkyl, ($C_2$-$C_{20}$)alkenyl, ($C_2$-$C_{20}$)alkynyl and ($C_6$-$C_{10}$)aryl; and
$R_8$, $R_9$, $R_{10}$ and $R_{11}$ are the same or different and each independently selected from the group consisting of hydrogen, halogen, ($C_1$-$C_{16}$)alkyl, ($C_1$-$C_{16}$)alkoxy, ($C_1$-$C_{16}$)perfluoroalkyl, ($C_3$-$C_7$)cycloalkyl, ($C_2$-$C_{16}$)alkenyl, ($C_6$-$C_{14}$)aryl, ($C_6$-$C_{14}$)perfluoroaryl,
($C_3$-$C_{12}$)heterocyclyl, $-OR_{16}$, $-NO_2$, -COOH, $-COOR_{16}$, $-CONR_{16}R_{17}$, $-SO_2NR_{16}R_{17}$, $-SO_2R_{16}$, -CHO, $-COR_{16}$, wherein $R_{16}$ and $R_{17}$ are the same or different and each independently selected from the group consisting of ($C_1$-$C_6$)alkyl, ($C_1$-$C_6$)perfluoroalkyl, ($C_6$-$C_{14}$)aryl, ($C_6$-$C_{14}$)perfluoroaryl; or wherein
two or more of $R_8$, $R_9$, $R_{10}$ and $R_{11}$ taken together with the carbon atoms to which they are attached to form a substituted or unsubstituted, fused

$(C_4\text{-}C_8)$carbocyclic ring, or a substituted or unsubstituted, fused aromatic ring;

each $R_{12}$, $R_{13}$ and $R_{14}$ may be the same or different and independently of the other selected from the group consisting of hydrogen, halogen, $(C_1\text{-}C_{16})$alkyl, $(C_1\text{-}C_{16})$alkoxy, $(C_1\text{-}C_{16})$perfluoroalkyl, $(C_3\text{-}C_7)$cycloalkyl, $(C_2\text{-}C_{16})$alkenyl, $(C_6\text{-}C_{14})$aryl,

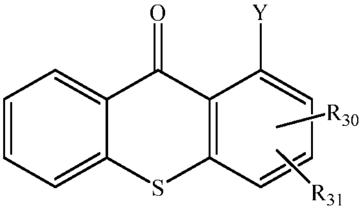
$(C_6\text{-}C_{14})$perfluoroaryl,$(C_3\text{-}C_{12})$heterocyclyl, $-OR_{16}$, $-NO_2$,

$-COOH$, $-COOR_{16}$, $-CONR_{16}R_{17}$, $-SO_2NR_{16}R_{17}$, $-SO_2R_{16}$, $-CHO$, $-COR_{16}$, wherein $R_{16}$ and $R_{17}$ are the same or different and each independently selected from the group consisting of $(C_1\text{-}C_6)$alkyl, $(C_1\text{-}C_6)$perfluoroalkyl, $(C_6\text{-}C_{14})$aryl, $(C_6\text{-}C_{14})$perfluoroaryl;

$R_{15}$ is selected from the group consisting of $(C_1\text{-}C_{16})$alkyl, $(C_1\text{-}C_{16})$perfluoroalkyl, $(C_3\text{-}C_{16})$cycloalkyl, $(C_6\text{-}C_{14})$aryl, $(C_6\text{-}C_{14})$perfluoroaryl and $(C_3\text{-}C_{12})$heterocyclyl;

$Ar_1$ and $Ar_2$ are the same or different and each independently selected from the group consisting of substituted or unsubstituted phenyl, substituted or unsubstituted biphenyl and substituted or unsubstituted naphthyl, wherein each of said substituents are independently selected from the group consisting of methyl, ethyl and linear or branched $(C_3\text{-}C_6)$alkyl;

c) a photoactive compound capable of releasing a Bronsted acid when it is subjected to photolytic condition, preferably it is selected from a compound represented by formula (III):



(III)

wherein

Y is halogen; and

$R_{30}$ and $R_{31}$ are the same or different and independently of each other selected from the group consisting of hydrogen, methyl, ethyl, linear or branched ($C_3$-$C_{12}$)alkyl, ($C_3$-$C_{12}$)cycloalkyl, ($C_6$-$C_{12}$)bicycloalkyl, ($C_7$-$C_{14}$)tricycloalkyl, ($C_6$-$C_{10}$)aryl, ($C_6$-$C_{10}$)aryl($C_1$-$C_3$)alkyl, ($C_1$-$C_{12}$)alkoxy, ($C_3$-$C_{12}$)cycloalkoxy, ($C_6$-$C_{12}$)bicycloalkoxy, ($C_7$-$C_{14}$)tricycloalkoxy, ($C_6$-$C_{10}$)aryloxy($C_1$-$C_3$)alkyl and ($C_6$-$C_{10}$)aryloxy.

13. A method for fabricating a stacked layer, preferably said stacked layer is being a protection layer for an optical device, comprising at least the following steps:

($X^{a1}$) providing a substrate having an organic layer,

($X^{a3'}$) fabricating an inorganic layer by Chemical Vapor Deposition (CVD) or Atomic Layer Deposition (ALD) over the organic layer, wherein the chamber pressure in step ($X^{a3}$) is in the range from 0.2 to 3 Torr, preferably 0.5 to 2 Torr; and

the power of a radio frequency power supply (RF) used in step ($X^{a3}$) is in the range from 10 to 600W, preferably from 15 to 500W.

14. A stacked layer, preferably it is being a protection layer for an optical device, obtained by the method of claim 12 or 13. Preferably the average layer thickness of the inorganic layer obtained by the method is in the range from 0.05 to 1μm, preferably from 0.1 to 0.5μm, even more preferably from 0.2 to 0.3μm when it is made by ALD and it is in the range from 1 to 15μm, preferably from 4 to 12μm, even more preferably from 5 to 9μm when it is made by CVD.

15. The layer of any one of embodiments 1 to 10 and 14, has the total layer thickness in the range from 0.01 to 100 μm, preferably from 1 to 20μm, more preferably from 8 to 12.

16. The layer of any one of embodiments 1 to 10 and 14, wherein the layer thickness of said organic layer is in the range from 1 to 75μm, preferably from 3 to 50μm, more preferably from 4 to 20μm, even more preferably from 5 to 15μm; wherein the layer thickness of said inorganic layer is in the

range from 0.01 to 10µm, preferably from 0.1 to 5µm, even more preferably from 0.2 to 1.5µm, furthermore preferably from 0.5 to 1 µm.

17. The layer of any one of embodiments 1 to 10 and 14 to 16, has the permittivity value $\varepsilon<2.5$, preferably $1.5\leq\varepsilon<2.5$, more preferably $2.0\leq\varepsilon\leq2.4$.

