Title: SULPHONIUM SALT INITIATORS

(57) Abstract: Compounds of the Formula (I), wherein
L₁, L₂, L₃, L₄, L₅, L₆, L₇, L₈, L₉, L₁₀, L₁₁, L₁₂, L₁₃, L₁₄, L₁₅, L₁₆, and L₁₇ are for example are hydrogen or COT; R, R¹ and R² for example are hydrogen,C₅H₅, or C₅H₅heteroaryl; X, X¹ and X² for example are O, S, single bond, Nₛ⁻, or NCOR₃, T is for example hydrogen, C₅H₅alkyl, C₅H₅alkenyl, C₅H₅alkynyl, C₅H₅alkylalkenyl, C₅H₅alkylalkynyl, C₅H₅alkenylalkenyl, C₅H₅alkenylalkynyl, or C₅H₅aryll, provided that at least one of R, R¹ or R² is unsubstituted or substituted C₅H₅heteroaryl; and Y is an inorganic or organic anion; are suitable as photolatent acid generators.
Sulphonium Salt Initiators

The invention pertains to novel sulphonium salt photoinitiators and their use in photocurable compositions.

Sulphonium salts are known in the art as photoinitiators. In GB 2061280 triarylsulphonium salts, comprising a phenlythio moiety, are disclosed. Other compounds of this type, inter alia with phenoxy groups, are known from US 4451409, US 4694029 and WO07/1 18794, for example tris(4-phenoxyphenyl)sulphonium hexafluorophosphate. WO 03/072567 and WO 03/008404 disclose sulphonium salts, wherein the sulphonium ion is located in a condensed ring system, for example in the thioxanthyl moiety. In JP08-31 1018-A a preparation process for sulphonium salts is disclosed as well as tris(4-butoxyphenyl)sulphonium and tris[4-(dimethylamino)phenyl]sulphonium cations. US 2003/0235782 and US 2005/0100819 provide sulphonium salts in photoresist applications. WO 07/003507 discloses sulphonium salts with a phenyl-COOR-moiety and WO08/040648 describe sulphonium salts with specific substituents.

One major problem of commercially available sulphonium salt photoinitiators is the formation of toxic and/or odorous break down products like diphenyl sulfide thioxanthone or benzene. In technique there is a need for effective cationic photoinitiators, which are reactive, in particular in both clear and pigmented coatings, thin and thick layers, with and without the addition of sensitizers as co-initiators, non toxic and which generate non toxic and odorless break down products and which further are low-yellowing.

It now has been found, that compounds of the formula I,

\[
\text{I, wherein}
\]
L₁, L'₁, Lᵢ, L′ᵢ, Lₙᵢ, Lₙ'ᵢ, L₃, L'₃, Lₙ₃, Lₙ'₃, L₄, L'₄ and Lₙ₄ independently of one another are hydrogen, R₁, OR₁, SR₁, NR₁R₂, halogen, NO₂, CN, NR₁COR₂, COOR₁, OCOR₁, CONR₁R₂, OCOCR₁, OCONR₁R₂, NR₁COOR₂, SO₃H, SO₃M, SOR₁, SO₂R₁, COOT or COT; R₁, R₁¹ and R₁² independently of each other are hydrogen, C₆C₁₆aryl, C₆C₁₆aryl substituted with at least one L, or are T, or are C₃⁻C₆heteroaryl or C₃⁻C₆heteroaryl substituted with at least one L, wherein the case that the C₃⁻C₆heteroaryl comprises an annelated benzene ring, the bond to the corresponding X, X' or X'' is not located on said annelated ring;

X, X₁ and X'' independently of each other are O, S, CR₅R₆, single bond, NR₅ or NCOR₅; provided that if X, X' or X'' is O, the corresponding R, R' or R'' is not pyridinyl;

T is hydrogen, CrC₂₀alkyl, CrC₂₀alkyl substituted by one or more D, C₂⁻C₂₀alkyl interrupted by one or more E, C₂⁻C₂₀alkyl substituted by one or more D and interrupted by one or more E; or T is C₅⁻C₁₂cycloalkyl, C₅⁻C₁₂cycloalkyl substituted by one or more D, C₂⁻C₁₂cycloalkyl interrupted by one or more O, CO, COO, CONR₅, S or NR₅, C₂⁻C₁₂cycloalkyl substituted by one or more D and interrupted by one or more O, CO, COO, CONR₅, S or NR₅; or T is C₂⁻C₂₀alkenyl, C₂⁻C₂₀alkenyl substituted by one or more D, C₃⁻C₂₀alkenyl interrupted by one or more E, C₃⁻C₂₀alkenyl substituted by one or more D and interrupted by one or more E, C₅⁻C₁₂cycloalkenyl, C₅⁻C₁₂cycloalkenyl substituted by one or more D, C₃⁻C₁₂cycloalkenyl interrupted by one or more D and interrupted by one or more O, CO, COO, CONR₅, S or NR₅, C₂⁻C₂₀alkenyl substituted by one or more D and interrupted by one or more E, C₅⁻C₁₂cycloalkenyl, C₅⁻C₁₂cycloalkenyl substituted by one or more D, C₃⁻C₁₂cycloalkenyl interrupted by one or more D and interrupted by one or more O, CO, COO, CONR₅, S or NR₅, C₂⁻C₂₀alkenyl substituted by one or more D and interrupted by one or more E, C₅⁻C₁₂cycloalkenyl, C₅⁻C₁₂cycloalkenyl substituted by one or more D, C₃⁻C₁₂cycloalkenyl interrupted by one or more D and interrupted by one or more O, CO, COO, CONR₅, S or NR₅, C₂⁻C₂₀alkenyl substituted by one or more D and interrupted by one or more E, C₅⁻C₁₂cycloalkenyl, C₅⁻C₁₂cycloalkenyl substituted by one or more D, C₃⁻C₁₂cycloalkenyl interrupted by one or more D and interrupted by one or more O, CO, COO, CONR₅, S or NR₅; or T is C₇⁻C₁₂bicycloalkyl, C₇⁻C₁₂bicycloalkyl substituted by one or more D, C₅⁻C₁₂bicycloalkyl interrupted by one or more O, CO, COO, CONR₅, S or NR₅, C₅⁻C₁₂bicycloalkyl substituted by one or more D and interrupted by one or more O, CO, COO, CONR₅, S or NR₅; or T is C₇⁻C₁₂bicycloalkenyl, C₇⁻C₁₂bicycloalkenyl substituted by one or more D, C₅⁻C₁₂bicycloalkenyl interrupted by one or more O, CO, COO, CONR₅, S or NR₅, C₅⁻C₁₂bicycloalkenyl substituted by one or more D and interrupted by one or more O, CO, COO, CONR₅, S or NR₅; or T is C₁₀⁻C₂₀tricycloalkyl, C₆⁻C₁₂tricycloalkyl substituted by one or more D, C₇⁻C₁₅tricycloalkyl interrupted by one or more O, CO, COO, CONR₅, S or NR₅, C₇⁻C₁₅tricycloalkyl substituted by one or more D and interrupted by one or more O, CO, COO, CONR₅, S or NR₅; or T is C₈⁻C₁₆cycloalkylenary, C₈⁻C₁₈cycloalkylenary substituted by one or more D, C₇⁻C₁₈cycloalkylenary interrupted by one or more O, CO, COO, CONR₅, S or NR₅.
Ciβcycloalkylenaryl substituted by one or more D and interrupted by one or more O, CO, COO, CONR₂, S or NR₂; or T is
C⁷-Ciβcycloalkylenheteroaryl, C⁷-Ciβcycloalkylenheteroaryl substituted by one or more D, C₆-
Ciβcycloalkylenheteroaryl interrupted by one or more O, CO, COO, CONR₂, S or NR₂, C₆-
Ciβcycloalkylenheteroaryl substituted by one or more D and interrupted by one or more O,
CO, COO, CONR₂, S or NR₂; or T is
C₆-Ci₄aryl, C₆-Ci₄aryl substituted by one or more D, C₃-Ci₄heteroaryl or C₃-Ci₄heteroaryl
substituted by one or more D;
R₁, R₂, R₃ and R₄ independently of one another have the meaning of T;
D is hydrogen, R₅, OR₅, SR₅, NR₅R₆, halogen, NO₂, CN, O-glycidyl, O-vinyl, O-allyl,
COR₅, NR₅COR₆, COOR₅, OCOR₅, CONR₅R₆, OCOCOR₅, OCONR₅R₆, NR₅COOR₆, SO₃H,
SO₃Me, =O, C₆-Ci₄aryl, C₆-Ci₄aryl substituted by one or more R₅, OR₅, halogen, SRI₂, NO₂,
CN, COR₁₂, NR₁₂COR₁₃, COOR₁₂, OCOR₁₂, CONR₁₂, OCONR₁₂COR₁₃, COOOR₁₂, OCONR₁₂R₁₃,
NR₁₂COOR₁₃ or SO₃H; or
is C₃-Ci₂cycloalkyl, C₃-Ci₂cycloalkyl substituted by one or more R₁₄, C₂-Ci₂cycloalkyl
interrupted by one or more O, CO, COO, CONR₅,S or NR₅, C₂-Ci₂cycloalkyl substituted by one
or more R₁₄ and interrupted by one or more O, CO, COO, CONR₅,S or NR₅; or D is
C₅-Ci₂cycloalkenyl, C₅-Ci₂cycloalkenyl substituted by one or more R₁₄, C₃-Ci₂cycloalkenyl
interrupted by one or more O, CO, COO, CONR₅,S or NR₅, C₃-Ci₂cycloalkenyl substituted by
one or more R₁₄ and interrupted by one or more O, CO, COO, CONR₅,S or NR₅; or D is
C₇-Ci₂ bicycloalkenyl, C₇-Ci₂ bicycloalkenyl substituted by one or more R₁₄, C₅-Ci₂ bicycloalkenyl
interrupted by one or more O, CO, COO, CONR₅, S or NR₅; or D is
C₇-Ci₂ bicycloalkenkyl substituted by one or more O, CO, COO, CONR₅, S or NR₅; or D is
Cio-C₂₀tricycloalkyl, Ci₀-C₂₀tricycloalkyl substituted by one or more R₁₄, C₇-Ci₂ tricycloalkyl
interrupted by one or more O, CO, COO, CONR₅, S or NR₅, C₆-Ci₂tricycloalkyl substituted by
one or more R₁₄ and interrupted by one or more O, CO, COO, CONR₅, S or NR₅; or
is C₈-Ci₈cycloalkylenaryl, C₈-Ci₈cycloalkylenaryl substituted by one or more O, CO, COO, CONR₅, S or NR₅; or C₇-
Ci₈cycloalkylenaryl substituted by one or more O, CO, COO, CONR₅, S or NR₅; or C₇-
Ciβcycloalkylenaryl substituted by one or more Ri₄ and interrupted by one or more O, CO, COO, CONR₅; S or NR₅; or
C₇-Ciβcycloalkylenheteroaryl, C₇-Ci₂cycloalkylenheteroaryl substituted by one or more Ri₄,
C₈-Ci₂cycloalkylenheteroaryl interrupted by one or more O, CO, COO, CONR₅; S or NR₅; C₇-
5 Ci₈cycloalkylenheteroaryl substituted by one or more Ri₄ and interrupted by one or more O, CO, COO, CONR₅; S or NR₅;
E is O, S, COO, OCO, CO, NR₅, NCOR₅, NR₅CO, CONR₅, OCOO, OCONR₅, NR₅COO,
SO₂, SO, CR₅=CR₆ or \( \text{R1}_5 = \text{R1}_6 \). is C₆-Ci₄arylene, C₅-Ci₂heteroarylene, C₃-
Ci₂cycloalkylene, C₃-Ci₂cycloalkylene substituted by one or more Ri₄, C₇-Ci₂cycloalkylene
interrupted by one or more O, CO, COO, CONR₅; S or NR₅; C₇-Ci₂cycloalkylene substituted by one or more Ri₄ and interrupted by one or more O, CO,
10 COO, CONR₅; S or NR₅; or E is
C₇-Ci₂bicycloalkylene, C₇-Ci₂bicycloalkylene substituted by one or more Ri₄, C₅-
Ci₂bicycloalkylene interrupted by one or more O, CO, COO, CONR₅; S or NR₅; C₇-
Ci₂bicycloalkylene substituted by one or more Ri₄ and interrupted by one or more O, CO,
COO, CONR₅; S or NR₅; or E is
20 C₇-Ci₂bicycloalkylene, C₇-Ci₂bicycloalkylene substituted by one or more Ri₄, C₅-
Ci₂bicycloalkylene interrupted by one or more O, CO, COO, CONR₅; S or NR₅; C₇-
Ci₂bicycloalkylene substituted by one or more Ri₄ and interrupted by one or more O, CO,
COO, CONR₅; S or NR₅; or E is
C₁₀-C₂₁cycloalkylene, C₁₀-C₂₁cycloalkylene substituted by one or more Ri₄, C₇-
25 Cistricycloalkylene interrupted by one or more O, CO, COO, CONR₅; S or NR₅; C₇-
Ci₈cycloalkylene substituted by one or more Ri₄ and interrupted by one or more O, CO,
COO, CONR₅; S or NR₅; or E is
C₈-Ci₈cycloalkylenarylene, C₈-Ci₈cycloalkylenarylene substituted by one or more Ri₄, C₇-
30 Ci₈cycloalkylenarylene interrupted by one or more O, CO, COO, CONR₅; S or NR₅; C₇-
Ci₈cycloalkylenarylene substituted by one or more Ri₄ and interrupted by one or more O, CO, COO, CONR₅,
S or NR₅, C₉-C₈cycloalkyleneheteroarylene substituted by one or more Rᵢ₄ and interrupted by one or more O, CO, COO, CONR₅, S or NR₅;
R₅ and R₆ independently of one another are hydrogen, a covalent bond to another substituent to form a ring, CrC₈ alkylene to form a ring with another substituent, Cl-C₂alkyl, phenyl or phenyl substituted by Cl-C₄alkyl and/or Cl-C₄alkoxy;
R₇, R₈, R₉, R₁₀ and R₁₁ independently of one another are hydrogen, d-C₅alkyl, d-C₅alkoxy, phenyl, phenoxy, substituted phenyl or substituted phenoxy;
R₁₂ and R₁₃ independently of one another are hydrogen, d-C₅alkyl, C₅-C₂cycloalkyl or phenyl;
R₁₄ is hydrogen, d-C₅alkyl, C₅-C₂cycloalkyl, Cl-d₂alkoxy, C₂-C₂cycloalkyloxy, phenyl or halogen;
n is an integer from 1 to 100;
Y is an inorganic or organic anion;
M is an inorganic or organic cation; and
provided that at least one of R, R' or R'' is C₃-C₂₀heteroaryl or C₃-C₂₀heteroaryl substituted with at least one L; are suitable as photoinitiators.

Said compounds excel at a good reactivity in combination with low yellowing, low odor and good solubility in the photocurable formulation. The photolatent acid sulphonium salt compounds of formula I exhibit a very satisfactory reactivity combined with good solubility and low yellowing properties. A very important advantage in view of environmental aspects is the fact that the compounds according to the present invention do not release benzene or thioxanthone.

Specific compounds of the formula I according to the present invention are such, wherein at least two of R, R' or R'' independently of one another are C₃-C₂₀heteroaryl or C₃-C₂₀heteroaryl substituted with at least one L.

Interesting are compounds
R, R' and R'' are identical; and L, L' and L'' are identical; and Li, L'i and L"i are identical; and L₂, L'₂ and L"₂, are identical; and L₃, L'₃ and L"₃, are identical; and L₄, L'₄ and L"₄ are
identical and $X$, $X'$ and $X''$ are identical, namely a compound of the formula (Ia) 

\[
\begin{array}{c}
\text{R} - X \\
\text{S}^+ - Y \\
\end{array}
\] 

(Ia), wherein $R$, $X$, $Y$, $L_1$, $L_2$, $L_3$ and $L_4$ are defined above.

$L_1$, $L'_1$, $L''_1$, $L_2$, $L'_2$, $L''_2$, $L_3$, $L'_3$, $L''_3$, $L_4$, $L'_4$ and $L''_4$ are for example hydrogen, $R_1$, $OR_1$, $SR_1$, $NR_1R_2$, halogen, $NO_2$, $CN$, $NR_1COR_2$, $COOR_1$, $COR_1$, $CONR_1R_2$, $OCOR_1$, $OCONR_1R_2$, $SO_3H$, $SO_3M$, $SOR_1$, $SO_2R_1$, COOT or COT; $R_1$ has one of the meanings given for $T$, as defined above.

Preferably $L_1$, $L'_1$, $L''_1$, $L_2$, $L'_2$, $L''_2$, $L_3$, $L'_3$, $L''_3$, $L_4$, $L'_4$ and $L''_4$ are independently of one another hydrogen, $R_1$, $OR_1$ or halogen. Even more preferred are compounds wherein $L_1$, $U_1$, $L'_1$, $L_2$, $L'_2$, $L''_2$ are independently of each other hydrogen, $R_1$, $OR_1$ or halogen; and $L_3$, $L'_3$, $L''_3$, $L_4$, $L'_4$ and $L''_4$ are hydrogen. Most preferred are compounds wherein $L_1$, $U_1$, $L'_1$, $L_2$, $L'_2$, $L''_2$ are independently of each other hydrogen, $CrC_6alkyl$, $C_5-C_6cycloalkyl$, $CrC_6alkoxy$ or phenyl; and $L_3$, $L'_3$, $L''_3$, $L_4$, $L'_4$ and $L''_4$ are hydrogen. In other preferred compounds $L_1$, $L'_1$, $L''_1$, $L_2$, $L'_2$, $L''_2$ are independently of each other $CrC_6alkyl$, $C_5-C_6cycloalkyl$, $CrC_6alkoxy$ or phenyl; and $L_3$, $L'_3$, $L''_3$, $L_4$, $L'_4$ and $L''_4$ are hydrogen.

$L_3$, $L'_3$, $L''_3$, $L_4$, $L'_4$ and $L''_4$ preferably are hydrogen.

$X$, $X'$ and $X''$ preferably are $O$, $S$ or $CR_4Rb$, in particular $O$ or $S$, especially $S$.

$R$, $R'$ and $R''$ are for example hydrogen, $C_6-C_{12}$aryl, $C_6-C_{12}$aryl substituted with at least one $L$, or are $T$, or are $C_3-C_{20}$heteroaryl or $C_3-C_{20}$heteroaryl substituted with at least one $L$, wherein the case that the $C_3-C_{20}$heteroaryl comprises an annelated benzene ring, the bond to the corresponding $X$, $X'$ or $X''$ is not located on said annelated ring.

In the case that $R$, $R'$ and $R''$ as $C_3-C_{20}$heteroaryl comprise an annelated benzene ring, the bond to the corresponding $X$, $X'$ or $X''$ is not located on said annelated ring. That is, for ex-
ample structures like the following are formed, whereas structures like are not covered by the present claims.

Especially R, R', and R'' are for example hydrogen, C₆-H₂aryl, or are C₃-C₂heteroaryl or C₃-C₂heteroaryl substituted with at least one L, wherein the case that the C₃-C₂heteroaryl comprises an annelated benzene ring, the bond to the corresponding X, X' or X'' is not located on said annelated ring.

Preferred R, R', and R'' are C₃-C₂heteroaryl unsubstituted or substituted as defined above, in particular by CrC₂alkyl.

In the context of the present invention a group that is defined to be substituted is meant to be substituted at least once, that is it bears one or more substituents. This refers in particular to substituted aryl or heteroaryl.

D is for example hydrogen, R₅, OR₅, SR₅, halogen, NO₂, CN, O-glycidyl, O-vinyl, O-allyl, COR₅, COOR₅, OCOR₅, OCOOR₅, SO₃H, SO₃M, =0, C₆-C₄aryl, C₆-C₄aryl substituted by one or more Ri₂, ORi₂, halogen, NO₂, SRi₂, SO₃H or CN, C₃-C₂heteroaryl, C₃-C₂heteroaryl substituted by one or more Ri₂, ORi₂, halogen, NO₂, SRi₂, SO₃H or CN; or D is is C₃-C₂cycloalkyl, C₃-C₂cycloalkyl substituted by one or more Ri₄, C₂-C₂cycloalkyl interrupted by one or more O, CO, COO or S, C₂-C₂cycloalkyl substituted by one or more Ri₄ and interrupted by one or more O, CO, COO or S; or D is C₅-C₂cycloalkenyl, C₅-C₂cycloalkenyl substituted by one or more Ri₄, C₃-C₂cycloalkenyl interrupted by one or more O, CO, COO or S, C₃-C₂cycloalkenyl substituted by one or more Ri₄ and interrupted by one or more O, CO, COO or S; or D is C₇-C₂bicycloalkyl, C₇-C₂bicycloalkyl substituted by one or more Ri₄, C₅-C₂bicycloalkyl interrupted by one or more O, CO, COO or S, C₅-C₂bicycloalkyl substituted by one or more Ri₄ and interrupted by one or more O, CO, COO or S; or D is C₇-C₂bicycloalkenyl, C₇-C₂bicycloalkenyl substituted by one or more Ri₄, C₅-C₂bicycloalkenyl interrupted by one or more O, CO, COO or S, C₅-C₂bicycloalkenyl substituted by one or more Ri₄ and interrupted by one or more O, CO, COO or S; or D is
C\textsubscript{6}-C\textsubscript{8} cycloalkylenaryl, C\textsubscript{8}-C\textsubscript{8} cycloalkylenaryl substituted by one or more R\textsubscript{i4}, C\textsubscript{7}-C\textsubscript{8} cycloalkylenaryl interrupted by one or more O, CO, COO or S, C\textsubscript{7}-C\textsubscript{8} cycloalkylenaryl substituted by one or more R\textsubscript{i4} and interrupted by one or more O, CO, COO or S; or Cr-Cis-cycloalkylenheteroaryl, C\textsubscript{7} d\textsubscript{s} cycloalkylenheteroaryl substituted by one or more R\textsubscript{i4},

C\textsubscript{8}-C\textsubscript{8} cycloalkylenheteroaryl interrupted by one or more O, CO, COO or S, C\textsubscript{8}-C\textsubscript{8} cycloalkylenheteroaryl substituted by one or more R\textsubscript{i4} and interrupted by one or more O, CO, COO or S.

e especially D is hydrogen, R\textsubscript{5}, OR\textsubscript{5}, SR\textsubscript{5}, halogen, NO\textsubscript{2}, CN, O-glycidyl, O-vinyl, O-allyl, COR\textsubscript{5}, COOR\textsubscript{5}, OCOR\textsubscript{5}, OCOOR\textsubscript{5}, SO\textsubscript{3}H, SO\textsubscript{3}M, =0, C\textsubscript{6}-C\textsubscript{8}aryl, C\textsubscript{8}-C\textsubscript{8}aryl substituted by one or more R\textsubscript{i4}, OR\textsubscript{i4}, halogen, NO\textsubscript{2}, SR\textsubscript{2}, SO\textsubscript{3}H or CN, C\textsubscript{3}-C\textsubscript{8}heteroaryl, C\textsubscript{3}-C\textsubscript{2}heteroaryl substituted by one or more R\textsubscript{i4} and interrupted by one or more O, CO, COO or S, C\textsubscript{2}-C\textsubscript{2}cycloalkyl substituted by one or more R\textsubscript{i4} and interrupted by one or more O, CO, COO or S; or D is

C\textsubscript{5}-C\textsubscript{2}cycloalkenyl, C\textsubscript{5}-C\textsubscript{2}cycloalkenyl interrupted by one or more R\textsubscript{i4}, C\textsubscript{3}-C\textsubscript{2}cycloalkenyl interrupted by one or more O, CO, COO or S, C\textsubscript{3}-C\textsubscript{2}cycloalkenyl substituted by one or more R\textsubscript{i4} and interrupted by one or more O, CO, COO or S; or D is

C\textsubscript{7}-C\textsubscript{2}bicycloalkyl, C\textsubscript{7}-C\textsubscript{2}bicycloalkyl substituted by one or more R\textsubscript{i4} and interrupted by one or more O, CO, COO or S, C\textsubscript{5}-C\textsubscript{i}bicycloalkyl substituted by one or more R\textsubscript{i4} and interrupted by one or more O, CO, COO or S; or D is

C\textsubscript{7}-C\textsubscript{2}bicycloalkenyl, C\textsubscript{7}-C\textsubscript{2}bicycloalkenyl substituted by one or more R\textsubscript{i4}, C\textsubscript{5}-C\textsubscript{2}bicycloalkenyl interrupted by one or more O, CO, COO or S, C\textsubscript{5}-C\textsubscript{2}bicycloalkenyl substituted by one or more R\textsubscript{i4} and interrupted by one or more O, CO, COO or S.

preferred D is hydrogen or OH.

E is for example O, S, COO, OCO, CO, OOCO, SO\textsubscript{2}, SO, CR\textsubscript{5}=CR\textsubscript{6} or \(\overset{\circ}{C}C\overset{\circ}{C}\)

is C\textsubscript{6}-C\textsubscript{2}aryl, C\textsubscript{3}-C\textsubscript{2}heteroaryl, C\textsubscript{3}-C\textsubscript{2}cycloalkylenylene, C\textsubscript{3}-C\textsubscript{2}cycloalkylenylene substituted by one or more R\textsubscript{i4}, C\textsubscript{2}-C\textsubscript{2}cycloalkylenylene interrupted by one or more O, CO, COO or S, C\textsubscript{2}-C\textsubscript{2}cycloalkylenylene substituted by one or more R\textsubscript{i4} and interrupted by one or more O, CO, COO or S; or E is

C\textsubscript{5}-C\textsubscript{2}cycloalkylenylene, C\textsubscript{5}-C\textsubscript{2}cycloalkylenylene substituted by one or more R\textsubscript{i4}, C\textsubscript{3}-C\textsubscript{2}cycloalkylenylene interrupted by one or more O, CO, COO or S, C\textsubscript{3}-C\textsubscript{2}cycloalkylenylene substituted by one or more R\textsubscript{i4} and interrupted by one or more O, CO, COO or S; or E is
C₇-C₈ bicycloalkylene, C₇-C₈ bicycloalkylene substituted by one or more R₁₄, C₆-C₇ bicycloalkylene interrupted by one or more O, CO, COO or S, C₅-C₆ bicycloalkylene substituted by one or more R₁₄ and interrupted by one or more O, CO, COO or S; or E is C₇-C₈ bicycloalkenylene, C/C₇ bicycloalkenylene substituted by one or more R₁₄, C₅-C₆ bicycloalkenylene interrupted by one or more O, CO, COO or S, C₅-C₆ bicycloalkenylene substituted by one or more R₁₄ and interrupted by one or more O, CO, COO or S; or E is

5 C₆-C₇ bicycloalkenylene interrupted by one or more O, CO, COO or S, C₅-C₆ bicycloalkenylene substituted by one or more R₁₄ and interrupted by one or more O, CO, COO or S; or E is C₆-C₇ bicycloalkenylene interrupted by one or more O, CO, COO or S, C₆-C₇ bicycloalkenylene interrupted by one or more O, CO, COO or S, C₆-C₇ bicycloalkenylene interrupted by one or more O, CO, COO or S, C₆-C₇ bicycloalkenylene interrupted by one or more O, CO, COO or S, C₆-C₇ bicycloalkenylene interrupted by one or more O, CO, COO or S; or E is

10 d-d bicycloalkenylenheteroarylene, d-d bicycloalkenylenheteroarylene substituted by one or more R₁₄, Cerd bicycloalkenylenheteroarylene interrupted by one or more O, CO, COO or S, C₆-C₇ bicycloalkenylenheteroarylene substituted by one or more R₁₄ and interrupted by one or more O, CO, COO or S;

15 Especially E is O, S, COO, OCO, CO, OCOO, SO₂, SO, CR₅=CR₆ or is C₆-C₇ arylenec, C₃-C₇ heteroarylene, C₃-C₇ cycloalkylene, C₃-C₇ cycloalkylene substituted by one or more C-C, alkyl or C-Calkoxy, C₂-C₇ cycloalkylene interrupted by one or more O, CO, COO or S, C₂-C₇ cycloalkylene substituted by one or more C-Calkyl or C-Calkoxy and interrupted by one or more O, CO, COO or S; or E is

20 C₅-C₆ cycloalkenylene, C₅-C₆ cycloalkenylene substituted by one or more C-Calkyl or d-Calkoxy, C₃-C₇ cycloalkenylene interrupted by one or more O, CO, COO or S, C₃-C₇ cycloalkenylene substituted by one or more C-Calkyl or C-Calkoxy and interrupted by one or more O, CO, COO or S; or E is

25 C₆-C₇ bicycloalkylene, C₆-C₇ bicycloalkylene substituted by one or more C-Calkyl or d-Calkoxy, C₅-C₇ bicycloalkylene interrupted by one or more O, CO, COO or S, C₅-C₇ bicycloalkylene substituted by one or more C-Calkyl or C-Calkoxy and interrupted by one or more O, CO, COO or S; or E is

30 C₇-C₈ bicycloalkenylene substituted by one or more C-Calkyl or C-Calkoxy and interrupted by one or more O, CO, COO or S. Preferred E is O, S or CR₅=CR₆.
Ri₄ preferably is d-C^alkyl or d-Cⁱ₂alkoxy.

CrCᵢ₂alkyl is linear or branched and is, for example, CrCᵢ₁-C₁₄-, C₁-C₁₂-, CrCᵢ₆-, CrCᵢ₆- or CrCᵢ₄alkyl. Examples are methyl, ethyl, propyl, isopropyl, n-butyl, sec-butyl, isobutyl, tert-butyl, pentyl, hexyl, heptyl, 2,4,4-trimethylpentyl, 2-ethylhexyl, octyl, nonyl, decyl, dodecyl, tetradecyl, pentadecyl, hexadecyl, octadecyl and icosyl.

Ci-Cⁱ₂alkyl, Ci-Cⁱ₂alkyl, Ci-Cⁱ₂alkyl, Ci-Cⁱ₂alkyl, Ci-Cⁱ₂alkyl and Ci-Cⁱ₂alkyl have the same meanings as given above for CrCᵢ₂alkyl up to the corresponding number of C-atoms.

Cᵢ₂-Cᵢ₂alkyl interrupted by one or more E, is for example interrupted 1-9, 1-7 or once or twice by E. In case the groups are interrupted by more than one E, said E preferably are separated from one another by at least one carbon atom, i.e. the E preferably are non-consecutive, in particular if E denotes O. Examples are the following structural units

-CH₂-O-CH₃, -CH₂CH₂O-CH₂CH₃, -[CH₂CH₂O]₇-CH₃, with y = 1-9, -(CH₂CH₂O)₂CH₂CH₃, -CH₂CH₂CH₂O-CH₂CH₃, -CH₂CH₂CH₃, -CH₂CH₂CH₂CH₂CH₃, -CH₂CH₂CH₂CH₃, -CH₂CH₂CH₃, -CH₂CH₂CH₃, -CH₂CH₂-CH₂CH₂CH₃,
-CH₂(OC)O-CH₃, -CH₂(OC)-CH₃, -CH₂NR₂CH₃, -CH₂CH₂NR₂CH₂CH₃, -CH₂COOCH₂CH₂CH₂O-CH₃ etc.

Cᵢ₂-Cwalkenyl is mono or polyunsaturated, linear or branched and is for example Cᵢ₂-C₈-, Cᵢ₂-C₆- or Cᵢ₂-C₄alkenyl. Examples are allyl, methallyl, vinyl, 1,1-dimethylallyl, 1-butene, 3-butene, 2-butene, 1,3-pentadienyl, 5-hexenyl or 7-octenyl, especially allyl or vinyl.

Cᵢ₅-Cᵢ₂cycloalkyl is for example cyclopentyl, cyclohexyl, cyclooctyl, cyclo-dodecyl, especially cyclopentyl and cyclohexyl, preferably cyclohexyl. Cᵢ₅-Cᵢ₂cycloalkyl in the context of the present application is to be understood as alkyl which at least comprises one ring. For example methyl-cyclopentyl, cyclopentyl, cyclohexyl, methyl- or dimethylcyclohexyl, cyclooctyl, especially cyclopentyl and cyclohexyl, preferably cyclohexyl are also meant. Further examples are structures like

(CH₂)₉, (CH₂)₉-CH₂CH₃, alkyl, e.g. \( \text{C}_n \text{H}_m \) or \( \text{C}_n \text{H}_m^{\text{alkyl}} \),

Cᵢ₂-Cᵢ₂cycloalkyl interrupted by one or more E with E defined as O, S, COO, COO, CO, CO, NR₂, NCOR₂, NR₂CO, CONR₂, OCOO, OCONR₂, NR₂COO, SO₂, SO, phenylene, C₄-
C₆cycloalkylene, CR₂=CR₃ or ＝C＝C＝, is for example

C₇-C₁₂ bicycloalkyl in the context of the present application is to be understood as alkyl which at least comprises two annelated rings. For example

C₅-C₁₂ bicycloalkyl interrupted by one or more E with E defined as O, S, COO, OCO, CO, NR₅, NCOR₅, NR₆CO, CONR₅, OCOO, OCONR₅, NR₅COO, SO₂, SO, CR₅=CR₆ or ＝C＝, is for example

C₁₀-C₂₄ tricycloalkyl interrupted by one or more E with E defined as O, S, COO, OCO, CO, NR₅, NCOR₅, NR₆CO, CONR₅, OCOO, OCONR₅, NR₅COO, SO₂, SO, CR₅=CR₆ or ＝C＝, is for example

C₅-C₆ cycloalkenyl, has one or more double bonds and is for example C₄-C₆ cycloalkenyl or C₆-C₈ cycloalkenyl. Examples are cyclopentenyl, cyclohexenyl or cyclooctenyl, especially cyclopentenyl and cyclohexenyl, preferably cyclohexenyl. C₅-C₆ cycloalkenyl in the context of the present application is to be understood as alkenyl which at least comprises one ring. For example methyl-cyclopentenyl, dimethylcyclohexenyl etc. are also meant.
C₇-C₁₂ bicycloalkenyl in the context of the present application is to be understood as alkenyl which at least comprises two annelated rings. For example

\[
\begin{align*}
\text{alkenyl} & \quad \text{alkenyl} \\
\text{alkenyl} & \quad \text{alkenyl} \\
\end{align*}
\]

\(\text{-alkenyl-} \quad \text{-alkenyl-} \quad \text{etc..}\)

\(\text{C₆-Cisaryl}\) is for example phenyl, 1-naphthyl, 2-naphthyl, anthryl or phenanthryl, in particular phenyl.

