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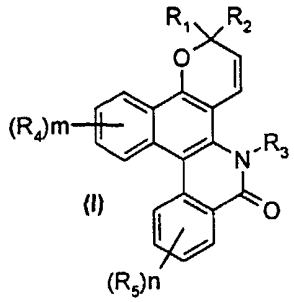
(54) Title: NAPHTHOPYRANS ANNELATED IN C_5-C_6 WITH A LACTAM-TYPE C_6 RING AND COMPOSITIONS AND (CO)POLYMER CONTAINING THEM



(I)

(57) Abstract: The invention relates to novel naphthopyran-type compounds having a lactam-type 6-membered ring annelated in position C_5-C_6. These compounds have formula (I). These compounds (I) have interesting photochromic properties. The invention also relates to their preparation, to their applications as photochromes, as well as to the compositions and (co)polymer matrices containing them.

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Naphthopyrans annelated in C_5-C_6 with a lactam-type C_6 ring and compositions and (co)polymer containing them

The present invention relates to novel naphthopyran-type compounds which are annelated in C_5-C_6 and which have, in particular, photochromic properties. The invention also relates to photochromic compositions and photochromic ophthalmic articles (lenses for example) which contain said naphthopyrans. The invention also covers the preparation of these novel compounds.

The photochromic compounds are capable of changing colour under the influence of a poly- or mono-chromatic light (UV for example) and of returning to their initial colour when the luminous irradiation ceases, or under the influence of temperature and/or a poly- or mono-chromatic light different from the first.

The photochromic compounds find applications in various fields, *e.g.* for the manufacture of ophthalmic lenses, contact lenses, solar protection glasses, filters, camera optics or photographic apparatus optics or other optical devices and observation devices, glazing, decorative objects, bill elements or even for information storage by optical inscription (coding).

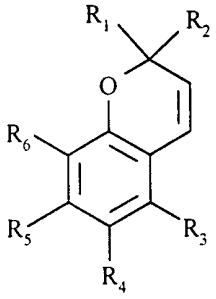
In the field of ophthalmic optics, and in particular the spectacles trade, a photochromic lens which comprises one or more photochromic compounds must have :

- a high transmission in the absence of ultraviolets,
- a low transmission (high colourability) under solar irradiation,
- adapted coloration and discoloration kinetics,
- a tint acceptable to the consumer (grey or brown preferably) with preferably a maintenance of the chosen tint during the coloration and the discoloration of the lens,
- a maintenance of the performances, the properties, within a temperature range of 0-40°C,
- a significant durability, since these objectives sought after are sophisticated corrective lenses and therefore expensive.

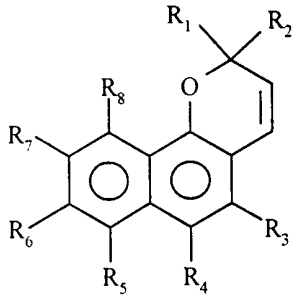
These lens characteristics are in fact determined by the active photochromic compounds which they contain; compounds which must furthermore be perfectly compatible with the organic or inorganic support which constitutes the lens.

Moreover, it is to be noted that obtaining a grey or brown tint may necessitate the use of at least two photochromes of different colours, *i.e.* having distinct maximal absorption wavelengths in the visible. This combination further imposes other requirements of the photochromic compounds. In particular, the coloration and discoloration kinetics of the (two or more) combined active photochromic compounds must be essentially identical. The same applies for their stability with time and also for their compatibility with a plastic or inorganic support.

Amongst the numerous photochromic compounds described in the prior art, benzopyrans and naphthopyrans may be cited which are described in patents or patent applications US-A-3,567,605, US-A-3,627,690, US-A-4,826,977, US-A-5,200,116, US-A-5,238,981, US-A-5,411,679, US-A-5,429,744, US-A-5,451,344, US-A-5,458,814, US-A-5,651,923, US-A-5,645,767, US-A-5,698,141, US-A-5,783,116, WO-A-95 05382, FR-A-2,718,447, WO-A-96 14596, and WO-A-97 21698, which are of the reduced formulae below :

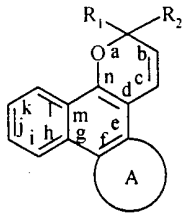


Benzopyrans



Naphthopyrans

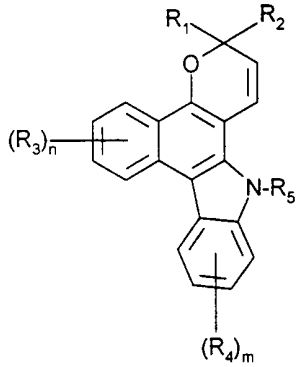
The US patent US-A-5,651,923 notably claims the general structure below :



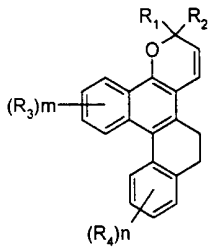
US-A- 5,651,923

in which ring A, which is annelated with side *f*, is a heterocycle.

The French patent application FR-A-2,770,524 of the Applicant claims the following structure :



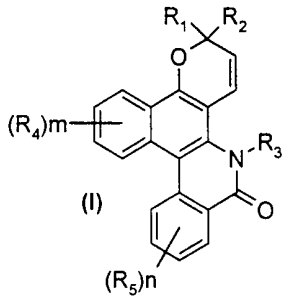
Further, the French patent application FR-A-2 783 249 notably claims the following annelated structure :



These compounds claim to satisfy the specifications defined above. In reality, if these compounds really do have one or more of the basic properties sought after, such as a high transmission in the absence of ultraviolets and a high colourability under solar irradiation, none of the compounds described hitherto have the complete combination of the properties sought after which are necessary for the production of satisfactory articles. In particular, none of these compounds is intrinsically grey or brown and the necessity of using an additional photochrome in order to obtain one of these two tints does subsist.

In this context, it is to the credit of the inventors for having been interested in this type of derivative as a base for developing novel photochromes, and for having proposed a novel family of molecules which have particularly advantageous photochromic properties.