18. The layer of any one of embodiments 1 to 10 and 14 to 17, has the haze value 5 or less, preferably it is in the range from 5 to 0.1.

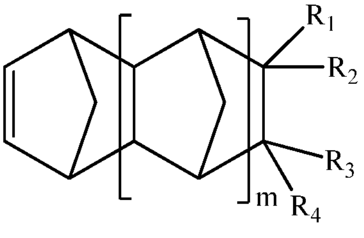
19. The layer of any one of embodiments 1 to 10 and 14 to 18, has Martens Hardness value in the range from 40 to 120 N/mm$^2$, preferably from 60 to 110 N/mm$^2$, more preferably from 70 to 95 N/mm$^2$.

20. The layer of any one of embodiments 1 to 10 and 14 to 19, has Young's modulus value in the range from 2,000 to 5,000 Mpa, preferably 2,500 to 4,000 Mpa, more preferably from 3,000 to 3,500 Mpa.

21. The layer of any one of embodiments 1 to 10 and 14 to 20, wherein the inorganic layer is selected from SiNx, SiOxNy or SiOx.

22. The layer of embodiment 1, said organic layer is obtained from a composition comprising at least:

a) a chemical compound of formula (I):



(I)

wherein:

m is an integer 0, 1 or 2;

$R_1$, $R_2$, $R_3$ and $R_4$ are the same or different and each independently selected from the group consisting of hydrogen, halogen, methyl, ethyl, linear or branched $(C_3-C_{16})$alkyl, perfluoro$(C_1-C_{12})$alkyl, hydroxy$(C_1-C_{16})$alkyl, $(C_3-C_{12})$cycloalkyl, $(C_6-C_{12})$bicycloalkyl, $(C_7-C_{14})$tricycloalkyl, $(C_6-C_{10})$aryl, $(C_6-C_{10})$aryl$(C_1-C_6)$alkyl, perfluoro$(C_6-C_{10})$aryl, perfluoro$(C_6-C_{10})$aryl$(C_1-C_6)$alkyl, tri$(C_1-C_6)$alkoxysilyl and a group of formula (A):

$$-Z^1\text{-Aryl} \quad (A)$$

wherein:

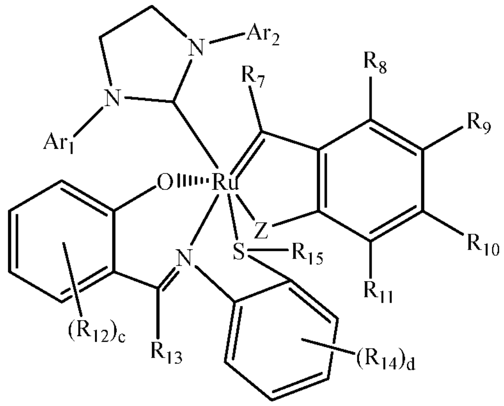
$Z^1$ is a connecting bond or a group selected from the group consisting of: $(CR_5R_6)_a$, $O(CR_5R_6)_a$, $(CR_5R_6)_aO$, $(CR_5R_6)_a$-O-$(CR_5R_6)_b$, $(CR_5R_6)_a$-O-$(SiR_5R_6)_b$, $(CR_5R_6)_a$-(CO)O-$(CR_5R_6)_b$, $(CR_5R_6)_a$-O(CO)-$(CR_5R_6)_b$, $(CR_5R_6)_a$-(CO)-$(CR_5R_6)_b$, where a and b are integers which may be the same or different and each independently is 1 to 12;

$R_5$ and $R_6$ are the same or different and each independently selected from the group consisting of hydrogen, methyl, ethyl, linear or branched $(C_3-C_6)$alkyl, hydroxy, methoxy, ethoxy, linear or branched $(C_3-C_6)$alkyloxy, acetoxy, $(C_2-C_6)$acyl, hydroxymethyl, hydroxyethyl, linear or branched hydroxy$(C_3-C_6)$alkyl, phenyl and phenoxy;

Aryl is phenyl or phenyl substituted with one or more of groups selected from the group consisting of methyl, ethyl, linear or branched $(C_3-C_6)$alkyl, hydroxy, methoxy, ethoxy, linear or branched $(C_3-C_6)$alkyloxy, acetoxy, $(C_2-C_6)$acyl, hydroxymethyl, hydroxyethyl, linear or branched hydroxy$(C_3-C_6)$alkyl, phenyl and phenoxy;

wherein at least one of $R_1$, $R_2$, $R_3$ and $R_4$ is not hydrogen when m is 0, wherein at least two of $R_1$, $R_2$, $R_3$ and $R_4$ may form a ring;

b) an organo-transition metal catalyst comprising a metal selected from ruthenium or osmium, preferably it is an organo-ruthenium compound, more preferably it is represented by formula (II):



(II)

wherein

c and d are integers from 0 to 5;

Z is oxygen or sulfur;

$R_7$ is selected from the group consisting of hydrogen, $(C_1\text{-}C_{20})$alkyl, $(C_2\text{-}C_{20})$alkenyl, $(C_2\text{-}C_{20})$alkynyl and $(C_6\text{-}C_{10})$aryl; and

$R_8$, $R_9$, $R_{10}$ and $R_{11}$ are the same or different and each independently selected from the group consisting of hydrogen, halogen, $(C_1\text{-}C_{16})$alkyl, $(C_1\text{-}C_{16})$alkoxy, $(C_1\text{-}C_{16})$perfluoroalkyl, $(C_3\text{-}C_7)$cycloalkyl, $(C_2\text{-}C_{16})$alkenyl, $(C_6\text{-}C_{14})$aryl, $(C_6\text{-}C_{14})$perfluoroaryl,

$(C_3\text{-}C_{12})$heterocyclyl, $-OR_{16}$, $-NO_2$, -COOH, $-COOR_{16}$, $-CONR_{16}R_{17}$, $-SO_2NR_{16}R_{17}$, $-SO_2R_{16}$, -CHO, $-COR_{16}$, wherein $R_{16}$ and $R_{17}$ are the same or different and each independently selected from the group consisting of $(C_1\text{-}C_6)$alkyl, $(C_1\text{-}C_6)$perfluoroalkyl, $(C_6\text{-}C_{14})$aryl, $(C_6\text{-}C_{14})$perfluoroaryl; or wherein

two or more of $R_8$, $R_9$, $R_{10}$ and $R_{11}$ taken together with the carbon atoms to which they are attached to form a substituted or unsubstituted, fused $(C_4\text{-}C_8)$carbocyclic ring, or a substituted or unsubstituted, fused aromatic ring;

each $R_{12}$, $R_{13}$ and $R_{14}$ may be the same or different and independently of the other selected from the group consisting of hydrogen, halogen, $(C_1\text{-}C_{16})$alkyl, $(C_1\text{-}C_{16})$alkoxy, $(C_1\text{-}C_{16})$perfluoroalkyl, $(C_3\text{-}C_7)$cycloalkyl, $(C_2\text{-}C_{16})$alkenyl, $(C_6\text{-}C_{14})$aryl,