**Substituted C₆-Cuaryl** is for example substituted one to four times, e.g. once, twice or three times, especially once or twice. Substituents on the phenyl ring are in position 2-, 3- or 4-, or in position 2,4-, 2,6-, 2,3-, 3,4-, 3,5-, 2,4,6- especially in position 2- or 4- of the phenyl ring.

**Substituted naphthyl, anthryl or phenanthryl** is for example substituted one to four times, e.g. once, twice or three times, preferably once.

**Glycidyl** is \(-\text{C}-\text{C}-\text{O}-\text{CH}_2\), O-glycidyl denotes \(-\text{0-C-C-CH}_2\), \(\alpha\)-vinyl is \(-\text{O-C=CH}_2\), O-allyl means \(-\text{O-C-C=CH}_2\).

\(\text{C₆-Ci₃cycloalkylenearyl}\) denotes an aryl as defined above with an annelated cycloalkyl, for example \(\begin{align*}
\text{X} & \quad \text{O} \\
\text{C} & \quad \text{etc..} \\
\end{align*}\), **interrupted C₇-C₁₈ cycloalkylenearyl** is for example \(\begin{align*}
\text{O} & \quad \text{etc..} \\
\end{align*}\), etc..

**Halogen** is fluorine, chlorine, bromine or iodine, especially chlorine or fluorine, preferably fluorine.

**Phenylene** is \(\begin{align*}
\text{O} & \quad \text{etc..} \\
\end{align*}\), \(\alpha\)-phenylene means, ortho-phenylene.

\(\text{C₃-C₂ heteroaryl}\), especially \(\text{C₃-Ci₂ heteroaryl}\), in the context of the present invention is meant to comprise either one ring or a multiple ring system, e.g. a fused ring-system. \(\text{C₃-C₂ heteroaryl}\) as heteroatom comprises one or more, e.g. 1-3 or 1 or, especially 1 heteroa- tom(s), in particular selected from the group consisting of O, S and N.
In the context of the present invention, any heteroaryl is not meant to include an ionic heteroatom, as for example $N^+$ or $S^+$. Examples are thiienyl, benzo[b]thienyl, naphtho[2,3-b]thienyl, thianthrenyl, dibenzofuryl, chromenyl, xanthenyl, thioxanthyl, phenoxathiinyl, pyrrolyl, imidazolyl, pyrazolyl, pyrazinyl, pyrimidinyl, pyridazinyl, indolizinyl, isoindolyl, indolyl, indazolyl, purinyl, quinolizinyl, isoquinolyl, quinolyl, phthalazinyl, naphthyridinyl, quinoxalinyl, quinazolinyl, cinnolinyl, pteridinyl, carbazolyl, β-carbolinyl, phenanthridinyl, acridinyl, perimidinyl, phenanthrolinyl, phenazinyl, isothiazolyl, phenothiazinyl, isoxazolyl, furazanyl, phenoxyazinyl, 7-phenanthryl, anthraquinone-2-yl (= 9,10-dioxo-9,10-dihydroanthracen-2-yl), 3-benzo[b]thienyl, 5-benzo[b]thienyl, 2-benzo[b]thienyl, 4-dibenzofuryl, 4,7-dibenzofuryl, 4-methyl-7-dibenzofuryl, 2-xanthenyl, 8-methyl-2-xanthenyl, 3-xanthenyl, 2-phenoxyathiinyl, 2,7-phenoxyathiinyl, 2-pyrrolyl, 3-pyrrolyl, 5-methyl-3-pyrrolyl, 2-imidazolyl, 4-imidazolyl, 5-imidazolyl, 2-methyl-4-imidazolyl, 2-ethyl-4-imidazolyl, 2-ethyl-5-imidazolyl, 3-pyrazolyl, 1-methyl-3-pyrazolyl, 1-propyl-4-pyrazolyl, 2-pyrazinyl, 5,6-dimethyl-2-pyrazinyl, 2-indolizinyl, 2-methyl-3-isodindolyl, 2-methyl-1-isodindolyl, 1-methyl-2-indolyl, 1,5-dimethyl-2-indolyl, 1-methyl-3-indolyl, 2,7-dimethyl-8-purinyl, 2-methoxy-7-methyl-8-purinyl, 2-quinolizinyl, 3-isoquinolyl, 6-isoquinolyl, 7-isoquinolyl, 3-methoxy-6-isoquinolyl, 2-isoquinolyl, 6-quinolyl, 7-quinolyl, 2-methoxy-3-quinolyl, 2-methoxy-6-quinolyl, 6-phthalazinyl, 7-phthalazinyl, 1-methoxy-6-phthalazinyl, 1,4-dimethoxy-6-phthalazinyl, 1,8-naphthyridin-2-yl, 2-quinolinyl, 6-quinolinyl, 2,3-dimethyl-6-quinolinyl, 2,3-dimethoxy-6-quinolinyl, 2-quinazolinyl, 7-quinazolinyl, 2-dimethylamino-6-quinazolinyl, 3-cinnolinyl, 6-cinnolinyl, 7-cinnolinyl, 3-methoxy-7-cinnolinyl, 2-pteridinyl, 6-pteridinyl, 7-pteridinyl, 6,7-dimethoxy-2-pteridinyl, 2-carbazolyl, 3-carbazolyl, 9-methyl-2-carbazolyl, 9-methyl-3-carbazolyl, β-carbolin-3-yl, 1-methyl-β-carbolin-3-yl, 1-methyl-β-carbolin-6-yl, 3-phenanthridinyl, 2-acridinyl, 3-acridinyl, 2-perimidinyl, 1-methyl-5-perimidinyl, 5-phenanthroinyl, 6-phenanthroinyl, 1-phenazinyl, 2-phenazinyl, 3-isothiazolyl, 4-isothiazolyl, 5-isothiazolyl, 2-phenothiazinyl, 3-phenothiazinyl, 10-methyl-3-phenothiazinyl, 3-isoxazolyl, 4-isoxazolyl, 5-isoxazolyl, 4-methyl-3-furazanyl, 2-phenoxazinyl or 10-methyl-2-phenoxazinyl.

Preferred are heterocycles not comprising a N-atom, that is in particular heterocycles comprising O and/or S as heteroatoms, especially S; For example, thiienyl, furyl, benzo[b]thienyl, naphtho[2,3-b]thienyl, thianthrenyl, benzofuryl, dibenzofuryl, chromenyl, xanthonyl, thioxanthyl, phenoxathiinyl, 7-phenanthryl, anthraquinone-2-yl (= 9,10-dioxo-9,10-dihydroanthracen-
2-yl), 3-benzo[b]thienyl, 5-benzo[b]thienyl, 2-benzo[b]thienyl, 4-dibenzofuryl, 4,7-dibenzofuryl, 4-methyl-7-dibenzofuryl, 2-xanthenyl, 8-methyl-2-xanthenyl, 3-xanthenyl, 2-phenoxathiinyl, 2,7-phenoxathiinyl. 

In particular preferred are compounds of the formula I or Ia, respectively, wherein R and R' and R" as C₃₋C₆ heteroaryl are thiienyl or furyl, both of which are unsubstituted or are substituted by at least one C₁-C₄ alkyl and/or COT.

\[ C₇-C₁₀ cycloalkylenheteroaryl \] denotes a heteroaryl as described above with an annelated cycloalkyl (up to the corresponding number of C-atoms), for example

\[ \text{etc., interrupted } C₆-C₅ cycloalkylenheteroaryl \] for example etc.

\[ C₃-C₂ cycloalkylene \] is for example cyclopentylenyl, cyclohexylenyl, cyclooctylene, cyclocyclododecylene, especially cyclopentylenyl and cyclohexylenyl, preferably cyclohexylenyl. C₃-C₂ cycloalkylene in the context of the present application is to be understood as alkylene which at least comprises one ring. For example methyl-cyclopentylenyl, cyclopentylenyl, cyclohexylenyl, methyl- or dimethylcyclohexylenyl, cyclooctylene, especially cyclopentylenyl and cyclohexylenyl, preferably cyclohexylenyl. Further examples are structures like

\[ C₇-C₁₀ bicycloalkylene \] in the context of the present application is to be understood as alkylene which at least comprises two annelated rings. For example

\[ C₅-C₆ bicycloalkylene \] interrupted by one or more E with E defined as O, S, COO, OCO, CO, NR₅, NCOR₅, NR₅CO, CONR₅, OCOO, OCONR₅, NR₅COO, SO₂, SO, CR₅=CR₆ or \[ \text{etc..} \]
Cio-C\textsubscript{2}otricycloalkylene in the context of the present application is to be understood as alkylene which at least comprises three annelated rings. For example, 

\begin{center}
\includegraphics[width=0.3\textwidth]{example.png}
\end{center}


\textit{C}_{5}-\textit{C}_{2}\text{cycloalkenylen}, has one or more double bonds and is for example \textit{C}_{4}-\textit{C}_{6}\text{cycloalkenylen} or \textit{Ce-C}\textbeta\text{cycloalkenylen}. Examples are cyclopentenylen, cyclohexenylen or cyclooctenylen, especially cyclopentenylen and cyclohexenylen, preferably cyclohexenylen. \textit{C}_{5}-\textit{C}_{2}\text{cycloalkenylen} in the context of the present application is to be understood as alkenylene which at least comprises one ring. For example methylcyclopentenylen, dimethylcyclohexenylen etc. are also meant. 

\textit{C}_{7}-\textit{C}_{2}\text{bicycloalkenylen} in the context of the present application is to be understood as alkenylene which at least comprises two annelated rings. For example

\begin{center}
\includegraphics[width=0.3\textwidth]{example.png}
\end{center}

\textit{C}_{6}-\textit{C}_{4}\text{arylenen} is for example phenylene, 1-naphthylene, 2-naphthylene, anthrenylen or phenanthrylen, in particular phenylene.

\textit{C}_{8}-\textit{C}_{2}\text{cycloalkylenearylenen} denotes an arylene as defined above with an annelated cycloalkyl for example \includegraphics[width=0.3\textwidth]{example.png}, \textit{interrupted C}_{7}-\textit{C}_{15}\text{cycloalkylenearylenen} is for example \includegraphics[width=0.3\textwidth]{example.png}, etc.

\textit{C}_{5}-\textit{C}_{2}\text{heteroarylenen}, especially \textit{C}_{3}-\textit{C}_{2}\text{heteroarylenen}, in the context of the present invention is meant to comprise either one ring or a multiple ring system, e.g. a fused ring-system, as
described above for the corresponding C_{3}-C_{2}heteroaryl, wherein the C_{3}-C_{2}heteroaryl com-
prises an additional bond. Examples are thiénylene, benzo[b]thiénylene etc..

\( \text{C}_4\text{C}_5\text{cycloalkyleneheteroarylene} \) denotes a heteroarylene as described above with an anne-
liated cycloalkyl (up to the corresponding number of C-atoms), for example \( \text{C}_4\text{N}_2 \), etc., \( \text{interrupted C}_6\text{C}_{16}\text{cycloalkyleneheteroarylene} \) is for example \( \text{C}_4\text{N}_2 \), etc..

Examples for \( Y \) as an organic or inorganic anion are halogenide, \( \text{ClO}_4 \), \( \text{CN} \), hydrogenosul-
fate, trifluoroacetate; or for example non-nucleophilic anions, selected from the group (\( \text{BZ}_n \)),
(\( \text{SbZ}_n \)), (\( \text{AsZ}_n \)), (\( \text{PZ}_n \)), (\( \text{B(C}_6\text{H}_5\text{Z})_n \)), with \( Z \) denoting a halogen, in particular \( F \) or \( \text{Cl} \), pre-
ferably \( F \) and \( n \) and \( m \) independently from each other being an integer from 0 to 5, provided that the sum of \( n+m \) is 5, e.g. (\( \text{B(C}_6\text{Z})_n \)); \( \text{Ci-C}_2\text{alkylsulphonate} \), \( \text{Ci-C}_2\text{haloalkylsulphonate} \), \( \text{d -C}_2\text{operfluoroalkylsulphonate} \), unsubstituted \( \text{C}_6\text{Ci}_0\text{arylsulphonate} \), camphorsulphonate, \( \text{d -C}_2\text{operfluoroalkylsulphonylmethide} \), \( \text{d-C^-perfluoroalkylsulphonylimide} \), and \( \text{C}_6\text{-Ci_2haloalkyl} \), \( \text{Ci-C}_2\text{alkoxy} \), phenylsulphonyloxy, \( \text{Ci-C}_4\text{alkylphenylsulphonyloxy} \) or by \( \text{COOR} \); wherein \( R \) is \( \text{Ci-C}_2\text{alkyl} \), \( \text{phenyl} \), \( \text{benzyl} \) or \( \text{phenyl mono-} \) or \( \text{poly-substituted by} \)
\( \text{Ci-C}_2\text{alkyl} \), \( \text{Ci-C}_2\text{alkoxy} \) or by halogen; and \( M \) is as defined above; or \( Y \) is a carborane as for example disclosed by CA. Reed in Accounts of Chemical Research (1998), 31(3), 133-
139 or US 5278119.

\( \text{CrC}_{20}\text{Alkysulphonate} \) is \( R_x\text{SO}_3^- \) whereby \( R_x \) is linear or branched \( \text{Ci-C}_2\text{alkyl} \) as described above. Examples thereof include methylsulphonate, ethylsulphonate, propylsulphonate, pent-
ysulphonate and hexylsulphonate.

\( \text{C}_2\text{C}_{20}\text{Haloalkysulphonate} \) is \( R_x\text{SO}_3^- \) whereby \( R_x \) is halo-substituted \( \text{C}_2\text{C}_{20}\text{alkyl} \), \( \text{C}_2\text{Cl}_0^- \), \( \text{C}_2\text{-C}_6\text{-C}_8 \) or \( \text{C}_4\text{-C}_6\text{-alkyl} \). Examples thereof include \( \text{C}_2\text{F}_6\text{SO}_3^- \), \( \text{C}_4\text{F}_9\text{SO}_3^- \) and \( \text{C}_6\text{F}_{17}\text{SO}_3^- \).

\( \text{C}_6\text{Cl}_0\text{Arylsulphonate} \) is \( R_x\text{SO}_3^- \) whereby \( R_x \) is \( \text{C}_6\text{Cl}_0\text{aryl} \), e.g. phenyl or naphthyl. Alkyl-substituted arylysulphonates are, for example, toluenesulphonate, \( 2,4,6\)-trimethylbenzene-sulphonate, \( 2,4,6\)-tris(isopropyl)benzenesulphonate, \( 4\text{-tert-butylbenzenesulphonate} \) and \( 4\text{-dodecylbenzenesulphonate} \).

Halo-substituted arylysulphonates are, for example, 4-chlorobenzenesulphonate, \( 4\text{-fluoro-
benzenesulphonate} \), \( 2,4,6\text{-trifluorobenzenesulphonate} \) and \( 5\text{afluorobenzenesulphonate} \).
Camphorsulphonate is \[ \text{H}_3\text{C} - \text{CH}_3 \]

\[ \text{H}_2\text{C} - \text{SO}_3^- \]

$\text{Ci-C}_2\text{o-Perfluoroalkylsulphonylmethide is } R_d - \text{SO}_2\text{C}^- \text{SO}_2 R_e, \text{ Ci-C}_2\text{o-perfluoroalkylsulphonyl-} \]

$\text{SO}_2 R_f$

imide is $R_d - \text{SO}_2 N - \text{SO}_2 R_e$, wherein $R_d$, $R_e$ and $R_f$ independently of one another are $\text{d-C}_2\text{operfluoroalkyl which is unsubstituted or is substituted by } N(R_g) (R_h)$, or $R_d$, $R_e$ and $R_f$ arephenyl unsubstituted or preferably substituted by $\text{CF}_3$; or $R_d$ and $R_e$ together are $\text{CrC}_6$-perfluoroalkylene, which optionally is interrupted by $-\text{O}$; $R_d$ and $R_h$ independently of one another are $\text{d-C}_4$-alkyl; or $R_d$ and $R_h$ together are $\text{Ci-C}_2$-perfluoroalkylene, which optionally is interrupted by $O$ or $N(C, \text{Ci}_2\text{-Alkyl})$.

Perfluoroalkyl is alkyl which is fully substituted by fluoro, i.e. the hydrogen atoms of the alkyl radical are replaced by fluoro. The same applies for the perfluoroalkylene.

Examples of such anions are $(\text{C}_2\text{F}_5\text{SO}_2)_{2}\text{N}^-$, $(\text{C}_4\text{F}_9\text{SO}_2)_{2}\text{N}^-$, $(\text{C}_6\text{F}_5\text{SO}_2)\text{SC}^-$, $(\text{CF}_3\text{SO}_2)_{3}\text{C}^-$, $(\text{CF}_3\text{SO}_2)_{2}\text{N}^-$, $(\text{C}_4\text{F}_9\text{SO}_2)_{3}\text{C}^-$, $(\text{CF}_3\text{SO}_2)_{2}(\text{C}_4\text{F}_9\text{SO}_2)\text{C}^-$, $(\text{CF}_3\text{SO}_2)(\text{C}_4\text{F}_9\text{SO}_2)\text{N}^-$, $[\text{3,5-bis(CF}_3)\text{(C}_6\text{H}_3\text{SO}_2)_{2}\text{N}]^-$, $\text{F}_2\text{C} - \text{SO}_2\text{N}^- - \text{SO}_2 \text{CF}_3$, $\text{F}_2\text{C} - \text{SO}_2\text{N}^- - \text{SO}_2 \text{CF}_3$, $\text{F}_2\text{C} - \text{SO}_2\text{N}^- - \text{SO}_2 \text{CF}_3$, $\text{F}_2\text{C} - \text{SO}_2\text{N}^- - \text{SO}_2 \text{CF}_3$.

Such anions are known the person skilled in the art. The anions as well as their preparation are described e.g. in US 5554664.

Other anions, that are suitable as $Y$ in the context of the present invention are for example those as described in US 2005/0100819, page 12, [0122] to page 20, [0146], which disclosure hereby is incorporated by reference.

$Y$ as organic or inorganic anion, for example is halogen or a non-nucleophilic anion, selected from the group $\text{CrC}_4$-alkylsulphate, or perfluoroalkyl sulfonyl methides of the formula
R_d—SO\textsubscript{2}C—SO\textsubscript{2}R_e (wherein R_d, R_e and R_f independently of one another are d-
SO\textsubscript{2}R, C\textsubscript{F\textsubscript{2}}SO\textsubscript{2}CF\textsubscript{3}, (as Z is a halogen; and f is an integer from 1 to 8.


Y in particular is halogen or a non-nucleophilic anion, selected from the group Cr

C\textsubscript{2}alkylsulphate, R_5—SO\textsubscript{2}C—SO\textsubscript{2}R_e (wherein Z is a halogen, in particular fluoro; and f is an integer from 1 to 8.

For example Y is a halogen or a non-nucleophilic anion, selected from the group CrC\textsubscript{20}-perfluoroalkylsulphonilmethide, C\textsubscript{F\textsubscript{2}}F\textsubscript{2}SO\textsubscript{3}\textsuperscript{−}, (as Z is a halogen, in particular fluoro; and f is an integer from 1 to 8.

Y in particular is halogen or a non-nucleophilic anion, selected from the group C\textsubscript{F\textsubscript{2}}F\textsubscript{2}SO\textsubscript{3}\textsuperscript{−}, (BF\textsubscript{4})\textsuperscript{−}, (SbF\textsubscript{6})\textsuperscript{−}, (AsF\textsubscript{6})\textsuperscript{−}, (PF\textsubscript{6})\textsuperscript{−} and (B(C\textsubscript{6}F\textsubscript{3})\textsubscript{4})\textsuperscript{−}; wherein f is an integer from 1 to 8.

M as an organic or inorganic cation, for example is Li, Na, K, Cs, N(R_m)\textsubscript{4}, N(R_m)\textsubscript{3}R_n, N(R_m)\textsubscript{2}R_nR_0, P(R_m)\textsubscript{4}, P(R_m)\textsubscript{3}R_n, P(R_m)\textsubscript{2}R_nR_0, S(R_m)\textsubscript{3}R_n, S(R_m)\textsubscript{2}R_nR_0 or SR_mR_nR_0.

M preferably is Li, Na, K, N(R_m)\textsubscript{4}, N(RJ\textsubscript{3})\textsubscript{3}R_n, N(RJ\textsubscript{3})\textsubscript{2}R_nR_0, S(R_m)\textsubscript{3}R_n, S(RJ\textsubscript{2})\textsubscript{2}R_n, SR_mR_nR_0; in particular Na, K, N(RJ\textsubscript{4}), N(RJ\textsubscript{3})\textsubscript{3}R_n, S(RJ\textsubscript{3})\textsubscript{3}R_n or S(RJ\textsubscript{2})\textsubscript{2}R_n.

R_m, R_n and R_0 independently of one another are CrC\textsubscript{20}alkyl, phenyl or phenyl which is substituted by one or more Cl-C\textsubscript{4}alkyl.
The terms "and/or" or "or/and" in the present context are meant to express that not only one of
the defined alternatives (substituents) may be present, but also several of the defined alterna-
tives (substituents) together, namely mixtures of different alternatives (substituents).
The term "at least" is meant to define one or more than one, for example one or two or three,
preferably one or two.
The term "optionally substituted" means that the radical to which it refers is either unsubsti-
tuted or substituted.
Throughout this specification and the claims which follow, unless the context requires other-
wise, the word "comprise", or variations such as "comprises" or "comprising", will be under-
stood to imply the inclusion of a stated integer or step or group of integers or steps but not the
exclusion of any other integer or step or group of integers or steps.
The preferences referring to the compounds of the formula I (la) as given hereinbefore and in
the context of the whole text, are intended not to refer to the compounds as such only, but to
all categories of the claims. That is to the compositions comprising the compounds of the for-

mula I, as well as the use or process claims in which said compounds are employed.

Another embodiment of the invention are compounds of the formula I as defined above,
wherein $L_1$, $U_1$, $L''_1$, $L''_2$, $L'_2$, $L'_3$, $L''_3$, $L'_4$, $L''_4$, and $L''_4$ independently of one another
are hydrogen, $R_1$, OR, or halogen; and $X$ is O or S.

Preferred are compounds of the formula I as defined above, wherein
$X$ is O or S;
$L_1$ and $L_2$, if $X$ is O then $L_1$, $L_2$ independently of each other are $R_1$, OR, or halogen; if $X$ is S,
then $L_1$, $L_2$ are independently of each other hydrogen, $R_1$, OR, or halogen; and

$L_3$ and $L_4$ are hydrogen.

Especially preferred are compounds of the formula I as defined above, wherein, if $X$ is O
then $L_1$ and $L_2$ independently of each other are CrC$_{12}$alkyl, C$_7$-C$_9$phenylalkyl, C$_5$-
C$_{12}$cycloalkyl, CrC$_{12}$alkoxy, C$_5$-C$_{12}$cycloalkoxy, phenyl or halogen; if $X$ is S, then $L_1$ and $L_2$

independently of each other are hydrogen, $R_1$, OR, halogen.

Preferred further are such compounds of the formula I, wherein
$L_i$, $L_2$, $L_3$ and $L_4$ independently of one another are hydrogen or an organic substituent;
R is C₃₋₇ heteroaryl or T; and, if both L₁ and L₂ are phenyl or cyclohexyl, R additionally denotes hydrogen;
X is O, S, NRₐ or NCORₐ;

Further preferred are compounds of the formula I, wherein
L₁ and L₂, L'i and L''₁, L''₂ independently of one another are are as defined above, except hydrogen; and
L₃ and L₄, L'_3 and L'_4, L''₃ and L''₄ independently of one another are as defined above; and all other substituents are as defined above (or below in preferred embodiments).

Other preferred compounds are of the formula I as defined above, wherein
T is CR₄-C₇ alkyl, CR₄-C₂₀ alkenyl, CR₄-C₂₀ alkyl substituted by one or more D, CR₄-C₂₀ alkyl interrupted by one or more E, CR₄-C₂₀ alkyl substituted by one or more D and interrupted by one or more E;
X is O or S;
D is hydrogen, R₅, OR₅, halogen, O-glycidyl, O-vinyl, O-allyl, COR₅, COOR₅, OCOOR₅, or OCOOR₅;
E is O, COO, OCO, CO, phenylene, C₅₋₇ cycloalkylene or CR₂=CR₃.

Particularly preferred are compounds of the formula I as defined above, wherein
L₃ and L₄ are hydrogen; and L₁, L₂ independently of one another are hydrogen or CR₄ alkyl;
L is hydrogen, R₁, OR₁, SRI, halogen, NO₂, CN, COOR₁, OCOR₁, OCOOR₁, COOT or COT;
X is O, S, CR₄R₅ or a single bond, provided that if X is O, R is not pyridinyl; and
R₁ has one of the meanings given for T as defined in claim 1.

The compounds according to the present invention can for example be prepared by reacting a compound of the formula II with a thionylhalogenide, especially thionylchloride in the presence of a Friedel-Crafts catalyst:

\[
\begin{align*}
R \quad X & \quad + \quad SOCl₂ \quad \xrightarrow{\text{AlCl₃}} \quad \begin{bmatrix}
L₁ & L₂ & L₃ \\
L₄ & H & L₅
\end{bmatrix} \\
\end{align*}
\]

where \( R \), \( L₁, L₂, L₃, L₄ \) and \( X \) are as defined above.
If compounds of the formula I, wherein $L$, $U_1$, $L''_1$, $L_2$, $L''_2$, $L_3$, $L''_3$, $L_4$, $L'_4$ and $L_4$ are not identical, mixtures of compounds of the formula (II), (II') and/or (N") are employed in the above reaction:

wherein $R$, $R'$, $X$, $X'$, $X''$, $L$, $U_1$, $L''_1$, $L_2$, $L''_2$, $L_3$, $L''_3$, $L_3$, $L_4$, $L'_4$ and $L_4$ are as defined above.

Preferably, the compounds according to the present invention can for example be prepared by reacting a compound of the formula Na, that is a compound of the formula II, wherein $R$ is hydrogen, with a thionylhalogenide, especially thionylchloride in the presence of a Friedel-Crafts catalyst, with a subsequent substitution reaction of the hydrogen with $R$ as defined above however other than hydrogen:

$$
\begin{align*}
\text{(IIa)} & \quad \text{H-}X- \quad + \quad \text{SOCl}_2 \quad \xrightarrow{\text{AlCl}_3} \quad \text{H-}X- \quad + \quad \text{S}^\text{+} \quad \text{Cl}^- \\
\text{(Ia)} & \quad \text{optionally base} \quad \xrightarrow{\text{RY'}} \quad \text{R-}X- \quad \text{Y'} \\
\text{(I)} & \quad \text{cf. wr} \quad \text{srein}
\end{align*}
$$

wherein $R$, $L_1$, $L_2$, $L_3$, $L_4$ and $X$ are as defined above and $Y'$ is halogenide, mesylate, tosylate, $\text{OR}_2$ or NCO.

If compounds wherein $L$, $L''_1$, $L''_1$, $L_2$, $L''_2$, $L_3$, $L''_3$, $L_4$, $L'_4$ and $L_4$ are not identical, mixtures of compounds of the formula (Na), (Na') and/or (Na") are employed in the above reaction:

wherein $X$, $X'$, $X''$, $L$, $U_1$, $L''_1$, $L_2$, $L''_2$, $L_3$, $L''_3$, $L_4$, $L'_4$ and $L_4$ are as defined above.

The reaction suitably is carried out in the presence of a Friedel-Crafts catalyst. Friedel-Crafts catalysts can be Lewis acids and/or strong Bronsted acids. Such catalysts are known to the person skilled in the art and published in textbooks of chemistry. The catalysts used for
Friedel-Crafts reactions for example are described in *George A. Olah, Friedel-Crafts and Related Reactions, Vol. I*, 201 and 284-90 (1963). Aluminium trihalides such as AlBr₃ and AlCl₃ are particularly suitable, especially AlCl₃.


Zeolite catalysts in Friedel Crafts reactions are for example disclosed *J. Molecular Catalysis: Chemical* 1998, 134, 121, *Applied Catalysis A: General*, 2000, 201, 159, while the use of clays or exchanged clays is known from US 4304941.

The application of heteropoly acids or heteropoly acid-containing solid supports is for example described in *Journal of Molecular Catalysis A: Chemical* 2004, 209(1-2), 189.

Mixtures of Friedel-Crafts catalysts can be used and mixtures of Friedel-Crafts catalysts with salts like MY or more specifically MPF₆ or more interestingly with NaPF₆ or KPF₆ can be used.

The preparation process conveniently is carried out in a solvent. However it is also possible, for example, to use the aromatic hydrocarbon of formula II or III itself, when liquid, as solvent, in which case it is used in excess. It will be readily understood that the process can also be carried out in inert solvents. Suitable solvents are, for example, the solvents described in *George A. Olah, Friedel-Crafts and Related Reactions, Vol. I*, 298-302 (1963). The choice of the respective solvent depends on the solubility of the educts and catalysts. Typical examples of solvents which may be used in the process are halogenated hydrocarbons such as chlorobenzene, dichlorobenzene, carbon tetrachloride, dichloromethane, tetrachloroethylene, bromobenzene, aromatic hydrocarbon derivatives such as nitrobenzene, dinitrobenzene, benzene and toluene, saturated aliphatic hydrocarbons such as pentane, hexane, heptane and the mixtures of isomers thereof, petroleum ether or cyclohexane, or further solvents, typically carbon disulfide, nitroalkanes such as nitromethane, diethyl ether, dimethyl sulfoxide or tetramethylene sulfone.

Dichloromethane, chlorobenzene and dichlorobenzene are preferred solvents.
The process is generally carried out by mixing the educt compound of formula \( \text{I} \) or \( \text{Na} \) with the thionylchloride and reacting said educts in a suitable vessel, which is optionally provided with a heating means. The reaction optionally is carried out under inert conditions, i.e. the vessel should be equipped with appropriate means to create said atmosphere by for example working in an atmosphere of nitrogen. Other inert gases, as for example Ar or He, could also be employed. The person skilled in the art is familiar with these facts.

The reaction of the compound of the formula \( \text{II} \) \( [\text{II}^1, (\text{II}^\prime)] \) or \( \text{Na} \) \( [(\text{Na}^1), (\text{Na}^\prime)] \) with the thionylchloride can be carried out in different manner. Representative, but not exclusive examples are given below.

a) the compound of formula \( \text{II} \) \( [\text{II}^1, (\text{II}^\prime)] \) or \( \text{Na} \) \( [(\text{Na}^1), (\text{Na}^\prime)] \) is placed, together with the catalyst and the thionylchloride, in the reaction vessel and is immediately cooled or heated to the final reaction temperature, or

b) the compound of formula \( \text{II} \) \( [\text{II}^1, (\text{II}^\prime)] \) or \( \text{Na} \) \( [(\text{Na}^1), (\text{Na}^\prime)] \), together with the catalyst and the thionylchloride, is placed in the reaction vessel and cooled or heated slowly during the reaction to the final temperature, or

c) the thionylchloride is added during the reaction, to the compound of formula \( \text{II} \) \( [\text{II}^1, (\text{II}^\prime)] \) or \( \text{Na} \) \( [(\text{Na}^1), (\text{Na}^\prime)] \) and the catalyst which have been previously cooled or heated to the reaction temperature,

d) the catalyst is suspended in a minimum amount of either one or both of the starting materials and then the reactants are added subsequently in any order or are added together.

The reaction vessel also may for example consist of a column that is filled with the catalyst and the thionylchloride and the compound of formula \( \text{II} \) \( [\text{II}^1, (\text{II}^\prime)] \) or \( \text{Na} \) \( [(\text{Na}^1), (\text{Na}^\prime)] \) are pumped (e.g. continuously) over the catalyst through the column.

A further possibility is to bring the reactants together via a reactive distillation, which is a process in which a catalytic chemical reaction and distillation occur simultaneously in a single apparatus.

The mol ratio of the compound of formula \( \text{II} \) \( [\text{II}^1, (\text{II}^\prime)] \) or \( \text{Na} \) \( [(\text{Na}^1), (\text{Na}^\prime)] \) to the thionylhalogenide in the above reaction is for example from 10:1 to 1:1; 10:1 to 1:2; or is 10:1 , 5:1 , 4:1 , 3.5 :1, 3:2, 3:1 , 1:1 or 1:2, preferably 3:1.
The reaction temperatures in principle depend on the boiling point of the educts and solvents that are employed in the reaction. Said temperature is conveniently in the range from -20°C to about 200°C, for example from -20°C to 140°C or from -20°C to 100°C, in particular from -20°C to 80°C, preferably from -10°C to 80°C, most preferably from 0°C to 60°C.

The substitution of hydrogen with R=other than hydrogen can for example be done in a solvent as e.g. formamide, acetone, methyl ethyl ketone, dimethylformamide, water, optionally in the presence of a base as e.g. tributylamine, potassium carbonate, sodium carbonate, sodium hydroxide, triethylamine, sodium acetate, at reaction temperatures between 0°C and 100°C. The person skilled in the art knows how to alkylate and acylate functional groups as OH, SH and NR₃H.

To prepare compounds of the formula I where Y is other than e.g. Cl, the chloride compound is reacted to the compound with the wanted anion by a conventional ion exchange reaction, known to the person skilled in the art. The anion Y may be already present during the Friedel-Crafts reaction.