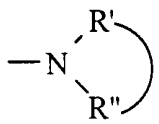
Thus, according to a first of its aspects, the present invention relates to compounds of formula (**I**) :



in which :

- R_1 and R_2, which are identical or different, independently represent :
  - hydrogen,
  - a linear or branched alkyl group comprising 1 to 12 carbon atoms,
  - a cycloalkyl group comprising 3 to 12 carbon atoms,
  - an aryl or heteroaryl group comprising in its basic structure 6 to 24 carbon atoms or 4 to 24 carbon atoms respectively and at least one heteroatom selected from sulphur, oxygen and nitrogen ; said basic structure being optionally substituted with at least one substituent selected from the whole of the substituents given below :
    + a halogen, and notably fluorine, chlorine and bromine,
    + a hydroxy,
    + a linear or branched alkyl group comprising 1 to 12 carbon atoms,
    + a linear or branched alkoxy group comprising 1 to 12 carbon atoms,
    + a haloalkyl or haloalkoxy group corresponding to the (C_1-C_{12}) alkyl or alkoxy groups above respectively which are substituted with at least one halogen atom, and notably a fluoroalkyl group of this type,
    + a linear or branched alkenyl group comprising 2 to 12 carbon atoms, and notably a vinyl group or an allyl group,
    + an -NH_2 group,
    + an -NHR group, R representing a linear or branched alkyl group comprising 1 to 6 carbon atoms,

+ a



group, R' and R", which are identical or different, representing independently a linear or branched alkyl group comprising 1 to 6 carbon atoms or representing together with the nitrogen atom to which they are bound a 5- to 7-membered ring which can comprise at least one other heteroatom selected from oxygen, sulphur and nitrogen, said nitrogen being optionally substituted with an R"' group, which is a linear or branched alkyl group comprising 1 to 6 carbon atoms,

+ a methacryloyl group or an acryloyl group,

- an aralkyl or heteroaralkyl group, the alkyl group, which is linear or branched, comprising 1 to 4 carbon atoms and the aryl part of which has the same definition as that given *supra* for the aryl and heteroaryl group ;

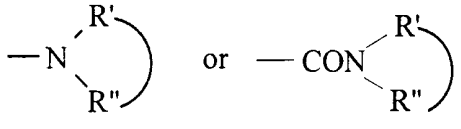
or

said two substituents R_1 and R_2 together form an adamantyl, norbornyl, fluorenylidene, di(C_1-C_6)alkylanthracenylidene or spiro(C_5-C_6)cycloalkylanthracenylidene group ; said group being optionally substituted with at least one of the substituents listed above for R_1 , R_2 : an aryl or heteroaryl group ;

- R_3 represents :
  - a hydrogen,
  - a linear or branched alkyl group comprising 1 to 12 carbon atoms (advantageously 1 to 6 carbon atoms),
  - a cycloalkyl group comprising 3 to 12 carbon atoms,
  - a haloalkyl or halocycloalkyl group corresponding to the alkyl and cycloalkyl groups above respectively, which are substituted with at least one halogen atom, notably selected from fluorine, chlorine and bromine,

- an aralkyl or heteroaralkyl group, the alkyl group, which is linear or branched, comprising 1 to 4 carbon atoms, and the aryl and heteroaryl groups having the same definitions as those given *supra* for R_1 , R_2,
- a $-COR_6$, $-COOR_6$ or $-CONHR_6$ group, R_6 representing a straight or branched alkyl group comprising 1 to 6 carbon atoms, or a cycloalkyl group comprising 3 to 6 carbon atoms, or a linear or branched alkenyl group comprising 2 to 12 carbon atoms, and notably an allyl group or a phenyl or benzyl group, optionally substituted with at least one of the substituents listed above for the values of R_1 , R_2 : aryl or heteroaryl ;

- R_4 and R_5 , which are identical or different, represent, independently :
  - a halogen, and notably fluorine, chlorine or bromine,
  - a linear or branched alkyl group comprising 1 to 12 carbon atoms (advantageously 1 to 6 carbon atoms),
  - a cycloalkyl group comprising 3 to 12 carbon atoms,
  - a linear or branched alkoxy group comprising 1 to 12 carbon atoms (advantageously 1 to 6 carbon atoms),
  - a haloalkyl, halocycloalkyl, or haloalkoxy group corresponding to the alkyl, cycloalkyl, alkoxy groups above respectively, which are substituted with at least one halogen atom, notably selected from fluorine, chlorine and bromine,
  - an aryl or heteroaryl group having the same definition as that given *supra* for R_1 , R_2 ,
  - an aralkyl or heteroaralkyl group, the alkyl group, which is linear or branched, comprising 1 to 4 carbon atoms, and the aryl and heteroaryl groups having the same definitions as those given *supra* for R_1 , R_2,
  - an amine or amide group : $-NH_2$, $-NHR$, $-CONH_2$, $-CONHR$,



;

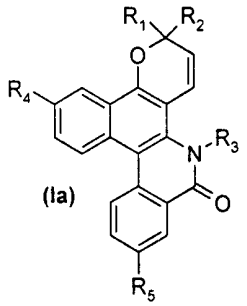
R, R', R" having their respective definitions given *supra* for the amine substituents of the values R_1 , R_2 : aryl or heteroaryl,

- an -$OCOR_7$ or -$COOR_7$ group, R_7 representing a straight or branched alkyl group comprising 1 to 6 carbon atoms, or a cycloalkyl group comprising 3 to 6 carbon atoms, or a phenyl group, optionally substituted with at least one of the substituents listed above for the values of R_1 , R_2 : aryl or heteroaryl ; and
- m and n are integers of 0 to 4.

The person skilled in the art will obviously have understood that the branched alkyl, alkoxy and alkenyl groups, as defined above, comprise a sufficient number of carbon in order to be branched (*i.e.* more than 3, more than 3, and more than 4 carbon atoms respectively).

The compounds of the invention - annelated naphthopyrans of formula **(I)** - have very fast discoloration kinetics.

Amongst said compounds of the invention, preferred are those which have the formula (**Ia**) :



(Ia)

in which :

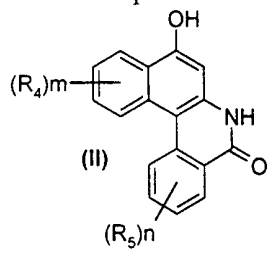
R_1 , R_2 are identical or different and represent independently optionally substituted aryl or heteroaryl groups the basic structure of which is selected from the group comprising phenyl, naphthyl, biphenyl, pyridyl, furyl, benzofuryl, dibenzofuryl, N-(C_1-C_6)alkylcarbazole, thienyl, benzothienyl, dibenzothienyl and julolidinyl groups ; R_1 and/or R_2 representing, advantageously, a para-substituted phenyl group ;

R_3 represents a hydrogen or a linear or branched alkyl group comprising 1 to 6 carbon atoms ;

R_4 and R_5, which are identical or different, independently represent a hydrogen, a linear or branched alkoxy group which comprises 1 to 6 carbon atoms, a halogen, a linear or branched alkyl group comprising 1 to 6 carbon atoms, a morpholino group or a diaalkylamino group –NR'R'' in which R' and R'' independently represent a linear or branched alkyl group comprising 1 to 6 carbon atoms .