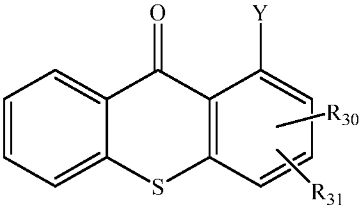
$(C_6\text{-}C_{14})$perfluoroaryl,$(C_3\text{-}C_{12})$heterocyclyl, $-OR_{16}$, $-NO_2$,

-COOH, -COOR$_{16}$, -CONR$_{16}$R$_{17}$, -SO$_2$NR$_{16}$R$_{17}$, -SO$_2$R$_{16}$, -CHO, -COR$_{16}$, wherein R$_{16}$ and R$_{17}$ are the same or different and each independently selected from the group consisting of (C$_1$-C$_6$)alkyl, (C$_1$-C$_6$)perfluoroalkyl, (C$_6$-C$_{14}$)aryl, (C$_6$-C$_{14}$)perfluoroaryl;

R$_{15}$ is selected from the group consisting of (C$_1$-C$_{16}$)alkyl, (C$_1$-C$_{16}$)perfluoroalkyl, (C$_3$-C$_{16}$)cycloalkyl, (C$_6$-C$_{14}$)aryl, (C$_6$-C$_{14}$)perfluoroaryl and (C$_3$-C$_{12}$)heterocyclyl;

Ar$_1$ and Ar$_2$ are the same or different and each independently selected from the group consisting of substituted or unsubstituted phenyl, substituted or unsubstituted biphenyl and substituted or unsubstituted naphthyl, wherein each of said substituents are independently selected from the group consisting of methyl, ethyl and linear or branched (C$_3$-C$_6$)alkyl;

c) a photoactive compound capable of releasing a Bronsted acid when it is subjected to photolytic condition, preferably it is selected from a compound represented by formula (III):



(III)

wherein

Y is halogen; and

R$_{30}$ and R$_{31}$ are the same or different and independently of each other selected from the group consisting of hydrogen, methyl, ethyl, linear or branched (C$_3$-C$_{12}$)alkyl, (C$_3$-C$_{12}$)cycloalkyl, (C$_6$-C$_{12}$)bicycloalkyl, (C$_7$-C$_{14}$)tricycloalkyl, (C$_6$-C$_{10}$)aryl, (C$_6$-C$_{10}$)aryl(C$_1$-C$_3$)alkyl, (C$_1$-C$_{12}$)alkoxy, (C$_3$-C$_{12}$)cycloalkoxy, (C$_6$-C$_{12}$)bicycloalkoxy, (C$_7$-C$_{14}$)tricycloalkoxy, (C$_6$-C$_{10}$)aryloxy(C$_1$-C$_3$)alkyl and (C$_6$-C$_{10}$)aryloxy.

23. The layer of any one of embodiments 1 to 10 and 14 to 22, wherein the average Transmission of the layer in the wavelength range from 380nm to

800nm is 90% or more, preferably 95% or more, more preferably 98% or more and less than 100%.

24. A device comprising at least the staked layer of any one of embodiments 1 to 10 and 14 to 23, preferably said device is an optical device, more preferably said device is a display device, preferably said device further comprises a functional module, more preferably said device comprises a functional module selected from OLED, LCD and μLED.

The working examples below provide descriptions of the present invention, as well as an in-detail description of their fabrication. However, the present invention is not limited to the working examples.

## Working Examples

The following abbreviations have been used hereinbefore and hereafter in describing some of the compounds, instruments and/or methods employed to illustrate certain of the embodiments of this invention:

HexylTD: 2-hexyl-1,2,3,4,4a,5,8,8a-octahydro-1,4:5,8-dimethanonaphthalene;

TD: 1,2,3,4,4a,5,8,8a-Octahydro-1,4:5,8-dimethanonaphthalene (Tetracyclododecene)

NBD: norbornadiene

Ru-catalyst I: [1,3-bis(2,6-diisopropylphenyl)-2-imidazolidinylidene]{2-[(E)-({2-[methylthio-κS]phenyl}imino-κN)methyl]phenoxido-κO}[2-(oxido-κO)benzylidene-κC]ruthenium(II);

CPTX: 1-chloro-4-propoxy-9H-thioxanthen-9-one;

Various monomers as used herein are either commercially available or can be readily prepared following the procedures as described in U. S. Patent No. 9,944,818.

**Working example 1:** Composition preparation

In glass brown bottles, CPTX (0.1wt.%) is dissolved in TD (99.85wt%) via sonication at 30 °C for 20 minutes to form a clear solution. The solution is purged with nitrogen for 8 hours. Ru-1 catalyst (0.05wt%) is added in a glove box to the purged solution and sonicated for 30 minutes to completely dissolve the catalyst. The sample is checked optically for full dissolution and filtered prior to further experiments. Then comparative sample (sample 0) is obtained.

**Working examples 2 to 4:** Composition preparations

The samples 2 to 4 (working examples 2 to 4) are prepared in the same manner as described above in working example 1 except for that the following materials as mentioned in table 1 are used instead of the materials used in working example 1.

Table 1:

| Examples | Sample No. | Composition (in weight%) | | | |
|---|---|---|---|---|---|
| | | TD | NBD | Ru-catelyst 1 | CPTX |
| 1 | 1 | 99.85 | 0 | 0.05 | 0.1 |
| 2 | 2 | 69.89 | 29.95 | 0.06 | 0.1 |
| 3 | 3 | 89.86 | 9.98 | 0.06 | 0.1 |
| 4 | 4 | 79.87 | 19.97 | 0.06 | 0.1 |

**Examples 5:** composition preparation

The sample 5 is prepared in the same manner as described in working example 1 above except for that the following materials as mentioned in table 1 are used instead of the materials used in working example 1.

| Examples | Sample No. | Composition (in weight%) | | | |
|---|---|---|---|---|---|
| | | HexylTD | NBD | Ru-catalyst 1 | CPTX |
| 5 | 5 | 99.87 | 0 | 0.03 | 0.1 |

**Working example 6 - Thin film preparation (Spin coating + UV curing)**

Three thin film samples (film samples 1 to 3) of the composition 1 are prepared by spin coating the composition from working example 1 in a glovebox under nitrogen. Namely, Said composition is provided by said spin coating onto the surface (SiNx layer) of Quartz substrates. Said Quarts substrate has a SiNx layer made by ALD with the average layer thickness about 0.73µm. The wet films are then illuminated with UV light of 395 nm to cure the film, the dose applied is between 1 and 5 J/cm², the exact dose used is summarized in Table 2. The spin coating parameters are optimized to obtain a cured films thickness of about 8 µm. Then, film samples 1 to 3 (organic layer / SiNx layer / Quarts substrate) are obtained.