It is of course also possible to synthesize the compounds of formula I via a stepwise synthesis through a diaryl-sulfoxide intermediate (synthesis of diarylsulphoxides from arenes and thionylchloride: Oae and Zalut, J. Am. Chem. Soc. 82, 5359 (1960), synthesis of diarylsulphoxides from diarylsulphides via oxidation: Drabowicz and Mikolajczyk, Org. Prep. Proced. Int. 14, 45-89 (1982)), which is then further reacted under the following conditions with a third compound of formula (M') to get a compound of formula (I). Again, the anion can then be exchanged optionally to an anion Y:

25

\[
\begin{align*}
\text{(II)} & \quad \text{catalyst} \quad \text{SOCl}_2 \\
\text{(III)} & \quad \text{(I)} \\
\text{(III)} & \quad \text{catalyst} \quad Y \\
\end{align*}
\]

In the case where R is hydrogen, the resulting product (Ia) is for example subsequently substituted by RY' as described above.
The introduction of the third compound of formula (II) in the reaction scheme depicted above can be done in a strongly acidic medium, followed by metathesis with a salt of the desired anion. Several strong acids are available as solvents, for example, sulfuric acid, polyphosphoric acid, methanesulfonic acid, or gaseous hydrogen chloride (US 3488378). Mixtures of methanesulfonic acid and phosphorus pentoxide (J.Org. Chem 1990, 55, 4222), or acetic anhydride and sulphuric acid, or methanesulfonic anhydride are also known. Typical conditions for these methods are temperatures between -50 and +100°C. Higher temperatures are usually not useful, because of secondary reactions, such as, for example, sulfonation of one aromatic ring. Lewis acids, such as aluminum chloride in terachloroethylene (WO 03/008404) can also be used. Usually, the sulfonium salt obtained by these methods has as counter-anion the anion derived from one of the acids, for instance, a hydrogenosulfate, methanesulfonate, or trifluoromethanesulfonate.

Conditions without metathesis, such as arylation in acetic acid /acetic anhydride /sulfuric acid in the presence of potassium hexafluorophosphate or aqueous 75% HPF₆ are described for example in US 2004/0030 158-A.

The starting compounds of formula I [(N'), (N'')] or Na [(Na'), (Na'')] are for example commercially available, known to the person skilled in the art, or can be synthesized easily by the person skilled in the art.

Accordingly, subject of the invention also is a process for the preparation of a compound of the formula I, by reacting

a compound of the formula II

or mixtures of compounds of the formula II, II' and/or II''
R, R₁, R*, X, X', X'', L₁, L₁', L₁'', L₂, U₂, L₂, L₃, L₃', L₃'', L₄, L₄', and L₄'' are as defined above, with thionylchloride in the presence of a Friedel-Crafts catalyst, optionally followed by an exchange of the anion Y.

5 The compounds of the formula I are used as photolatent acids, i.e compounds that upon irradiation release an acid.

Accordingly, an object of the invention is a radiation-sensitive composition comprising
(a1) a cationically or acid-catalytically polymerisable or crosslinkable compound or
(a2) a compound that increases its solubility in a developer under the action of acid; and/or
10 (ax) a radically polymerisable or crosslinkable compound; and
(b) at least one compound of the formula I according to claim 1; as well as
a radiation-sensitive composition, additionally to components (a1) or (a2) and/or (ax) and (b),
comprising additives (c) and/or sensitiser compounds (d) and optionally further photoinitiators
(e).

Further subject of the invention is the use of a compound of formula I as described above as photolatent acid donor in the polymerisation or crosslinking of cationically or acid-catalytically polymerisable or crosslinkable compounds or to increase the solubility of compounds that increase their solubility in a developer under the action of acid.

20 The compositions according to the invention comprise as component (a1), for example, resins and compounds that can be cationically polymerised by alkyl- or aryl-containing cations or by protons. Examples thereof include cyclic ethers, especially epoxides and oxetanes, and also vinyl ethers and hydroxy-containing compounds. Lactone compounds and cyclic thioethers as well as vinyl thioethers can also be used. Further examples include aminoplastics or phenolic resole resins. These are especially melamine, urea, epoxy, phenolic, acrylic, polyester and alkyd resins, but especially mixtures of acrylic, polyester or alkyd resins with a melamine resin. These include also modified surface-coating resins, such as, for example, acrylic-modified polyester and alkyd resins. Examples of individual types of resins that are included under the terms acrylic, polyester and alkyd resins are described, for example, in Wagner, Sarx/Lackkunstharze (Munich, 1971), pages 86 to 123 and 229 to 238, or in Ullmann/Encyclopadie der techn. Chemie, 4th edition, volume 15 (1978), pages 613 to 628, or Ullmann’s Encyclopedia of Industrial Chemistry, Verlag Chemie, 1991, Vol. 18, 360 ff., Vol. A19, 371 ff. The surface-coating preferably comprises an amino resin. Examples thereof
include etherified and non-etherified melamine, urea, guanidine and biuret resins. Of special importance is acid catalysis for the curing of surface-coatings comprising etherified amino resins, such as, for example, methylated or butylated melamine resins (N-methoxymethyl- or N-butoxymethyl-melamine) or methylated/butylated glycolurils.

It is possible, for example, to use all customary epoxides, such as aromatic, aliphatic or cycloaliphatic epoxy resins. These are compounds having at least one, preferably at least two, epoxy group(s) in the molecule. Examples thereof are the glycidyl ethers and β-methyl glycidyl ethers of aliphatic or cycloaliphatic diols or polyols, e.g. those of ethylene glycol, propane-1,2-diol, propane-1,3-diol, butane-1,4-diol, diethylene glycol, polyethylene glycol, propylene glycol, glycerol, trimethylolpropane or 1,4-dimethylolcyclohexane or of 2,2-bis(4-hydroxy cyclohexyl)propane and N,N-bis(2-hydroxyethyl)aniline; the glycidyl ethers of di- and poly-phenols, for example of resorcinol, of 4,4'-dihydroxyphenyl-2,2-propane, of novolaks or of 1,1,2,2-tetrakis(4-hydroxyphenyl)ethane. Examples thereof include phenyl glycidyl ether, p-tert-butyl glycidyl ether, o-icresyl glycidyl ether, polytetrahydrofuran glycidyl ether, n-butyl glycidyl ether, 2-ethylhexylglycidylether, C_{12}-isalkyl glycidyl ether and cyclohexanediethanol diglycidyl ether. Further examples include N-glycidyl compounds, for example the glycidyl compounds of ethyleneurea, 1,3-propyleneurea or 5-dimethyl-hydantoin or of 4,4'-methylene-5,5'-tetramethylidihydantoin, or compounds such as triglycidyl isocyanurate.

Further examples of glycidyl ether components (a1) that are used in the formulations according to the invention are, for example, glycidyl ethers of polyhydric phenols obtained by the reaction of polyhydric phenols with an excess of chlorohydrin, such as, for example, epichlorohydrin (e.g. glycidyl ethers of 2,2-bis(2,3-epoxypropoxyphenol)propane. Further examples of glycidyl ether epoxides that can be used in connection with the present invention are described, for example, in US 3 018 262 and in "Handbook of Epoxy Resins" by Lee and Neville, McGraw-Hill Book Co., New York (1967).

There is also a large number of commercially available glycidyl ether epoxides that are suitable as component (a1), such as, for example, glycidyl methacrylate, diglycidyl ethers of bisphenol A, for example those obtainable under the trade names EPON 828, EPON 825, EPON 1004 and EPON 1010 (Shell); DER-331, DER-332 and DER-334 (Dow Chemical); 1,4-butanediol diglycidyl ethers of phenolformaldehyde novolak, e.g. DEN-431, DEN-438 (Dow Chemical); and resorcinol diglycidyl ethers; alkyl glycidyl ethers, such as, for example, C_5-C_10 glycidyl ethers, e.g. HELOXY Modifier 7, C_{12}-C_{14} glycidyl ethers, e.g. HELOXY Modifier
8, butyl glycidyl ethers, e.g. HELOXY Modifier 61, cresyl glycidyl ethers, e.g. HELOXY Modifier 62, p-tert-butylphenyl glycidyl ethers, e.g. HELOXY Modifier 65, polyfunctional glycidyl ethers, such as diglycidyl ethers of 1,4-butanediol, e.g. HELOXY Modifier 67, diglycidyl ethers of neopentyl glycol, e.g. HELOXY Modifier 68, diglycidyl ethers of cyclohexanedi-methanol, e.g. HELOXY Modifier 107, trimethylolethane triglycidyl ethers, e.g. HELOXY Modifier 44, trimethylolpropane triglycidyl ethers, e.g. HELOXY Modifier 48, polyglycidyl ethers of aliphatic polyols, e.g. HELOXY Modifier 84 (all HELOXY glycidyl ethers are obtainable from Shell).

Also suitable are glycidyl ethers that comprise copolymers of acrylic esters, such as, for example, styrene-glycidyl methacrylate or methyl methacrylate-glycidyl acrylate. Examples thereof include 1:1 styrene/glycidyl methacrylate, 1:1 methyl methacrylate/glycidyl acrylate, 62.5:24:13.5 methyl methacrylate/ethyl acrylate/glycidyl methacrylate.

The polymers of the glycidyl ether compounds can, for example, also comprise other functionalities provided that these do not impair the cationic curing.

Other glycidyl ether compounds suitable as component (a1) that are commercially available are polyfunctional liquid and solid novolak glycidyl ether resins, e.g. PY 307, EPN 1179, EPN 1180, EPN 1182 and ECN 9699.

It will be understood that mixtures of different glycidyl ether compounds may also be used as component (a1).

The glycidyl ethers (a1) are, for example, compounds of formula XX

\[ \begin{array}{c}
R \quad \left[ \begin{array}{c}
H \\
O
\end{array} \right] \\
\quad \begin{array}{c}
CH_2O-J-R \\
s_0
\end{array}
\end{array} \]  

(XX), wherein

x is a number from 1 to 6; and

R_sO is a mono- to hexavalent alkyl or aryl radical.

Preference is given, for example, to glycidyl ether compounds of formula XX, wherein

x is the number 1, 2 or 3; and

R_sO when x = 1, is unsubstituted or d-C^alkyl-substituted phenyl, naphthyl, anthracyl, biphenyl, CrC_2oalkyl, or C_2-C_2oalkyl interrupted by one or more oxygen atoms, or

R_sO when x = 2, is 1,3-phenylene, 1,4-phenylene, C_6-C_10cycloalkylene, unsubstituted or halosubstituted Ci-C_4alkylene, C_2-C_4oalkylene interrupted by one or more oxygen atoms, or a group

\[ \begin{array}{c}
R_{11}
\end{array} \], or
When \( x = 3 \), is a radical \( \text{C}_3\text{H}_5 \), \( \text{C}_3\text{H}_3 \), or \( \text{C}_3\text{H}_3 \); and

\[ \text{R}_5 \text{O} \]

is a number from 1 to 10; and

\[ \text{R}_6 \text{O} \]

is \( \text{Ci-C}_2\text{Oalkylene}, \) oxygen or

The glycidyl ethers \((a1)\) are, for example, compounds of formula \(XXa\)

\[ \text{R}_5\text{O-C} \hspace{1cm} \text{H}_2 \hspace{1cm} \text{C}_2\text{OCH}_2 \hspace{1cm} (XXa), \text{ wherein} \]

\[ \text{R}_7 \]

is unsubstituted or \( d\text{-C}^\text{alkyl}-\text{substituted} \) phenyl; naphthyl; anthracyl; biphenyl;

\[ \text{CrC}_2\text{Oalkyl, C}_2\text{-C}_2\text{Oalkyl interrupted by one or more oxygen atoms; or a group of formula} \]

\[ \text{H}_2\text{C} \hspace{1cm} \text{C-OCH}_2 \hspace{1cm} \text{H}_2 \hspace{1cm} \text{R}_5 \]

\[ \text{R}_5 \]

is phenylene, \( \text{Ci-C}_2\text{Oalkylene, C}_2\text{-C}_2\text{Oalkylene interrupted by one or more oxygen atoms,} \)

or a group \( \text{H}_2\text{C} \hspace{1cm} \text{C-OCH}_2 \hspace{1cm} \text{H}_2 \hspace{1cm} \text{R}_5 \)

\[ \text{R}_5 \]

is \( \text{Ci-C}_2\text{Oalkylene or oxygen.} \)

Preference is given to the glycidyl ether compounds of formula \(XXb\)

\[ \text{O} \hspace{1cm} \text{H}_2\text{C} \hspace{1cm} \text{C-OCH}_2 \hspace{1cm} \text{H}_2\text{O-R} \hspace{1cm} \text{TO-C-C} \hspace{1cm} \text{H}_2\text{O} \hspace{1cm} (XXb), \text{ wherein} \]

\[ \text{R}_5 \]

is phenylene, \( \text{Ci-C}_2\text{Oalkylene, C}_2\text{-C}_2\text{Oalkylene interrupted by one or more oxygen atoms,} \)

or a group \( \text{H}_2\text{C} \hspace{1cm} \text{C-OCH}_2 \hspace{1cm} \text{H}_2\text{O-R} \hspace{1cm} \text{TO-C-C} \hspace{1cm} \text{H}_2\text{O} \)

\[ \text{R}_5 \]

is \( \text{Ci-C}_2\text{Oalkylene or oxygen.} \)

Further examples for component \((a1)\) are polyglycidyl ethers and poly(\(\beta\text{-methylglycidyl})\) ethers obtainable by the reaction of a compound containing at least two free alcoholic and/or phenolic hydroxy groups per molecule with the appropriate epichlorohydrin under alkaline conditions, or alternatively in the presence of an acid catalyst with subsequent alkali treatment. Mixtures of different polyols may also be used.
Such ethers can be prepared with poly(epichlorohydrin) from acyclic alcohols, such as ethylene glycol, diethylene glycol and higher poly(oxyethylene) glycols, propane-1,2-diol and poly(oxypropylene) glycols, propane-1,3-diol, butane-1,4-diol, poly(oxytetramethylene) glycols, pentane-1,5-diol, hexane-1,6-diol, hexane-2,4,6-triol, glycerol, 1,1,1-trimethylol-propane, pentaerythritol and sorbitol, from cycloaliphatic alcohols, such as resorcinol, quinitol, bis(4-hydroxycyclohexyl)methane, 2,2-bis(4-hydroxycyclohexyl)propane and 1,1-bis-(hydroxyethyl)cyclohex-3-ene, and from alcohols having aromatic nuclei, such as N,N-bis(2-hydroxyethyl)aniline and p,p'-bis(2-hydroxyethylamino)diphenylmethane. They can also be prepared from mononuclear phenols, such as resorcinol and hydroquinone, and polynuclear phenols, such as bis(4-hydroxyphenyl)methane, 4,4-dihydroxydiphenyl, bis(4-hydroxyphenyl)sulphone, 1,1,2,2-tetrakis(4-hydroxyphenyl)ethane, 2,2-bis(4-hydroxyphenyl)-propane (bis-phenol A) and 2,2-bis(3,5-dibromo-4-hydroxyphenyl)propane.

Further hydroxy compounds suitable for the preparation of polyglycidyl ethers and poly(β-methylglycidyl) ethers are the novolaks obtainable by the condensation of aldehydes, such as formaldehyde, acetaldehyde, chloral and furfural, with phenols, such as, for example, phenol, o-cresol, m-cresol, p-cresol, 3,5-dimethylphenol, 4-chlorophenol and 4-tert-butylphenol.

Poly(N-glycidyl) compounds can be obtained, for example, by dehydrochlorination of the reaction products of epichlorohydrin with amines containing at least two aminohydrogen atoms, such as aniline, n-butylamine, bis(4-aminophenyl)methane, bis(4-aminophenyl)-propane, bis-(4-methylaminophenyl)methane and bis(4-aminophenyl) ether, sulphone and sulphoxide. Further suitable poly(N-glycidyl) compounds include triglycidyl isocyanurate, and N,N'-diglycidyl derivatives of cyclic alkylenecreas, such as ethyleneurea and 1,3-propyleneurea, and hydantoins, such as, for example, 5,5-dimethylhydantoin.

Poly(S-glycidyl) compounds are also suitable. Examples thereof include the di-S-glycidyl derivatives of dithiols, such as ethane-1,2-dithiol and bis(4-mercaptopmethylphenyl) ether.

There also come into consideration as component (a1) epoxy resins in which the glycidyl groups or β-methyl glycidyl groups are bonded to hetero atoms of different types, for example the N,N,O-triglycidyl derivative of 4-aminophenol, the glycidyl ether/glycidyl ester of salicylic acid or p-hydroxybenzoic acid, N-glycidyl-N'-[(2-glycidyloxypropyl)-5,5-dimethylhydantoin and 2-glycidyloxy-1,3-bis(5,5-dimethyl-1-glycidylhydantoin-3-yl)propane.
Preference is given to diglycidyl ethers of bisphenols. Examples thereof include diglycidyl ethers of bisphenol A, e.g. ARALDIT® GY 250, diglycidyl ethers of bisphenol F and diglycidyl ethers of bisphenol S. Special preference is given to diglycidyl ethers of bisphenol A.

Further glycidyl compounds of technical importance are the glycidyl esters of carboxylic acids, especially di- and poly-carboxylic acids. Examples thereof are the glycidyl esters of succinic acid, adipic acid, azelaic acid, sebacic acid, phthalic acid, terephthalic acid, tetra- and hexa-hydrophthalic acid, isophthalic acid or trimellitic acid, or of dimerised fatty acids.

Examples of polyepoxides that are not glycidyl compounds are the epoxides of vinylcyclohexane and dicyclopentadiene, 3-(3',4'-epoxycyclohexyl)-8,9-epoxy-2,4-dioxaspiro-[5.5]undecane, the 3',4'-epoxycyclohexylmethyl esters of 3,4-epoxycyclohexane carboxylic acid, (3,4-epoxycyclohexyl-methyl 3,4-epoxycyclohexanecarboxylate), butadiene diepoxide or isoprene diepoxide, epoxidised linoleic acid derivatives or epoxidised polybutadiene.

Further suitable epoxy compounds are, for example, limonene monoxide, epoxidised soybean oil, bisphenol-A and bisphenol-F epoxy resins, such as, for example, Araldit® GY 250 (A), ARALDIT® GY 282 (F), ARALDIT® GY 285 (F)), and photocurable siloxanes that contain epoxy groups.

Further suitable cationically polymerisable or crosslinkable components (a1) can be found, for example, also in US 3117099, US 4299938 and US 4339567.

From the group of aliphatic epoxides there are suitable especially the monofunctional symbol \(\alpha\)-olefin epoxides having an unbranched chain consisting of 10, 12, 14 or 16 carbon atoms.

Because nowadays a large number of different epoxy compounds are commercially available, the properties of the binder can vary widely. One possible variation, for example depending upon the intended use of the composition, is the use of mixtures of different epoxy compounds and the addition of flexibilisers and reactive diluents.

The epoxy resins can be diluted with a solvent to facilitate application, for example when application is effected by spraying, but the epoxy compound is preferably used in the solventless state. Resins that are viscous to solid at room temperature can be applied hot.
Also suitable as component (a1) are all customary vinyl ethers, such as aromatic, aliphatic or cycloaliphatic vinyl ethers and also silicon-containing vinyl ethers. These are compounds having at least one, preferably at least two, vinyl ether groups in the molecule. Examples of vinyl ethers suitable for use in the compositions according to the invention include triethylene glycol divinyl ether, 1,4-cyclohexanediol divinyl ether, 4-hydroxybutyl vinyl ether, the propenyl ether of propylene carbonate, dodecyl vinyl ether, tert-butyl vinyl ether, tert-amyl vinyl ether, cyclohexyl vinyl ether, 2-ethylhexyl vinyl ether, ethylene glycol monovinyl ether, butanediol monovinyl ether, hexanediol monovinyl ether, 1,4-cyclohexanediol monovinyl ether, diethylene glycol monovinyl ether, ethylene glycol divinyl ether, ethylene glycol butylvinyl ether, butane-1,4-diol divinyl ether, hexanediol divinyl ether, diethylene glycol divinyl ether, triethylene glycol divinyl ether, triethylene glycol methylvinyl ether, tetra-ethylene glycol divinyl ether, pluriol-E-200 divinyl ether, polytetrahydrofuran divinyl ether-290, trimethylolpropane trivinyl ether, dipropylene glycol divinyl ether, octadecyl vinyl ether, (4-cyclohexylmethyleneoxyethene)-glutaric acid methyl ester and (4-butoxyethene)-iso-phthalic acid ester.

Examples of hydroxy-containing compounds include polyester polyols, such as, for example, polycaprolactones or polyester adipate polyols, glycols and polyether polyols, castor oil, hydroxy-functional vinyl and acrylic resins, cellulose esters, such as cellulose acetate butyrate, and phenoxy resins.

Further cationically curable formulations can be found, for example, in EP 119425.

As component (a1), preference is given to cycloaliphatic epoxides, or epoxides based on bisphenol A.

Accordingly, the invention relates also to a radiation-sensitive composition wherein component (a1) is at least one compound selected from the group of cycloaliphatic epoxy compounds, glycidyl ethers, oxetane compounds, vinyl ethers, acid-crosslinkable melamine resins, acid-crosslinkable hydroxymethylene compounds and acid-crosslinkable alkoxy-methylene compounds.

If desired, the composition according to the invention can also contain free-radically polymerisable components, such as ethylenically unsaturated monomers, oligomers or polymers. These radically polymerizable components may be added to either component (a1) or com-
ponent (a2). Said radically curable components may, however, also be part of (a1) or (a2), see description of (A1), (A2) and (A3), components comprising both, radically crosslinking and cationically crosslinking groups, further below. Suitable materials contain at least one ethylenically unsaturated double bond and are capable of undergoing addition polymerisation.

Examples of suitable monomers that contain an ethylenic double bond include alkyl and hydroxyalkyl acrylates and methacrylates, such as methyl, ethyl, propyl, isopropyl, butyl, hexyl, 2-ethylhexyl and 2-hydroxyethyl (meth)acrylate, stearyl acrylate and isobornyl acrylates. Further suitable examples include acrylonitrile, acrylamide, methacrylamide, N-substituted (meth)acrylamides, vinyl esters, such as vinyl acetate, vinyl ethers, such as isobutylvinyl ether, styrene, alkyl- and halo-substituted styrene, N-vinylpyrrolidone, vinyl chloride and vinylidene chloride.

Examples of suitable monomers that contain at least two double bonds include glycerol diacrylates, glycerol triacrylates, ethylene glycol diacrylates, diethylene glycol diacrylate, triethylene glycol dimethacrylates, 1,3-propanediol diacrylate, 1,3-propanediol dimethacrylate, neopentyl glycol diacrylates, hexamethylene glycol diacrylate, bisphenol-A diacrylates, 4,4'-bis(2-acryloyloxyethoxy)diphenylpropane, pentaerythritol triacrylate or tetraacrylate, pentaerythritol tetramethacrylate, trimethylolpropane triacrylate, 1,2,4-butanetriol trimethacrylate, 1,4-cyclohexanediol diacrylate, sorbitol hexaacrylate, bis[1-(2-acryloxy)]-p-ethoxyphenylidimethylmethane, bis[1-(3-acryloxy-2-hydroxy)]-p-propoxyphenyldimethylmethane and trishydroxyethyl isocyanurate trimethacrylate; the bis-acrylates and bis-methacrylates of poly(ethylene glycol) having a molecular weight of from 200 to 500, diallyl phthalate, divinyl succinate, divinyl adipate and divinyl phthalate, vinyl acrylate, divinyl benzene, triallyl phosphate, triallyl isocyanurates and tris(2-acryloyl-ethyl) isocyanurate.

Examples of higher-molecular-weight (oligomeric) poly-unsaturated compounds include acrylated epoxy resins, acrylated or vinyl ether- or epoxy-group-containing polyesters, polyurethanes and polyethers. Further examples of unsaturated oligomers are unsaturated polyester resins, which are usually prepared from maleic acid, phthalic acid and one or more diols and have molecular weights of approximately from 500 to 3000. Vinyl ether monomers and oligomers, and maleate-terminated oligomers having polyester, poly-urethane, polyether, polyvinyl ether and epoxy main chains can also be used. Also copolymers of vinyl ethers and monomers which are functionalised with maleic acid, as described in WO 90/01512, are also
very suitable. Also suitable, however, are copolymers of monomers functionalised with vinyl ether and maleic acid. Such unsaturated oligomers can also be referred to as pre-polymer. Functionalised acrylates are also suitable. Examples of suitable monomers that are normally used to form the base polymer (the backbone) of the functionalised acrylate or methacrylate polymer are acrylate, methacrylate, methyl methacrylate, ethyl acrylate, ethyl methacrylate, n-butyl acrylate, n-butyl methacrylate, isobutyl acrylate, isobutyl methacrylate, 2-ethylhexyl acrylate, 2-ethylhexyl methacrylate, etc.. In addition, suitable amounts of functional monomers are copolymerised during the polymerisation in order to obtain the functional polymers. Acid-functionalised acrylate or methacrylate polymers are obtained using acid-functional monomers, such as acrylic acid and methacrylic acid. Hydroxy-functional acrylate or methacrylate polymers are obtained from hydroxy-functional monomers, such as 2-hydroxyethyl methacrylate, 2-hydroxypropyl methacrylate and 3,4-dihydroxybutyl methacrylate. Epoxy-functionalised acrylate or methacrylate polymers are obtained using epoxy-functional monomers, such as glycidyl methacrylate, 2,3-epoxybutyl methacrylate, 3,4-epoxybutyl methacrylate, 2,3-epoxycyclohexyl methacrylate, 10,1 1-epoxyundecyl meth-acrylate, etc.. It is also possible to obtain isocyanate-functional polymers from isocyanate-functionalised monomers, such as meta-isopropenyl- α,α-dimethylbenzyl isocyanate. Especially suitable are, for example, esters of ethylenically unsaturated mono- or poly-functional carboxylic acids and polyols or polyeoxides, and polymers having ethylenically unsaturated groups in the chain or in side groups, such as unsaturated polyesters, polyamides and polyurethanes and copolymers thereof, alkyd resins, polybutadiene and butadiene copolymers, polyisoprene and isoprene copolymers, polymers and copolymers having (meth)acrylic groups in side chains, and mixtures of one or more such polymers. Examples of suitable mono- or poly-functional unsaturated carboxylic acids are acrylic acid, methacrylic acid, crotonic acid, itaconic acid, cinnamic acid, maleic acid and fumaric acid and unsaturated fatty acids, such as linolenic acid or oleic acid. Preference is given to acrylic acid and methacrylic acid. Mixtures of saturated di- or poly-carboxylic acids with unsaturated carboxylic acids may, however, also be used. Examples of suitable saturated di- or poly-carboxylic acids include, for example, tetrachlorophthalic acid, tetrabromophthalic acid, phthalic acid anhydride, adipic acid, tetrahydrophthalic acid, isophthalic acid, terephthalic acid, trimellitic acid, heptanedicarboxylic acid, sebacic acid, dodecanedicarboxylic acid, hexahydrophthalic acid, etc.. Suitable polyols are aromatic and especially aliphatic and cycloaliphatic polyols. Examples of aromatic polyols are hydroquinone, 4,4’-dihydroxydiphenyl, 2,2-di(4-hydroxyphenyl)-prop-
ane, and novolaks and resoles. Examples of polyepoxides are those based on the polyols mentioned, especially the aromatic polyols and epichlorohydrin. Also suitable as polyols are polymers and copolymers containing hydroxyl groups in the polymer chain or in side groups, such as polyvinyl alcohol and copolymers thereof or polymethacrylic acid hydroxylalkyl esters or copolymers thereof. Further suitable polyols are oligoesters having hydroxyl terminal groups.

Examples of aliphatic and cycloaliphatic polyols are alkenediols having preferably from 2 to 12 carbon atoms, such as ethylene glycol, 1,2- or 1,3-propanediol, 1,2-, 1,3- or 1,4-butanediol, pentanediol, hexanediol, octanediol, dodecanediol, diethylene glycol, triethylene glycol, polyethylene glycols having molecular weights of preferably from 200 to 1500, 1,3-cyclopentanediol, 1,2-, 1,3- or 1,4-cyclohexanediol, 1,4-dihydroxymethylcyclohexane, glycerol, tris(β-hydroxyethyl)amine, trimethylethane, trimethylolpropane, pentaerythritol, dipentaerythritol and sorbitol.

The polyols may be partially or fully esterified by one or by different unsaturated carboxylic acid(s), it being possible for the free hydroxyl groups in partial esters to have been modified, for example etherified, or esterified by other carboxylic acids.

Examples of esters are:
- trimethylolpropane triacrylate, trimethylethane triacrylate, trimethylolpropane trimethacrylate, trimethylethane trimethacrylate, tetramethylene glycol dimethacrylate, triethylene glycol dimethacrylate, tetraethylene glycol diacrylate, pentaerythritol diacrylate, pentaerythritol tetraacrylate, dipentaerythritol diacrylate, dipentaerythritol triacrylate, dipentaerythritol tetraacrylate, dipentaerythritol pentaacrylate, dipentaerythritol hexa-acrylate, tripentaerythritol octaacrylate, pentaerythritol dimethacrylate, penta-erythritol trimethacrylate, dipentaerythritol dimethacrylate, dipentaerythritol tetrameth-acrylate, tri-pentaerythritol octamethacrylate, pentaerythritol dilaconate, dipentaerythritol trisitaconate, dipentaerythritol pentaitaconate, dipentaerythritol hexahtaconate, ethylene glycol diacrylate, 1,3-butanediol diacrylate, 1,3-butanediol dimethacrylate, 1,4-butanediol diitaconate, sorbitol triacrylate, sorbitol tetraacrylate, pentaerythritol-modified triacrylate, sorbitol tetramethacrylate, sorbitol pentaacrylate, sorbitol hexaacylate, oligoester acrylates and methacrylates, glycerol di- and tri-acrylate, 1,4-cyclohexane diacrylate, bisacylates and bismethacrylates of polyethylene glycol having a molecular weight of from 200 to 1500, and mixtures thereof.

Suitable unsaturated, free-radically polymerisable compounds are also the amides of the same or different unsaturated carboxylic acids and aromatic, cycloaliphatic and aliphatic polyamines having preferably from 2 to 6, especially from 2 to 4, amino groups. Examples of
such polyamines are ethylenediamine, 1,2- or 1,3-propylenediamine, 1,2-, 1,3- or 1,4-butylenediamine, 1,5-pentylenediamine, 1,6-hexylenediamine, octylenediamine, dodecylendiamine, 1,4-diaminocyclohexane, isophoronediamine, phenylenediamine, bisphenylenediamine, di-β-aminoethyl ether, diethylenetriamine, triethylenetetramine and di[(β-aminoethoxy)- or di-(β-aminoproxy)-ethane. Further suitable polyamines are polymers and copolymers which may have additional amino groups in the side chain and oligoamides having amino terminal groups. Examples of such unsaturated amides are: methylene bisacrylamide, 1,6-hexamethylene bisacrylamide, bis(methacrylamidopropoxy)ethane, β-methacrylamidoethyl methacrylate and N-[(β-hydroxyethoxy)ethyl]-acrylamide.

Suitable unsaturated polyesters and polyamides are derived, for example, from maleic acid and diols or diamines. The maleic acid may have been partially replaced by other dicarboxylic acids. They can be used together with ethylenically unsaturated comonomers, for example styrene. The polyesters and polyamides can also be derived from dicarboxylic acids and ethylenically unsaturated diols or diamines, especially from those having longer chains of, for example, from 6 to 20 carbon atoms. Examples of polyurethanes are those composed of saturated or unsaturated disocyanates and saturated or unsaturated diols.

Polybutadiene and polyisoprene and copolymers thereof are known. Suitable comonomers include, for example, olefins, such as ethylene, propene, butene, hexene, (meth)acrylates, acrylonitrile, styrene and vinyl chloride. Polymers having (meth)acrylate groups in the side chain are also known. They may be, for example, reaction products of novolak-based epoxy resins with (meth)acrylic acid; homo- or co-polymers of vinyl alcohol or hydroxyalkyl derivatives thereof that have been esterified with (meth)acrylic acid; or homo- and co-polymers of (meth)acrylates that have been esterified with hydroxyalkyl (meth)acrylates.

It is also possible to use compounds that can be crosslinked equally both free-radically and cationically. Such compounds contain, for example, both a vinyl group and a cycloaliphatic epoxy group. Examples thereof are described in JP 2-28961 1-A and US 6048953.

Mixtures of two or more of such free-radically polymerisable materials can also be used.

Binders may also be added to the compositions according to the invention, this being especially advantageous when the photopolymerisable compounds are liquid or viscous substances. The amount of binder may be, for example, from 5 to 95 % by weight, preferably from 10 to 90 % by weight and especially from 40 to 90 % by weight, based on total solids.
The binder will be selected according to the field of use and the properties required therefor, such as developability in aqueous and organic solvent systems, adhesion to substrates and sensitivity to oxygen.

Suitable binders are, for example, polymers having a molecular weight of approximately from 2000 to 2 000 000, preferably from 5000 to 1 000 000. Examples thereof are: homo- and co-polymers of acrylates and methacrylates, for example copolymers of methyl methacrylate/ethyl acrylate/methacrylic acid, poly(methacrylic acid alkyl esters), poly(acrylic acid alkyl esters); phenolic resins, cellulose derivatives, such as cellulose esters and ethers, for example cellulose acetate, cellulose acetate butyrate, methyl cellulose, ethyl cellulose; polyvinyl butyral, polyvinylformal, polyolefins, cyclised rubber, polyethers, such as poly-ethylene oxide, polypropylene oxide, polytetrahydrofuran; polystyrene, polycarbonate, poly-urethane, chlorinated polyolefins, polyvinyl chloride, copolymers of vinyl chloride/vinylidene chloride, copolymers of vinylidene chloride with acrylonitrile, methyl methacrylate and vinyl acetate, polyvinyl acetate, copoly(ethylene/vinyl acetate), polymers such as polycaprolactam and poly(hexamethyleneadipamide), polyesters such as poly(ethylene glycol terephthalate) and poly(hexamethylene glycol succinate); and polyamides.