According to a second of its aspects, the present invention relates to a method of preparation of the compounds **(I)**, characterised in that it consists essentially in carrying out a condensation :

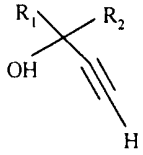
- of an intermediate compound of formula **(II)** given below :



(II)

in which R_4 , R_5 , m and n are as defined above with reference to formula **(I)**,

- with a derivative of propargylic alcohol, having formula **(III)** below :



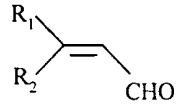
(III)

in which R_1 and R_2 are as defined *supra* with reference to formula **(I)** ;

the condensation **(II)/(III)** being carried out advantageously in the presence of a catalyst, this catalyst being preferably selected from the group comprising para-toluenesulphonic acid, dodecylsulphonic acid or bromoacetic acid ;

or

- with an aldehyde derivative, having formula **(III')** below :



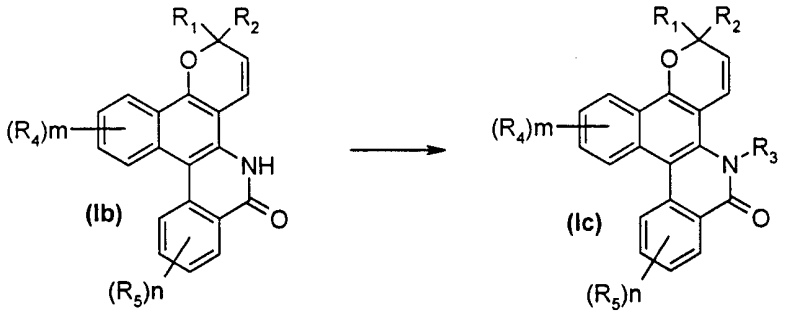
(III')

in which R_1 and R_2 are as defined *supra* with reference to formula **(I)** ;

the condensation **(II)/(III')** being carried out, advantageously, in the presence of a metallic complex, preferably a complex of titanium, titanium (IV) ethoxide being particularly preferred.

In practice, the condensation reaction between compounds **(II)** and **(III')** can take place in solvents such as toluene, xylene or tetrahydrofuran, to which appropriate catalysts are optionally added. For more details on the condensation of compounds **(II)**, **(III')**, reference may be made to the EP-A-0 562 915 patent application.

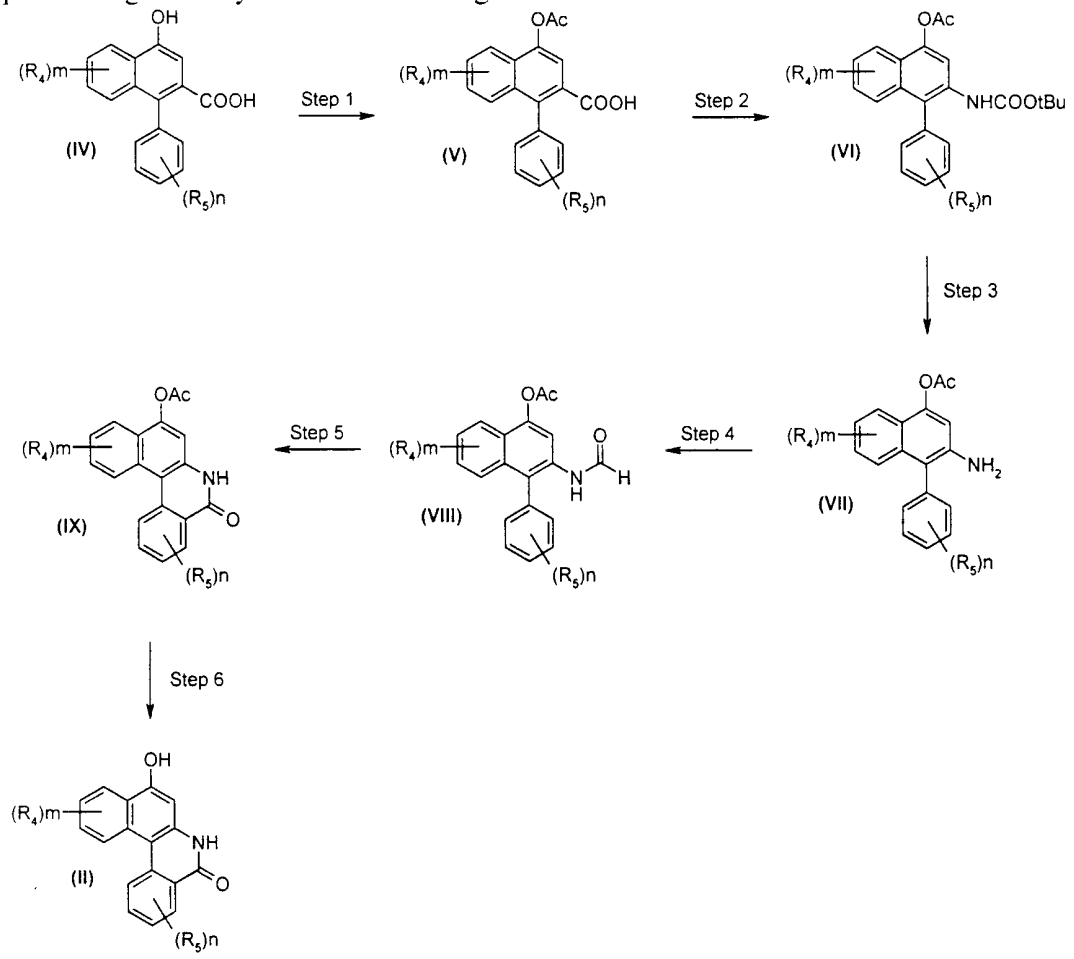
The compounds of the invention, which are obtained by this condensation, and which have the formula (I_b) below (formula (I) in which R_3 = H) are then, optionally, for the preparation of compounds of formula (I) in which $R_3 \neq H$ (formula (I_c) below), after deprotonation in the presence of sodium hydride, allowed to react with a suitable electrophilic compound of formula R_3X, in which X is a leaving group ; this can be schematised by the reaction below :



The compounds of formula **(III)** are known to the person skilled in the art and are obtained from the corresponding ketone according to a method described notably in the WO-A-96 14596 patent application. The ketone is itself commercial or is prepared according to the known methods such as the Friedel Crafts method (*cf.* WO-A-96 14596 and cited references).

Aldehydes **(III')**, which are derivatives of **(III)**, are obtained by rearrangement in an acid medium (*cf. J. Org. Chem.*, 1977, *42*, 3403).

The compounds of formula **(II)** are obtained according to a synthetic scheme the various steps of which are adaptations of known methods. The preferred general synthesis scheme is given below :

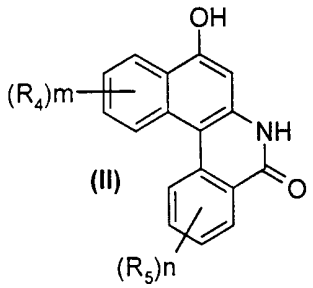


Compounds **(IV)** are known to the person skilled in the art and are easily obtainable, from the corresponding benzophenones, according to a synthesis route described in the application WO-A-96 14596. They lead to the acids **(V)** which undergo, in a manner known *per se*, a Curtius rearrangement to generate the amines of formula **(VI)**. This rearrangement is generally carried out in refluxing toluene in the presence of diphenylphosphorazide (DPPA), triethylamine (NEt_3) and *tert*-butanol (tBuOH).