The film thickness is determined by profilometry after curing the film as the height difference between the film surface and the substrate surface (after scratching with a scalpel) with a stylus-type profilometer.

In the same manner as described above, compositions 2 to 5 are spin coated each separately onto the substrates to make 3 samples each instead of composition 1.
Then film samples 4 to 6 of composition 2, film samples 7 to 9 of composition 3, film samples 10 to 12 of composition 4, film samples 13-15 of composition 5 are obtained.

**Preparation example:** setting process conditions of CVD/ALD deposition for fabricating SiNx layer
To find good process conditions of CVD/ALD deposition, SiNx thin film layer is fabricated onto glass substrate. Below table shows different process conditions of CVD/ALD deposition.

**Working example 7 – fabrication of (B) inorganic layer**
Onto the thin film samples 1, 4, 7,10 and 13, 700 nm of silicon nitride (SiNx) is deposited by CVD. Then, 25 nm SiNx is deposited by ALD onto the film samples 2, 5, 8, 11 and 14; finally 73nm SiNx is deposited by ALD onto the thin film samples 3, 6, 9, 12 and 15.
Following table shows the process conditions of CVD and ALD deposition.

| | PE-CVD | PE-ALD |
|---|---|---|
| Process Temperature | 85°C | 85°C |
| Chamber pressure | 0.7 torr | 1.0 torr |
| RF Power | 25 Watt | 150 Watt |
| Process time/cycle (related depositioni rate) | around 5 min | around 9.5 hour |

Then, resulting stack samples 1 to 15 are obtained.

**Working example 8 - Haze measurement**

After silicon nitride deposition, the haze value of the resulting stack samples 1 to 15 (quartz glass / 73nm SiNx / cured polymer / SiNx) is determined according to ASTM D1003-21. The measurement is performed using the BYK Gardner Haze-Gard plus 4725 haze meter. The measurements are done at room temperature in air atmosphere.

**HM (Martens Hardness) and Young‘s module value measurements**

The obtained stacked layers on the Quartz substrates are further analyzed by nanoindentation to determine material properties such as HM (Martens Hardness) and Young‘s module value. An indenter is pressed into the test object with a defined force curve, the penetration depth is recorded. From the registered indentation depth, force applied and the shape of the indenter, various parameters can be calculated. The measurements are performed with a Fischerscope HM2000S (Loading Force = 1 mN, Loading Time = 8 sec, Creep = 20 sec) and the instrument software is used to calculate HM and Young’s module values.

Table 2 shows the results of the measurements.

Table 2:

| Sample No. of the compositons | Postbake | Thickness | Hardness | Modulus | Haze value | | |
|---|---|---|---|---|---|---|---|
| | | µm | N/mm² | MPa | CVD(7000A) | ALD(250A) | ALD(730A) |
| 5 | - | 7.5 | 28.32 | 1219 | 45.61 | 6.46 | - |
| 5 | 30 min. / 40°C | - | - | - | 46.29 | 7.12 | - |
| 1 | - | 7.7 | 87.79 | 3167 | 0.47 | 0.7 | 1.37 |
| 2 | - | 6.4 | 89.7 | 3299 | 18.37 | 1.44 | 11.07 |
| 4 | - | 8 | 88.92 | 3089 | 7.8 | 0.93 | 4.3 |

Although the invention has been illustrated by certain of the preceding examples, it is not to be construed as being limited thereby; but rather, the invention encompasses the generic area as hereinbefore disclosed. Various modifications and embodiments can be made without departing from the spirit and scope thereof.

## Patent Claims

1. A stacked layer, comprising at least;

(C) an organic layer, and

(D) an inorganic layer placed over the organic layer,

wherein the haze value of the stacked layer is less than 5.

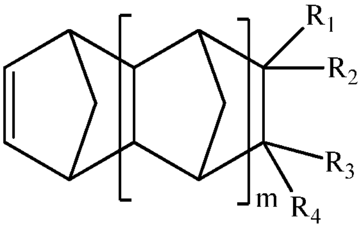
2. A stacked layer comprising at least;

(C) an organic layer, and

(D) an inorganic layer placed over the organic layer,

wherein said organic layer is obtained from a composition comprising at least:

a) a chemical compound of formula (I):



(I)

wherein:

m is an integer 0, 1 or 2;

$R_1$, $R_2$, $R_3$ and $R_4$ are the same or different and each independently selected from the group consisting of hydrogen, halogen, methyl, ethyl, linear or branched $(C_3\text{-}C_{16})$alkyl, perfluoro$(C_1\text{-}C_{12})$alkyl, hydroxy$(C_1\text{-}C_{16})$alkyl, $(C_3\text{-}C_{12})$cycloalkyl, $(C_6\text{-}C_{12})$bicycloalkyl, $(C_7\text{-}C_{14})$tricycloalkyl, $(C_6\text{-}C_{10})$aryl, $(C_6\text{-}C_{10})$aryl$(C_1\text{-}C_6)$alkyl, perfluoro$(C_6\text{-}C_{10})$aryl, perfluoro$(C_6\text{-}C_{10})$aryl$(C_1\text{-}C_6)$alkyl, tri$(C_1\text{-}C_6)$alkoxysilyl and a group of formula (A):

$$-Z^1\text{-Aryl} \quad (A)$$

wherein:

$Z^1$ is a connecting bond or a group selected from the group consisting of: $(CR_5R_6)_a$, $O(CR_5R_6)_a$, $(CR_5R_6)_aO$, $(CR_5R_6)_a\text{-}O\text{-}(CR_5R_6)_b$, $(CR_5R_6)_a\text{-}O\text{-}(SiR_5R_6)_b$, $(CR_5R_6)_a\text{-}(CO)O\text{-}(CR_5R_6)_b$,

$(CR_5R_6)_a$-O(CO)-$(CR_5R_6)_b$, $(CR_5R_6)_a$-(CO)-$(CR_5R_6)_b$, where a and b are integers which may be the same or different and each independently is 1 to 12;

$R_5$ and $R_6$ are the same or different and each independently selected from the group consisting of hydrogen, methyl, ethyl, linear or branched ($C_3$-$C_6$)alkyl, hydroxy, methoxy, ethoxy, linear or branched ($C_3$-$C_6$)alkyloxy, acetoxy, ($C_2$-$C_6$)acyl, hydroxymethyl, hydroxyethyl, linear or branched hydroxy($C_3$-$C_6$)alkyl, phenyl and phenoxy;