The resins mentioned below under (C1) may also be used as the free-radically curable component (ax). Of particular interest are, for example, unsaturated acrylates having reactive functional groups. The reactive functional group may be selected, for example, from a hydroxyl, thiol, isocyanate, epoxy, anhydride, carboxyl, amino or blocked amino group. Examples of OH-group-containing unsaturated acrylates are hydroxyethyl and hydroxybutyl acrylates and also glycidyl acrylates.

A further description of the radically polymerizing component (ax) is for example given in WO 07/062963 page 29, line 25 to page 32, line 19 the disclosure of which hereby is incorporated by reference. Further the additives, described as suitable in such radically polymerizable compositions, as given in WO 07/062963 also are suitable in the context of the present invention in case a component (ax) is present.

The unsaturated compounds may also be used in admixture with non-photopolymerisable film-forming components. These may be, for example, polymers that can be dried physically or solutions thereof in organic solvents, such as nitrocellulose or cellulose acetobutyrate.
They may alternatively be chemically or thermally curable resins, such as polyisocyanates, polyepoxides or melamine resins. Drying oils, such as linseed oil, linseed-oil-modified alkyd resins, tung oil and soybean oil, can also be present. The concomitant use of thermally curable resins is important for use in so-called hybrid systems which are photopolymerised in a first step and crosslinked by thermal aftertreatment in a second step.

Thus, the radiation-curable compositions of the present invention may also comprise:

(A1) compounds having one or more free-radically polymerisable double bonds that additionally contain at least one further functional group that is reactive in addition and/or condensation reactions (examples are given above),

(A2) compounds having one or more free-radically polymerisable double bonds that additionally contain at least one further functional group that is reactive in addition and/or condensation reactions, the additional functional group being complementary to or reactive towards the additional functional group of component (A1),

(A3) at least one monomeric, oligomeric and/or polymeric compound having at least one functional group that is reactive in addition and/or condensation reactions towards the functional groups of component (A1) or (A2) that are present in addition to the free-radically polymerisable double bonds.

Component (A2) in each case carries the groups complementary to or reactive towards component (A1). Different types of functional groups may also be present in a component.

Component (A3) provides a component that contains further functional groups that are reactive in addition and/or condensation reactions and that are able to react with the functional groups of (A1) or (A2) that are present in addition to the free-radically polymerisable double bonds. Component (A3) contains no free-radically polymerisable double bonds.

Examples of such combinations (A1), (A2), (A3) can be found in WO 99/55785.

Examples of suitable functional groups are hydroxyl, isocyanate, epoxy, anhydride, carboxyl and blocked amino groups. Examples have been described above.

Constituents of the thermally curable component (C) are, for example, thermally curable lacquer or coating system constituents customary in the art. Component (C) accordingly may consist of a large number of constituents.

Examples of component (C) include oligomers and/or polymers derived from \(\alpha,\beta\)-unsaturated acids and derivatives thereof, for example polyacrylates and polymethacrylates, polymethyl
methacrylates impact-resistant-modified with butyl acrylate, polyacrylamides and polyacrylonitriles. Further examples of component (C) are urethanes, polyurethanes derived on the one hand from polyethers, polyesters and polyacrylates having free hydroxyl groups and on the other hand from aliphatic or aromatic polyisocyanates, and educts thereof. Component (C) accordingly also includes, for example, crosslinkable acrylic resins derived from substituted acrylic acid esters, for example epoxy acrylates, urethane acrylates and polyester acrylates. Alkyd resins, polyester resins and acrylate resins and modifications thereof that are crosslinked with melamine resins, urea resins, isocyanates, isocyanurates, polyisocyanates, polyisocyanurates and epoxy resins, may also be a constituent of component (C).

Component (C) is, for example, generally a film-forming binder based on a thermoplastic or thermocurable resin, especially on a thermocurable resin. Examples thereof are alkyd, acrylic, polyester, phenolic, melamine, epoxy and polyurethane resins and mixtures thereof. Examples thereof can be found, for example, in Ullmann's Encyclopedia of Industrial Chemistry, 5th Ed., Vol. A18, pp. 368-426, VCH, Weinheim 1991.

Component (C) may also be a cold-curable or hot-curable binder, in which case the addition of a curing catalyst may be advantageous. Suitable catalysts that accelerate the full cure of the binder can be found, for example, in Ullmann's Encyclopedia of Industrial Chemistry, Vol. A18, page 469, VCH Verlagsgesellschaft, Weinheim 1991.

Specific examples of binders suitable as component (C) are:

1. surface-coatings based on cold- or hot-crosslinkable alkyd, acrylate, polyester, epoxy or melamine resins or mixtures of such resins, optionally with the addition of a curing catalyst;
2. two-component polyurethane surface-coatings based on hydroxyl-group-containing acrylate, polyester or polyether resins and aliphatic or aromatic isocyanates, isocyanurates or polyisocyanates;
3. one-component polyurethane surface-coatings based on blocked isocyanates, isocyanurates or polyisocyanates, which are de-blocked during heating; it is also possible to add melamine resins as appropriate;
4. one-component polyurethane surface-coatings based on aliphatic or aromatic urethanes or polyurethanes and hydroxyl-group-containing acrylate, polyester or polyether resins;
5. one-component polyurethane surface-coatings based on aliphatic or aromatic urethane acrylates or polyurethane acrylates having free amine groups in the urethane structure and melamine resins or polyether resins, optionally with the addition of a curing catalyst;
6. two-component surface-coatings based on (poly)ketimines and aliphatic or aromatic isocyanates, isocyanurates or polyisocyanates;
7. two-component surface-coatings based on (poly)ketimines and an unsaturated acrylate resin or a polyacetoacetate resin or a methacrylamidoglycolate methyl ester;
8. two-component surface-coatings based on carboxyl- or amino-group-containing polyacrylates and polyepoxides;
9. two-component surface-coatings based on anhydride-group-containing acrylate resins and a polyhydroxy or polyamino component;
10. two-component surface-coatings based on acrylate-containing anhydrides and polyepoxides;
11. two-component surface-coatings based on (poly)oxazolines and anhydride-group-containing acrylate resins or unsaturated acrylate resins or aliphatic or aromatic isocyanates, isocyanurates or polyisocyanates;
12. two-component surface-coatings based on unsaturated polyacrylates and polymalonates;
13. thermoplastic polyacrylate surface-coatings based on thermoplastic acrylate resins or extrinsically crosslinking acrylate resins in combination with etherified melamine resins;
14. surface-coating systems based on urethane (meth)acrylate having (meth)acryloyl groups and free isocyanate groups and on one or more compounds that react with isocyanates, for example free or esterified polyols. Such systems have been published, for example, in EP 928800.

Blocked isocyanates that can also be used as component (C) are described, for example, in Organischer Metallschutz: Entwicklung und Anwendung von Beschichtungsstoffen, pages 159-160, Vincentz Verlag, Hanover (1993). These are compounds in which the highly reactive NCO group is "blocked" by reaction with specific radicals, for example a primary alcohol, phenol, acetic acid ethyl ester, ε-caprolactam, phthalimide, imidazole, oxime or amine. The blocked isocyanate is stable in liquid systems and also in the presence of hydroxy groups. Upon heating, the blocking group (protecting group) is removed again and the NCO group is freed.

1-Component (1C) and 2-component (2C) systems may be used as component (C). Examples of such systems are described in Ullmann's Encyclopedia of Industrial Chemistry, Vol. A18, Paints and Coatings, pages 404-407, VCH Verlagsgesellschaft mbH, Weinheim (1991). It is possible to optimise the composition by specific adaptation, for example by varying the binder/crosslinking agent ratios. Such measures will be known to the person skilled in the art and are customary in coating technology.
In the curing process according to the invention, component (C) is preferably a mixture based on acrylate/melamine (and melamine derivatives), 2-component polyurethane, 1-component polyurethane, 2-component epoxy/carboxy or 1-component epoxy/carboxy. Mixtures of such systems are also possible, for example the addition of melamine (or derivatives thereof) to 1-component polyurethanes.

Component (C) is preferably a binder based on a polyacrylate with melamine or on a melamine derivative or a system based on a polyacrylate and/or polyester polyol with an unblocked polyisocyanate or polyisocyanurate.

Component (C) may also comprise monomeric and/or oligomeric compounds having ethylenically unsaturated bonds (prepolymers) that additionally contain at least one or more OH, NH\(_2\), COOH, epoxy or NCO group(s) (= C1) that are capable of reaction with the binder and/or the crosslinking agent constituent of component (C). After application and thermal curing, the ethylenically unsaturated bonds are converted to a crosslinked, high molecular weight form by irradiation with UV light. Examples of such components (C) are described, for example, in the above-mentioned publication, Ullmann's Encyclopedia of Industrial Chemistry, 5th Ed., Vol. A18, pages 451-453, or by S. Urano, K. Aoki, N. Tsuboniva and R. Mizuguchi in Progress in Organic Coatings, 20 (1992), 471-486, or by H. Terashima and O. Isozaki in JOCCA 1992 (6), 222.

(C1) may, for example, also be an OH-group-containing unsaturated acrylate, for example hydroxyethyl or hydroxybutyl acrylate or a glycidyl acrylate. Component (C1) may be of any desired structure (for example it may contain units of polyester, polyacrylate, polyether, etc.), provided that it contains an ethylenically unsaturated double bond and additionally free OH, COOH, NH\(_2\), epoxy or NCO groups.

(C1) may, for example, also be obtained by reacting an epoxy-functional oligomer with acrylic acid or methacrylic acid. A typical example of an OH-functional oligomer having vinylic double bonds is

\[
\begin{align*}
\text{CH}_2=\text{CH-C-OCH}_2-\text{CH}_2-\text{O-C-CH}_3 &\quad \text{CH}_3
\end{align*}
\]

obtained by reaction of \(\text{CH}_2=\text{CHCOOH}\) with

\[
\begin{align*}
\text{H}_3\text{C}-\text{CH}-\text{CH}_2-\text{O-C-CCH}_3 &\quad \text{CH}_3
\end{align*}
\]

Another possible method of obtaining component (C1) is, for example, the reaction of an oligomer that contains only one epoxy group and has a free OH group at another position in the molecule.
The quantity ratio of the free-radically radiation-curable-polymerisable components to the thermally polymerisable component (C) in the UV- and thermally-crosslinkable formulations is not critical. "Dual-cure" systems are known to the person skilled in the art, who will therefore be familiar with the optimum mixing ratios of the free-radically- and thermally-crosslinkable components according to the intended use. For example, the ratio can be in the range from 5:95 to 95:5, from 20:80 to 80:20 or from 30:70 to 70:30, for example from 40:60 to 60:40. Examples of "dual-cure" systems, that is to say systems comprising both radiation-curable and thermally curable components, can be found inter alia in US 5922473, columns 6 to 10.

The formulations according to the invention can further comprise as component (a1) non-aqueous coating compositions based on an oxidatively drying alkyd resin which contains at least one, preferably two or more, functional group(s) capable of undergoing polymerisation or polycondensation reactions in the presence of an acid. Examples of such resins are vinyl-ether-functionalised alkyd resins, acetal-functionalised alkyd resins, and/or alkoxyxilane-functionalised alkyd resins, as proposed, e.g., in WO 99/47617. Those modified alkyd resins may be used alone or in combination with other alkyd resins. At least some of the alkyd resin composition in the non-aqueous coating is oxidatively drying as a result of the incorporation of a large number of unsaturated, aliphatic compounds, at least some of which are polyunsaturated.

Formulations containing those modified alkyd resins as component (a1) may optionally contain, in addition to the photoinitiator (b), an oxidative dryer. Suitable oxidative dryers are, for example, metal siccatives. There may be mentioned as suitable siccatives, for example, the metal salts of (cyclo)aliphatic acids, such as octanoic acid and naphthenic acid, the metals to be used being, for example, cobalt, manganese, lead, zirconium, calcium, zinc and rare earth metals. Mixtures of siccatives may be used. Preference is given to metal salts of cobalt, zirconium and calcium, or mixtures thereof. The siccatives (calculated as metal) are usually used in an amount of from 0.001 to 3 % by weight.

Under certain conditions it may also be advantageous, when using the modified alkyd resins as component (a1), to use one or more mono- or bis-acylphosphine oxide photoinitiators in addition to the sulphonium salt of formula (I). Suitable monoacyl- or bisacyl-phosphine oxide photoinitiators include, for example, monoacylphosphine oxides such as (2,4,6-trimethylbenzoyl)-diphenylphosphine oxide (DAROCUR®TPO) or (2,4,6-trimethylbenzoyl-
phenyl-ethoxy-phosphine oxide, or bisacylphosphine oxide photoinitiators such as bis(2,6-di-methoxybenzoyl)-2,4,4-trimethylpentyl-phosphine oxide, bis(2,4,6-trimethylbenzoyl)-(2,4-dipentyloxyphenyl)-phosphine oxide and bis(2,4,6-trimethylbenzoyl)phenyl-phosphine oxide (IRGACURE®819). Those monoacyl- or bisacyl-phosphine oxides are advantageously used in an amount of from 0.5 to 5%.

When component \(a1\) contains modified alkyd resins, in addition to the photoinitiator \(b\) it is also possible to use an oxidative dryer and suitable monoacyl- or bisacyl-phosphine oxide photoinitiators.

The alkyd resins used as component \(a1\) contain a large number of unsaturated, aliphatic compounds, at least some of which are polyunsaturated. The unsaturated aliphatic compounds preferably used for the preparation of those alkyd resins are unsaturated aliphatic monocarboxylic acids, especially polyunsaturated aliphatic monocarboxylic acids. Examples of mono-unsaturated fatty acids are myristoleic acid, palmitic acid, oleic acid, gadoleic acid, erucic acid and ricinoleic acid. Preferably fatty acids containing conjugated double bonds, such as dehydrogenated castor oil fatty acid and/or tung oil fatty acid, are used. Other suitable monocarboxylic acids include tetrahydrobenzoic acid and hydrogenated or non-hydrogenated abietic acid or the isomers thereof. If desired, the monocarboxylic acid in question may be used wholly or in part in the form of a triglyceride, e.g. as vegetable oil, in the preparation of the alkyd resin. If desired, mixtures of two or more such mono-carboxylic acids or triglycerides may be used, optionally in the presence of one or more saturated, (cyclo)aliphatic or aromatic monocarboxylic acids, e.g. pivalic acid, 2-ethyl-hexanoic acid, lauric acid, palmitic acid, stearic acid, 4-tert-butyl-benzoic acid, cyclo-pentanecarboxylic acid, naphthenic acid, cyclohexanecarboxylic acid, 2,4-dimethylbenzoic acid, 2-methylbenzoic acid and benzoic acid.

If desired, polycarboxylic acids may also be incorporated into the alkyd resin, such as phthalic acid, isophthalic acid, terephthalic acid, 5-tert-butylisophthalic acid, trimellitic acid, pyromellitic acid, succinic acid, adipic acid, 2,2,4-trimethyladipic acid, azelaic acid, sebacic acid, dimerised fatty acids, cyclopentane-1,2-dicarboxylic acid, cyclohexane-1,2-dicarboxylic acid, 4-methylcyclohexane-1,2-dicarboxylic acid, tetrahydrophthalic acid, endomethylene-cyclohexane-1,2-dicarboxylic acid, butane-1,2,3,4-tetracarboxylic acid, endoisopropylidene-cyclohexane-1,2-dicarboxylic acid, cyclohexane-1,2,4,5-tetra-carboxylic acid and butane-1,2,3,4-tetra-carboxylic acid. If desired, the carboxylic acid in question may be used as an an-
hydride or in the form of an ester, for example an ester of an alcohol having from 1 to 4 carbon atoms.

In addition, the alkyd resin can be composed of di- or poly-valent hydroxyl compounds. Examples of suitable divalent hydroxyl compounds are ethylene glycol, 1,3-propanediol, 1,6-hexanediol, 1,12-dodecanediol, 3-methyl-1,5-pentanediol, 2,2,4-trimethyl-1,6-hexane-diol, 2,2-dimethyl-1,3-propanediol and 2-methyl-2-cyclohexyl-1,3-propanediol. Examples of suitable triols are glycerol, trimethylolethane and trimethylolpropane. Suitable polyols having more than 3 hydroxyl groups are pentaerythritol, sorbitol and etherified products of the compounds in question, such as ditrimethylolpropa ne and di-, tri- and tetra-pentaerythritol. Preferably, compounds having from 3 to 12 carbon atoms, e.g. glycerol, pentaerythritol and/or dipentaerythritol, are used.

The alkyd resins can be obtained by direct esterification of the constituents, with the option that some of those components may already have been converted into ester diols or polyether diols. The unsaturated fatty acids can also be used in the form of a drying oil, such as Nn-seed oil, tuna fish oil, dehydrogenated castor oil, coconut oil and dehydrogenated coconut oil. The final alkyd resin is then obtained by transesterification with the other acids and diols added. The transesterification is advantageously carried out at a temperature in the range of from 115 to 250°C, optionally in the presence of solvents such as toluene and/or xylene. The reaction is advantageously carried out in the presence of a catalytic amount of a transesterification catalyst. Examples of suitable transesterification catalysts include acids, such as p-toluenesulphonic acid, basic compounds, such as an amine, or compounds such as calcium oxide, zinc oxide, tetraisopropyl orthotitanate, dibutylin oxide and tri-phenylbenzylphosphonium chloride.

The vinyl ether, acetal and/or alkoxy silane compounds used as part of component (a1) preferably contain at least two vinyl ether, acetal and/or alkoxy silane groups and have a molecular weight of 150 or more. Those vinyl ether, acetal and/or alkoxy silane compounds can be obtained, for example, by the reaction of a commercially available vinyl ether, acetal and/or alkoxy silane compound containing a vinyl ether, acetal and/or alkoxy silane group and in addition a maximum of one functional amino, epoxy, thiol, isocyanate, acrylic, hydride or hydroxyl group, with a compound having at least two groups capable of reacting with an amino, epoxy, thiol, isocyanate, acrylic, hydride or hydroxyl group. As examples thereof there may be mentioned compounds having at least two epoxy, isocyanate, hydroxyl and/or ester groups or compounds having at least two ethylenically or ethynyl enically unsaturated groups.
As component (a1), preference is given to a composition in which the vinyl ether, acetal and/or alkoxy silane compounds are covalently bonded to the alkyd resin by addition via a reactive group such as an amino, hydroxyl, thiol, hydride, epoxy and/or isocyanate group. For that purpose, the compounds must have at least one group capable of forming an adduct with the reactive groups present in the alkyd resin.

To incorporate vinyl ether groups into the alkyd resin, use is made of a vinyloxyalkyl compound, the alkyl group of which is substituted by a reactive group, such as a hydroxyl, amino, epoxy or isocyanate group, that is capable of forming an adduct with one or more of the reactive groups present in the alkyd resin.

As component (a1), preference is given to compositions in which the ratio of the number of oxidatively drying groups present in the alkyd resin to the number of groups that are reactive in the presence of an acid is in the range of from 1/10 to 15/1, especially from 1/3 to 5/1. Instead of a single modified alkyd resin, it is also possible to use a plurality of alkyd resins, with one alkyd resin being highly modified and the others being less modified or not modified at all.

Examples of vinyl ether compounds capable of being covalently bonded to the alkyd resin are ethylene glycol monovinyl ether, butanediol monovinyl ether, hexanediol monovinyl ether, triethylene glycol monovinyl ether, cyclohexanediethanol monovinyl ether, 2-ethylhexane- nediol monovinyl ether, polytetrahydrofuran monovinyl ether, tetraethylene glycol monovinyl ether, trimethylolpropane divinyl ether and aminopropyl vinyl ether.

Adducts can be formed, for example, by reacting the vinyl ether compounds containing a hydroxyl group or amino group with an excess of a diisocyanate, followed by the reaction of that free-isocyanate-group-containing adduct with the free hydroxyl groups of the alkyd resin.

Preferably, a process is used in which first the free hydroxyl groups of the alkyd resin react with an excess of a polysisocyanate, and then the free isocyanate groups react with an amino-group- or hydroxyl-group-containing vinyl ether compound. Instead of a diisocyanate, it is also possible to use a diester. Transesterification of the hydroxyl groups present in the alkyd resin with an excess of the diester, followed by transesterification or transamidation of the remaining ester groups with hydroxy-functional vinyl ether compounds or amino-functional vinyl ether compounds, respectively, yields vinyl-ether-functional alkyd resins. It is also possible to incorporate (meth)acrylate groups into the alkyd resin during preparation of the alkyd resin, by carrying out the preparation in the presence of a hydroxy-functional (meth)acrylate
ester, such as hydroxyethyl methacrylate (HEMA), and then reacting the thus functionalised alkyd resin by means of a Michael reaction with a vinyl-ether-group-containing compound and a primary-amino-group-containing compound, followed by reaction with e.g. an isocyanate compound, in order to obtain a non-basic nitrogen atom.

An example of such a reaction is described, for example, in WO 99/47617. Esterification of ricinene fatty acid with dipentaerythritol, followed by transesterification of the free hydroxyl groups with diethyl malonate and 4-hydroxybutyl vinyl ether in a suitable ratio, yields a vinyl-ether-functional alkyd resin suitable for use as component (a1).

For the preparation of acetal-functional alkyd resins, use is generally made of dialkyl acetal functionalised with an amino group. Examples of suitable acetal compounds include 4-aminobutyraldehyde dimethyl acetal and 4-aminobutyraldehyde diethyl acetal. The alkyd resin is modified by the addition of the aminoacetal monomer to an alkyd resin functionalised with isocyanate groups, with ester groups of a low-boiling alcohol or with (meth)acrylate groups. The resulting dialkyl-acetal-modified alkyd resin can be incorporated into the coating composition having a high solids content and low viscosity. The preparation of acetal-functional alkyd resins can also be carried out by reacting hydroxyacetal with the carboxyl groups of the alkyd resin or by reacting a diisocyanate or diester compound with the hydroxyl groups of the alkyd resin.

An example of this preparative method is described in WO 99/47617, for example the esterification of a hydroxy-functional alkyd resin with diethyl malonate, followed by transamidation of the free ester group with 4-aminobutyraldehyde dimethyl acetal in a suitable ratio. The resulting acetal-modified alkyd resin is suitable as component (a1).

For the incorporation of alkoxy silane groups into the alkyd resin, use is made of a siloxane compound having one or more reactive group(s) which are subsequently reacted with one or more of the constituents making up the alkyd resin. These are, for example, alkoxy-silanes of the formula: \((E)_{n_1}-Si(R)\_o(b(R)\_2o)c\), wherein

- Rio is alkoxy or oxyalkylenealkoxy or, when E is hydrogen, \(R_{10}\) is halogen,
- \(R_2O\) is an aliphatic, cycloaliphatic or aromatic group, and E is hydrogen or an alkyl group substituted by an amino, isocyanate, mercapto or epoxy group; a is from 1 to 3, b is from 1 to 3, c is from 0 to 2, and \(a + b + c = 4\).
- Rio is preferably an alkoxy group having from 1 to 4 carbon atoms in the alkoxy group, and \(R_2O\) is preferably a group having not more than 18 carbon atoms.
Examples of suitable siloxane compounds are 3-aminopropyl-triethoxysilane, polyglycol-
ether-modified aminosilane, 3-aminopropyl-trimethoxysilane, 3-aminopropyltris-methoxy-
ethoxyethoxysilane, 3-aminopropyl-methyl-diethoxysilane, N-2-aminoethyl-3-aminopropyl-tri-
methoxy-silane, N^-aminoethyl-S-aminopropyl-methyldimethoxy-silane, N-methyl-3-amino-
propyl-trimethoxysilane, 3-ureidopropyl-triethoxysilane, 3,4,5-dihydroimidazol-1 -yl-propyltri-
ethoxysilane, 3-methacryloxypropyl-trimethoxysilane, 3-glycidyloxypropyl-trimethoxysilane, 3-
mercaptpropyl-trimethoxysilane and 3-mercaptopropyl-methyl-dimethoxysilane, triethoxysil-
ane, diethoxymethylsilane, dimethoxymethylsilane, tri-methoxysilane, trichlorosilane, triiodo-
silane, tribromosilane, dichloromethylsilane and dibromomethylsilane.

The alkyd resin can be modified, for example, by the insertion of an amino-group-modified
alkoxysilane into an alkyd resin modified with a polyisocyanate or a polyester of a low-boiling
alcohol. Hydride-functional alkoxysilanes can be bonded directly to the alkyd, i.e. without
modification with a binding molecule such as a diisocyanate or diester, by adding a com-
pound containing a silylhhydride group to an ethylenically unsaturated group in the alkyd resin.

That addition is catalysed by a transition metal. In that process, use is preferably made of a
halogenated silylhhydride and, in order to terminate the addition reaction, conversion into an
alkoxysilane compound with a low-boiling alcohol. The addition reaction is advantageously
carried out in the absence of sterically hindering groups and proceeds in optimum manner
when the ethylenically unsaturated groups are terminal groups, as is the case, for example,
with esters of 10-undecenecarboxylic acid.

Examples of the preparation of alkoxysiloxane-modified alkyd resins are described in
WO 99/47617. Esterification of a hydroxy-functional alkyd resin with diethyl malonate, fol-
lowed by transamidation of the free ester group with 3-aminopropyltriethoxysilane in a suit-
able ratio yields an alkoxysilane-modified alkyd resin. Hydroxy-modified alkyd resin can also
be reacted with an excess of isophorone disocyanate, followed by reaction of the free isocy-
anate groups with 3-aminopropyltriethoxysilane. Both alkoxysiloxane-modified alkyd resins
obtained by the processes described are suitable for use in component (a1).

When free-radically polymerisable components are added to the formulation according to the
invention, or in case that a component (ax) is present, it may be advantageous to add also a
suitable free-radical photoinitiator or a mixture of such photoinitiators, e.g. camphor quinone;
benzophenone and derivatives thereof, ESACURE TZT® available from Lamberti, a mixture
of 2,4,6-trimethylbenzophenone and 4-methylbenzophenone, Darocur®BP, benzophenone,
2-methylbenzophenone, 3-methylbenzophenone, 4-methyl benzophenone, 2,4,6-
trimethylbenzophenone, 3-methyl-4'-phenyl-benzophenone, 2,4,6-trimethyl-4'-phenyl-benzophenone, 2-methoxycarboxylbenzophenone 4,4'-bis(chloromethyl)benzophenone, 4-chlorobenzophenone, 4-phenylbenzophenone, 3,3'-dimethyl-4-methoxy-benzophenone, [4-(4-methylphenylthio)phenyl]-phenylmethanone, methyl-2-benzoylbenzoate, 3-methyl-4'-phenylbenzophenone, 2,4,6-trimethyl-4'-phenylbenzophenone, 4,4'-bis(dimethylamino)benzophenone, 4,4'-bis(diethylamino)benzophenone etc., acetophenone and derivatives thereof, e.g. i-hydroxy-cyclohexyl-phenyl-ketone (IRGACURE®184) or IRGACURE®500 (a mixture of IRGACURE®184 with benzophenone); or 2-hydroxy-2-methyl-1-phenyl-propanone (DAROCUR® 1173), 2-hydroxy-1-[3-[4-(2-hydroxy-2-methyl-propionyl)-phenyl]-1,3-trimethyl-indan-5-yl]-2-methyl-propan-1-one, 4-aryloxy-1,3-dioxolane, 1-(4-dodecylbenzoyl)-1-hydroxy-1-methyl-ethane, 1-(4-isopropylbenzoyl)-1-hydroxy-1-methyl-ethane, α-hydroxy- or α-amino-acetophenone such as, for example, 2-methyl-1-[4-(methylthio)phenyl]-2-morpholinopropan-1-one (IRGACURE®907), 2-benzyl-2-dimethylamino-1-(4-morpholinophenyl)-butanone-1 (IRGACURE®369), 2-dimethylamino-2-(4-methyl-benzyl)-1-(4-morpholin-4-yl-phenyl)-butan-1-one (IRGACURE®379), (4-(2-hydroxyethyl)aminobenzoyl)-1-benzyl-1-dimethylaminopropane, (3,4-dimethoxybenzoyl)-1-benzyl-1-dimethylaminopropane, 1-[4-(2-hydroxyethoxy)-phenyl]-2-hydroxy-2-methyl-1-propan-1-one (IRGACURE®2959), 2,2-dimethoxy-1,2-diphenylethan-1-one (IRGACURE®651), 2-hydroxy-1-[4-(2-hydroxy-2-methyl-propionyl)-benzyl]-phenyl]-2-methyl-propan-1-one (IRGACURE®127), 2-benzyl-1-(3,4-dimethoxy-phenyl)-2-dimethylamino-butan-1-one, 2-hydroxy-1-[4-(2-hydroxy-2-methyl-propionyl)-phenoxyl]-phenyl]-2-methyl-propan-1-one, ESACUREOKIP provided by F. Lamberti, 2-hydroxy-1-[1-4-(2-hydroxy-2-methyl-propionyl)-phenyl]-1,3,3-trimethyl-indan-5-yl]-2-methyl-propan-1-one; benzoin alkyl ethers and benzil ketal, such as, for example, benzil dimethyl ketal, phenyl glyoxalate and derivatives thereof, e.g. oxo-phenyl-acetic acid 2-[2-(2-oxo-2-phenyl-acetoxy)-ethoxy]-ethyl ester (IRGACURE®754); mono- or bis-acylphosphine oxide, such as, for example, (2,4,6-trimethyl-benzoyl)-phenyl-phosphine oxide (DAROCUR®TPO), bis(2,6-dimethoxybenzoyl)-(2,4,4-trimethyl-pent-1-yI)phosphine oxide, bis(2,4,6-trimethylbenzoyl)-phenyl-phosphine oxide (IRGACURE®819) or bis(2,4,6-trimethylbenzoyl)-(2,4-dipentoxyphenyl)phosphine oxide; or oximeesters, e.g. 1,2-octanedione 1-[4-(phenylthio)phenyl]-2-(O-benzoyloxime) (IRGACURE® OXE01), ethanone 1-[9-ethyl-6-(2-methylbenzoyl)-9H-carbazol-3-yl]-1-(O-acetylloxime) (IRGACURE® OXE02), 9H-thioxanthen-2-carboxaldehyde 9-oxo-2-(O-acetylloxime), peresters, e.g. benzophenone tetracarboxylic peresters as described for ex-
ample in EP 126541, as well as any other radical photoinitiator known to the art-skilled person.

The DAROCUR® and IRGACURE® compounds are available from Ciba Specialty Chemicals.

Other additional components can be, for example, hydroxy-functional components, such as alcohols, polyester polyols, polyether polyols, hydroxy-group-containing polyurethanes, castor oil, etc. Examples thereof include aliphatic and cycloaliphatic polyols, such as alkylene diols having preferably from 2 to 12 carbon atoms, e.g. ethylene glycol, 1,2- or 1,3-propanediol, 1,2-, 1,3- or 1,4-butandiol, pentanediol, hexanediol, octanediol, dodecanediol, diethylene glycol, triethylene glycol, polyethylene glycols having molecular weights of preferably from 200 to 1500, 1,3-cyclopentanediol, 1,2-, 1,3- or 1,4-cyclohexanediol, 1,4-di-hydroxymethylcyclohexane, glycerol, tris(β-hydroxy-ethyl)amine, trimethyleneolthane, tri-methylolpropylene, pentaerythritol, dipentaerythritol and sorbitol. The polyols can be partially or fully esterified by one or by different unsaturated carboxylic acids, it being possible for the free hydroxyl groups in partial esters to have been modified, e.g. etherified, or esterified by other carboxylic acids. Examples of esters include: trimethylolpropane triacrylate, trimethylolpropane triacrylate, trimethylolpropane trimethacrylate, trimethylolpropane trimeth-acrylate, tetramethylene glycol dimethacrylate, triethylene glycol dimethacrylate, tetraethylene glycol diacylate, pentaerythritol diacrylate, pentaerythritol triacrylate, pentaerythritol tetraacrylate, dipentaerythritol diacrylate, dipentaerythritol triacrylate, dipentaerythritol tetraacrylate, dipentaerythritol pentaacrylate, dipentaerythritol hexacrylate, tripentaerythritol octaacylate, pentaerythritol dimethacrylate, pentaerythritol trimethacrylate, dipenta-erythritol dimethacrylate, dipentaerythritol tetramethacrylate, tripentaerythritol octamethacrylate, pentaerythritol diitaconate, dipentaerythritol trisitaconate, dipentaerythritol pentaitaconate, dipentaerythritol hexaitaconate, ethylene glycol diacylate, 1,3-butandiol diacylate, 1,3-butandiol dimethacrylate, 1,4-butandiol diitaconate, sorbitol triacrylate, sorbitol tetraacrylate, pentaerythritol-modified triacrylate, sorbitol tetramethacrylate, sorbitol pentaacrylate, sorbitol hexaacylate, oligoester acrylates and methacrylates, glycerol di- and tri-acrylate, 1,4-cyclohexane diacylate, bisacrylates and bismethacrylates of polyethylene glycol having a molecular weight of from 200 to 1500, or mixtures thereof.

The sulphonium salt compounds of formula I can also be used, for example, as photoactivatable hardeners for siloxane-group-containing resins. Those resins can, for example,
either undergo self-condensation by way of acid-catalysed hydrolysis or can be crosslinked with a second resin component, such as, for example, a polyfunctional alcohol, a hydroxy-group-containing acrylic or polyester resin, a partially hydrolysed polyvinylacetel or a polyvinyl alcohol. That type of polycondensation of polysiloxanes is described, for example, in JJ. Lebrun, H. Pode, Comprehensive Polymer Science Vol. 5, page 593, Pergamon Press, Oxford, 1989.