The protected amine function of compound **(VI)** is deprotected to lead to compound **(VII)**, generally with trifluoroacetic acid in dichloromethane. After formylation (by the action of formic acid) of the amine **(VII)** to give compound

(VIII), the latter is cyclised to give **(IX)** in refluxing chlorobenzene in the presence of tert-butyl peroxide. Finally, a saponification leads to the desired compound **(II)**.

According to a third of its aspects, the invention also relates to the novel intermediate products of formula **(II)**, recalled below :



in which R_4 , R_5 , m and n are as defined *supra* with reference to formula **(I)**.

According to a fourth of its aspects, the object of the invention is (co)polymer(s) and/or reticulate(s) obtained by polymerising and/or cross-linking and/or grafting at least one monomer consisting of a compound **(I)** as defined above. Thus, the compounds **(I)** according to the invention can be *per se* (co)monomers and/or be comprised in (co)polymerisable and/or cross-linkable (co)monomers. The (co)polymers and/or reticulates thus obtained can constitute photochromic matrices such as those presented *infra*.

According to a fifth of its aspects, the present invention relates to the use of said compounds of formula **(I)** of the invention as photochromic agents. Another object of the invention is, therefore :

- firstly, novel photochromic compounds which are constituted by the C_5-C_6-annelated naphthopyran derivatives such as defined above, taken alone or in a mixture of themselves and/or with at least one other photochromic compound of another type and/or with at least one non-photochromic colouring agent ;
- secondly, novel photochromic compositions which comprise at least one compound **(I)** as defined above, and/or at least one linear or cross-linked (co)polymer containing at least one compound **(I)** according to the invention in its structure. Such photochromic compositions can contain at least one other photochromic compound, of another type and/or at least one non-photochromic colouring agent and/or at least one stabilising agent. These photochromic compounds of another type, non-

photochromic colouring agents, and stabilising agents are prior art products known to the person skilled in the art.

Within the context of the present invention, combinations of photochromic compounds of the invention and/or combinations of photochromic compounds of the invention and photochromic compounds of another type according to the prior art are particularly recommended ; such combinations being interesting in that they are suitable for generating grey or brown tints, which are desired by the public in applications such as ophthalmic spectacles or solar spectacles. These additional photochromic compounds can be those known to the person skilled in the art and described in the literature, *e.g.* chromenes (US-A-3,567,605, US-A-5,238,981, WO-A-94 22850, EP-A-0 562 915), spiropyrans or naphthospiropyrans (US-A-5,238,981) and spiroxazines (Crano *et al.*, "Applied Photochromic Polymer Systems", Ed. Blackie & Son Ltd, 1992, chapter 2).

Said compositions according to the invention can also comprise :

- non-photochromic colouring agents which enable adjusting the tint,
- and/or one or more stabilising agents, such as an anti-oxidising agent for example,
- and/or one or more anti-UV,
- and/or one or more anti-radicals,
- and/or one or more photochimic excited state deactivators.

These additives can notably enable improving the durability of said compositions.

The compounds of the invention envisaged within the context of their photochromic applications can be used in solution. Thus, a photochromic solution can be obtained by dissolving at least one of said compounds in an organic solvent such as toluene, dichloromethane, tetrahydrofuran or ethanol. The solutions obtained are in general colourless and transparent. When exposed to sunlight, they develop a strong coloration and regain the colourless state when they are placed in an area of less exposure to the sun's rays or, in other words, when they are no longer submitted to UV. In general, a very low concentration of product (of the order of 0.01 to 5% by weight) is sufficient to obtain an intense coloration.

The compounds according to the invention are furthermore compatible with support matrices of organic polymer or of inorganic material (even of an inorganic-organic hybrid material), in a form included in said matrices as well as in the form of a coating of said matrices.

Also, within the context of the fifth aspect of the invention in relation to the photochromic applications, the object of the invention is a matrix which comprises :

- at least one compound **(I)**, as defined *supra* ;
- and/or at least one (co)polymer and/or reticulate, as defined *supra* ;
- and/or at least one composition, as presented above.

The most interesting applications of the compounds of the invention are in fact those in which the photochrome is dispersed uniformly within or on the surface of a matrix formed by a polymer and/or copolymer and/or mixture of (co)polymers.

Following the example of their behaviour in solution, the compounds **(I)**, included in a polymer matrix are colourless or slightly coloured in the initial state and rapidly develop an intense coloration under a UV light (365 nm) or under a light source of the solar type. Finally, they regain their initial coloration once the irradiation ceases.

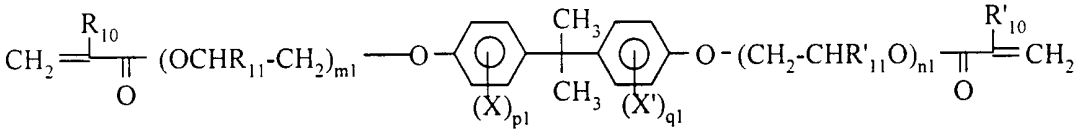
The methods of implementation which can be envisaged in order to obtain such a matrix are very varied. Amongst those known to the person skilled in the art, the diffusion in the (co)polymer, from a suspension or solution of the photochrome, in a silicone oil, in an aliphatic or aromatic hydrocarbon, or in a glycol, or from another polymer matrix, can be cited for example. The diffusion is commonly carried out at a temperature of 50 to 200°C for a period of time of 15 minutes to several hours, according to the nature of the polymer matrix. Another implementation technique consists in mixing the photochrome in a formulation of polymerisable materials, depositing this mixture on a surface or in a mould, and then carrying out the copolymerisation. These implementation techniques , and others, are described in the article by Crano *et al.* "Spiroxazines and their use in photochromic lenses" published in Applied Photochromic Polymer Systems, Ed. Blackie and Son Ltd - 1992.