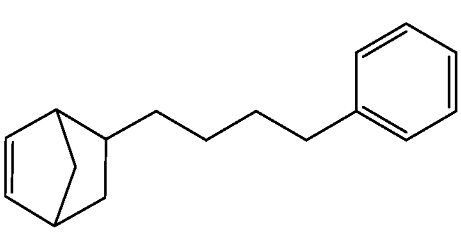
Aryl is phenyl or phenyl substituted with one or more of groups selected from the group consisting of methyl, ethyl, linear or branched ($C_3$-$C_6$)alkyl, hydroxy, methoxy, ethoxy, linear or branched ($C_3$-$C_6$)alkyloxy, acetoxy, ($C_2$-$C_6$)acyl, hydroxymethyl, hydroxyethyl, linear or branched hydroxy($C_3$-$C_6$)alkyl, phenyl and phenoxy;

wherein at least one of $R_1$, $R_2$, $R_3$ and $R_4$ is not hydrogen when m is 0, wherein at least two of $R_1$, $R_2$, $R_3$ and $R_4$ may form a ring;

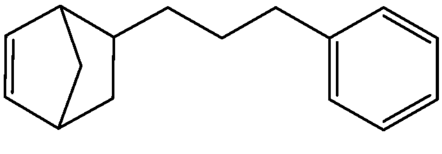
b) an organo-transition metal catalyst comprising a metal selected from ruthenium or osmium;

c) a photoactive compound capable of releasing a Bronsted acid when it is subjected to photolytic condition.

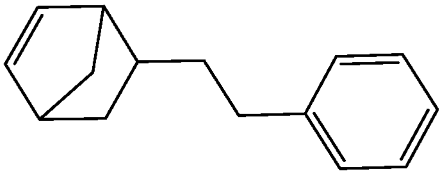
3. The layer of claim 2, wherein the monomer of formula (I) of the composition is selected from the group consisting of:



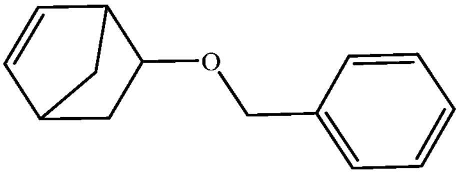
5-(4-phenylbutyl)bicyclo[2.2.1]hept-2-ene;



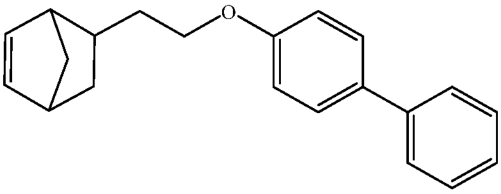
5-(3-phenylpropyl)bicyclo[2.2.1]hept-2-ene;



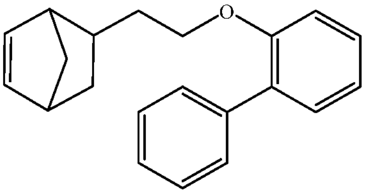
5-phenethylbicyclo[2.2.1]hept-2-ene (PENB);



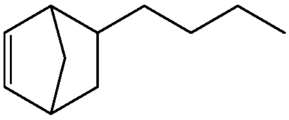
5-(benzyloxy)bicyclo[2.2.1]hept-2-ene;



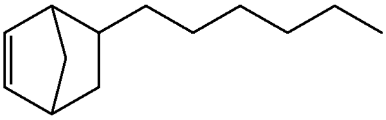
5-(2-([1,1'-biphenyl]-4-yloxy)ethyl)bicyclo[2.2.1]hept-2-ene;



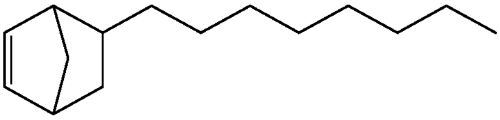
5-(2-([1,1'-biphenyl]-2-yloxy)ethyl)bicyclo[2.2.1]hept-2-ene (NBEtO-2-PhPh);



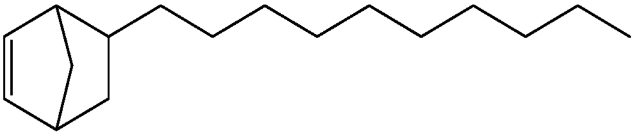
5-butylbicyclo[2.2.1]hept-2-ene (BuNB);



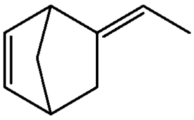
5-hexylbicyclo[2.2.1]hept-2-ene (HexylNB);



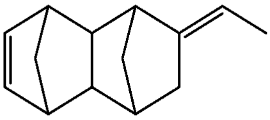
5-octylbicyclo[2.2.1]hept-2-ene (OctNB);



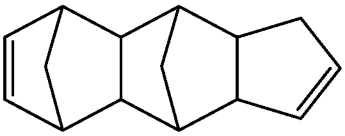
5-decylbicyclo[2.2.1]hept-2-ene (DecNB);



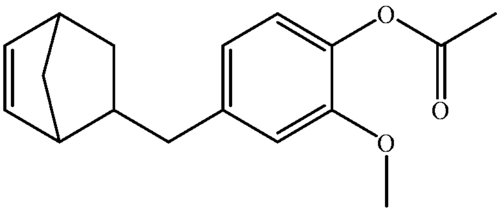
5-ethylidenebicyclo[2.2.1]hept-2-ene;



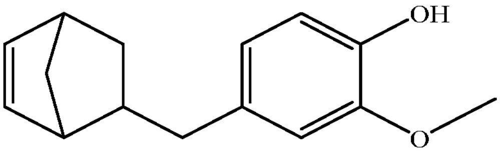
2-ethylidene-1,2,3,4,4a,5,8,8a-octahydro-1,4:5,8-dimethanonaphthalene;



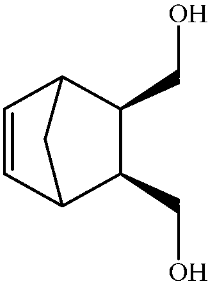
3a,4,4a,5,8,8a,9,9a-octahydro-1H-4,9:5,8-dimethanocyclopenta[b]naphthalene (one of trimers of cyclopentadiene, TCPD1, also known as CPD3);



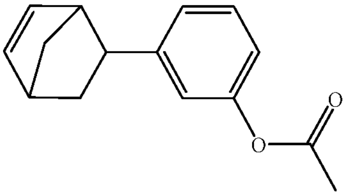
5-norbornenylmethyleugenyl acetate (EuAcNB);



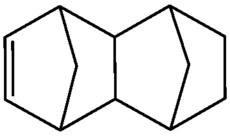
5-norbornenylmethyleugenol (EuOHNB);



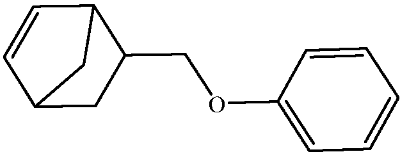
NB(MeOH)2;