Examples of compounds whose solubility increases in a developer under the action of acid, i.e., component (a2) include oligomers, polymers and copolymers that can be obtained by co-polymerisation of, for example, the following monomers: non-cyclic or cyclic secondary and tertiary alkyl (meth)acrylates, such as tert-butyl acrylate, tert-butyl methacrylate, 3-oxocyclohexyl (meth)acrylate, tetrahydroprpyraln (meth)acrylate, 2-methyl-2-adamantyl (meth)acrylate, cyclohexyl (meth)acrylate, norbornyl (meth)acrylate, isobornyl methacrylate, 5-norbornene-2-tert-butyl ester, 8-ethyl-8-tricyclodecanyl (meth)acrylate, (2-tetrahydropyranol)oxynorbornylalcohol acrylates, (2-tetrahydroprpyranol)oxymethyltricyclododecane-methanol methacrylates, trimethylsilylmethyl (meth)acrylates, (2-tetrahydroprpyranol)oxy-norbornylalcohol acrylates, (2-tetrahydroprpyranol)oxymethyltricyclododecanemethanol methacrylates, trimethylsilylmethyl (meth)acrylate, o-/m-/p-(3-oxocyclohexyl oxy)styrene, o-/m-/p-(1-methyl-1-phenylethoxy)styrene, o-/m-/p-tetrahydroprpyranoloxystrene, o-/m-/p-adamantyl oxy styrene, o-/m-/p-cyclohexyl oxy styrene, non-cyclic or cyclic alkoxycarbonylstyrenes, such as o-/m-/p-tert-butoxycarbonylstyrene, o-/m-/p-(3-oxocyclohexyl oxy oxo)carbonylstyrene, o-/m-/p-(1-methyl-1-phenylethoxycarbonyl) styrene, o-/m-/p-tetrahydroprpyranol oxycarbonyl styrene, o-/m-/p-adamantyl oxycarbonylstyrene, o-/m-/p-cyclohexyl oxycarbonyl styrene, o-/m-/p-norbornyl oxycarbonyl styrene, non-cyclic or cyclic alkoxycarbonyl oxy styrenes, such as o-/m-/p-tert-butoxycarbonyl oxy styrene, o-/m-/p-(3-oxocyclohexyl oxo)carbonyl styrene, o-/m-/p-(1-methyl-1-phenylethoxycarbonyl) styrene, o-/m-/p-cyclohexyl oxycarbonyl styrene, o-/m-/p-norbornyl oxycarbonyl styrene, non-cyclic or cyclic alkoxycarbonyl alkoxy styrenes, such as o-/m-/p-butoxycarbonyl methoxystyrene, p-tert-butoxycarbonyl methoxystyrene, o-/m-/p-(3-oxocyclohexyl oxy oxo)carbonyl styrene, o-/m-/p-(1-methyl-1-phenylethoxycarbonyl) styrene, o-/m-/p-tetrahydroprpyranol oxycarbonyl oxystyrene, o-/m-/p-adamantyl oxycarbonyl styrene, o-/m-/p-norbornyl oxycarbonyl styrene, trimethyl siloxystyrene, dimethyl(butyl) siloxystyrene, unsaturated alkyl ace-
tates, such as isopropenyl acetate and derivatives thereof, 5-norbornenyl-2-tert-butyl ester; also monomers that carry acid-labile groups having low activation energy, such as, for example, \( p \)- or \( m \)-(1-methoxy-1-methylethoxy)styrene, \( p \)- or \( m \)-(1-methoxy-1-methylethoxy)methylstyrene, \( p \)- or \( m \)-(1-methoxy-1-methylpropoxy)styrene, \( p \)- or \( m \)-(1-methoxy-1-methylpropoxy)methylstyrene, \( p \)- or \( m \)-(1-ethoxy-1-methylethoxy)styrene, \( p \)- or \( m \)-(1-ethoxy-1-methylethoxy)methylstyrene, \( p \)- or \( m \)-(1-ethoxy-1-methylpropoxy)styrene, \( p \)- or \( m \)-(1-ethoxy-1-methylpropoxy)methylstyrene, \( p \)- or \( m \)-(1-iethoxyethoxy)methylstyrene, \( p \)- or \( m \)-(1-iethoxyethoxy)methylstyrene, \( p \)- or \( m \)-(1-ethoxyphenylethoxy)styrene, \( p \)- or \( m \)-(1-n-propoxy-1-methylethoxy)-styrene, \( p \)- or \( m \)-(1-n-propoxy-1-methylethoxy)methylstyrene, \( p \)- or \( m \)-(1-n-propoxy-1-methylethoxy)methylstyrene, \( p \)- or \( m \)-(1-isopropoxy-1-methylethoxy)-styrene, \( p \)- or \( m \)-(1-isopropoxy-1-methylethoxy)methylstyrene, \( p \)- or \( m \)-(1-isopropoxy-1-methylethoxy)methylstyrene, \( p \)- or \( m \)-(1-isopropoxy-1-methylpropoxy)styrene, \( p \)- or \( m \)-(1-isopropoxy-1-methylpropoxy)methylstyrene, \( p \)- or \( m \)-(1-isopropoxy-1-methylpropoxy)methylstyrene, \( p \)- or \( m \)-(1-isopropoxy-1-methylpropoxy)methylstyrene, \( p \)- or \( m \)-(1-isopropoxy-1-methylpropoxy)methylstyrene, \( p \)- or \( m \)-(1-isopropoxy-1-methylpropoxy)methylstyrene, \( p \)- or \( m \)-(1-isopropoxy-1-methylpropoxy)methylstyrene, \( p \)- or \( m \)-(1-isopropoxy-1-methylpropoxy)methylstyrene, \( p \)- or \( m \)-(1-isopropoxy-1-methylpropoxy)methylstyrene, \( p \)- or \( m \)-(1-isopropoxy-1-methylpropoxy)methylstyrene, \( p \)- or \( m \)-(1-isopropoxy-1-methylpropoxy)methylstyrene, \( p \)- or \( m \)-(1-isopropoxy-1-methylpropoxy)methylstyrene, \( p \)- or \( m \)-(1-isopropoxy-1-methylpropoxy)methylstyrene, \( p \)- or \( m \)-(1-isopropoxy-1-methylpropoxy)methylstyrene, \( p \)- or \( m \)-(1-isopropoxy-1-methylpropoxy)methylstyrene, \( p \)- or \( m \)-(1-isopropoxy-1-methylpropoxy)methylstyrene, \( p \)- or \( m \)-(1-isopropoxy-1-methylpropoxy)methylstyrene, \( p \)- or \( m \)-(1-isopropoxy-1-methylpropoxy)methylstyrene, \( p \)- or \( m \)-(1-isopropoxy-1-methylpropoxy)methylstyrene, \( p \)- or \( m \)-(1-isopropoxy-1-methylpropoxy)methylstyrene, \( p \)- or \( m \)-(1-isopropoxy-1-methylpropoxy)methylstyrene, \( p \)- or \( m \)-(1-isopropoxy-1-methylpropoxy)methylstyrene, \( p \)- or \( m \)-(1-isopropoxy-1-methylpropoxy)methylstyrene, \( p \)- or \( m \)-(1-isopropoxy-1-methylpropoxy)methylstyrene, \( p \)- or \( m \)-(1-isopropoxy-1-methylpropoxy)methylstyrene, \( p \)- or \( m \)-(1-isopropoxy-1-methylpropoxy)methylstyrene, \( p \)- or \( m \)-(1-isopropoxy-1-methylpropoxy)methylstyrene, \( p \)- or \( m \)-(1-isopropoxy-1-methylpropoxy)methylstyrene, \( p \)- or \( m \)-(1-isopropoxy-1-methylpropoxy)methylstyrene, \( p \)- or \( m \)-(1-isopropoxy-1-methylpropoxy)methylstyrene, \( p \)- or \( m \)-(1-isopropoxy-1-methylpropoxy)methylstyrene, \( p \)- or \( m \)-(1-isopropoxy-1-methylpropoxy)methylstyrene, \( p \)- or \( m \)-(1-isopropoxy-1-methylpropoxy)methylstyrene, \( p \)- or \( m \)-(1-isopropoxy-1-methylpropoxy)methylstyrene, \( p \)- or \( m \)-(1-isopropoxy-1-methylpropoxy)methylstyrene, \( p \)- or \( m \)-(1-isopropoxy-1-methylpropoxy)methylstyrene, \( p \)- or \( m \)-(1-isopropoxy-1-methylpropoxy)methylstyrene, \( p \)- or \( m \)-(1-isopropoxy-1-methylpropoxy)methylstyrene, \( p \)- or \( m \)-(1-isopropoxy-1-methylpropoxy)methylstyrene, \( p \)- or \( m \)-(1-isopropoxy-1-methylpropoxy)methylstyrene, \( p \)- or \( m \)-(1-isopropoxy-1-methylpropoxy)methylstyrene, \( p \)- or \( m \)-(1-isopropoxy-1-methylpropoxy)methylstyrene, \( p \)- or \( m \)-(1-isopropoxy-1-methylpropoxy)methylstyrene, \( p \)- or \( m \)-(1-isopropoxy-1-methylpropoxy)methylstyrene, \( p \)- or \( m \)-(1-isopropoxy-1-methylpropoxy)methylstyrene, \( p \)- or \( m \)-(1-isopropoxy-1-methylpropoxy)methylstyrene, and \( p \)- or \( m \)-(1-isopropoxy-1-methylpropoxy)methylstyrene. Further examples of polymers having alkoxyalkyl ester acid-labile groups can be found in US 5225316 and EP 829766. Examples of polymers having acetal protecting groups are described, for example, in US 5670299, EP 780732, US 5627006, US 5558976, US 5558971, US 5468589, EP 704762, EP 762206, EP 342498, EP 553737 and in ACS Symp. Ser. 614, Microelectronics Technology, pp. 35-55 (1995), J. Photopolymer Sci. Technol. Vol. 10, No. 4 (1997), pp. 571-578, J. Photopolymer Sci. Technol. Vol. 12, no. 4 (1999) pp. 591-599 and in "Proceedings of SPIE", Advances in Resist Technology and Processing XVII, Vol. 3999, Part One, pp. 579-590, 28. Feb.-1. March 2000. The polymers suitable in the composition according to the invention are not, however, limited thereto. The monomers having an acid-labile group can, where appropriate, also be co-polymerised with other free-radically polymerisable monomers that do not carry acid-labile groups, such
as, for example, styrene, acrylonitrile, methyl (meth)acrylate, (meth)acrylic acid, 4-hydroxy-
styrene, 4-acetoxy styrene, 4-methoxystyrene, 4-vinylcyclohexanol, norbornene, ethyl-
norbornene and maleic anhydride, in order to establish specific solubility properties and
adhesive properties. Alternatively, the acid-labile groups can be introduced only subse-
5 quently in a polymer-analogous reaction. It is also known to the person skilled in the art that
the prepolymer can be modified in targeted manner before such a polymer-analogous
reaction, for example by partial hydrogenation, partial alkylation, partial acetylation. That is
to say, that the polymer having acid-labile groups does not, in every case, have to be
synthesised from monomers by copolymerisation.

10 It is also possible to introduce acid-labile crosslinking, as described, for example, in H.-T.
Schacht, P. Falcigno, N. Muenzel, R. Schulz and A. Medina, ACS Symp. Ser. 706 (Micro-
Holzwarth and J. Schneider, J. Photopolymer Science and Technology, Vol.9, (1996), 573-
15 586. Such acid-crosslinked systems are preferred in resist applications from the standpoint
of heat stability. Such acid-labile crosslinking can also be obtained by the reaction of phenol-
group-containing polymers, such as, for example, 4-hydroxystyrene co-polymers, with di- and
poly-functional vinyl ethers.

20 Other examples of component (a2) that increase their solubility in an alkaline developer upon
reaction with acid are monomeric compounds, such as, for example, carboxylic acids and
phenol-group-containing compounds, in which the carboxylic acid group or phenolic OH
group, respectively, has been blocked by acid-labile protecting groups. Such acid-labile
blocking can be effected, for example, by conversion of the carboxyl group into a tert-butyl
ester group, a 2-methyl-2-adamantyl ester group, an 8-ethyl-8-tricyclodecanyl ester group, a
tetrahydropyranyl ester group or some other acid-cleavable ester group. Phenolic OH
groups can be blocked according to known processes by conversion, e.g. into acid-cleavable
tert-butylcarbonate groups, silyl ethers, acetal groups and ketal groups.

25 The invention relates also to a radiation-sensitive composition wherein component (a2) is at
least one compound selected from the group of cycloaliphatic copolymers, 4-hydroxy-phenyl-
group-containing copolymers, maleic acid anhydride-containing copolymers and acrylic acid-
acrylic acid ester- and methacrylic acid ester-containing copolymers, with the proviso that
those copolymers carry functional groups that increase the solubility of the polymer in an alkaline developer after reaction with an acid.

In the compositions according to the invention, the photoinitiator (b) is advantageously used in an amount of from 0.05 % to 15 %, e.g. from 0.5 % to 10 %, preferably from 1 % to 5 %, based on the composition.

The compositions according to the invention can be used in numerous applications, for example in cationically radiation-curable printing inks, in cationically radiation-curable coating compounds which may or may not be pigmented, in cationically radiation-curable adhesives, coatings and mouldings, including glass fibre-reinforced and carbon fibre-reinforced composites and inner and outer layers of printed circuit boards.

The compositions according to the invention include also adhesives, as used, for example, for adhesive bonding (DVD bonding) in the manufacture of digital versatile disks (DVD) and as described, for example, in: WO 99/66506, WO 99/63017, JP 11241055 A2 Heisei, JP 11181391 A2 Heisei, WO 98/31765, and also as radiation-curable laminating adhesives for flexible packaging (see, e.g., US 5328940), optical adhesives (e.g. German Patent Application DD 225985) and pressure-sensitive adhesives (e.g. US 4988741 and EP 115870).

The compositions according to the invention are also suitable for use in uv-curing adhesives, e.g. in the preparation of pressure-sensitive adhesives, laminating adhesives, hot-melt adhesives, moisture-cure adhesives, silane reactive adhesives or silane reactive sealants and the like, and related applications.

Said adhesives can be hot melt adhesives as well waterborne or solvent borne adhesives, liquid solventless adhesives or 2-part reactive adhesives. In particular suitable are pressure-sensitive adhesives (PSA), for example uv-curable hot melt pressure sensitive adhesives. Said adhesives for example comprise at least one rubber component, at least one resin component as tackyfier and at least one oil component, for example in the weight ratio 30:50:20. Suitable tackyfiers are natural or synthetic resins. The person skilled in the art is aware of suitable corresponding compounds as well as of suitable oil components or rubbers.

The pre-polymerized adhesives containing the isocyanates, for example in blocked form, can for example be processed at high temperature and coated onto the substrate following the
hotmelt process, afterwards full cure is achieved by an additional curing step involving the
blocked isocyanates, which is realized by photoactivation of the photolatent catalyst.

Hotmelt adhesives are interesting as pressure sensitive adhesives and suitable to replace
the use of solvent base compositions, which from an environmental point of view are un-
wanted. The hotmelt extrusion process in order to achieve the high flow viscosity necessitates
high application temperatures. The compositions of the present invention comprising isocy-
anates are suitable as crosslinkers in the preparation of a hotmelt coating, where the crosslink-
ers enter into a chemical reaction with the functional comonomers of the (meth)acrylate PSA.

After the coating operation, the PSAs are first crosslinked thermally, or implementing the dual
crosslinking mechanism, the PSA is subsequently crosslinked with UV light. UV crosslinking
irradiation takes place by means of shortwave ultraviolet radiation in a wavelength range
from 200 to 400 nm, even expanding in the visible range, e.g. up to 650 nm, depending on
the source of the UV radiation equipment, as well as on the photolatent metal catalyst. Such
systems and processes are for example described in US 2006/0052472, the disclosure of
which hereby is incorporated by reference.

The compositions according to the invention are advantageously used where there is a need
for hard coatings, adhesive bonds or photopolymerised dimensionally stable three-dimen-
sional mouldings (e.g. for rapid prototyping) having good adhesion to paper, glass, metal, sili-
con, polycarbonate, acrylate polymers and other polymer substrates, and that exhibit only
slight shrinkage during curing.

Depending on the kind of application of the compounds of formula I according to the present
invention it may be advantageous to add appropriate further additives, sensitziers and/or
photoinitiators. Such additives, sensitizers and photoinitiators are customary in the art and
known to the person skilled in the art.

The photopolymerisable mixtures can comprise various additives (c) in addition to the
photoinitiator. Examples thereof include thermal inhibitors, light stabilisers, optical bright-
eners, fillers and pigments, as well as white and coloured pigments, dyes, antistatics, adhe-
sion promoters, wetting agents, flow auxiliaries, lubricants, waxes, anti-adhesive agents, dis-
persants, emulsifiers, anti-oxidants; fillers, e.g. talcum, gypsum, silicic acid, rutile, carbon
black, zinc oxide, iron oxides; reaction accelerators, thickeners, matting agents, antifoams,
and other adjuvants customary, for example, in lacquer and coating technology.
The formulations can also comprise dyes and/or white or coloured pigments as additional additives (c). Depending upon the intended use, it is possible to use both inorganic and organic pigments. Such additives are known to the person skilled in the art; some examples thereof are titanium dioxide pigments, for example of the rutile or anatase type, carbon black, zinc oxide, such as zinc white, iron oxides, such as iron oxide yellow, iron oxide red, chromium yellow, chromium green, nickel titanium yellow, ultramarine blue, cobalt blue, bismuth vanadate, cadmium yellow and cadmium red. Examples of organic pigments are mono- or bis-azo pigments, and metal complexes thereof, phthalocyanine pigments, polycyclic pigments, such as, for example, perylene, anthraquinone, thioindigo, quinacridone and triphenylmethane pigments, and diketo- pyrrolo-pyrrole, isoindolinone, e.g. tetrachloro-isoindolinone, isoindoline, dioxazine, benzimidazolone and quinophthalone pigments. The pigments can be used individually or in admixture in the formulations. Depending upon the intended use, the pigments are added to the formulations in amounts customary in the art, for example in an amount of from 1 to 60 % by weight, or from 10 to 30 % by weight, based on the total weight.

The formulations may, for example, also comprise organic dyes of a wide variety of classes. Examples thereof include azo dyes, methine dyes, anthraquinone dyes and metal complex dyes. Customary concentrations are, for example, from 0.1 to 20 %, especially from 1 to 5 %, based on the total weight.

The pigments, latent pigments or dyes or differently coloured precursors of such pigments and dyes that are added may be so selected that they undergo a colour change in the presence of the acid formed from the iodonium salt as a result of irradiation. Such compositions then show, by the colour change, that they have been irradiated and can be used, for example, as irradiation dose indicators, e.g. for UV radiation, electron beams, X-rays, etc..

The choice of additives will depend upon the field of use in question and upon the properties desired for that field. The additives (c) described above are customary in the art and are accordingly used in amounts customary in the art.

The compositions according to the present invention as component (c) also may comprise a stabilizer for the compounds of the formula I, e.g. from the hindered nitroxyl or phosphite type as are for example described as stabilizers for iodonium salts in WO 05/070989.
Examples for said stabilizer compounds are organic phosphorus stabilizers as disclosed for example in US 6444733, the disclosure of which is hereby incorporated by reference. Organic phosphorus stabilizers are known and many are commercially available. Other examples for said stabilizer compounds are hindered nitroxyl stabilizers, or hindered nitroxides, as are well known in the art and are disclosed for example in US 6337426 and, US 5254760, the relevant disclosures of which are hereby incorporated by reference. Other suitable stabilizers (c) for the sulphonium salts of the formula I are for example disclosed in WO 99/35188. Examples are tertiary and sterically hindered amines, such as the TINUVIN® products, provided by Ciba Specialty Chemicals, in particular TINUVIN® 144 and TINUVIN® 292.

Acceleration of the photopolymerisation can also be effected by adding as further additives (d) photosensitisers that shift or broaden the spectral sensitivity. These are especially aromatic carbonyl compounds, such as, for example, benzophenone, thioxanthone, and especially 3-isopropylthioxanthone, phenothiazine derivatives, anthraquinone and 3-acylcoumarin derivatives, terphenyls, styril ketones, and 3-(arylmethylene)-thiazolines, camphorquinone, and also eosin, rhodamine and erythrosin dyes, and anthracene derivatives, such as, for example, 9-methylnanthracene, 9,10-dimethylnanthracene, 9,10-diethoxy anthracene, 9,10-dibutoxy anthracene, 9-methoxy anthracene, 9-anthracenemethanol, especially 9,10-dimethoxy-2-ethyl-anthracene, 9,10-dibutoxyanthracene and 9,10-diehthoxyanthracene. Further suitable photosensitisers are mentioned, for example, in WO 98/47046.

Subject of the invention also are radiation-sensitive compositions as described above, additionally to components (a1) or (a2) and (b) comprising at least one sensitizer compound (d), in particular benzophenone, thioxanthone, anthracene or derivatives thereof.

Further examples of suitable photosensitisers (d) are disclosed in WO 06/008251, page 36, line 30 to page 38, line 8, the disclosure of which is hereby incorporated by reference.

It is also possible to use electron donor compounds, such as, for example, alkyl- and arylamine donor compounds, in the composition. Such compounds are, for example, 4-di-methylaminobenzoic acid, ethyl 4-dimethylaminobenzoate, 3-dimethylaminobenzoic acid, 4-dimethylaminobenzoin, 4-dimethylaminobenzaldehyde, 4-dimethylaminobenzonitrile and 1,2,4-trimethoxy benzene. Such donor compounds are preferably used in a concentration of from 0.01 to 5 %, especially in a concentration of from 0.05 to 0.50 %, based on the formulation.
The sensitisers (d) described above are customary in the art and are accordingly used in amounts customary in the art, preferably in a concentration of from 0.05 to 5 %, especially in a concentration of from 0.1 to 2 %, based on the composition.

The compositions according to the invention may additionally comprise further photo-initiators (e), such as, for example, cationic photoinitiators, photo acid-formers and free-radical photoinitiators as co-initiators in amounts of from 0.01 to 15 %, preferably from 0.1 to 5 %.

Examples of cationic photoinitiators and acid-formers are phosphonium salts, diazonium salts, pyridinium salts, iodonium salts, such as for example tolylcumyliodonium tetrakis(pentafluorophenyl)borate, 4-[(2-hydroxy-tetradecyloxy)phenyl]phenylidonium hexafluoroantimonate or hexafluorophosphate (SarCat® CD 1012; Sartomer), tolylcumyliodonium hexafluorophosphate, 4-isobutylphenyl-4'-methylphenyliodonium hexafluorophosphate (IRGACURE® 250, Ciba Specialty Chemicals), 4-octyloxyphenyl-phenyliodonium hexafluorophosphate or hexafluoroantimonate, bis(dodecylphenyl)iodonium hexafluoroantimonate or hexafluorophosphate, bis(4-methylphenyl)iodonium hexafluorophosphate, bis(4-methoxyphenyl)iodonium hexafluorophosphate, 4-methylphenyl-4'-ethoxyphenyliodonium hexafluorophosphate, 4-methylphenyl-4'-dodecyl phenyliodonium hexafluorophosphate, 4-methylphenyl-4'-phenoxyphenyliodonium hexafluorophosphate. Of all the iodonium salts mentioned, compounds with other anions are, of course, also suitable; further sulphonium salts, obtainable, for example, under the trade names CYRACURE® UVI-6990, CYRACURE® UVI-6974 (Union Carbide), DEGACURE® KI 85 (Degussa), SP-55, SP-150, SP-170 (Asahi Denka), GE UVE 1014 (General Electric), SarCat® KI-85 (= triarylsulphonium hexafluorophosphate; Sartomer), SarCat® CD 1010 (= mixed triarylsulphonium hexafluoroantimonate; Sartomer); SarCat® CD 1011 (= mixed triarylsulphonium hexafluorophosphate; Sartomer); ferrocenium salts, e.g. (η⁶-isopropylbenzene)(η⁵-cyclopentadienyl)-iron-ll hexafluorophosphate, nitrobenzylsulphonates, alkyl- and aryl-N-sulphonyloximidines and further known alkylsulphonic acid esters, haloalkylsulphonic acid esters, 1,2-disulphones, oxime sulphonates, benzoin tosylate, tolylsulphonyloxy-2-hydroxy-2-methyl-1-phenyl-1-propanone and further known beta-ketosulphones, beta-sulphonylsulphones, bis(alkylsulphonyldiazomethane, bis(4-tert-butylphenyl-sulphonyl)-diazomethane, benzoyl-tosyl-diazomethane, iminosulphonates and imidosulphonates and trichloromethyl-s-triazines and other haloalkyl-group-containing compounds. Examples of further suitable additional photolatent acids (b1) include the examples of cati-
onic photoinitiators and acid-formers as given in WO 04/074242, page 38, line 10 to page 41, line 14, as well as the compounds disclosed in the examples of WO 04/074242, the relevant disclosure of which is incorporated herein by reference.

Examples of free-radical photoinitiators as co-initiators are compounds as described above.

The compositions according to the invention may be used for a variety of purposes, for example as printing inks, such as screen-printing inks, flexo printing inks or offset printing inks, as clear lacquer, as coloured surface-coating compositions, as white surface-coating compositions, e.g. for wood or metal, as powder coating compositions, as paint, *inter alia* for paper, wood, metal or plastics, as daylight-curable paint for marking structures and roads, for photographic reproduction processes, for holographic recording materials, for image-recording processes or for the production of printing plates that are to be developed with organic solvents or using aqueous-alkaline media, in the production of masks for screen-printing, as dental filling compounds, as radiation-curable adhesives, as pressure-sensitive adhesives, as anti-adhesive coatings, as laminating resins, as photoresists, e.g. galvano-resists, etch resists or permanent resists, liquid films and dry films, as photostructurable dielectrics, and as solder masks for electronic circuits, as resists in the manufacture of colour filters for any type of screen or for producing structures in the manufacture of plasma displays and electroluminescent displays, in the manufacture of optical switches, optical gratings (interference gratings), in the coating or sealing of electronic components, e.g. as electroinsulating compounds, or as coatings for optical fibres, for coil coating, as indicator systems for UV radiation, X-rays and electron beams, and in the manufacture of three-dimensional articles, e.g. for stereolithography and for composites, e.g. for composites reinforced with glass or carbon or graphite fibres. The compositions are also suitable for the manufacture of optical lenses, e.g. contact lenses or Fresnel lenses, and also in the manufacture of medical apparatus, aids or implants.

The photocurable compositions according to the invention are suitable, for example, as coating materials for all kinds of substrates, for example wood, textiles, paper, ceramics, glass, marble, plastics, such as polyester, polyethylene terephthalate, polyolefins or cellulose acetate, especially in the form of films, and metals, such as Al, Cu, Ni, Fe, Zn, Mg or Co and GaAs, Si or SiO₂, to which a coating is to be applied or an image is to be applied by image-wise exposure, or to which a structured resist layer is to be applied.
The coating of the substrates can be effected by applying a liquid composition, a solution or suspension to the substrate. The choice of solvent in a solution and the concentration are governed chiefly by the nature of the composition and by the coating method. The solvent should be inert, that is to say it should not enter into any chemical reaction with the components and it should be capable of being removed again upon drying after the coating operation.

Examples of suitable solvents are ketones, ethers and esters, such as methyl ethyl ketone, isobutyl methyl ketone, cyclopentanone, cyclohexanone, 2-heptanone, methyl amyl ketone, N-methylpyrrolidone, gamma-butyrolactone, dioxane, tetrahydrofuran, 2-methoxyethanol, 2-ethoxyethanol, 1-methoxy-2-propanol, 1,2-dimethoxyethane, acetic acid ethyl ester, acetic acid n-butyl ester, propylene glycol monomethyl ether acetate, lactic acid ethyl ester, propylene carbonate and 3-ethoxy-propionic acid ethyl ester.

After coating of the substrates, the solvent is generally removed by drying.

The formulation is applied uniformly to a substrate by known coating methods, for example by spin-coating, immersion, knife coating, curtain pouring, brush application or spraying, especially by electrostatic spraying and reverse-roll coating, and by electrophoretic deposition.

It is also possible to apply the photosensitive layer to a temporary flexible support and then coat the final substrate, e.g. a copper-laminated printed circuit board, by transferring the layer by lamination.

The amount applied (layer thickness) and the type of substrate (layer support) are dependent upon the desired field of use. The layer thickness range generally includes values from about 0.1 µm to more than 100 µm, preferably from 0.5 micrometre to 50 micrometres. In the manufacture of three-dimensional articles, e.g. by stereolithography, the dimensions of the articles that can be obtained are limited only by the size of the exposure apparatus.

The compounds of the formula 1 can be used as photosensitive acid donors in a photoresist. Resist systems can be prepared by image-wise irradiation of systems comprising compounds of formula 1 followed by a developing step.

The invention accordingly relates to a radiation-sensitive composition as described above, which is a chemically amplified photoresist composition.

In particular a chemically amplified photoresist composition comprising
(a1) a compound which cures upon the action of an acid or
(a2) a compound whose solubility is increased upon the action of an acid; and
(b) as photosensitive acid donor, at least one compound of the formula I.

A chemically amplified photoresist is understood to be a resist composition wherein the radiation sensitive component provides a catalytic amount of acid which subsequently catalyses a chemical reaction of at least one acid-sensitive component of the resist. Resulting is the induction of a solubility difference between the irradiated and non-irradiated areas of the resist. Because of the catalytic nature of this process, one acid molecule can trigger reactions at multiple sites as it diffuses through the reactive polymer matrix, from one reaction site to the next, as long as it is not trapped or destroyed by any secondary reaction. Therefore, a small acid concentration is sufficient to induce a high difference in the solubility between exposed and unexposed areas in the resist. Thus, only a small concentration of the latent acid compound is necessary. As a result, resists with high contrast and high transparency at the exposure wavelength in optical imaging can be formulated, which in turn produce steep, vertical image profiles at high photosensitivity. However, as a result of this catalytic process, it is required that the latent acid catalysts are chemically and thermally very stable (as long as not irradiated) in order not to generate acid during resist storage or during processing, which in most cases requires a post exposure bake step to start or to complete the catalytic reaction which leads to the solubility differential. It is also required to have good solubility of the latent catalysts in the liquid resist formulation and the solid resist film to avoid any particle generation which would interfere with the application of these resists in microelectronic manufacturing processes.

In contrast, positive resist materials which are not based on the chemical amplification mechanism must contain a high concentration of the latent acid, because it is only the acid concentration which is generated from the latent acid under exposure which contributes to the increased solubility of the exposed areas in alkaline developer. Because small acid concentration has only a little effect on the change of the dissolution rate of such resist and the reaction proceeds typically without a post exposure bake here, the requirements regarding chemical and thermal stability of the latent acid are less demanding than for chemically amplified positive resists. These resists require also a much higher exposure dose to generate enough acid for achieving sufficient solubility in the alkaline developer in the exposed areas and also suffer from the relatively low optical transparency (due to the high concentration of latent acid necessary) and thus also lower resolution and sloped images. Resist com-
positions based on non-chemically amplified technology are therefore inferior in photosensitivity, resolution and image quality compared to chemically amplified resists.

From the above it becomes clear that chemical and thermal stability of a latent catalyst is vital for a chemically amplified resist and that latent acids which can work in a non-chemically amplified resist are not necessarily applicable to chemically amplified resists because of the different acid diffusion requirements, acid strength requirements and thermal and chemical stability requirements.

The difference in resist solubility between irradiated and non-irradiated sections that occurs as a result of the acid-catalysed reaction of the resist material during or after irradiation of the resist may be of two types depending upon which further constituents are present in the resist. If the compositions according to the invention comprise components that increase the solubility of the composition in the developer after irradiation, the resist is positive.

The invention accordingly relates to a chemically amplified positive photoresist.

If, on the other hand, the components of the formulation reduce the solubility of the composition after irradiation, the resist is negative.

The invention accordingly relates also to a chemically amplified negative photoresist.

A monomeric or polymeric compound which - in the unexposed areas - reduces the dissolution rate of an additionally present alkaline soluble binder resin in the resist formulation and which is essentially alkali-insoluble in the unexposed areas so that the resist film remains in the unexposed area after development in alkaline solution, but which is cleaved in the presence of acid, or is capable of being rearranged, in such a manner that its reaction product becomes soluble in the alkaline developer is referred to hereinafter as dissolution inhibitor.

The invention includes, as a special embodiment a chemically amplified positive alkaline-developable photoresist composition, comprising

(a1) at least one polymer having acid-labile groups which decompose in the presence of an acid and increase the solubility of the resist film in an aqueous alkaline developer solution in the exposed area and

(b) at least one compound of formula I.
A further embodiment of the invention is a chemically amplified positive alkaline-developable photoresist composition, comprising

(a21) at least one monomeric or oligomeric dissolution inhibitor having at least one acid-labile group which decomposes in the presence of acid and increases the solubility in an aqueous alkaline developer solution and at least one alkali-soluble polymer and,

(b) at least one compound of formula 1.

Another specific embodiment of the invention resides in a chemically amplified positive alkaline-developable photoresist composition, comprising

(a1 1) at least one polymer having acid labile groups which decompose in the presence of an acid and increase the solubility in an alkaline developer in the exposed area;

(a21) a monomeric or oligomeric dissolution inhibitor, having at least one acid labile group, which decomposes in the presence of an acid and increase the alkaline solubility in the exposed area;

(a31) an alkali-soluble monomeric, oligomeric or polymeric compound at a concentration which still keeps the resist film in the unexposed area essentially insoluble in the alkaline developer, and

(b) at least one compound of formula 1.