The following products may be mentioned as examples of preferred polymer materials for forming matrices which are useful in optical applications of the photochromic compounds according to the invention :

- alkyl, cycloalkyl, (poly or oligo)ethylene glycol, aryl or arylalkyl poly[mono-, di- tri- or tetra]acrylate or poly[mono-, di-, tri- or tetra]methacrylate, which is optionally halogenated or which

comprises at least one ether and/or ester and/or carbonate and/or carbamate and/or thiocarbamate and/or urea and/or amide group,

- polystyrene, polyether, polyester, polycarbonate (*e.g.* bisphenol-A polycarbonate, diallyl diethylene glycol polycarbonate), polycarbamate, polyepoxy, polyurea, polyurethane, polythiourethane, polysiloxane, polyacrylonitrile, polyamide, aliphatic or aromatic polyester, vinylic polymers, cellulose acetate, cellulose triacetate, cellulose acetate-propionate or polyvinylbutyral,
- those obtained from difunctional monomers having the formula below :



in which :

- Δ R_{10}, R'_{10}, R_{11} and R'_{11} are identical or different and represent independently a hydrogen or a methyl group ;
- Δ m_1 and n_1 are, independently, integers between 0 and 4 (inclusive) ; and are advantageously independently equal to 1 or 2 ;
- Δ X and X', which are identical or different, are a halogen and represent, preferably, a chlorine and/or a bromine ;
- Δ p_1 and q_1 are, independently, integers between 0 and 4 (inclusive);

- copolymers of at least two types of copolymerisable monomers selected from the precursor monomers of the polymers listed *supra*, and preferably those belonging to the groups comprising : (meth)acrylic monomers, vinylic monomers, allylic monomers, and mixtures thereof.

In a particularly preferred manner, the photochromes of the invention are used with resins which have a nanobiphasic structure and which are obtained by copolymerising at least two different, specific difunctional monomers. Such resins have been described by the Applicant in the International patent Application WO-A-98 50443.

The amount of photochrome used in the (co)polymer matrix depends upon the degree of darkening desired. Usually, between 0.001 and 20% by weight of it is used.

Still according to the fifth of its aspects in relation to the applications of the compounds **(I)** as photochromes, another object of the present invention is ophthalmic articles, such as ophthalmic or solar spectacle articles, comprising :

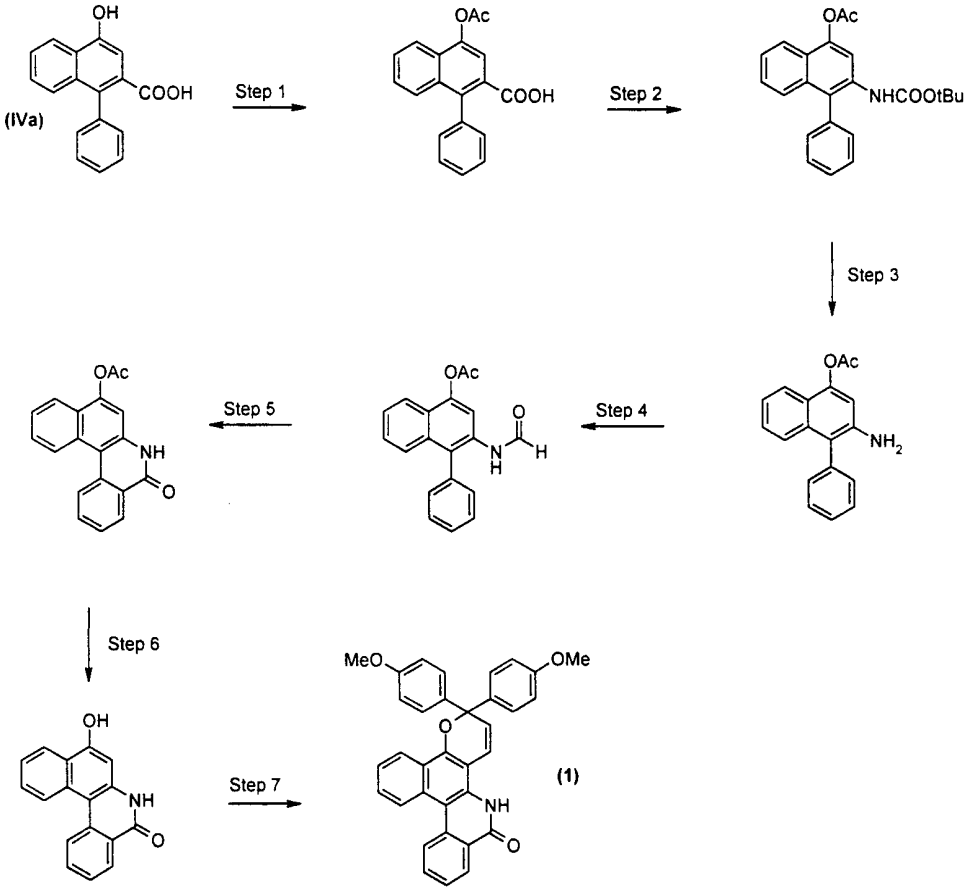
- at least one compound **(I)** according to the invention,
- and/or at least one (co)polymer and/or reticulate formed, at least in part, from compound(s) of the invention,
- and/or at least one photochromic composition as defined above,
- and/or at least one matrix (as defined *supra*), of an organic polymer material or of an inorganic material, or even of a hybrid inorganic-organic material, said matrix initially comprising at least one compound of the invention.

In practice, the articles which are more particularly covered by the present invention are ophthalmic lenses or photochromic solar lenses, glazing (windows for buildings, for locomotion engines, automobile vehicles), optical devices, decorative articles, solar protection articles, information storage, ...

The present invention is illustrated by the Example which follows, of synthesis and of photochromic validation, of a compound of the invention. This compound of the invention is compared to prior art compound C1.

EXAMPLES

EXAMPLE 1 : SYNTHESIS OF COMPOUND (1) ($R_1 = R_2 = p\text{-}C_6H_4OCH_3$, $R_3 = H$, $m = n = 0$)



Step 1 :

A solution of 10 g of acid **(IVa)** in 50 ml of acetic anhydride is stirred under reflux for 2 hours. After cooling, 150 ml of water are added and the precipitate formed is filtered off. 12.5 g of a beige solid are obtained after drying, which is dissolved in 80 ml of THF. A solution of 4 g of sodium bicarbonate in 40 ml of water is added, and vigorous stirring is effected under reflux for 30 minutes. The reaction mixture is acidified with a solution of HCl to pH = 1. Then, the organic phase is dried over magnesium sulphate and evaporated to dryness to give 10.8 g of a beige solid.

Step 2 :

The product obtained from step 1 (6.36 g) is placed in suspension in 100 ml of toluene and 3.1 ml of triethylamine are then added. Stirring is effected for 10 minutes at ambient temperature, and 5.39 ml of diphenylphosphorazide are added. Stirring is effected for 30 minutes at ambient temperature. 2.36 ml of *tert*-butanol are added and stirring is effected for one night under reflux. After evaporation of the solvent, the mixture is taken up into ethyl acetate and is washed with a solution of sodium bicarbonate. After drying over magnesium sulphate and evaporation of the solvents, the resulting brown oil is crystallised in methanol to give 5.28 g of a white solid.