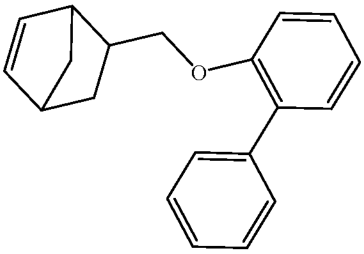
PhAcNB;



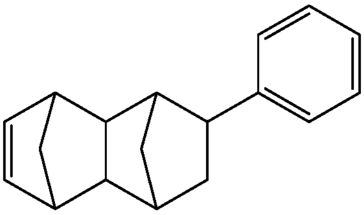
tetracyclododecene (TD);



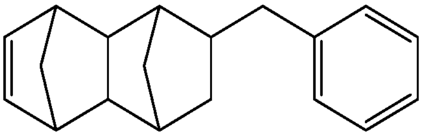
5-(phenoxymethyl)bicyclo[2.2.1]hept-2-ene (NBMeOPh);



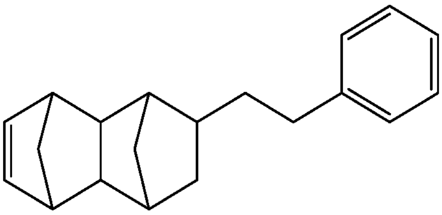
5-(([1,1'-biphenyl]-2-yloxy)methyl)bicyclo[2.2.1]hept-2-ene (NBMeOPhPh);



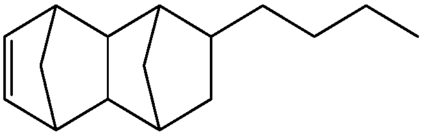
2-phenyl-tetracyclododecene (PhTD);



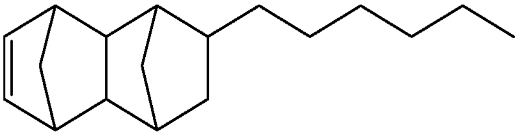
2-benzyl-1,2,3,4,4a,5,8,8a-octahydro-1,4:5,8-dimethanonaphthalene;



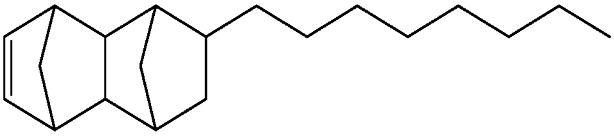
2-phenethyl-1,2,3,4,4a,5,8,8a-octahydro-1,4:5,8-dimethanonaphthalene (PETD);



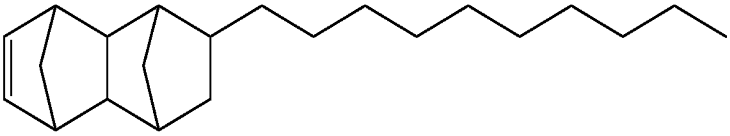
2-butyl-1,2,3,4,4a,5,8,8a-octahydro-1,4:5,8-dimethanonaphthalene (ButylTD);



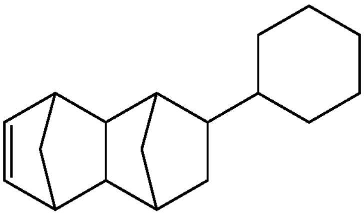
2-hexyl-1,2,3,4,4a,5,8,8a-octahydro-1,4:5,8-dimethanonaphthalene (HexylTD);



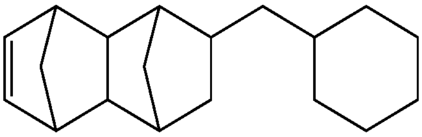
2-octyl-1,2,3,4,4a,5,8,8a-octahydro-1,4:5,8-dimethanonaphthalene (OctylTD);



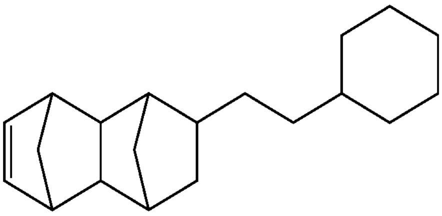
2-decyl-1,2,3,4,4a,5,8,8a-octahydro-1,4:5,8-dimethanonaphthalene (DecylTD);



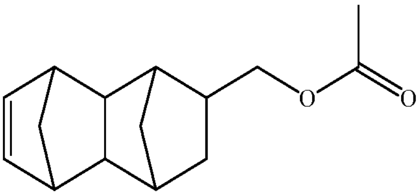
2-cyclohexyl-tetracyclododecene (CyclohexylTD);



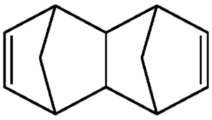
2-cyclohexylmethyl-1,2,3,4,4a,5,8,8a-octahydro-1,4:5,8-dimethanonaphthalene;



2- cyclohexylethyl-1,2,3,4,4a,5,8,8a-octahydro-1,4:5,8-dimethanonaphthalene;

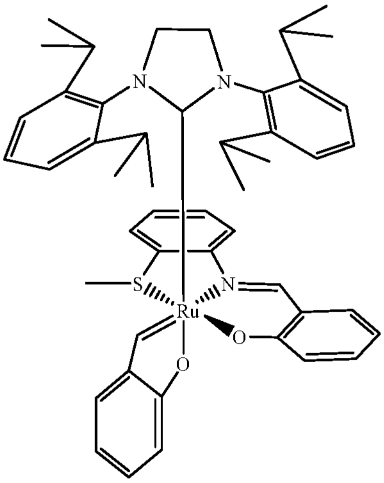


(1,2,3,4,4a,5,8,8a-octahydro-1,4:5,8-dimethanonaphthalen-2-yl)methyl acetate (TDMeOAc); and

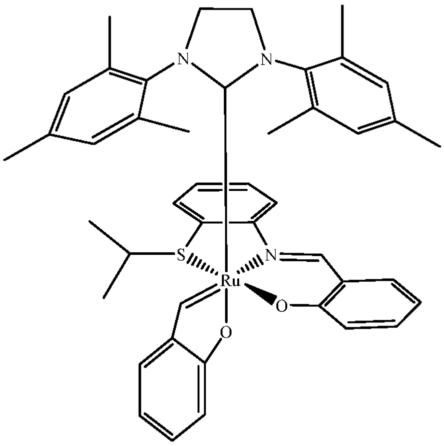


tetracyclododecadiene (TDD).