The invention therefore pertains to a chemically amplified photoresist composition, comprising

(a1 1) at least one polymer having an acid-labile group which decomposes in the presence of an acid to increase the solubility in aqueous alkaline developer solution and/or

(a21) at least one monomeric or oligomeric dissolution inhibitor having an acid-labile group which decomposes in the presence of an acid to increase the solubility in aqueous alkaline developer solution and/or

(a31) at least one alkali-soluble monomeric, oligomeric or polymeric compound; and

(b) as photosensitive acid donor, at least one compound of formula 1.

The compositions may comprise additionally to the component (b) other photosensitive acid donors (b1) and/or other additives(c).

Such chemically amplified positive resist systems are described, for example, in E. Reichmanis, F. M. Houlihan, O. Nalamasu, T. X. Neenan, Chem. Mater. 1991, 3, 394; or in C. G.
Suitable examples of acid-labile groups (in the polymers (a1 1)) which decompose in the presence of an acid to produce aromatic hydroxy groups, carboxylic groups, keto groups and aldehyde groups and increase the solubility in aqueous alkaline developer solution are, for example, alkoxyalkyl ether groups, tetrahydrofuranyl ether groups, tetrahydropyranyl ether groups, tert.-alkyl ester groups, trityl ether groups, silyl ether groups, alkyl carbonate groups as for example tert.-butyloxy carbonyloxy-, trityl ester groups, silyl ester groups, alkoxymethyl ester groups, cumyl ester groups, acetal groups, ketol groups, tetrahydropyranyl ester groups, tetrafuranyl ester groups, tertiary alkyl ether groups, tertiary alkyl ester groups, and the like. Examples of such group include alkyl esters such as methyl ester and tert-butyl ester, acetal type esters such as methoxymethyl ester, ethoxymethyl ester, 1-ethoxyethyl ester, 1-isobutoxyethyl ester, 1-isoproxyethyl ester, 1-ethoxypropyl ester, 1-(2-methoxyethoxy) ethyl ester, 1-(2-acetoxyethoxy)ethyl ester, 1-[2-(1-adamantyloxy) ethoxy]ethyl ester, 1-[2-(1-adamantylcarbonyloxy)ethoxy]ethyl ester, tetrahydro-2-furyl ester and tetrahydro-2-pyranyl ester, and alicyclic ester such as isobornyl ester.

The polymer having functional groups capable of decomposing by the action of an acid to enhance solubility of the resist film comprising this polymer in an alkaline developing solution, which can be incorporated in the positive resist according to the present invention, may have the acid-labile groups in the backbone and/or side chains thereof, preferably in side chains thereof.

The polymer having acid-labile groups suitable for the use in the present invention can be obtained with a polymer analogous reaction where the alkaline soluble groups are partially or completely converted into the respective acid labile groups or directly by (co)-polymerization of monomers which have the acid labile groups already attached, as is for instance disclosed in EP 254853, EP 878738, EP 877293, JP-A-2-25850, JP-A-3-223860, and JP-A-4-251259. The polymers which have acid labile groups pendant to the polymer backbone, in the present invention preferably are polymers which have, for example silyl ether, acetal, ketol and alkoyalkylester groups (called "low-activation energy blocking groups") which cleave completely at relatively low post exposure bake temperatures (typically between room temperature and 110°C) and polymers which have, for example, tert-butylester groups or tert-butyloxycarbonyl (TBOC) groups or other ester groups which contain a secondary or tertiary
carbon atom next to the oxygen atom of the ester bond (called “high-activation energy blocking groups”) which need higher bake temperatures (typically > 110°C) in order to complete the deblocking reaction in the presence of acid. Hybrid systems can also be applied, wherein, both, high activation energy blocking groups as well as low activation energy blocking groups are present within one polymer. Alternatively, polymer blends of polymers, each utilizing a different blocking group chemistry, can be used in the photosensitive positive resist compositions according to the invention.

Preferred polymers which have acid labile groups are polymers and co-polymers comprising the following distinct monomer types:

1) monomers that contain acid-labile groups which decompose in the presence of an acid to increase the solubility in aqueous alkaline developer solution and

2) monomers that are free of acid labile groups and free of groups that contribute to the alkaline solubility and/or

3) monomers that contribute to aqueous alkaline solubility of the polymer.

Examples of monomers of type 1) are:
- non-cyclic or cyclic secondary and tertiary-alkyl (meth)acrylates such as butyl acrylate, including t-butyl acrylate, butyl methacrylate, including t-butyl methacrylate, 3-oxocyclohexyl (meth)acrylate, tetrahydropyranyl (meth)acrylate, 2-methyl-adamantyl (meth)acrylate, cyclohexyl (meth)acrylate, norbornyl (meth)acrylate, (2-tetrahydropyranyl)oxynorbonylalcohol acrylates, (2-tetrahydropyranyl)oxymethyltricyclododecanemethanol methacrylates, trimethylsilylmethyl (meth)acrylate, (2-tetrahydropyranyl)oxynorbonylalcohol acrylates, (2-tetrahydropyranyl)oxymethyltricyclododecanemethanol methacrylates, trimethylsilylmethyl (meth)acrylate o-/m-/p- (3-oxocyclohexyloxy)styrene, o-/m-/p- (1-methyl-1-phenylethoxy)styrene, o-/m-/p- tetrahydropyranyloxy styrene, o-/m-/p- adamantyloxystyrene, o-/m-/p- cyclohexyloxy styrene, o-/m-/p-norbornyloxystyrene, non-cyclic or cyclic alkoxy carbonylstyrenes such as o-/m-/p- butoxy carbonylstyrene, including p- t-butoxycarbonylstyrene, o-/m-/p- (3-oxocyclohexyloxy carbonyl)- styrene, o-/m-/p- (1-methyl-1-phenylethoxy carbonyl) styrene, o-/m-/p- tetrahydropyranoxy carbonylstyrene, o-/m-/p- adamantyloxycarbonylstyrene, o-/m-/p- cyclohexyloxy carbonylstyrene, o-/m-/p- norbornyloxy carbonylstyrene, non-cyclic or cyclic alkoxy carbonylstyrenes such as o-/m-/p- butoxy carbonyloxystyrene, including p- t-butoxycarbonyloxystyrene, o-/m-/p- (3-oxocyclohexyloxy carbonyl) styrene, o-/m-/p- (1-methyl-1-phenylethoxy carbonyl) styrene, o-/m-/p- tetrahydropyranoxy carbonyloxystyrene, o-/m-/p- adamantyloxycarbonyloxy-
ystyrene, o-/m-/p- cyclohexyloxycarbonyloxy styrene, o-/m-/p- norbornyloxycarbonyl oxy styrene, non-cyclic or cyclic alkoxy carbonylalkoxy styrenes such as o/s/m/p-butoxycarbonylmethoxy styrene, p- t-butoxycarbonylmethoxy styrene, o-/m-/p- (3-oxocyclohexyloxycarbonylmethoxy)- styrene, o-/m-/p- (1-methyl-1-phenylethoxy carbonylmethoxy) styrene, o-/m-/p- tetrahydropropy ranloxy carbonylmethoxy styrene, o-/m-/p- adamantyl oxycarbonylmethoxy styrene, o-/m-/p- cyclohexyloxycarbonylmethoxy styrene, o-/m-/p- norbornyloxycarbonyl methoxy styrene, trimethylsiloxy styrene, dimethyl (butyl) siloxy styrene, unsaturated alkyl acetates such as isopropenyl acetate and the derivatives thereof.

Monomers of type 1) bearing low activation energy acid labile groups include, for example, p- or m-(1-methoxy-1-methylethoxy)-styrene, p- or m-(1-methoxy-1-methylethoxy)- methyl styrene, p- or m-(1-methoxy-1-methylpropoxy) styrene, p- or m-(1-methoxy-1-methylpropoxy) methyl styrene, p- or m-(1-methoxy-1-methylethoxy)-styrene, p- or m-(1-methoxy-1-methylpropoxy)-methyl styrene, p- or m-(1-ethoxy-1-methylethoxy)-styrene, p- or m-(1-ethoxy-1-methylethoxy)-methyl styrene, p- or m-(1-ethoxy-1-methylethoxy)-methyl styrene, p- or m-(1-ethoxy-1-methylethoxy)-methyl styrene, p- or m-(1-ethoxy-1-methylethoxy)-methyl styrene, p- or m-(1-ethoxy-1-methylethoxy)-methyl styrene, p- or m-(1-ethoxy-1-methylethoxy)-methyl styrene, p- or m-(1-ethoxy-1-methylethoxy)-methyl styrene, p- or m-(1-ethoxy-1-methylethoxy)-methyl styrene, p- or m-(1-ethoxy-1-methylethoxy)-methyl styrene, p- or m-(1-ethoxy-1-methylethoxy)-methyl styrene, p- or m-(1-ethoxy-1-methylethoxy)-methyl styrene, p- or m-(1-ethoxy-1-methylethoxy)-methyl styrene, p- or m-(1-ethoxy-1-methylethoxy)-methyl styrene, p- or m-(1-ethoxy-1-methylethoxy)-methyl styrene, p- or m-(1-ethoxy-1-methylethoxy)-methyl styrene, p- or m-(1-ethoxy-1-methylethoxy)-methyl styrene, p- or m-(1-ethoxy-1-methylethoxy)-methyl styrene, p- or m-(1-ethoxy-1-methylethoxy)-methyl styrene, p- or m-(1-ethoxy-1-methylethoxy)-methyl styrene, p- or m-(1-ethoxy-1-methylethoxy)-methyl styrene, p- or m-(1-ethoxy-1-methylethoxy)-methyl styrene, p- or m-(1-ethoxy-1-methylethoxy)-methyl styrene, p- or m-(1-ethoxy-1-methylethoxy)-methyl styrene, p- or m-(1-ethoxy-1-methylethoxy)-methyl styrene, p- or m-(1-ethoxy-1-methylethoxy)-methyl styrene, p- or m-(1-ethoxy-1-methylethoxy)-methyl styrene, p- or m-(1-ethoxy-1-methylethoxy)-methyl styrene, p- or m-(1-ethoxy-1-methylethoxy)-methyl styrene, p- or m-(1-ethoxy-1-methylethoxy)-methyl styrene, p- or m-(1-ethoxy-1-methylethoxy)-methyl styrene, p- or m-(1-ethoxy-1-methylethoxy)-methyl styrene, p- or m-(1-ethoxy-1-methylethoxy)-methyl styrene, p- or m-(1-ethoxy-1-methylethoxy)-methyl styrene, p- or m-(1-ethoxy-1-methylethoxy)-methyl styrene, p- or m-(1-ethoxy-1-methylethoxy)-methyl styrene, p- or m-(1-ethoxy-1-methylethoxy)-methyl styrene, p- or m-(1-ethoxy-1-methylethoxy)-methyl styrene, p- or m-(1-ethoxy-1-methylethoxy)-methyl styrene, p- or m-(1-ethoxy-1-methylethoxy)-methyl styrene, p- or m-(1-ethoxy-1-methylethoxy)-methyl styrene, p- or m-(1-ethoxy-1-methylethoxy)-methyl styrene, p- or m-(1-ethoxy-1-methylethoxy)-methyl styrene, p- or m-(1-ethoxy-1-methylethoxy)-methyl styrene, p- or m-(1-ethoxy-1-methylethoxy)-methyl styrene, p- or m-(1-ethoxy-1-methylethoxy)-methyl styrene, p- or m-(1-ethoxy-1-methylethoxy)-methyl styrene, p- or m-(1-ethoxy-1-methylethoxy)-methyl styrene, p- or m-(1-ethoxy-1-methylethoxy)-methyl styrene.


Monomers with high activation energy acid labile groups are, for example, p-tert.-butoxycarbonyloxy styrene, tert.-butyl-acrylate, tert.-butyl-methacrylate, 2-methyl-2-adamantyl-methacrylate, isobornyl-methacrylate.


Examples of comonomers according to type 2) are:

aromatic vinyl monomers, such as styrene, α-methylstyrene, acetoxy styrene, α-methylene naphthylene, acenaphthylene, vinyl alicyclic compounds such as vinyl norbornane, vinyl adamantane. vinyl cyclohexane, alkyl (meth)acrylates such as methyl methacrylate, (meth)acrylonitrile, vinylcyclohexane, vinylcyclohexanol, itaconic anhydride, as well as maleic anhydride.

Examples of comonomers according to type 3) are:
vinyl aromatic compounds such as hydroxystyrene, acrylic acid compounds such as methacrylic acid, ethylcarbonyloxy-styrene and derivatives of thereof. These polymers are described, for example, in US 5827634, US 5625020, US 5492793, US 5372912, EP 660187, US 5679495, EP 813113 and EP 831369. Further examples are crotonic acid, isocrotonic acid, 3-butenolic acid, acrylic acid, 4-pentenoic acid, propiolic acid, 2-butynoic acid, maleic acid, fumaric acid, and acetylenecarboxylic acid. The polymer used in the present invention is not limited thereto.

Comonomers according to type 3) suitable for ArF resist technology in particular include, for example, 3-hydroxy-1-adamantyl acrylate, 3-hydroxy-1-adamantyl methacrylate, 3,5-dihydroxy-1-adamantyl acrylate, 3,5-dihydroxy-1-adamantyl methacrylate, 2-hydroxy-5-norbornene, 5-norbornene-2-carboxylic acid, 1-(4-hydroxycyclohexyl)-1-methylethyl 5-norbornene-2-carboxylate, 2-hydroxy-1-ethyl 5-norbornene-2-carboxylate, 5-norbornene-2-methanol.


The content of acid labile monomers in the polymer may vary over a wide range and depends on the amount of the other comonomers and the alkaline solubility of the deprotected polymer. Typically, the content of monomers with acid labile groups in the polymer is between 5 and 60 mol%. If the content is too small, too low development rates and residues of the resist in the exposed areas result. If the content of acid labile monomers is too high, resist patterns are poorly defined (eroded) after development and narrow features cannot be resolved anymore and/or the resist looses its adhesion to the substrate during development. Preferably the copolymers which have acid labile groups have a $M_w$ of from about 3000 to about 200000, more preferably from about 5000 to about 50000 with a molecular weight distribution of about 3 or less, more preferably a molecular weight distribution of about 2 or less. Non-phenolic polymers, e.g. a copolymer of an alkyl acrylate such as t-butyl acrylate or t-butyl-methacrylate and a vinyl alicyclic compound, such as a vinyl norbonanyl or vinyl cyclohexanol compound, also may be prepared by such free radical polymerization or other known procedures and suitably will have a $M_w$ of from about 8000 to about 50000, and a molecular weight distribution of about 3 or less.

Other comonomers may suitably be added in an appropriate amount for the purpose of controlling the glass transition point of the polymer and the like.

In the present invention a mixture of two or more polymers having acid-labile groups may be used. For example, use may be made of a mixture of a polymer having acid-labile groups, which are cleaved very easily, such as acetal groups or tetrahydropyranoxy- groups and a polymer having acid-cleavable groups, that are less easily cleaved, such as for example tertiary alkyl ester groups. Also, acid cleavable groups of different size can be combined by blending two or more polymers having different acid cleavable groups, such as a tert-butylster group and 2-methyl-adamantyl group or an 1-ethoxy-ethoxy group and a tetrahydropyranloxy group. A mixture of a non-crosslinked resin and a crosslinked resin may also be used.
The amount of these polymers in the present invention is preferably from 30 to 99% by weight, more preferably from 50 to 98% by weight, based on the total amount of all solid components. An alkali-soluble resin or monomeric or oligomeric compound having no acid-labile groups may be further incorporated into the composition in order to control the alkali solubility.

Examples of polymer blends with polymers having different acid-labile groups are given in EP 780732, EP 679951 and US 5817444.

Preferably monomeric and oligomeric dissolution inhibitors (a21) are used in the present invention.

The monomeric or oligomeric dissolution inhibitor having the acid-labile group for use in the present invention is a compound which has at least one acid-labile group in the molecular structure, which decomposes in the presence of acid to increase the solubility in aqueous alkaline developer solution. Examples are alkoxyethyl ether groups, tetrahydrofuranyl ether groups, tetrahydropyranyl ether groups, alkoxyethyl ether groups, trityl ether groups, silyl ether groups, alkyl carbonate groups, trityl ester groups, silyl ester groups, alkoxyethyl ester groups, vinyl carbamate groups, tertiary alkyl carbamate groups, trityl amino groups, cumyl ester groups, acetal groups, ketal groups, tetrahydropyranyl ester groups, tetrafuranyl ester groups, tertiary alkyl ether groups, tertiary alkyl ester groups, and the like. The molecular weight of the acid-decomposable dissolution inhibitive compound for use in the present invention is 3'000 or lower, preferably from 100 to 3000, more preferably from 200 to 2'500.

The composition can also contain polymeric dissolution inhibitors, for example, polyacetals as described for example in US 5354643 or poly-N,O-acetals for example those described in US 5498506, either in combination with an alkaline soluble polymer, or in combination with a polymer containing acid labile groups which increase the solubility of the resist film in the developer after exposure, or with a combination of both types of polymers.

In the case where the dissolution inhibitor having acid-labile groups is used in the present invention in combination with the sulfonium salts of formula I, the alkaline-soluble polymer and/or the polymer having acid-labile groups, the amount of the dissolution inhibitor is from 3 to 55% by weight, preferably from 5 to 45% by weight, most preferably from 10 to 35% by weight, based on the total amount of all solid components of the photosensitive composition.

A polymer soluble in an aqueous alkali solution (a31) is preferably used in the present invention. Examples of these polymers include novolak resins, hydrogenated novolak resins, acetone-pyrogallol resins, poly(o-hydroxystyrene), poly(m-hydroxystyrene), poly(p-hydroxystyrene), hydrogenated poly(hydroxystyrene)s, halogen-or alkyl-substituted poly(hydroxystyrene)s, hydroxystyrene/N-substituted maleimide copolymers, o/p- and m/p-hydroxystyrene copolymers, partially o-alkylated poly(hydroxystyrene)s, [e.g., o-methylated, o-(1-methoxy)ethylated, o-(1-ethoxy)ethylated, o-2-tetrahydropyranylated, and o-(t-butoxycarbonyl)methylated poly(hydroxystyrene)s having a degree of substitution of from 5 to 30 mol% of the hydroxyl groups], o-acylated poly(hydroxystyrene)s [e.g., o-acetylated and o-(t-butoxy)carbonylated poly(hydroxystyrene)s having a degree of substitution of from 5 to 30 mol% of the hydroxyl groups], styrene/maleic anhydride copolymers, styrene/hydroxystyrene copolymers, α-methylstyrene/hydroxystyrene copolymers, carboxylated methacrylic resins, and derivatives thereof. Further suitable are poly (meth)acrylic acid [e.g. poly(acrylic acid)], (meth)acrylic acid/(meth)acrylate copolymers [e.g. acrylic acid/methyl acrylate copolymers, methacrylic acid/methyl methacrylate copolymers or methacrylic acid/methyl methacrylate/t-butyl methacrylate copolymers], (meth)acrylic acid/alkene copolymers [e.g. acrylic acid/ethylene copolymers], (meth)acrylic acid/(meth)acrylamide copolymers [e.g. acrylic acid/acrylamide copolymers], (meth)acrylic acid/vinyl chloride copolymers [e.g. acrylic acid/ vinyl chloride copolymers], (meth)acrylic acid/vinyl acetate copolymer [e.g. acrylic acid/ vinyl acetate copolymers], maleic acid/vinyl ether copolymers [e.g. maleic acid/methyl vinyl ether copolymers], maleic acid mono ester/methyl vinyl ester copolymers [e.g. maleic acid mono methyl es-
ter/methyl vinyl ether copolymers, maleic acid/(meth)acrylic acid copolymers [e.g. maleic acid/acrylic acid copolymers or maleic acid/methacrylic acid copolymers], maleic acid/(meth)acrylate copolymers [e.g. maleic acid/methyl acrylate copolymers], maleic acid/vinyl chloride copolymers, maleic acid/vinyl acetate copolymers and maleic acid/alkene copolymers [e.g. maleic acid/ethylene copolymers and maleic acid/1-chloropropene copolymers].

However, the alkali-soluble polymer for use in the present invention should not be construed as being limited to these examples.

Especially preferred alkali-soluble polymers (a31) are novolak resins, poly(o-hydroxy styrene), poly(m-hydroxy styrene), poly(p-hydroxy styrene), copolymers of the respective hydroxy styrene monomers, for example with p-vinyl cyclohexanol, alkyl-substituted poly(hydroxy styrene)s, partially o- or m-alkylated and o- or m-acylated poly(hydroxy styrene)s, styrene/hydroxy styrene copolymer, and α-methyl styrene/hydroxy styrene copolymers. The novolak resins are obtained by addition-condensing one or more given monomers as the main ingredient with one or more aldehydes in the presence of an acid catalyst.

Examples of monomers useful in preparing alkaline soluble resins include hydroxylated aromatic compounds such as phenol, cresols, i.e., m-cresol, p-cresol, and o-cresol, xylenols, e.g., 2,5-xylenol, 3,5-xylenol, 3,4-xylenol, and 2,3-xylenol, alkoxyphenols, e.g., p-methoxyphenol, m-methoxyphenol, 3,5-dimethoxyphenol, 2-methoxy-4-methylphenol, m-ethoxyphenol, p-ethoxyphenol, m-propoxyphenol, p-propoxyphenol, m-butoxyphenol, and p-butoxyphenol, dialkylphenols, e.g., 2-methyl-4-isopropylphenol, and other hydroxylated aromatics including m-chlorophenol, p-chlorophenol, o-chlorophenol, dihydroxybiphenyl, bisphenol A, phenylphenol, resorcinol, and naphthal. These compounds may be used alone or as a mixture of two or more thereof. The main monomers for novolak resins should not be construed as being limited to the above examples.

Examples of the aldehydes for polycondensation with phenolic compounds to obtain novolaks include formaldehyde, p-formaldehyde, acetaldehyde, propionaldehyde, benzaldehyde, phenylacetaldehyde, α-phenylpropionaldehyde, β-phenylpropionaldehyde, o-hydroxy benzaldehyde, m-hydroxy benzaldehyde, p-hydroxy benzaldehyde, o-chlorobenzaldehyde, m-chlorobenzaldehyde, p-chlorobenzaldehyde, o-nitrobenzaldehyde, m-nitrobenzaldehyde, o-methyl benzaldehyde, m-methyl benzaldehyde, p-methyl benzaldehyde, p-ethyl benzaldehyde, p-n-butyl benz aldehyde, furfural, chloro acetaldehyde, and acetals derived from these, such as chloroacetaldehyde diethyl acetal. Preferred of these is formaldehyde.
These aldehydes may be used alone or in combination of two or more thereof. Examples of the acid catalyst include hydrochloric acid, sulfuric acid, formic acid, acetic acid, and oxalic acid.

The weight-average molecular weight of the thus-obtained novolak resin suitably is from 1000 to 30000. If the weight-average molecular weight thereof is lower than 1000, the film reduction at unexposed parts during development is liable to be large. If the weight-average molecular weight thereof is lower than 50000, the developing rate may be too low. The especially preferred range of the molecular weight of the novolak resin is from 2000 to 200000.

The poly(hydroxystyrene)s and derivatives and copolymers thereof shown above as alkali-soluble polymers other than novolak resins each have a weight-average molecular weight of 2000 or higher, preferably from 4000 to 200000, more preferably from 5000 to 50000. From the standpoint of obtaining a polymer film having improved heat resistance, the weight-average molecular weight thereof is desirably at least 5000 or higher.

Weight-average molecular weight in the context of the present invention is meant to be the one determined by gel permeation chromatography and calibrated for with polystyrene standard.

In the present invention the alkali-soluble polymers may be used as a mixture of two or more thereof. In the case where a mixture of an alkali-soluble polymer and the polymer having groups which decompose by the action of an acid to enhance solubility in an alkaline developing solution is used, the addition amount of the alkali-soluble polymer is preferably up to 80% by weight, more preferably up to 60% by weight, most preferably up to 40% by weight, based on the total amount of the photosensitive composition (excluding the solvent). The amount exceeding 80% by weight is undesirable because the resist pattern suffers a considerable decrease in thickness, resulting in poor images and low resolution.

In the case where an alkali-soluble polymer is used together with a dissolution inhibitor, without the polymer having groups which decompose by the action of an acid, to enhance solubility in an alkaline developing solution, the amount of the alkali-soluble polymer is preferably from 40% to 90% by weight, more preferably from 50 to 85% by weight, most preferably 60 to 80% by weight. If the amount thereof is smaller than 40% by weight, undesirable results such as reduced sensitivity are caused. On the other hand, if it exceeds 90% by weight, the resist pattern suffers a considerable decrease in film thickness, resulting in poor resolution and image reproduction.
The content of the sulfonium salts of formula I (component (b)) in the positive resist according to the present invention is preferably between 0.01% to 20% by weight, based on the total amount of all solid components in the photoresist.

The use of the sulfonium salts according to the invention in chemically amplified systems, which operates on the principle of the removal of a protecting group from a polymer, generally produces a positive resist. Positive resists are preferred over negative resists in many applications, especially because of their higher resolution. There is, however, also interest in producing a negative image using the positive resist mechanism, in order to combine the advantages of the high degree of resolution of the positive resist with the properties of the negative resist. This can be achieved by introducing a so-called image-reversal step as described, for example, in EP 361906. For this purpose, the image-wise irradiated resist material is before the developing step treated with, for example, a gaseous base, thereby image-wise neutralizing the acid which has been produced. Then, a second irradiation, over the whole area, and thermal aftertreatment are carried out and the negative image is then developed in the customary manner.

The compounds of the formula I according to the present invention are in particular suitable as photolatent acids in the ArF resist technology, i.e. a technology using ArF excimer lasers (193 nm) for the imaging step. This technology requests the use of specific polymers/copolymers. Suitable formulations and the preparation of suitable polymer/copolymers are for example published in

Suitable solvents are alkyl halides, chlorinated hydrocarbons, ketones, esters, 
acids, and their esters. Suitable compounds are 1-chloro-2,4-dinitrobenzene, 
2-chloro-4,6-dinitroanisole, 2-chloro-4,6-dinitrophenol, trichloromethane, 
and dichloromethane. Suitable compositions are 1% (by volume) of the 
photolatent compound in chloroform. Suitable compositions of polymers/ 
copolymers for use as photolatent acid in all the polymers/copolymers are 
described in the cited publications.

The compounds of the formula I according to the present invention are 
suitable as photolatent acids in the bi-layer resist. This technology requests 
the use of specific polymers/copolymers. Suitable formulations and the 
preparation of suitable polymer/copolymers are for example published in Proc. 

The compounds of the formula I according to the present invention are 
suitable as photolatent acids in the multi-layer resist. This technology requests 
the use of specific polymers/copolymers. Suitable formulations and the 

In order to make fine hole pattern, thermal flow process or chemical 
shrink technology, so-called RELACS (resolution enhancement lithography 
assisted by chemical shrink) process, are applied for chemically amplified 
resist. The compounds of the formula I according to the present invention 
are suitable as photolatent acids in the resists for thermal flow process or 
RELACS process. These technologies request the use of specific polymers/copolymers. 
Suitable formulations and the preparation of suitable polymer/copolymers are for example 
The compounds of the formula I according to the present invention are suitable as photo-
lative acids in the F₂ resist technology, i.e. a technology using F₂ excimer lasers (157 nm) for
the imaging step. This technology requests the use of specific polymers/copolymers which
have high transparency at 157 nm. Examples of polymer suitable for this application are
fluoropolymers described in, for example, Proc. SPIE 3999, 330-334 (2000), Proc. SPIE
20020102490, US 20020146639, US 20030003379, US 20030017404, WO 2002021212,
silicon-containing polymers described in, for example, Proc. SPIE 3999, 365-374 (2000),
55456, JP-A-2002-348332. Polymers containing (meth)acrylonitrile monomer unit described
in, for example, JP-A-2002-1 96495 is also suitable for F₂ resist.

The compounds of the formula I according to the present invention are suitable as photo-
lative acids in the EUV resist, i.e. a technology using light source of extreme ultra violet
(13 nm) for the imaging step. This technology requests the use of specific poly-
mers/copolymers. Suitable formulations and the preparation of suitable polymer/copolymers

The compounds of the formula I according to the present invention are suitable as photolatent acids in the chemically amplified resist for immersion lithography. This technology reduces minimum feature size of resist pattern using liquid medium between the light source and the resist as described in Proceeding of SPIE 5040, 667 (2003), Proceeding of SPIE 5040, 679 (2003), Proceeding of SPIE 5040, 690 (2003), Proceeding of SPIE 5040, 724 (2003).


The formulations disclosed in the aforementioned publications are incorporated herein by reference. It is understood, that the compounds of the present invention are in particular suitable for use as photolatent acid in all the polymers/copolymers and compositions described in these cited publications.

Acid-sensitive components that produce a negative resist characteristically are especially compounds which, when catalysed by an acid (e.g. the acid formed during irradiation of the
compounds of formulae I are capable of undergoing a crosslinking reaction or a polymerization with themselves and/or with one or more further components of the composition. Compounds of this type are, for example, the known acid-curable resins, such as, for example, acrylic, polyester, alkyd, melamine, urea, epoxy, vinyl ether and phenolic resins or mixtures thereof. Amino resins, phenolic resins and epoxy resins are very suitable. Acid-curable resins of this type are generally known and are described, for example, in "Ullmann's Enyclopadie der technischen Chemie" [Ullmanns Enceyclopeda of Technical Chemistry], 4th Edition, Vol. 15 (1978), p. 613 - 628. The crosslinker components should generally be present in a concentration of from 2 to 40, preferably from 5 to 30, percent by weight, based on the total solids content of the negative resist composition.

The invention thus includes, as a special embodiment, chemically amplified negative, alkali-developable photoresists, comprising (a4) an alkali-soluble resin as binder

(a5) a component that when catalysed by an acid undergoes a crosslinking reaction with itself and/or with the binder, and
(b) as photosensitive acid donor an sulfonate derivative of formula I.

The composition may comprise additionally to the component (b) other photosensitive acid donors (b1), other photoinitiators (d) and/or (c) other additives.

Especially preferred as acid-curable resins (a5) are amino resins, such as non-etherified or etherified melamine, urea, guanidine or biuret resins, especially methylated melamine resins or butylated melamine resins, corresponding glycolurils and urones. By "resins" in this context, there are to be understood both customary technical mixtures, which generally also comprise oligomers, and pure and high purity compounds. N-hexa(methoxymethyl) melamine and tetramethoxymethyl glucoril and N,N'-dimethoxymethylurone are the acid-curable resins given the greatest preference.

The concentration of the compound of formula I in negative resists in general is from 0.1 to 30, preferably up to 20, percent by weight, based on the total solids content of the compositions. From 1 to 15 percent by weight is especially preferred.

Where appropriate, the negative compositions may comprise a film-forming polymeric binder (a4). This binder is preferably an alkali-soluble phenolic resin. Well suited for this purpose
are, for example, novolaks, derived from an aldehyde, for example acetaldehyde or furfuraldehyde, but especially from formaldehyde, and a phenol, for example unsubstituted phenol, mono- or di-chlorosubstituted phenol, such as p-chlorophenol, phenol mono- or di-substituted by Cl-C₉ alkyl, such as o-, m- or p-cresol, the various xylenols, p-tert-butylphenol, p-nonylphenol, p-phenylphenol, resorcinol, bis(4-hydroxyphenyl)methane or 2,2-bis(4-hydroxyphenyl)propane. Also suitable are homo- and co-polymers based on ethylenically unsaturated phenols, for example homopolymers of vinyl- and 1-propenyl-substituted phenols, such as p-vinylphenol or p-(1-propenyl)phenol or copolymers of these phenols with one or more ethylenically unsaturated materials, for example styrenes. The amount of binder should generally be from 30 to 95 percent by weight or, preferably, from 40 to 80 percent by weight.

An especially preferred negative resist composition comprises from 0.5 to 15 percent by weight of an sulfonate derivative of formula I (component (b)), from 40 to 99 percent by weight of a phenolic resin as binder (component (a41)), for example one of those mentioned above, and from 0.5 to 30 percent by weight of a melamine resin (component (a51)) as crosslinking agent, the percentages relating to the solids content of the composition. With novolak or especially with polyvinyl phenol as binder, a negative resist having especially good properties is obtained.

Sulfonium salts can also be used as acid generators, which can be activated photochemically, for the acid-catalysed crosslinking of, for example, poly(glycidyl)methacrylates in negative resist systems. Such crosslinking reactions are described, for example, by Chae et al. in Pollimo 1993, 17(3), 292.


The compounds of the formula I according to the present invention are suitable as photo-l latent acids in a chemically amplified solvent-developable negative photoresists. This technology requests the use of a specific component that when catalysed by an acid undergoes a crosslinking reaction or a polymerization with itself and/or with other components in the for-

The positive and the negative resist compositions may comprise in addition to the photosensitive acid donor compound of formula I further photosensitive acid donor compounds (b1), further additives (c), other photoinitiators (d), and/or sensitizers (e).

Therefore, subject of the invention also are chemically amplified resist compositions as described above, in addition to components (a) and (b), or components (a1 1), (a21), (a31 ) and (b), or components (a41), (a51) and (b) comprising further additives (c), further photosensitive acid donor compounds (b1), other photoinitiators (d), and/or sensitizers (e).

Sulfonium salts of the present invention in the positive and negative resist can also be used together with other, known photolatent acids (b1), for example, onium salts, 6-nitrobenzylsulfonates, bis-sulfonyl diazomethane compounds, cyano group-containing oximesulfonate compounds., etc.. Examples of known photolatent acids for chemically amplified resists are described in US 5731364, US 5800964, EP 704762, US 5468589, US 5558971, US 5558976, US 6004724, GB 2348644 and particularly in EP 794457 and EP 795786.

If a mixture of photolatent acids is used in the resist compositions according to the invention, the weight ratio of sulfonium salts of formula I to the other photolatent acid (b1) in the mixture is preferably from 1:99 to 99:1.