Step 3 :

The product of step 2 (5.2 g) is placed in solution at 0°C in 90 ml of a 1/1 mixture of trifluoroacetic acid in dichloromethane. After stirring at 0°C for 30 minutes, the reaction mixture is diluted in 150 ml of toluene and the solvents are evaporated off under vacuum. The resulting oil is taken up in 100 ml of ethyl acetate and then washed with a solution of sodium bicarbonate. After drying over magnesium sulphate, the evaporation of the solvents enables isolating 4.03 g of a just yellow solid.

Step 4 :

The product of step 3 (1.9 g) is stirred under reflux for 2 hours in 20 ml of formic acid. The formic acid is evaporated off, the mixture is dissolved in toluene, and the solvent is evaporated off. The resulting solid is dissolved in ethyl acetate, washed with a solution of sodium bicarbonate and then dried over magnesium sulphate and evaporated to dryness to give 2 g of a solid.

Step 5 :

The product of step 4 (1 g) and 2.4 g of tert-butyl peroxide are stirred under the reflux of chlorobenzene (30 ml) for 48 hours (this experiment must be carried out behind a solid protective screen). The precipitate formed is filtered off and dried in order to give 300 mg of a beige solid.

Step 6 :

The product of step 5 (about 600 mg of an orange powder) is dissolved in 25 ml of THF and is stirred at 0°C. 20 ml of a 0.5N solution of NaOH are added and the mixture is stirred at 0°C for 1 hour. A solution of hydrochloric acid is added up to pH = 1, and extraction is made with ethyl acetate. The organic phase is dried over

magnesium sulphate and evaporated in order to give 450 mg of an orange oil which is used as such for the next step.

Step 7 :

The product of step 6 (160 mg), a few bromoacetic acid crystals and 250 mg of 1,1-bis(para-methoxyphenyl)propyn-1-ol are stirred under the reflux of xylene for 2 hours. The solvent is evaporated off, and the mixture is purified by chromatography on a silica column (elution : heptane/EtOAc 6/4) and then recrystallised from ethyl acetate to give 50 mg of a beige solid correct by ^1H NMR.

EXAMPLE 2 : COMPOUND C1

Compound C1 is described in the French patent application FR-A-2,770,524 of the Applicant (see Example 1).

EXAMPLE 3 :

The photochromic properties of said compounds (1) and C1 were evaluated.

To this end, said compounds are incorporated, at the rate of about 0.05 % by weight, in a matrix.

A mixture of the starting materials is in fact made, the nature and the incorporated amounts of which materials are specified below ; this mixture is poured into a lens mould of 2 mm thickness and which is then subjected to a heating cycle of 2 hours at 70°C and then of 1 hour at 100°C.

Precursor starting materials of the matrix :

0.05 parts by weight of the photochromic colouring agent : compound (1) or C1 ; per

60 parts by weight of DIACRYL 121 from AKZO Chimie (tetraethoxylated bisphenol A dimethacrylate) ;

10 parts by weight of divinylbenzene ;

30 parts by weight of polyethylene glycol dimethacrylate from ALDRICH ;

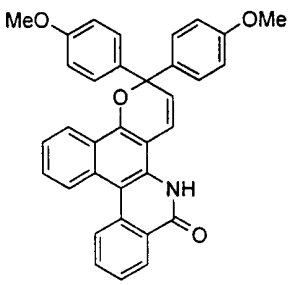
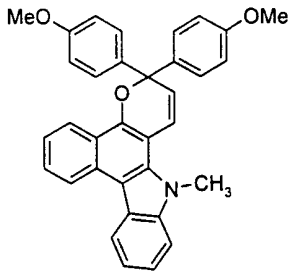
0.5 parts by weight of n-dodecanethiol ;

0.2 parts by weight of AMBN (2,2'-azobis(2-methylbutyronitrile) provided by AKZO (Perkadox®)).

Said matrix, which contains said photochromic compounds within its mass, is exposed to UV rays (source : xenon lamp).

The λ_{max}'s in the visible and the discoloration kinetics are given in the Table below. Said discoloration kinetics are measured by the decrease in the absorbance at the λmax of the activated form after irradiation (T½ = time for the absorbance

to decrease by a half). The properties of these compounds are given in the Table below.

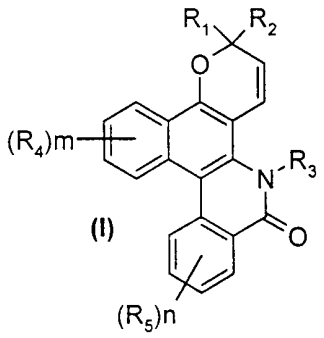
COMPOUND	STRUCTURE	λ max*	T½
(1)		550 nm	12 s
C1		566 nm	26 s

* λmax of the longest wavelength band of the compound after exposure.

The observation of the matrices in the presence of solar radiation or UV radiation shows that the compounds of the invention have very rapid discoloration kinetics. Moreover, and notably in comparison with C1, they possess an extremely low initial coloration.

Claims

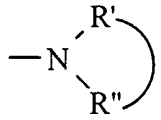
1 - Compounds of the following formula **(I)** :



in which :

- R_1 and R_2, which are identical or different, independently represent :
  - hydrogen,
  - a linear or branched alkyl group comprising 1 to 12 carbon atoms,
  - a cycloalkyl group comprising 3 to 12 carbon atoms,
  - an aryl or heteroaryl group comprising in its basic structure 6 to 24 carbon atoms or 4 to 24 carbon atoms respectively and at least one heteroatom selected from sulphur, oxygen and nitrogen ; said basic structure being optionally substituted with at least one substituent selected from the whole of the substituents given below :
    + a halogen, and notably fluorine, chlorine and bromine,
    + a hydroxy,
    + a linear or branched alkyl group comprising 1 to 12 carbon atoms,
    + a linear or branched alkoxy group comprising 1 to 12 carbon atoms,
    + a haloalkyl or haloalkoxy group corresponding to the (C_1-C_{12}) alkyl or alkoxy groups above respectively which are substituted with at least one halogen atom, and notably a fluoroalkyl group of this type,

+ a linear or branched alkenyl group comprising 2 to 12 carbon atoms, and notably a vinyl group or an allyl group,
+ an $-NH_2$ group,
+ an -NHR group, R representing a linear or branched alkyl group comprising 1 to 6 carbon atoms,
+ a



group, R' and R", which are identical or different, representing independently a linear or branched alkyl group comprising 1 to 6 carbon atoms or representing together with the nitrogen atom to which they are bound a 5- to 7-membered ring which can comprise at least one other heteroatom selected from oxygen, sulphur and nitrogen, said nitrogen being optionally substituted with an R"' group, which is a linear or branched alkyl group comprising 1 to 6 carbon atoms,