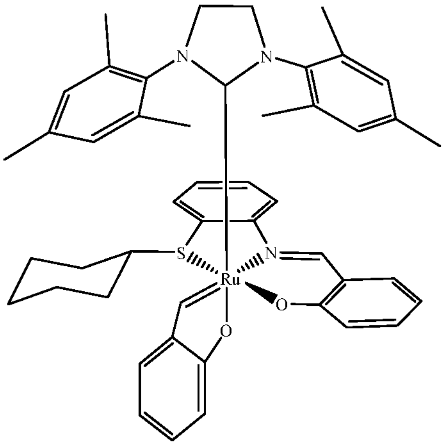
4. The layer of any one of claim 2 or 3, wherein the organo-ruthenium compound is represented by formula (II) selected from the group consisting of:



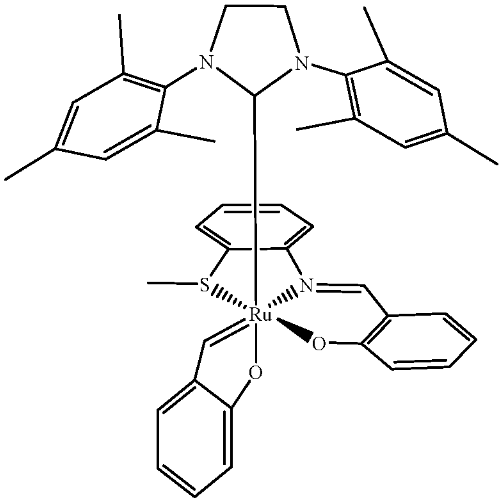
[1,3-Bis(2,6-diisopropylphenyl)-2-imidazolidinylidene]{2-[(E)-({2-[methylthio-κS]phenyl}imino-κN)methyl]phenoxido-κO}[2-(oxido-κO)benzylidene-κC]ruthenium(II) (Ru-1);



[1,3-Bis(2,4,6-trimethylphenyl)-2-imidazolidinylidene]{2-[(E)-({2-[isopropylthio-κS]phenyl}imino-κN)methyl]phenoxido-κO}[2-(oxido-κO)benzylidene-κC]ruthenium(II);



[1,3-Bis(2,4,6-trimethylphenyl)-2-imidazolidinylidene]{2-[(E)-({2-[cyclohexylthio-κS]phenyl}imino-κN)methyl]phenoxido-κO}[2-(oxido-κO)benzylidene-κC]ruthenium(II); and



[1,3-Bis(2,4,6-trimethylphenyl)-2-imidazolidinylidene]{2-[(E)-({2-[methylthio-κS]phenyl}imino-κN)methyl]phenoxido-κO}[2-(oxido-κO)benzylidene-κC]ruthenium(II).

5.The layer of any one of claims 2 to 4, wherein said composition further comprises a UV light blocker and/or a crosslinker.

6. The layer of any one of claims 1 to 5, wherein said composition further comprises an additive of formula (I) with the proviso that said additive is different from a) the chemical compound of formula (I).

7. The layer of any one of preceding claims, wherein said composition comprises a solvent 10wt% or less based on the total amount of the composition.

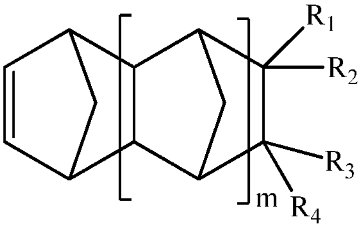
8. Use of a composition for fabricating an organic layer of a stacked layer, wherein said stacked layer comprises at least;

(A) said organic layer, and

(B) an inorganic layer placed over the organic layer.

wherein said composition comprises at least:

a) a chemical compound of formula (I):



(I)

wherein:

m is an integer 0, 1 or 2;

$R_1$, $R_2$, $R_3$ and $R_4$ are the same or different and each independently selected from the group consisting of hydrogen, halogen, methyl, ethyl, linear or branched ($C_3$-$C_{16}$)alkyl, perfluoro($C_1$-$C_{12}$)alkyl, hydroxy($C_1$-$C_{16}$)alkyl, ($C_3$-$C_{12}$)cycloalkyl, ($C_6$-$C_{12}$)bicycloalkyl, ($C_7$-$C_{14}$)tricycloalkyl, ($C_6$-$C_{10}$)aryl, ($C_6$-$C_{10}$)aryl($C_1$-$C_6$)alkyl, perfluoro($C_6$-$C_{10}$)aryl, perfluoro($C_6$-$C_{10}$)aryl($C_1$-$C_6$)alkyl, tri($C_1$-$C_6$)alkoxysilyl and a group of formula (A):

$$-Z^1\text{-Aryl} \quad (A)$$

wherein:

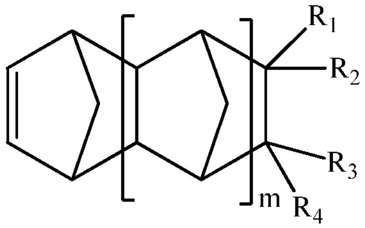
$Z^1$ is a connecting bond or a group selected from the group consisting of: $(CR_5R_6)_a$, $O(CR_5R_6)_a$, $(CR_5R_6)_aO$, $(CR_5R_6)_a$-O-$(CR_5R_6)_b$, $(CR_5R_6)_a$-O-$(SiR_5R_6)_b$, $(CR_5R_6)_a$-(CO)O-$(CR_5R_6)_b$, $(CR_5R_6)_a$-O(CO)-$(CR_5R_6)_b$, $(CR_5R_6)_a$-(CO)-$(CR_5R_6)_b$, where a and b are integers which may be the same or different and each independently is 1 to 12;

$R_5$ and $R_6$ are the same or different and each independently selected from the group consisting of hydrogen, methyl, ethyl, linear or branched ($C_3$-$C_6$)alkyl, hydroxy, methoxy, ethoxy, linear or branched ($C_3$-$C_6$)alkyloxy, acetoxy, ($C_2$-$C_6$)acyl, hydroxymethyl, hydroxyethyl, linear or branched hydroxy($C_3$-$C_6$)alkyl, phenyl and phenoxy;
Aryl is phenyl or phenyl substituted with one or more of groups selected from the group consisting of methyl, ethyl, linear or branched ($C_3$-$C_6$)alkyl, hydroxy, methoxy, ethoxy, linear or branched ($C_3$-$C_6$)alkyloxy, acetoxy, ($C_2$-$C_6$)acyl, hydroxymethyl, hydroxyethyl, linear or branched hydroxy($C_3$-$C_6$)alkyl, phenyl and phenoxy;
wherein at least one of $R_1$, $R_2$, $R_3$ and $R_4$ is not hydrogen when m is 0,
wherein at least two of $R_1$, $R_2$, $R_3$ and $R_4$ may form a ring;

b) an organo-transition metal catalyst comprising a metal selected from ruthenium or osmium;

c) a photoactive compound capable of releasing a Bronsted acid when it is subjected to photolytic condition.