Examples of photolatent acids which are suitable to be used in admixture with the compounds of formula I, e.g. as component (b1), are

1. onium salt compounds, for example,
(2) Halogen-containing compounds

Haloalkyl group-containing heterocyclic compounds, haloalkyl group-containing hydrocarbon compounds and the like. Preferred are (trichloromethyl)-s-triazine derivatives such as phenyl-bis(trichloromethyl)-s-triazine, methoxyphenyl-bis(trichloromethyl)-s-triazine, naphthyl-bis-(trichloromethyl)-s-triazine and the like; 1,1-bis(4-chlorophenyl)-2,2,2-trichloroethane; and the like.

(3) Sulfone compounds, for example of the formula

\[ R_a^\alpha \text{S-C-S-R}_b \]

wherein \( R_a \) and \( R_b \) independently of one another are alkyl, cycloalkyl or aryl, each of which may have at least one substituent, e.g.

\[ \text{Such compounds are disclosed for example in US 2002/01 72886-A, JP-A-2003-192665, US2002/9663. More examples are } \beta \text{-ketosulfones, } \beta \text{-sulfonylsulfones and their } \alpha \text{-diazo derivatives and the like. Preferred are phenacylphenylsulfone, mesitylphenacylsulfone, bis(phenylsulfonyl)methane, bis(phenylsulfonyl)diazomethane.}

(4) Sulfonate compounds, for example

Alkylsulfonic acid esters, haloalkylsulfonic acid esters, arylsulfonic acid esters, iminosulfonates, imidosulfonates and the like. Preferred imidosulfonate compounds are, for example, N-(trifluoromethylsulfonyloxy)succinimide, N-(trifluoromethylsulfonyloxy)phthalimide, N-(trifluoromethylsulfonyloxy)naphthylimide, N-(trifluoromethylsulfonyloxy)diphenylmaleimide, N-(trifluoromethylsulfonyloxy)\( P^\text{bicyclo-P^Jl-hept-5-ene} \text{-dicarboximide}, N-(\text{trifluoromethylsulfonyloxy})\text{7-oxabicyclo[2,2,1]-heptan-5,6-oxy-2,3-dicarboximide}, N-(\text{camphanylsulfonyloxy})\text{succinimide}, N-(\text{camphanylsulfonyloxy})\text{phthalimide}, N-(\text{4-methylphenylsulfonyloxy})\text{naphthylimide}, N-(\text{camphanylsulfonyloxy})\text{diphenylmaleimide}, N-(\text{4-methylphenylsulfonyloxy})\text{bicyclo-[2,2,1]-heptan-5,6-oxy-2,3-dicarboximide}, N-(\text{4-methylphenylsulfonyloxy})\text{naphthylimide}, N-(\text{4-methylphenylsulfonyloxy})\text{diphenylmaleimide}, N-(\text{4-methylphenylsulfonyloxy})\text{bicyclo-[2,2,1]-heptan-5,6-oxy-2,3-dicarboximide}, N-(\text{4-methylphenylsulfonyloxy})\text{7-oxabicyclo-[2,2,1]-heptan-5,6-oxy-2,3-dicarboximide}, N-(\text{4-methylphenylsulfonyloxy})\text{7-oxabicyclo-[2,2,1]-heptan-5,6-oxy-2,3-dicarboximide}, N-(\text{4-methylphenylsulfonyloxy})\text{7-oxabicyclo-[2,2,1]-heptan-5,6-oxy-2,3-dicarboximide}, N-(\text{4-methylphenylsulfonyloxy})\text{naphthylimide}, N-(\text{4-methylphenylsulfonyloxy})\text{diphenylmaleimide}, N-(\text{4-methylphenylsulfonyloxy})\text{bicyclo-[2,2,1]-heptan-5,6-oxy-2,3-dicarboximide}.
N-(4-methylphenylsulfonyloxy)-bicyclo-[2,2,1]-hept-5-ene-2,3-dicarboximide, N-(4-methylphenylsulfonyloxy)-7-oxabicyclo-[2,2,1]-hept-5-ene-2,3-dicarboximide, N-(4-methylphenylsulfonyloxy)-bicyclo-p^il-heptan-5,6-oxy-2,3-dicarboximide, N-(2-trifluoromethylphenylsulfonyloxy)succinimide, N-(2-trifluoromethylphenylsulfonyloxy)naphthylimide, N-(2-trifluoromethylphenylsulfonyloxy)diphenylmaleimide, N-(2-trifluoromethylphenylsulfonyloxy)-bicyclo-[2,2,1]-hept-5-ene-2,3-dicarboximide, N-(2-trifluoromethylphenylsulfonyloxy)-7-oxabicyclo-[2,2,1]-hept-5-ene-2,3-dicarboximide, N-(2-trifluoromethylphenylsulfonyloxy)-bicyclo-[2,2,1]-heptan-5,6-oxy-2,3-dicarboximide and the like.

Other suitable sulfonate compounds preferably are, for example, benzoin tosylate, pyrogallol tristiflate, pyrogallolomethanesulfonic acid triester, nitorobenzyl-9,10-diethoxyanthracene-2-sulfonate, α-(4-toluene-sulfonyloxyiminobenzyl cyanide, α-(4-toluene-sulfonyloxyiminobenzyl)cyanoxybenzyl cyanide, α-(4-toluene-sulfonyloxyimino)-2-thienylmethyl cyanide, α-(methanesulfonyloxyiamino)-1-cyclohexenylacetonitrile, α-(butylsulfonyloxyimino)-1-cyclopenteny lacetonitrile, (4-methylsulfonyloxyimino-5H-thiophen-2-ylidene)-phenyl-acetonitrile, (4-methylsulfonyloxyimino-5H-thiophen-2-ylidene)-phenyl-acetonitrile, (4-methylsulfonyloxyimino-5H-thiophen-2-ylidene)-(2-methylphenyl)-acetonitrile, (4-methylsulfonyloxyimino-5H-thiophen-2-ylidene)-(2-methylphenyl)-acetonitrile, (4-methylsulfonyloxyimino-5H-thiophen-2-ylidene)-(2-methylphenyl)-acetonitrile, (4-methylsulfonyloxyimino-5H-thiophen-2-ylidene)-(2-methylphenyl)-acetonitrile, (4-methylsulfonyloxyimino-5H-thiophen-2-ylidene)-(2-methylphenyl)-acetonitrile, (4-methylsulfonyloxyimino-5H-thiophen-2-ylidene)-(2-chlorophenyl)-acetonitrile, 2,2,2-trifluoro-1-4-(3-[4-{2,2,2-trifluoro-1-(1-propanesulfonyloxyimino)-ethyl]-phenoxy]-propoxy)-phenyl)-ethanone oxime 1-propanesulfonate, 2,2,2-trifluoro-1-[4-(3-[4-{2,2,2-trifluoro-1-(1-p-toluenesulfonyloxyimino)-ethyl]-phenoxy]-propoxy)-phenyl]-ethanone oxime 1-p-toluenesulfonate and the like.

In the radiation sensitive resin composition of this invention, particularly preferred sulfonate compounds include pyrogallolmethanesulfonic acid triester, N-(trifluoromethylsulfonyloxy) bicyclo-[2,2,1]-hept-5-ene-2,3-dicarboximide, N-(camphanylsulfonyloxy)naphthylimide, N-(2-trifluoromethylphenylsulfonyloxy)phthalimide, N-(trifluoromethylsulfonyloxy)-bicyclo-[2,2,1]-hept-5-ene-2,3-dicarboximide, N-(camphanylsulfonyloxy)naphthylimide, N-(2-trifluoromethyl phenylsulfonyloxy)phthalimide and the like.

(5) Quinonediazide compounds, for example 1,2-quinonediazidesulfonic acid ester compounds of polyhydroxy compounds. Preferred are compounds having a 1,2-quinonediazidesulfonyl group, e.g. a 1,2-benzoquinonediazide-4-sulfonyl group, a 1,2-naphthoquinonediazide-4-sulfonyl group, a 1,2-naphthoquinonediazide-5-sulfonyl group, a 1,2-naphthoquinonediazide-6-sulfonyl group or the like. Particularly pre-
ferred are compounds having a 1,2-naphthoquinonediazide-4-sulfonyl group or a 1,2-naphthoquinonediazide-5-sulfonyl group. In particular suitable are 1,2-quinonediazidesulfonic acid esters of (poly)hydroxyphenyl aryl ketones such as 2,3,4-trihydroxybenzophenone, 2,4,6-trihydroxybenzophenone, 2,3,4,4'-tetrahydroxybenzophenone, 2,2',3,4-tetrahydroxybenzophenone, 2,3,4,4'-tetrahydroxybenzophenone, 2,2',4,4'-tetrahydroxybenzophenone 2,2',3,6'-pentahydroxybenzophenone, 2,3,3',4,4',5'-hexahydroxybenzophenone, 2,3',4,4',5'-hexahydroxybenzophenone and the like; 1,2-quinonediazidesulfonic acid esters of bis-[(poly)hydroxyphenyl]alkanes such as bis(4-hydroxyphenyl)ethane, bis(2,4-dihydroxyphenyl)ethane, 2,2-bis(4-hydroxyphenyl)propane, 2,2-bis(2,4-dihydroxyphenyl)propane and the like; 1,2-quinonediazidesulfonic acid esters of (poly)hydroxyphenylalkanes such as 4,4'-dihydroxytriphenylmethane, 4,4',4''-tri hydroxytriphenylmethane, 4,4',5,5'-tetramethyl-2,2,2''-trihydroxytriphenylmethane, 2,2,5,5'-tetramethyl-4,4',4''-trihydroxytriphenylmethane, 1,1,1-tris(4-hydroxyphenyl)ethane, 1,1-bis(4-hydroxyphenyl)-1-phenylethane, 1,1-bis(4-hydroxyphenyl)-1-(4-[1-(hydroxyphenyl)-1-methylethyl]phenyl)ethane and the like; 1,2-quinonediazidesulfonic acid esters of (poly)hydroxyphenylflavans such as 2,4,4-trimethyl-2',4',7-trihydroxy-2-phenylflavan, 2,4,4-trimethyl-2',4',5',6,7-pentahydroxy-2-phenylflavan and the like.


The positive and negative photoresist composition of the present invention may optionally contain one or more additives (c) customarily used in photoresists in the customary amounts known to a person skilled in the art, for example, dyes, pigments, plasticizers, surfactants, flow improvers, wetting agents, adhesion promoters, thixotropic agents, colourants, fillers, solubility accelerators, acid-amplifier, photosensitizers and organic basic compounds.

Further examples for organic basic compounds which can be used in the resist composition of the present invention are compounds which are stronger bases than phenol, in particular, nitrogen-containing basic compounds. These compounds may be ionic, like, for example, tetraalkylammonium salts or non-ionic. Preferred organic basic compounds are nitrogen-containing basic compounds having, per molecule, two or more nitrogen atoms having different chemical environments. Especially preferred are compounds containing both at least one substituted or unsubstituted amino group and at least one nitrogen-containing ring structure, and compounds having at least one alkylamino group. Examples of such preferred com-
Compounds include guanidine, aminopyridine, amino alkylpyridines, aminopyrrolidine, indazole, imidazole, pyrazole, pyrazine, pyrimidine, purine, imidazoline, pyrazoline, piperazine, amino-morpholine, and aminoalkylmorpholines. Suitable are both, the unsubstituted compounds or substituted derivatives thereof. Preferred substituents include amino, aminoalkyl groups, alkylamino groups, aminoaryl groups, arylamino groups, alkyl groups alkoxy groups, acyl groups acyloxy groups aryl groups, aryl groups, nitro, hydroxy, and cyano. Specific examples of especially preferred organic basic compounds include guanidine, 1,1-dimethylguanidine, 1,1,3,3-tetramethylguanidine, 2-aminopyridine, 3-aminopyridine, 4-aminopyridine, 2-dimethylaminopyridine, 4-dimethylaminopyridine, 2-diethylaminopyridine, 2-(aminomethyl)pyridine, 2-amino-3-methylpyridine, 2-amino-4-methylpyridine, 2-amino-5-methylpyridine, 2-amino-6-methylpyridine, 3-aminoethylpyridine, 4-aminoethylpyridine, 3-aminopyrrolidine, piperazine, N-(2-aminomethyl)piperazine, N-(2-aminomethyl)piperidine, 4-amino-2,2,6,6-tetramethylpiperidine, 4-piperidinopiperidine, 2-imidopiperidine, 1-(2-aminomethyl)pyrrolidine, pyrazole, 3-amino-5-methylpyrazole, 5-amino-3-methyl-1-p-tolylpyrazole, pyrazine, 2-(aminomethyl)-5-methylpyrazine, pyrimidine, 2,4-diaminopyrimidine, 4,6-dihydroxy pyrimidine, 2-pyrazoline, 3-pyrazoline, N-aminomorpholine, and N-(2-aminomethyl)morpholine.


The nitrogen-containing basic compounds may be used alone or in combination of two or more thereof. The added amount of the nitrogen-containing basic compounds is usually from 0.001 to 10 parts by weight, preferably from 0.01 to 5 parts by weight, per 100 parts by weight of the photosensitive resin composition (excluding the solvent). If the amount thereof is smaller than 0.001 part by weight, the effects of the present invention cannot be obtained. On the other hand, if it exceeds 10 parts by weight, reduced sensitivity and impaired developability at unexposed parts are liable to be caused.

The composition can further contain a basic organic compound which decomposes under actinic radiation ("suicide base") such as for example described in EP 710885, US 5663035, US 5595855, US 5525453, and EP 611998.
Examples of dyes (c) suitable for the compositions of the present invention are oil-soluble dyes and basic dyes, e.g. Oil Yellow #101, Oil Yellow #103, Oil Pink #312, Oil Green BG, Oil Blue BOS, Oil Blue #603, Oil Black BY, Oil Black BS, Oil Black T-505 (all manufactured by Orient Chemical Industries Ltd., Japan), crystal violet (CI42555), methyl violet (CI 42535), rhodamine B (CI 45170B), malachite green (CI 42000), and methylene blue (CI52015).

Spectral sensitizers (e) may be further added to sensitize the photo latent acid to exhibit absorption in a region of longer wavelengths than far ultraviolet, whereby the photosensitive composition of the present invention can, for example, be rendered sensitive to an i-line or g-line radiation. Examples of suitable spectral sensitizers include 9,10-dialkoxyanthracene, benzophenones, p,p'-tetramethyledianobenzophenone, p,p'-tetraethylaminobenzophenone, thioxanthone, 2-chlorothioxanthone, anthrone, pyrene, perylene, phenothiazine, benzil, acridine orange, benzoflavins, cheto flavin T, 9,10-diphenylantheracene, 9-fluorenone, acetophenone, phenanthrene, 2-nitrofluorene, 5-nitroacenaphthene, benzoquinone, 2-chloro-4-nitroaniline, N-acetyl-p-nitroaniline, p-nitroaniline, N-acetyl-4-nitro-1-naphthylamine, picramide, anthraquinone, 2-ethylanthraquinone, 2-tert-butylanthraquinone, 1,2-benzanthraquinone, 3-methyl-1,3-diaza-1,9-benzanthrone, dibenzalacetone, 1,2-naphthoquinone, 3-acylicoumarin derivatives, 3,3'-carbonyl-bis(5,7-dimethoxyxycarbonylcoumarin), 3-(arylmethylene) thiazolines, eosin, rhodamine, erythrosine, and coronene. However, the suitable spectral sensitizers are not limited to these examples. These spectral sensitizers can be used also as light absorbers for absorbing the far ultraviolet emitted by a light source. In this case, the light absorber reduces light reflection from the substrate and lessens the influence of multiple reflection within the resist film, thereby diminishing the effect of standing waves.

Specific examples of such compounds are disclosed in WO 06/008251, page 36, line 30 to page 38, line 8, the disclosure of which is hereby incorporated by reference.

Further suitable additives (c) are "acid-amplifiers", compounds that accelerate the acid formation or enhance the acid concentration. Such compounds may also be used in combination with the sulfonium salts of the formula I according to the invention in positive or negative resists, or in imaging systems as well as in all coating applications. Such acid amplifiers are described e.g. in Arimitsu, K. et al. J. Photopolym. Sci. Technol. 1995, 8, pp 43; Kudo, K. et al. J. Photopolym. Sci. Technol. 1995, 8, pp 45; Ichimura, K. et al. Chem: Letters 1995, pp 551.

Usually, for the application to a substrate of the photosensitive composition of the present invention, the composition is dissolved in an appropriate solvent. Preferred examples of these solvents include ethylene dichloride, cyclohexanone, cyclopentanone, 2-heptanone, γ-butyrolactone, methyl ethyl ketone, ethylene glycol monomethyl ether, ethylene glycol monoethyl ether, 2-methoxyethyl acetate, 2-ethoxyethyl acetate, 2-ethoxyethanol, diethyl glycol dimethyl ether, ethylene glycol monoethyl ether acetate, propylene glycol monomethyl ether, propylene glycol monomethyl ether acetate, toluene, ethyl acetate, butyl acetate, methyl lactate, ethyl lactate, methyl methoxypropionate, ethyl ethoxypropionate, methyl pyruvate, ethyl pyruvate, propyl pyruvate, N, N-dimethylformamide, dimethyl sulfoxide, N-methylpyrrolidone, and tetrahydrofuran. These solvents may be used alone or as mixtures. Preferred examples of the solvents are esters, such as 2-methoxyethyl acetate, ethylene glycolmonoethyl ether acetate, propylene glycol monomethyl ether acetate, methyl methoxypropionate, ethyl ethoxypropionate, and ethyl lactate. Use of such solvents is advantageous because the sulfonium salts represented by formulae I according to the present invention have good compatibility therewith and better solubility therein.

A surfactant can be added to the solvent. Examples of suitable surfactants include nonionic surfactants, such as polyoxyethylene alkyl ethers, e.g. polyoxyethylene lauryl ether, polyoxyethylene stearyl ether, polyoxyethylene acetyl ether, and polyoxyethylene oleyl ether; polyoxyethylene alkylaryl ethers, e.g. polyoxyethylene, octylphenol ether and polyoxyethylene nonylphenol ether; polyoxyethylene/polyoxypropylene block copolymers, sorbitan/fatty acid esters, e.g. sorbitan monolaurate, sorbitan monopalmitate, sorbitan monostearate, sorbitan monooleate, sorbitan trioleate; fluorochemical surfactants such as F-top EF301, EF303, and EF352 (manufactured by New Akita Chemical Company, Japan). Megafac F171 and F17.3
(manufactured by Dainippon Ink & Chemicals, Inc., Japan), Fluorad FC 430 and FC431 (manufactured by Sumitomo 3M Ltd., Japan), Asahi Guard AG710 and Surflon S-382, SC101, SC102, SC103, SC104, SC105, and SC106 (manufactured by Asahi Grass Col. Ltd., Japan); organosiloxane polymer KP341 (manufactured by Shin-Etsu Chemical Co., Ltd., Japan); and acrylic or methacrylic (co)polymers Poly-flow Now.75 and NO.95 (manufactured by Kyoeisha Chemical Co., Ltd., Japan). Other examples are described in JP-A-2001-318459, JP-A-2002-6483. The added amount of the surfactant usually is 2 parts by weight or lower, desirably 0.5 part by weight or lower, per 100 parts by weight of the solid components of the composition of the present invention. The surfactants may be added alone or in combination of two or more thereof.

The solution is uniformly applied to a substrate by means of known coating methods, for example by spin-coating, immersion, knife coating, curtain pouring techniques, brush application, spraying and roller coating. It is also possible to apply the photosensitive layer to a temporary, flexible support and then to coat the final substrate by coating transfer (laminating).

The amount applied (coating thickness) and the nature of the substrate (coating substrate) are dependent on the desired field of application. The range of coating thicknesses can in principle include values from approximately 0.01 µm to more than 100 µm.

After the coating operation generally the solvent is removed by heating, resulting in a layer of the photoresist on the substrate. The drying temperature must of course be lower than the temperature at which certain components of the resist might react or decompose. In general, drying temperatures are in the range from 60 to 160°C.

The resist coating is then irradiated image-wise. The expression "image-wise irradiation" includes irradiation in a predetermined pattern using actinic radiation, i.e. both irradiation through a mask containing a predetermined pattern, for example a transparency, a chrome mask or a reticle, and irradiation using a laser beam or electron beam that writes directly onto the resist surface, for example under the control of a computer, and thus produces an image. Another way to produce a pattern is by interference of two beams or images as used for example in holographic applications. It is also possible to use masks made of liquid crystals that can be addressed pixel by pixel to generate digital images, as is, for example described by A. Bertsch; J.Y. Jezequel; J.C. Andre in Journal of Photochemistry and Photobiology A: Chemistry 1997, 107 pp. 275-281 and by K. P. Nicolay in Offset Printing 1997, 6, pp. 34-37.
After the irradiation and, if necessary, thermal treatment, the irradiated sites (in the case of positive resists) or the non-irradiated sites (in the case of negative resists) of the composition are removed in a manner known *per se* using a developer.

In order to accelerate the catalytic reaction and hence the development of a sufficient difference in solubility between the irradiated and unirradiated sections of the resist coating in the developer, the coating is preferably heated before being developed. The heating can also be carried out or begun during the irradiation. Temperatures of from 60 to 160°C are preferably used. The period of time depends on the heating method and, if necessary, the optimum period can be determined easily by a person skilled in the art by means of a few routine experiments. It is generally from a few seconds to several minutes. For example, a period of from 10 to 300 seconds is very suitable when a hotplate is used and from 1 to 30 minutes when a convection oven is used. It is important for the latent acid donors according to the invention in the unirradiated sites on the resist to be stable under those processing conditions.

The coating is then developed, the portions of the coating that, after irradiation, are more soluble in the developer being removed. If necessary, slight agitation of the workpiece, gentle brushing of the coating in the developer bath or spray developing can accelerate that process step. The aqueous-alkaline developers customary in resist technology may, for example, be used for the development. Such developers comprise, for example, sodium or potassium hydroxide, the corresponding carbonates, hydrogen carbonates, silicates or metasilicates, but preferably metal-free bases, such as ammonia or amines, for example ethylamine, n-propylamine, diethylamine, di-n-propylamine, triethylamine, methyl diethyamine, alkanolamines, for example dimethyl ethanolamine, triethanolamine, quaternary ammonium hydroxides, for example tetrathylammonium hydroxide or tetraethylammonium hydroxide. The developer solutions are generally up to 0.5 N, but are usually diluted in a suitable manner before use. For example solutions having a normality of approximately 0.1 - 0.3 are well suited. The choice of developer depends on the nature of the photocurable surface coating, especially on the nature of the binder used or of the resulting photolysis products. The aqueous developer solutions may, if necessary, also comprise relatively small amounts of wetting agents and/or organic solvents. Typical organic solvents that can be added to the developer fluids are, for example, cyclohexane, 2-ethoxyethanol, toluene, acetone, isopropanol and also mixtures of two or more of these solvents. A typical aqueous/organic developer system is based on Butylcellosolve \textsuperscript{RTM} /water.
Subject of the invention also is a process for the preparation of a photoresist by
(1) applying to a substrate a composition as described above;
(2) post apply baking the composition at temperatures between 60°C and 160°C;
(3) image-wise irradiating with light of wavelengths between 10 nm and 1500 nm;
(4) optionally post exposure baking the composition at temperatures between 60°C and
160°C; and
(5) developing with a solvent or with an aqueous alkaline developer.

Preferred is a process, wherein the image-wise irradiation is carried out with monochromatic
or polychromatic radiation in the wavelength range from 150 to 450 nm, in particular in the
range from 190 to 260 nm.

The photoresist compositions can be used on all substrates and with all exposure techniques
known to the person skilled in the art. For example, semiconductor substrates can be used,
such as silicon, gallium arsenide, germanium, indium antimonide; furthermore substrate cov-
ered by oxide or nitride layers, such as silicon dioxide, silicon nitride, titanium nitride, silox-
anes, as well as metal substrates and metal coated substrates with metals such as aluminium,
copper, tungsten, etc. The substrate can also be coated with polymeric materials, for ex-
ample with organic antireflective coatings, insulation layers and dielectric coatings from poly-
meric materials prior to coating with the photoresist.

The photoresist layer can be exposed by all common techniques, such as direct writing, i.e.
with a laser beam or projection lithography in step- and repeat mode or scanning mode, or by
contact printing through a mask.

In case of projection lithography a wide range of optical conditions can be used such as co-
herent, partial coherent or incoherent irradiation. This includes off-axis illumination tech-
niques, for example annular illumination and quadrupol illumination where the radiation is al-
lowed to pass only certain regions of the lens, excluding the lens center.

The mask used to replicate the pattern can be a hard mask or a flexible mask. The mask can
include transparent, semitransparent and opaque patterns. The pattern size can include also
patterns which are at or below the resolution limit of the projection optics and placed on the
mask in a certain way in order to modify the aerial image, intensity and phase modulation of
the irradiation after having passed the mask. This includes phase shift masks and half-tone
phase shift masks.

5 The patterning process of the photoresist composition can be used to generate patterns of
any desired geometry and shape, for example dense and isolated lines, contact holes,
trenches, dots, etc.

The photoresists according to the invention have excellent lithographic properties, in particu-
lar a high sensitivity, and high resist transparency for the imaging radiation.

Possible areas of use of the composition according to the invention are as follows: use as
photoresists for electronics, such as etching resists, ion-implantation resist, electroplating
resists or solder resists, the manufacture of integrated circuits or thin film transistor-resist
(TFT); the manufacture of printing plates, such as offset printing plates or screen printing
stencils, use in the etching of mouldings or in stereolithography or holography techniques,
which are employed for various applications, for example, 3D optical information storage
The composition according to the invention is also suitable for making inter-metal dielectrics
layer, buffer layer, passivation coat of semiconductor devices and suitable for making
waveguide for optoelectronics. For MEMS (micro electro mechanical systems) application,
the composition according to the invention can be used as etching resist, mold for material
deposition, and three dimensional objects of device itself. The coating substrates and pro-
cessing conditions vary accordingly. Such example is described in US 6391523.

20 The compounds of formula I according to the present invention, in combination with a sensi-
tizer compound as described above, can also be used in holographic data storage (HDS)
systems as for example described in WO 03/021358.

25 The compositions according to the invention are also outstandingly suitable as coating com-
positions for substrates of all types, including wood, textiles, paper, ceramics, glass, plastics,
such as polyesters, polyethylene terephthalate, polyolefins or cellulose acetate, especially in
the form of films, but especially for coating metals, such as Ni, Fe, Zn, Mg, Co or especially
Cu and Al, and also Si, silicon oxides or nitrides, to which an image is to be applied by means of image-wise irradiation.

The invention relates also to the use of compounds of formula I as photolatent acid donors in compositions that can be crosslinked under the action of an acid and/or as dissolution enhancers in compositions wherein the solubility is increased under the action of an acid.

Subject of the invention further is a process of crosslinking compounds that can be crosslinked under the action of an acid, which method comprises adding a compound of formula I to the above-mentioned compounds and irradiating imagewise or over the whole area with light having a wavelength of 10-1500 nm.

The invention relates also to the use of compounds of formula I as photosensitive acid donors in the preparation of pigmented and non-pigmented surface coatings, adhesives, laminating adhesives, structural adhesives, pressure-sensitive adhesives, printing inks, printing plates, relief printing plates, planographic printing plates, intaglio printing plates, processless printing plates, screen printing stencils, dental compositions, colour filters, spacers, electroluminescence displays and liquid crystal displays (LCD), waveguides, optical switches, color proofing systems, resists, photoresists for electronics, electroplating resists, etch resists both for liquid and dry films, solder resist, photoresist materials for a UV and visible laser direct imaging system, photoresist materials for forming dielectric layers in a sequential build-up layer of a printed circuit board, colour filters, chemically amplified resist materials, image-recording materials, image-recording materials for recording holographic images, optical information storage or holographic data storage, decolorizing materials, decolorizing materials for image recording materials, image recording materials using microcapsules, magnetic recording materials, micromechanical parts, plating masks, etch masks, glass fibre cable coatings, microelectronic circuits; as well as to method for the preparation for the preparation of pigmented and non-pigmented surface coatings, adhesives, laminating adhesives, structural adhesives, pressure-sensitive adhesives, printing inks, printing plates, relief printing plates, planographic printing plates, intaglio printing plates, processless printing plates, screen printing stencils, dental compositions, colour filters, spacers, electroluminescence displays and liquid crystal displays (LCD), waveguides, optical switches, color proofing systems, resists, photoresists for electronics, electroplating resists, etch resists both for liquid and dry films, solder resist, photoresist materials for a UV and visible laser direct imaging system, photoresist materials for forming dielectric layers in a sequential build-up layer of a printed circuit board, colour filters, chemically amplified resist materials, image-recording materials, image-
recording materials for recording holographic images, optical information storage or holo-
graphic data storage, decolorizing materials, decolorizing materials for image recording ma-
terials, image recording materials using microcapsules, magnetic recording materials, mi-
cromechanical parts, plating masks, etch masks, glass fibre cable coatings, microelectronic
circuits.

Subject of the invention is also the use of compounds of formula I as photosensitive acid do-
nors in the preparation of colour filters or chemically amplified resist materials; as well as to a
process for the preparation of colour filters or chemically amplified resist materials.
The invention further pertains to a color filter prepared by providing red, green and blue pic-
ture elements and a black matrix, all comprising a photosensitive resin and a pigment and/or
dye on a transparent substrate and providing a transparent electrode either on the surface of
the substrate or on the surface of the color filter layer, wherein said photosensitive resin
comprises compounds of formula I as photosensitive acid donors.
The person skilled in the art is aware of suitable pigments or dyes to provide the color ele-
ments, as well as the black matrix and corresponding suitable resins as shown in, for exam-

As already mentioned above, in photocrosslinkable compositions, sulfonium salts act as la-
tent curing catalysts: when irradiated with light they release acid which catalyses the
crosslinking reaction. In addition, the acid released by the radiation can, for example, cata-
lyse the removal of suitable acid-sensitive protecting groups from a polymer structure, or the
cleavage of polymers containing acid-sensitive groups in the polymer backbone. Other ap-
lications are, for example, colour-change systems based on a change in the pH or in the
solubility of, for example, a pigment protected by acid-sensitive protecting groups.

Sulfonium salts according to the present invention can also be used to produce so-called
"print-out" images when the compound is used together with a colourant that changes colour
when the pH changes, as described e.g. in JP Hei 4 328552-A or in US 5237059. Such col-
or-change systems can be used according to EP 199672 also to monitor goods that are sen-
sitive to heat or radiation.

In addition to a colour change, it is possible during the acid-catalysed deprotection of soluble
pigment molecules (as described e.g. in EP 648770, EP 648817 and EP 742255) for the pig-

ment crystals to be precipitated; this can be used in the production of colour filters as described e.g. in EP 654711 or print out images and indicator applications, when the colour of the latent pigment precursor differs from that of the precipitated pigment crystal.

Compositions using pH sensitive dyes or latent pigments in combination with sulfonium salts can be used as indicators for electromagnetic radiation, such as gamma radiation, electron beams, UV- or visible light, or simple throw away dosimeters. Especially for light, that is invisible to the human eye, like UV- or IR-light, such dosimeters are of interest.

Finally, sulfonium salts that are sparingly soluble in an aqueous-alkaline developer can be rendered soluble in the developer by means of light-induced conversion into the free acid, with the result that they can be used as solubility enhancers in combination with suitable film-forming resins.

The sulfonium salts of the present invention can also be used to shape polymers that undergo an acid induced transition into a state where they have the required properties using photolithography. For instance the sulfonium salts can be used to pattern conjugated emissive polymers as described, for example, in M.L. Renak; C. Bazan; D. Roitman; Advanced materials 1997, 9, 392. Such patterned emissive polymers can be used to manufacture microscalar patterned Light Emitting Diodes (LED) which can be used to manufacture displays and data storage media. In a similar way precursors for polyimides (e.g. polyimide precursors with acid labile protecting groups that change solubility in the developer) can be irradiated to form patterned polyimide layers which can serve as protective coatings, insulating layers and buffer layers in the production of microchips and printed circuit boards.

The formulations of the invention may also be used as conformal coatings, photoimagable insulating layers and dielectrics as they are used in sequential build up systems for printed circuit boards, stress buffer layers in the manufacturing of integrated circuits.

It is known that conjugated polymers like, e.g. polyanilines can be converted from semiconductive to conductive state by means of proton doping. The sulfonium salts of the present invention can also be used to imagewise irradiate compositions comprising such conjugated polymers in order to form conducting structures (exposed areas) embedded in insulating ma-
terial (non exposed areas). These materials can be used as wiring and connecting parts for the production of electric and electronic devices.

The composition according to the present invention, comprising a cationic photoinitiator of the formula I may also be employed in a vacuum deposition process as described in WO 02/064268. That is, the photoinitiators are suitable to be flash-evaporated vacuum-deposited. Accordingly, in a process for forming a solid polymeric structure from flash-evaporated vacuum-deposited cationically curable monomeric material, comprising the steps

(i) preparing a mixture of a cationically-curable monomer with a thermally stable, chemically inactive at room temperature, cationic photoinitiator;

(ii) flash-evaporating said mixture in a vacuum to produce a vapor;

(iii) condensing the vapor to produce a film; and

(iv) exposing said film to a radiation source to produce a polymeric solid film, said photoinitiator is of the formula I as described above.

Suitable apparatus for said procedure, as well as details concerning the monomers are described in WO 02/064268, the teachings of which are incorporated by reference.