+ a methacryloyl group or an acryloyl group,

- an aralkyl or heteroaralkyl group, the alkyl group, which is linear or branched, comprising 1 to 4 carbon atoms and the aryl part of which has the same definition as that given *supra* for the aryl and heteroaryl group ;

or

said two substituents R_1 and R_2 together form an adamantyl, norbornyl, fluorenylidene, di(C_1-C_6)alkylanthracenylidene or spiro(C_5-C_6)cycloalkylanthracenylidene group ; said group being optionally substituted with at least one of the substituents listed above for R_1 , R_2 : an aryl or heteroaryl group ;

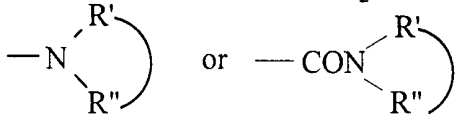
- R_3 represents :
  - a hydrogen,
  - a linear or branched alkyl group comprising 1 to 12 carbon atoms (advantageously 1 to 6 carbon atoms),
  - a cycloalkyl group comprising 3 to 12 carbon atoms,

- a haloalkyl or halocycloalkyl group corresponding to the alkyl and cycloalkyl groups above respectively, which are substituted with at least one halogen atom, notably selected from fluorine, chlorine and bromine,
- an aralkyl or heteroaralkyl group, the alkyl group, which is linear or branched, comprising 1 to 4 carbon atoms, and the aryl and heteroaryl groups having the same definitions as those given *supra* for R_1 , R_2,
- a $-COR_6$, $-COOR_6$ or $-CONHR_6$ group, R_6 representing a straight or branched alkyl group comprising 1 to 6 carbon atoms, or a cycloalkyl group comprising 3 to 6 carbon atoms, or a linear or branched alkenyl group comprising 2 to 12 carbon atoms, and notably an allyl group or a phenyl or benzyl group, optionally substituted with at least one of the substituents listed above for the values of R_1 , R_2 : aryl or heteroaryl ;

• R_4 and R_5 , which are identical or different, represent, independently :

- a halogen, and notably fluorine, chlorine or bromine,
- a linear or branched alkyl group comprising 1 to 12 carbon atoms (advantageously 1 to 6 carbon atoms),
- a cycloalkyl group comprising 3 to 12 carbon atoms,
- a linear or branched alkoxy group comprising 1 to 12 carbon atoms (advantageously 1 to 6 carbon atoms),
- a haloalkyl, halocycloalkyl, or haloalkoxy group corresponding to the alkyl, cycloalkyl, alkoxy groups above respectively, which are substituted with at least one halogen atom, notably selected from fluorine, chlorine and bromine,
- an aryl or heteroaryl group having the same definition as that given *supra* for R_1 , R_2 ,
- an aralkyl or heteroaralkyl group, the alkyl group, which is linear or branched, comprising 1 to 4 carbon atoms, and the aryl and heteroaryl groups having the same definitions as those given *supra* for R_1 , R_2,

- an amine or amide group : $-NH_2$, -NHR, $-CONH_2$, -CONHR,

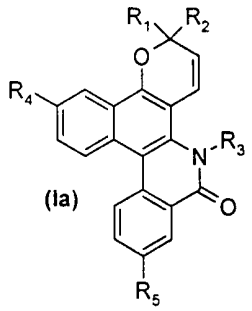


R, R', R" having their respective definitions given *supra* for the amine substituents of the values R_1 , R_2 : aryl or heteroaryl,

- an $-OCOR_7$ or $-COOR_7$ group, R_7 representing a straight or branched alkyl group comprising 1 to 6 carbon atoms, or a cycloalkyl group comprising 3 to 6 carbon atoms, or a phenyl group, optionally substituted with at least one of the substituents listed above for the values of R_1 , R_2 : aryl or heteroaryl ; and

- m and n are integers of 0 to 4.

2 - Compounds according to claim 1, characterised in that they have a formula **(Ia)** :



(Ia)

in which :

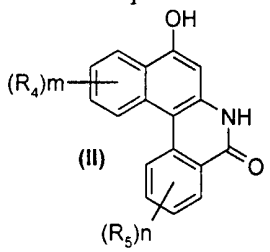
- R_1 , R_2 are identical or different and represent independently optionally substituted aryl or heteroaryl groups the basic structure of which is selected from the group comprising phenyl, naphthyl, biphenyl, pyridyl, furyl, benzofuryl, dibenzofuryl, N-(C_1-C_6)alkylcarbazole, thienyl, benzothienyl, dibenzothienyl and julolidinyl groups ; R_1 and/or R_2 representing, advantageously, a para-substituted phenyl group ;

- R_3 represents a hydrogen or a linear or branched alkyl group comprising 1 to 6 carbon atoms ;

- R_4 and R_5, which are identical or different, independently represent a hydrogen, a linear or branched alkoxy group which comprises 1 to 6 carbon atoms, a halogen, a linear or branched alkyl group comprising 1 to 6 carbon atoms, a morpholino group or a diaalkylamino group –NR'R'' in which R' and R'' independently represent a linear or branched alkyl group comprising 1 to 6 carbon atoms .

3 - A method of preparation of the compounds according to one of claims 1 or 2, characterised in that it consists essentially in carrying out a condensation :

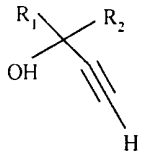
- of an intermediate compound of formula **(II)** given below :



(II)

in which R_4 , R_5 , m and n are as defined in claims 1 or 2 above with reference to formula **(I)**,

- with a derivative of propargylic alcohol, having formula **(III)** below :



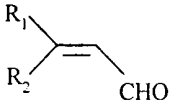
(III)

in which R_1 and R_2 are as defined in claims 1 or 2 above with reference to formula **(I)** ;

the condensation **(II)/(III)** being carried out advantageously in the presence of a catalyst, this catalyst being preferably selected from the group comprising para-toluenesulphonic acid, dodecylsulphonic acid or bromoacetic acid ;

or

- with an aldehyde derivative, having formula **(III')** below :



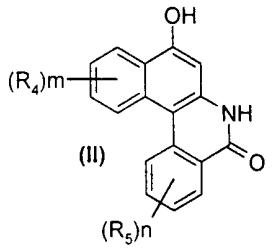
(III')

in which R_1 and R_2 are as defined in claims 1 or 2 above with reference to formula **(I)** ;

the condensation **(II)/(III')** being carried out, advantageously, in the presence of a metallic complex, preferably a complex of titanium, titanium (IV) ethoxide being particularly preferred ;

said condensation being optionally followed by a deprotonation and then by a reaction with an electrophilic compound of formula R_3X in which R_3 is different from hydrogen.

4 - Intermediate products, which are notably useful for the preparation of compounds according to one of claims 1 or 2, characterised in that they have the following formula **(II)** :



(II)

in which R_4 , R_5 , m and n are as defined *supra*, in claims 1 or 2, with reference to formula **(I)**.