9. A method for fabricating a stacked layer, comprising at least the following steps:
($X^{a1}$) providing a composition of onto a substrate, a layer, or an outermost surface of a device to obtain an organic layer,
($X^{a2}$) irradiating the coated layer with light (applying light irradiation) to form a cured film,
($X^{a3}$) fabricating an inorganic layer over the organic layer to form a stacked layer,
wherein said composition comprises at least :
a) a chemical compound of formula (I):



(I)

wherein:

m is an integer 0, 1 or 2;

$R_1$, $R_2$, $R_3$ and $R_4$ are the same or different and each independently selected from the group consisting of hydrogen, halogen, methyl, ethyl, linear or branched $(C_3\text{-}C_{16})$alkyl, perfluoro$(C_1\text{-}C_{12})$alkyl, hydroxy$(C_1\text{-}C_{16})$alkyl, $(C_3\text{-}C_{12})$cycloalkyl, $(C_6\text{-}C_{12})$bicycloalkyl, $(C_7\text{-}C_{14})$tricycloalkyl, $(C_6\text{-}C_{10})$aryl, $(C_6\text{-}C_{10})$aryl$(C_1\text{-}C_6)$alkyl, perfluoro$(C_6\text{-}C_{10})$aryl, perfluoro$(C_6\text{-}C_{10})$aryl$(C_1\text{-}C_6)$alkyl, tri$(C_1\text{-}C_6)$alkoxysilyl and a group of formula (A):

$$-Z^1\text{-Aryl}\quad (A)$$

wherein:

$Z^1$ is a connecting bond or a group selected from the group consisting of: $(CR_5R_6)_a$, $O(CR_5R_6)_a$, $(CR_5R_6)_aO$, $(CR_5R_6)_a\text{-O-}(CR_5R_6)_b$, $(CR_5R_6)_a\text{-O-}(SiR_5R_6)_b$, $(CR_5R_6)_a\text{-(CO)O-}(CR_5R_6)_b$, $(CR_5R_6)_a\text{-O(CO)-}(CR_5R_6)_b$, $(CR_5R_6)_a\text{-(CO)-}(CR_5R_6)_b$, where a and b are integers which may be the same or different and each independently is 1 to 12;

$R_5$ and $R_6$ are the same or different and each independently selected from the group consisting of hydrogen, methyl, ethyl, linear or branched $(C_3\text{-}C_6)$alkyl, hydroxy, methoxy, ethoxy, linear or branched $(C_3\text{-}C_6)$alkyloxy, acetoxy, $(C_2\text{-}C_6)$acyl, hydroxymethyl, hydroxyethyl, linear or branched hydroxy$(C_3\text{-}C_6)$alkyl, phenyl and phenoxy;

Aryl is phenyl or phenyl substituted with one or more of groups selected from the group consisting of methyl, ethyl, linear or branched $(C_3\text{-}C_6)$alkyl, hydroxy, methoxy, ethoxy, linear or branched $(C_3\text{-}C_6)$alkyloxy, acetoxy, $(C_2\text{-}C_6)$acyl, hydroxymethyl, hydroxyethyl, linear or branched hydroxy$(C_3\text{-}C_6)$alkyl, phenyl and phenoxy;

wherein at least one of $R_1$, $R_2$, $R_3$ and $R_4$ is not hydrogen when m is 0, wherein at least two of $R_1$, $R_2$, $R_3$ and $R_4$ may form a ring;

b) an organo-transition metal catalyst comprising a metal selected from ruthenium or osmium;

c) a photoactive compound capable of releasing a Bronsted acid when it is subjected to photolytic condition.

10. A method for fabricating a stacked layer comprising at least the following steps:
($X^{a1}$) providing a substrate having an organic layer,
($X^{a3'}$) fabricating an inorganic layer by Chemical Vapor Deposition (CVD) or Atomic Layer Deposition (ALD) over the organic layer, wherein the chamber pressure in step ($X^{a3}$) is in the range from 0.2 to 3 Torr; and the power of a radio frequency power supply (RF) used in step ($X^{a3}$) is in the range from 10 to 600W.

11. The layer of any one of claims 1 to 7, has the total layer thickness in the range from 0.01 to 100 μm.

12. The layer of any one of claims 1 to 7 and 11, wherein the layer thickness of said organic layer is in the range from 1 to 75μm; wherein the layer thickness of said inorganic layer is in the range from 0.01 to 10μm.

13. The layer of any one of claims 1 to 7, 11 and 12, has the permittivity value $\varepsilon<2.5$.

14. The layer of any one of claims 1 to 7 and 11 to 13, has the haze value 5 or less.

15. The layer of any one of claims 1 to 7 and 11 to 14, has Martens Hardness value in the range from 40 to 120 N/mm$^2$.

16. The layer of any one of claims 1 to 7 and 11 to 15, has Young's modulus value in the range from 2,000 to 5,000 Mpa.

17. A device comprising at least the staked layer of any one of claims 1 to 7 and 11 to 16.

# INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2024/069145

**A. CLASSIFICATION OF SUBJECT MATTER**
INV. H10K50/844 H10K59/80
ADD. H10K85/30

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)
H10K

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

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| X | US 10 707 442 B2 (ZEON CORP [JP]) 7 July 2020 (2020-07-07)<br>column 25, line 50 - line 51; claims 1-10<br>column 30, line 10 - line 55; example 2 | 1,11, 13-17 |
| X | US 2017/288170 A1 (ITO YUTAKA [JP]) 5 October 2017 (2017-10-05)<br>page 22, paragraph 213 - page 23, paragraph 216; example 1<br>page 15, paragraph 150 | 1,10,11, 13-17 |
| X | US 2016/343986 A1 (INOUE HIROYASU [JP] ET AL) 24 November 2016 (2016-11-24)<br>page 18, paragraph 223 - paragraph 224; example 2<br>page 16, paragraph 177 | 1,11-17 |

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"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<br>7 October 2024 | Date of mailing of the international search report<br>10/12/2024 |
| Name and mailing address of the ISA/<br>European Patent Office, P.B. 5818 Patentlaan 2<br>NL - 2280 HV Rijswijk<br>Tel. (+31-70) 340-2040,<br>Fax: (+31-70) 340-3016 | Authorized officer<br>Parashkov, Radoslav |

## INTERNATIONAL SEARCH REPORT

International application No.
PCT/EP2024/069145

**Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)**

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

**Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)**

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims;; it is covered by claims Nos.:
1(completely); 10-17(partially)

**Remark on Protest**

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

**FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210**

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1(completely); 10-17(partially)

   a stacked layer, comprising at least;(C) an organic layer, and (D)an inorganic layer placed over the organic layer,wherein the haze value of the stacked layer is less than 5;

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2. claims: 2-9(completely); 10-17(partially)

   a stacked layer comprising at least;(C) an organic layer, and (D)an inorganic layer placed over the organic layer,wherein said organic layer is obtained from a composition comprising at least: a) a chemical compound of formula (I) of the present claim 1; b) an organo-transition metal catalyst comprising a metal selected from ruthenium or osmium; c) a photoactive compound capable of releasing a Bronsted acid when it is subjected to photolytic condition;

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## INTERNATIONAL SEARCH REPORT

**Information on patent family members**

International application No
PCT/EP2024/069145

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