5 - A (co)polymer and/or reticulate obtained by polymerising and/or cross-linking and/or grafting at least one monomer consisting of a compound according to one of claims 1 or 2.

6 - A photochromic compound, characterised in that it is constituted by a compound according to one of claims 1 or 2, or by a mixture of at least two compounds according to one of claims 1 or 2, or by a mixture of at least one compound according to one of claims 1 or 2 with at least one other photochromic compound of another type and/or at least one non-photochromic colouring agent.

7 - A photochromic composition, characterised in that it comprises :

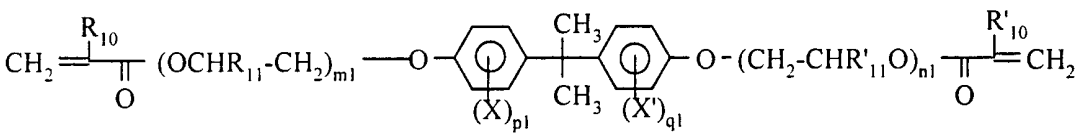
- at least one compound according to claims 1 or 2,
- and/or at least one linear or cross-linked (co)polymer which contains, in its structure, at least one compound **(I)** according to one of claims 1 or 2,
- and, optionally, at least one other photochromic compound of another type and/or at least one non-photochromic colouring agent and/or at least one stabilising agent.

8 - A matrix, characterised in that it comprises :

- at least one compound **(I)** according to one of claims 1 or 2,
- and/or at least one composition according to claim 7,
- and/or at least one co(polymer) and/or reticulate according to claim 5.

9 - A (co)polymer matrix according to claim 8, characterised in that the (co)polymer(s) which constitute it is (are) selected from the following list :

- alkyl, cycloalkyl, (poly or oligo)ethylene glycol, aryl or arylalkyl poly[mono-, di- tri- or tetra]acrylate or poly[mono-, di-, tri- or tetra]methacrylate which is optionally halogenated or comprises at least one ether and/or ester and/or carbonate and/or carbamate and/or thiocarbamate and/or urea and/or amide group,
- polystyrene, polyether, polyester, polycarbonate (*e.g.* bisphenol-A polycarbonate, diallyl diethylene glycol polycarbonate), polycarbamate, polyepoxy, polyurea, polyurethane, polythiourethane, polysiloxane, polyacrylonitrile, polyamide, aliphatic or aromatic polyester, vinylic polymers, cellulose acetate, cellulose triacetate, cellulose acetate-propionate or polyvinylbutyral,
- difunctional monomers having the formula below :



in which :

- Δ R_{10}, R'_{10}, R_{11} and R'_{11} are identical or different and represent independently a hydrogen or a methyl group ;
- Δ m_1 and n_1 are, independently, integers between 0 and 4 (inclusive) ; and are advantageously independently equal to 1 or 2 ;
- Δ X and X', which are identical or different, are a halogen and represent, preferably, a chlorine and/or a bromine ;
- Δ p_1 and q_1 are, independently, integers between 0 and 4 (inclusive);

- copolymers of at least two types of copolymerisable monomers selected from the precursor monomers of the polymers listed *supra*, and preferably those belonging to the groups comprising : (meth)acrylic monomers, vinylic monomers, allylic monomers, and mixtures thereof.

10 - An ophthalmic or solar article comprising :

- at least one compound **(I)** according to one of claims 1 or 2,
- and/or at least one composition according to claim 7,
- and/or at least one (co)polymer and/or reticulate according to claim 5,
- and/or at least one matrix according to one of claims 8 or 9.

11 - The article according to claim 10, characterised in that it is constituted by a lens, by a glazing or by an optical device.

AMENDED CLAIMS

[received by the International Bureau on 16 November 2000 (16.11.00);
original claim 9 amended; remaining claims unchanged (1 page)]

7 - A photochromic composition, characterised in that it comprises :

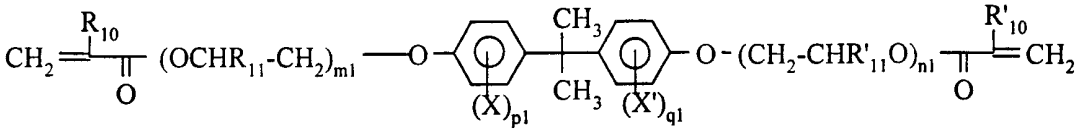
- at least one compound according to claims 1 or 2,
- and/or at least one linear or cross-linked (co)polymer which contains, in its structure, at least one compound **(I)** according to one of claims 1 or 2,
- and, optionally, at least one other photochromic compound of another type and/or at least one non-photochromic colouring agent and/or at least one stabilising agent.

8 - A matrix, characterised in that it comprises :

- at least one compound **(I)** according to one of claims 1 or 2,
- and/or at least one composition according to claim 7,
- and/or at least one co(polymer) and/or reticulate according to claim 5.

9 - A (co)polymer matrix according to claim 8, characterised in that the (co)polymer(s) which constitute it is (are) selected from the following list :

- alkyl, cycloalkyl, (poly or oligo)ethylene glycol, aryl or arylalkyl poly[mono-, di- tri- or tetra]acrylate or poly[mono-, di-, tri- or tetra]methacrylate which is optionally halogenated or comprises at least one ether and/or ester and/or carbonate and/or carbamate and/or thiocarbamate and/or urea and/or amide group,
- polystyrene, polyether, polyester, polycarbonate (*e.g.* bisphenol-A polycarbonate, diallyl diethylene glycol polycarbonate), polycarbamate, polyepoxy, polyurea, polyurethane, polythiourethane, polysiloxane, polyacrylonitrile, polyamide, aliphatic or aromatic polyester, vinylic polymers, cellulose acetate, cellulose triacetate, cellulose acetate-propionate or polyvinylbutyral,
- those obtained from difunctional monomers having the formula below :



INTERNATIONAL SEARCH REPORT

Interna al Application No
PCT/EP 00/05162

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 C07D491/052 C08G73/06 G02B5/23 G03C1/73 C07D221/18
C08K5/3415 //(C07D491/052,311:00,221:00)

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)
IPC 7 C07D C08G G02B G03C C08K

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 practical, search terms used)
CHEM ABS Data, EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 99 23071 A (CORNING INC (US)) 14 May 1999 (1999-05-14) claims 1,5,6,11 & FR 2 770 524 A 7 May 1999 (1999-05-07) cited in the application	1,5,7,10
P,A	WO 00 31080 A (CORNING S A (US)) 2 June 2000 (2000-06-02) claims 1,4,10,12	1,5,7,10

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

☒ Patent family members are listed in 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 document 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	Date of mailing of the international search report
19 September 2000	29/09/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Alfaro Faus, I

1

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

Internat l Application No
PCT/EP 00/05162

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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