Suitable radiation sources for the compositions comprising compounds of formula I are radiation sources that emit radiation of a wavelength of approximately from 150 to 1500, for example from 180 to 1000, or preferably from 190 to 700 nanometers as well as e-beam radiation and high-energy electromagnetic radiation such as X-rays. Both, point sources and planiform projectors (lamp carpets) are suitable. Examples are: carbon arc lamps, xenon arc lamps, medium pressure, high pressure and low pressure mercury lamps, optionally doped with metal halides (metal halide lamps), microwave-excited metal vapour lamps, excimer lamps, superactinic fluorescent tubes, fluorescent lamps, argon filament lamps, electronic flash lamps, photographic flood lights, electron beams and X-ray beams generated by means of synchrotrons or laser plasma. The distance between the radiation source and the substrate according to the invention to be irradiated can vary, for example, from 2 cm to 150 cm, according to the intended use and the type and/or strength of the radiation source. Suitable radiation sources are especially mercury vapour lamps, especially medium and high pressure mercury lamps, from the radiation of which emission lines at other wavelengths can, if desired, be filtered out. That is especially the case for relatively short wavelength radiation.

It is, however, also possible to use low energy lamps (for example fluorescent tubes) that are capable of emitting in the appropriate wavelength range. An example thereof is the Philips
TL03 lamp. Another type of radiation source that can be used are the light emitting diodes (LED) that emit at different wavelengths throughout the whole spectrum either as small band emitting source or as broad band (white light) source. Also suitable are laser radiation sources, for example excimer lasers, such as Kr-F lasers for irradiation at 248 nm, Ar-F lasers at 193 nm, or F₂ laser at 157 nm. Lasers in the visible range and in the infrared range can also be used. Especially suitable is radiation of the mercury i, h and g lines at wavelengths of 365, 405 and 436 nanometers. As a light source further EUV (Extreme Ultra Violet) at 13 nm is also suitable. A suitable laser-beam source is, for example, the argon-ion laser, which emits radiation at wavelengths of 454, 458, 466, 472, 478, 488 and 514 nanometers. Nd-YAG-lasers emitting light at 1064 nm and its second and third harmonic (532 nm and 355 nm respectively) can also be used. Also suitable is, for example, a helium/cadmium laser having an emission at 442 nm or lasers that emit in the UV range. With that type of irradiation, it is not absolutely essential to use a photomask in contact with the photopolymeric coating to produce a positive or negative resist; the controlled laser beam is capable of writing directly onto the coating. For that purpose the high sensitivity of the materials according to the invention is very advantageous, allowing high writing speeds at relatively low intensities. On irradiation, the sulfonium salts in the composition in the irradiated sections of the surface coating decompose to form the acids.

In contrast to customary UV curing with high-intensity radiation, with the compounds according to the invention activation is achieved under the action of radiation of relatively low intensity. Such radiation includes, for example, daylight (sunlight), and radiation sources equivalent to daylight. Sunlight differs in spectral composition and intensity from the light of the artificial radiation sources customarily used in UV curing. The absorption characteristics of the compounds according to the invention are as well suitable for exploiting sunlight as a natural source of radiation for curing. Daylight-equivalent artificial light sources that can be used to activate the compounds according to the invention are to be understood as being projectors of low intensity, such as certain fluorescent lamps, for example the Philips TL05 special fluorescent lamp or the Philips TL09 special fluorescent lamp. Lamps having a high daylight content and daylight itself are especially capable of curing the surface of a surface-coating layer satisfactorily in a tack-free manner. In that case expensive curing apparatus is superfluous and the compositions can be used especially for exterior finishes. Curing with daylight or daylight-equivalent light sources is an energy-saving method and prevents emissions of volatile organic components in exterior applications. In contrast to the conveyor belt
method, which is suitable for flat components, daylight curing can also be used for exterior finishes on static or fixed articles and structures. The surface coating to be cured can be exposed directly to sunlight or daylight-equivalent light sources. The curing can, however, also take place behind a transparent layer (e.g. a pane of glass or a sheet of plastics).

The examples which follow illustrate the invention in more detail. Parts and percentages are, as in the remainder of the description and in the claims, by weight, unless stated otherwise. Where alkyl radicals having more than three carbon atoms are referred to without any mention of specific isomers, the n-isomers are meant in each case.

Example 1 Preparation of

1.1: Preparation of the intermediate \(X_a\)

In a 350 ml reactor 25g of 2-acetyl-5-bromothiophene are dissolved in 40ml dimethylformamide and then 15.35g of sodiumcarbonate are added. 15.9g of thiophenol are added dropwise and the mixture is stirred for 6h at 35°C. The reaction mass is poured on ice and extracted with ethyl acetate. After evaporation the product is obtained.

\(^{1}\text{H-NMR data (ppm, CDCl}_3\): 7.53 1H d, 7.41-7.08 5H m, 7.07 1H d.}

1.2: 13.2g of aluminium chloride are suspended in 30ml of dichloromethane. Then 12g of the intermediate \(X_a\) (in 10ml dichloromethane) are added dropwise at 0°C. To the reaction mixture are added dropwise 1.9g of thionylchloride at -5°C, and the whole mass is stirred for 5h at 25°C. The reaction mixture is then poured on ice and the organic phase is dried and evaporated. The product is purified by column chromatography.

\(^{1}\text{H-NMR data (ppm, CDCl}_3\): 7.76 6H d, 7.68 3H d, 7.33 6H d, 7.29 3H d, 2.56 9H s.}

Example 2 Preparation of

2.85g of the compound of example 1 is dissolved in 10ml dichloromethane and 1.02g of potassium hexafluorophosphate is dissolved in 100ml water. The two solutions are mixed to-
gether and stirred for 1h at room temperature. Then the organic phase is separated, washed with water and dried and evaporated. The compound of example 2 is obtained.

$^1$H-NMR data (ppm, CDCl$_3$): 7.69 3H d, 7.47 6H d, 7.37-7.33 9H m, 2.55 9H s.

5 Example 3: Preparation of

The compound is prepared from compound of example 1 according to the method as described in example 2, exchanging potassium hexafluorophosphate by lithium-tris(trifluoromethanesulfonyl)-methide.

$^1$H-NMR data (ppm, CDCl$_3$): 7.69 6H d, 7.42 6H d, 7.36 6H d, 7.34 6H d, 2.55 9H s.

10 Example 4: Preparation of

The compound is prepared according to the method as described in example 1 using the appropriate starting materials and exchanging potassium hexafluorophosphate by lithium-tris(trifluoromethanesulfonyl)-methide in the method as described in example 2.

$^1$H-NMR data (ppm, CDCl$_3$): 7.68 3H d, 7.42 6H d, 7.37-7.33 9H m, 2.55 9H s.

15 The compounds of the following examples 5-12 are prepared according to the method as described in example 1, optionally with an anion exchange as described in examples 2 or 3, by employing the appropriate intermediates.

20 Example 5:

Example 6:

Example 7:
Example 8:

```
H2C
|   |
|   |
H2C

H3C
|   |
|   |
H3C
```

Example 9:

```
H2C
|   |
|   |
H2C

H3C
|   |
|   |
H3C
```

Example 10:

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H2C
|   |
|   |
H2C

H3C
|   |
|   |
H3C
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Example 11:

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H2C
|   |
|   |
H2C
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Example 12:

```
H2C
|   |
|   |
H2C
```

Application Example A1:

A composition is prepared by mixing the following components:

- 81.80 parts of 3,4-epoxycyclohexylmethyl carboxylate (CYRACURE® UVR 6105, provided by Dow Chemical)
- 11.73 parts of 3-ethyl-3-hydroxymethyl-oxetane (CYRACURE® UVR 6000, provided by Dow Chemical)
- 5.92 parts of ε-caprolactone triol (Tone Polyol 301, provided by Dow Chemical)
- 0.56 parts of a silicon surface additive (Byk 307, provided by BYK)
- 100.0 parts overprint varnish, flexo ink basic formulation

3% of the compound of example 2 is stirred into said formulation, which then is applied with a 4μm wire bar onto an aluminum film of 85μm thickness.

Curing is effected by moving the sample on a conveyor belt under a 1x120 W/cm medium pressure mercury lamp (IST) fitted with an aluminum reflector. A cured coating is obtained.

Application Example A2:

A chemically amplified negative resist formulation is prepared by mixing the following components:
100.00 parts of an epoxy resin (SU-8 R 2002 provided by MicroChem., USA)
245.00 parts of cyclopentanone (ibidem)
5.00 parts of the photoacid generator (PAG) of example 3

The resist formulation is spin-coated onto a silicone wafer, on which chemical treatment with hexamethyldisilazane is applied beforehand, and soft-baked for 60 seconds at 95°C on a hotplate to obtain a film thickness of 2 µm. The resist film is then exposed to UV radiation through V-42 and UV-D35 filters (provided by Asahi Technoglass, Japan) and a multidensity quartz mask using an Ushio's high-pressure mercury lamp, HB-25106AP, and a mask aligner Canon PLA-501 F. The samples then are post-exposure-baked for 120 seconds at 95°C on a hotplate and developed. The dose (E₁₁), which is the dose just sufficient to give the same resist thickness after 60 seconds immersion development in ethyl lactate as the one before exposure, is determined from the measured contrast curve. The smaller the required dose the higher sensitive is the resist formulation. With the the compound of example 3 a dose to clear E₁₁ of 107 mJ/cm² is obtained.
Claims

1. A compound of the formula I

\[ \text{I} \]

\[
\begin{array}{c}
\text{R} \\
\text{L}_1 \\
\text{L}_2 \\
\text{L}_3 \\
\text{L}_4 \\
\text{L}'_1 \\
\text{L}'_2 \\
\text{L}'_3 \\
\text{L}'_4 \\
\text{L}''_1 \\
\text{L}''_2 \\
\text{Y}^{-} \\
\text{(I), wherein}
\end{array}
\]

Wherein

- \( L_1, L'_1, L''_1, L_2, L'_2, L''_2, L_3, L'_3, L''_3, L_4, L'_4 \) and \( L''_4 \) independently of one another are hydrogen, \( R_1, \text{OR}_1, \text{SR}_1, \text{NR}_1 \text{R}_1, \text{halogen}, \text{NO}_2, \text{CN}, \text{NR}_1 \text{COR}_2, \text{COOR}_1, \text{OCOR}_1, \text{CONR}_1 \text{R}_2, \text{OCOOR}_1, \text{OCONR}_1 \text{R}_2, \text{NR}_1 \text{COOR}_2, \text{SO}_3 \text{H}, \text{SO}_3 \text{M}, \text{SOR}_1, \text{SO}_2 \text{R}_1, \text{COOT} \text{ or } \text{COT} \);
- \( R, R_1 \text{ and } R'' \) independently of each other are hydrogen, \( C_6 \text{C}_{12} \text{aryl, } C_6 \text{C}_{12} \text{aryl substituted with at least one } L, \text{ or are } C_3 \text{C}_{20} \text{heteroaryl or } C_3 \text{C}_{20} \text{heteroaryl substituted with at least one } L, \text{ wherein the case that the } C_3 \text{C}_{20} \text{heteroaryl comprises an annelated benzene ring, the bond to the corresponding } X, X' \text{ or } X'' \text{ is not located on said annelated ring; }
- \( X, X' \text{ and } X'' \) independently of each other are \( O, S, \text{CR}_2 \text{R}_3, \text{single bond, } \text{NR}_4 \text{ or } \text{NCO}_R; \text{ provided that if } X, X' \text{ or } X'' \text{ is } O, \text{ the corresponding } R, R' \text{ or } R'' \text{ is not pyridinyl; }
- \( T \) is hydrogen, \( \text{CrC}_{20} \text{alkyl, } \text{CrC}_{20} \text{alkyl substituted by one or more } D, \text{ or } C_2 \text{C}_{20} \text{alkyl interrupted by one or more } E, \text{ or } C_2 \text{C}_{20} \text{alkyl substituted by one or more } D \text{ and interrupted by one or more } E; \text{ or } T \text{ is }
- C_3 \text{C}_{12} \text{cycloalkyl, } C_3 \text{C}_{12} \text{cycloalkyl substituted by one or more } D, \text{ or } C_2 \text{C}_{12} \text{cycloalkyl interrupted by one or more } O, \text{ CO, } \text{COO, } \text{CONR}_5, \text{ or } \text{NR}_5, \text{ or } C_2 \text{C}_{12} \text{cycloalkyl substituted by one or more } D \text{ and interrupted by one or more } O, \text{ CO, } \text{COO, } \text{CONR}_5, \text{ or } \text{NR}_5; \text{ or } T \text{ is }
- C_2 \text{C}_{20} \text{alkenyl, } C_2 \text{C}_{20} \text{alkenyl substituted by one or more } D, \text{ or } C_3 \text{C}_{20} \text{alkenyl interrupted by one or more } E, \text{ or } C_3 \text{C}_{20} \text{alkenyl substituted by one or more } D \text{ and interrupted by one or more } E, \text{ or } C_5 \text{C}_{12} \text{cycloalkenyl, } C_5 \text{C}_{12} \text{cycloalkenyl substituted by one or more } D \text{ and interrupted by one or more } E, \text{ or } C_5 \text{C}_{12} \text{cycloalkenyl interrupted by one or more } O, \text{ CO, } \text{COO, } \text{CONR}_5, \text{ or } \text{NR}_5, \text{ or } C_3 \text{C}_{12} \text{cycloalkenyl substituted by one or more } D \text{ and interrupted by one or more } O, \text{ CO, } \text{COO, } \text{CONR}_5, \text{ or } \text{NR}_5; \text{ or } T \text{ is }
- C_2 \text{C}_{20} \text{alkynyl, } C_2 \text{C}_{20} \text{alkynyl substituted by one or more } D, \text{ or } C_4 \text{C}_{20} \text{alkynyl interrupted by one or more } O, \text{ CO, } \text{COO, } \text{CONR}_5, \text{ or } \text{NR}_5, \text{ or } C_4 \text{C}_{20} \text{alkynyl substituted by one or more } D \text{ and interrupted by one or more } O, \text{ CO, } \text{COO, } \text{CONR}_5, \text{ or } \text{NR}_5; \text{ or } T \text{ is }
\]
C7-Ci2bicycloalkyl, C7-Ci2bicycloalkyl substituted by one or more D, C5-Ci2bicycloalkyl interrupted by one or more O, CO, COO, CONR5, S or NR5, C5-Ci2bicycloalkyl substituted by one or more D and interrupted by one or more O, CO, COO, CONR5, S or NR5; or T is
C7-Ci2bicycloalkenyl, C7-Ci2bicycloalkenyl substituted by one or more D, C5-Ci2bicycloalkenyl interrupted by one or more O, CO, COO, CONR5, S or NR5, C5-Ci2bicycloalkenyl substituted by one or more D and interrupted by one or more O, CO, COO, CONR5, S or NR5; or T is Cio-C20tricycloalkyl, C6-Ci2tricycloalkyl substituted by one or more D, C7-Ci3tricycloalkyl interrupted by one or more O, CO, COO, CONR5, S or NR5, C7-Ci3tricycloalkyl substituted by one or more D and interrupted by one or more O, CO, COO, CONR5, S or NR5; or T is
C8-Ci8cycloalkylenary, C8-Ci8cycloalkylenary substituted by one or more D, C7-Ci8cycloalkylenary interrupted by one or more O, CO, COO, CONR5, S or NR5, C7-Ci8cycloalkylenary substituted by one or more D and interrupted by one or more O, CO, COO, CONR5, S or NR5; or T is
C7-d6cycloalkylenetheteroaryl, C7-d6bicycloalkylenetheteroaryl substituted by one or more D, C6-
C8-Ci8cycloalkylenetheteroaryl interrupted by one or more O, CO, COO, CONR5, S or NR5, C6-
C8-cycloalkylenetheteroaryl substituted by one or more D and interrupted by one or more O, CO, COO, CONR5, S or NR5; or T is
C6-Ci4aryl, C6-Ci4aryl substituted by one or more D, C3-Ci2heteroaryl or C3-Ci2heteroaryl substituted by one or more D;
Ri, R2, Ra and Rb independently of one another have the meaning of T;
D is hydrogen, R5, OR5, SR5, NR5R5, halogen, NO2, CN, O-glycidyl, O-vinyl, O-allyl, COR5, NR5COR5, COOR5, OCOR5, CONR5R5, OCOO5, OCONR5R5, NR5COOR5, SO3H, SO3M, =0, C6-Ci4aryl, C6-Ci4aryl substituted by one or more Ri2, ORi2, halogen, SRi2, NO2, CN, CORi2, NRi2CORi3, COORi2, OCORi2, CONRi2Ri3, OCOORi2, OCONRi2Ri3, NRi2COORi3 or SO3H; or
is C3-Ci2cycloalkyl, C3-Ci2cycloalkyl substituted by one or more Ri4, C2-Ci2cycloalkyl interrupted by one or more O, CO, COO, CONR5S or NR5, C2-Ci2cycloalkyl substituted by one or more Ri4 and interrupted by one or more O, CO, COO, CONR5S or NR5; or D is
C5-Ci2cycloalkenyl, C5-Ci2cycloalkenyl substituted by one or more Ri4, C2-Ci2cycloalkenyl interrupted by one or more O, CO, COO, CONR5S or NR5, C3-Ci2cycloalkenyl substituted by one or more Ri4 and interrupted by one or more O, CO, COO, CONR5S or NR5; or D is
C₇-C₈ bicycloalkyl, C₇-C₈ bicycloalkyl substituted by one or more R₁₄, C₅-C₈ bicycloalkyl interrupted by one or more O, CO, COO, CONR₅, S or NR₅, C₅-C₈ bicycloalkyl substituted by one or more R₁₄ and interrupted by one or more O, CO, COO, CONR₅, S or NR₅; or D is C₇-C₈ bicycloalkenylen, C₇-C₈ bicycloalkenylen substituted by one or more R₁₄, C₅-C₈ bicycloalkenylen substituted by one or more R₁₄ and interrupted by one or more O, CO, COO, CONR₅, S or NR₅; or D is C₇-C₈ bicycloalkenylen, C₇-C₈ bicycloalkenylen substituted by one or more R₁₄, C₅-C₈ bicycloalkenylen substituted by one or more R₁₄ and interrupted by one or more O, CO, COO, CONR₅, S or NR₅; or D is Cₗ-C₂₆ tricycloalkyl, C₁₀-C₂₆ tricycloalkyl substituted by one or more R₁₄, C₇-C₈ tricycloalkyl interrupted by one or more O, CO, COO, CONR₅, S or NR₅, C₅-C₈ tricycloalkyl substituted by one or more O, CO, COO, CONR₅, S or NR₅; or E is C₇-C₈ bicycloalkylenheteroaryl, C₇-C₈ bicycloalkylenheteroaryl substituted by one or more R₁₄, C₇-C₈ bicycloalkylenheteroaryl interrupted by one or more O, CO, COO, CONR₅, S or NR₅, C₅-C₈ bicycloalkylenheteroaryl substituted by one or more O, CO, COO, CONR₅, S or NR₅; or E is C₇-C₈ bicycloalkylenheteroaryl, C₇-C₈ bicycloalkylenheteroaryl substituted by one or more R₁₄, C₅-C₈ bicycloalkylenheteroaryl substituted by one or more O, CO, COO, CONR₅, S or NR₅, C₅-C₈ bicycloalkylenheteroaryl substituted by one or more O, CO, COO, CONR₅, S or NR₅; or E is Cₗ-C₂₆ tricycloalkyl, C₁₀-C₂₆ tricycloalkyl substituted by one or more R₁₄, C₅-C₈ tricycloalkyl substituted by one or more O, CO, COO, CONR₅, S or NR₅; or E is Cₗ-C₂₆ tricycloalkyl, C₁₀-C₂₆ tricycloalkyl substituted by one or more R₁₄, C₅-C₈ tricycloalkyl substituted by one or more O, CO, COO, CONR₅, S or NR₅; or E is Cₗ-C₂₆ tricycloalkyl, C₁₀-C₂₆ tricycloalkyl substituted by one or more R₁₄, C₅-C₈ tricycloalkyl substituted by one or more O, CO, COO, CONR₅, S or NR₅; or E is Cₗ-C₂₆ tricycloalkyl, C₁₀-C₂₆ tricycloalkyl substituted by one or more R₁₄, C₅-C₈ tricycloalkyl substituted by one or more O, CO, COO, CONR₅, S or NR₅; or E is Cₗ-C₂₆ tricycloalkyl, C₁₀-C₂₆ tricycloalkyl substituted by one or more R₁₄, C₅-C₈ tricycloalkyl substituted by one or more O, CO, COO, CONR₅, S or NR₅; or E is Cₗ-C₂₆ tricycloalkyl, C₁₀-C₂₆ tricycloalkyl substituted by one or more R₁₄, C₅-C₈ tricycloalkyl substituted by one or more O, CO, COO, CONR₅, S or NR₅; or E is Cₗ-C₂₆ tricycloalkyl, C₁₀-C₂₆ tricycloalkyl substituted by one or more R₁₄, C₅-C₈ tricycloalkyl substituted by one or more O, CO, COO, CONR₅, S or NR₅; or E is Cₗ-C₂₆ tricycloalkyl, C₁₀-C₂₆ tricycloalkyl substituted by one or more R₁₄, C₅-C₈ tricycloalkyl substituted by one or more O, CO, COO, CONR₅, S or NR₅; or E is Cₗ-C₂₆ tricycloalkyl, C₁₀-C₂₆ tricycloalkyl substituted by one or more R₁₄, C₅-C₈ tricycloalkyl substituted by one or more O, CO, COO, CONR₅, S or NR₅; or E is Cₗ-C₂₆ tricycloalkyl, C₁₀-C₂₆ tricycloalkyl substituted by one or more R₁₄, C₅-C₈ tricycloalkyl substituted by one or more O, CO, COO, CONR₅, S or NR₅; or E is Cₗ-C₂₆ tricycloalkyl, C₁₀-C₂₆ tricycloalkyl substituted by one or more R₁₄, C₅-C₈ tricycloalkyl substituted by one or more O, CO, COO, CONR₅, S or NR₅; or E is Cₗ-C₂₆ tricycloalkyl, C₁₀-C₂₆ tricycloalkyl substituted by one or more R₁₄, C₅-C₈ tricycloalkyl substituted by one or more O, CO, COO, CONR₅, S or NR₅; or E is Cₗ-C₂₆ tricycloalkyl, C₁₀-C₂₆ tricycloalkyl substituted by one or more R₁₄, C₅-C₈ tricycloalkyl substituted by one or more O, CO, COO, CONR₅, S or NR₅; or E is Cₗ-C₂₆ tricycloalkyl, C₁₀-C₂₆ tricycloalkyl substituted by one or more R₁₄, C₅-C₈ tricycloalkyl substituted by one or more O, CO, COO, CONR₅, S or NR₅; or E is Cₗ-C₂₆ tricycloalkyl, C₁₀-C₂₆ tricycloalkyl substituted by one or more R₁₄, C₅-C₈ tricycloalkyl substituted by one or more O, CO, COO, CONR₅, S or NR₅; or E is
Cl\textsubscript{2} bicycloalkenylene substituted by one or more R\textsubscript{i4} and interrupted by one or more O, CO, COO, CONR\textsubscript{5}, S or NR\textsubscript{5}; or E is 

Cl\textsubscript{5}C\textsubscript{2} tricycloalkylene, Cl\textsubscript{0}C\textsubscript{2} tricycloalkylene substituted by one or more R\textsubscript{i4}, C\textsubscript{7}Cl\textsubscript{5}tricycloalkylene interrupted by one or more O, CO, COO, CONR\textsubscript{5}, S or NR\textsubscript{5}, C\textsubscript{7} 

5 Cl\textsubscript{5}tricycloalkylene substituted by one or more R\textsubscript{i4} and interrupted by one or more O, CO, COO, CONR\textsubscript{5}, S or NR\textsubscript{5}; or E is 

CβClβ cycloalkylarylene, C\textsubscript{9}Cl\textsubscript{5} cycloalkylarylene substituted by one or more R\textsubscript{i4}, C\textsubscript{7}C\textsubscript{5}cycloalkylarylene interrupted by one or more O, CO, COO, CONR\textsubscript{5}, S or NR\textsubscript{5}, C\textsubscript{7} 

C\textsubscript{5} cycloalkylarylene substituted by one or more R\textsubscript{i4} and interrupted by one or more O, CO, COO, CONR\textsubscript{5}, S or NR\textsubscript{5}; or E is 

d-d β cycloalkylheteroarylene, d-d β cycloalkylheteroarylene substituted by one or more R\textsubscript{i4}, d-d C\textsubscript{1}e cycloalkylheteroarylene interrupted by one or more O, CO, COO, CONR\textsubscript{5}, S or NR\textsubscript{5}, d-d β cycloalkylheteroarylene substituted by one or more R\textsubscript{i4} and interrupted by one or more O, CO, COO, CONR\textsubscript{5}, S or NR\textsubscript{5}; 

15 R\textsubscript{5} and R\textsubscript{6} independently of one another are hydrogen, a covalent bond to another substituent to form a ring, CrC\textsubscript{0} alkylene to form a ring with another substituent, d-C\textsuperscript{1} alkyl, phenyl or phenyl substituted by Cl-C\textsubscript{4} alkyl and/or Cl-C\textsubscript{4} alkoxy; 

R\textsubscript{7}, R\textsubscript{8}, R\textsubscript{9}, R\textsubscript{10} and R\textsubscript{11} independently of one another are hydrogen, d-C\textsuperscript{1} alkyl, d - C\textsubscript{1} alkoxy, phenyl, phenoxy, substituted phenyl or substituted phenoxy; 

20 R\textsubscript{i2} and R\textsubscript{i3} independently of one another are hydrogen, Cl-C\textsubscript{2} alkyl, C\textsubscript{5}C\textsubscript{2} cycloalkyl or phenyl; 

R\textsubscript{i4} is hydrogen, Cl-C\textsubscript{2} alkyl, C\textsubscript{5}C\textsubscript{2} cycloalkyl, Cl-C\textsubscript{2} alkoxy, C\textsubscript{2}C\textsubscript{2} cycloalkyloxy, phenyl or halogen; 

n is an integer from 1 to 100; 

25 Y is an inorganic or organic anion; 

M is an inorganic or organic cation; and 

provided that at least one of R, R' or R" is C\textsubscript{3}-C\textsubscript{20} heteroaryl or C\textsubscript{3}-C\textsubscript{20} heteroaryl substituted with at least one L. 

30 2. A compound of the formula I according to claim 1, wherein 

at least two of R, R' or R" independently of one another are C\textsubscript{3}-C\textsubscript{20} heteroaryl or C\textsubscript{3}-C\textsubscript{2} heteroaryl substituted with at least one L. 

3. A compound of the formula I according to claim 1, wherein
R, R' and R" are identical; and L, L' and L" are identical; and L_1, L'_1 and L_i are identical; and L_2, L'_2 and L_2" are identical; and L_3, L'_3 and L_3" are identical; and L_4, L'_4 and L_4" are identical and X, X' and X" are identical, namely a compound of the formula (Ia), wherein R, X, Y, L_1, L_2 and L_4 are defined in claim 1.

4. A compound of the formula (Ia) according to claim 3, wherein L_3 and L_4 are hydrogen; and L_1, L_2 independently of one another are hydrogen or COOR_i or COOR_i, halogen, NO_2, CN, COOR_i, OCOR_i, OCOOR_i, COOT or COT; X is O, S, CR_R'R_b or a single bond, provided that if X is O, R is not pyridinyl; and R_1 has one of the meanings given for T as defined in claim 1.

5. A compound of the formula I or Ia, respectively, according to anyone of claims 1-4, wherein R and R'_1 and R" are C_3-C_2 heteroaryl are are thienyl, benzo[b]thienyl, naphtho[2,3-b]thienyl, thianthrenyl, dibenzofuryl, chromenyl, xanthlenyl, thioxanthenyl, phenoxathiinyl, pyrrolyl, imidazolyl, pyrazolyl, pyrazinyl, pyridinyl, pyridazinyl, indoliziny, isoindolyl, indolyl, indazolyl, purinyl, quinoliziny, isoquinolyl, quinolyl, phthalazinyl, naphthoyridinyl, quinoxalinyl, quinazolinyl, cinnolinyl, pteridinyl, carbazalyl, 3-carbolinyl, phenanthridinyl, acridinyl, perimidis, phenanthrolinyl, phenazinyl, isothiazolyl, phenothiazinyl, isoazolyl, furazanyl, phenoxazinyl, 7-phenanthryl, anthraquinone-2-yl (=9,10-dioxo-9,10-dihydroanthracen-2-yl), 3-benzo[b]thienyl, 5-benzo[b]thienyl, 2-benzo[b]thienyl, 4-dibenzofuryl, 4,7-dibenzofuryl, 4-methyl-7-dibenzofuryl, 2-xanthlenyl, 8-methyl-2-xanthlenyl, 3-xanthlenyl, 2-phenoxathiinyl, 2,7-phenoxyathiinyl, 2-pyrrollyl, 3-pyrrollyl, 5-methyl-3-pyrrollyl, 2-imidazolyl, 4-imidazolyl, 5-imidazolyl, 2-methyl-4-imidazolyl, 2-ethyl-4-imidazolyl, 2-ethyl-5-imidazolyl, 3-pyrazolyl, 1-methyl-3-pyrazolyl, 1-propyl-4-pyrazolyl, 2-pyrazinyl, 5,6-dimethyl-2-pyrazinyl, 2-indoliziny, 2-methyl-3-indoliziny, 2-methyl-1-indoliziny, 1-methyl-2-indoliziny, 1-methyl-3-indoliziny, 1,5-dimethyl-2-indoliziny, 1-methyl-3-indolazolyl, 2,7-dimethyl-8-purinyl, 2-methoxy-7-methyl-8-purinyl, 2-quinoliziny, 3-isoquinolyl, 6-isoquinolyl, 7-isoquinolyn, 3-methoxy-6-isoquinolyn, 2-quinolyn, 3-quinolyn, 7-quinolyn, 2-methoxy-3-quinolyn, 2-methoxy-6-quinolyn, 6-phthalazinyl, 7-phthalazinyl, 1-methoxy-6-phthalazinyl, 1,4-dimethoxy-6-phthalazinyl, 1,8-naphthryd-2-yl,
2-quinoxalinyl, 6-quinoxalinyl, 2,3-dimethyl-6-quinoxalinyl, 2,3-dimethoxy-6-quinoxalinyl, 2-quinazolinyl, 7-quinazolinyl, 2-dimethylamino-6-quinazolinyl, 3-cinnolinyl, 6-cinnolinyl, 7-cinnolinyl, 3-methoxy-7-cinnolinyl, 2-pteridinyl, 6-pteridinyl, 7-pteridinyl, 6,7-dimethoxy-2-pteridinyl, 2-carbazolyl, 3-carbazolyl, 9-methyl-2-carbazolyl, 9-methyl-3-carbazolyl, β-carbolin-3-yl, 1-methyl-β-carbolin-3-yl, 1-methyl-β-carbolin-6-yl, 3-phenanthridinyl, 2-acridinyl, 3-acridinyl, 2-acridinyl, 5-phenanthrolinyl, 6-phenanthrolinyl, 1-phenazinyl, 2-phenazinyl, 3-isothiazolyl, 4-isothiazolyl, 5-isothiazolyl, 2-phenothiazinyl, 3-phenothiazinyl, 10-methyl-3-phenothiazinyl, 3-isoxazolyl, 4-isoxazolyl, 5-isoxazolyl, 4-methyl-3-furazanyl, 2-phenoxazinyl, 10-methyl-2-phenoxazinyl,

wherein all of said C₃-C₂₀ heteroaryl are unsubstituted or substituted by one or more halogen, Ci-C₄ alkyl or COT; and

wherein the case that the C₃-C₂₀ heteroaryl comprises an annelated benzene ring, the bond to the corresponding X, X' or X'' is not located on said annelated ring.

6. A compound of the formula I or Ia, respectively, according to anyone of claims 1-5, wherein
R and R¹ and R² as C₃-C₂₀ heteroaryl are thiienyl, furyl, benzol[b]thienyl, naphtho[2,3-b]thienyl, thianthrenyl, benzofuryl, dibenzofuryl, chromenyl, xanthenyl, thioxanthyl, phenoxathiinyl, 7-phenanthryl, anthraquinone-2-yl (= 9,10-dioxo-9,10-dihydroanthracen-2-yl), 3-benzo[b]-thienyl, 5-benzo[b]thienyl, 2-benzo[b]thienyl, 4-dibenzofuryl, 4,7-dibenzofuryl, 4-methyl-7-dibenzofuryl, 2-xanthenyl, 8-methyl-2-xanthenyl, 3-xanthenyl, 2-phenoxathiinyl, 2,7-phenoxathiinyl;

wherein all said C₃-C₂₀ heteroaryl are unsubstituted or substituted by one or more halogen, Ci-C₄ alkyl or COT; and

wherein the case that the C₃-C₂₀ heteroaryl comprises an annelated benzene ring, the bond to the corresponding X, X' or X'' is not located on said annelated ring.

7. A compound of the formula I or Ia, respectively, according to anyone of claims 1-6, wherein
R and R¹ and R² as C₃-C₂₀ heteroaryl are thiienyl or furyl, both of which are unsubstituted or are substituted by at least one Ci-C₄ alkyl and/or COT.

8. A process for the preparation of a compound of the formula I, by reacting
a compound of the formula II
or mixtures of compounds of the formula II, II' and/or II"

R, R', R'', X, X', X'', L_1, L'_1, L''_1, L_2, L'_2, L''_2, L_3, L'_3, L''_3, L_4, L'_4 and L''_4 are as defined in claim 1,

with thionylchloride in the presence of a Friedel-Crafts catalyst, optionally followed by an exchange of the anion Y.

9. A radiation-sensitive composition comprising

(a1) a cationically or acid-catalytically polymerisable or crosslinkable compound or

(a2) a compound that increases its solubility in a developer under the action of acid; and/or

(ax) a radically polymerisable or crosslinkable compound; and

(b) at least one compound of the formula I according to claim 1.

10. Use of a compound of formula I according to claim 1 as photolatent acid donor in the polymerisation or crosslinking of cationically or acid-catalytically polymerisable or crosslinkable compounds or to increase the solubility of compounds that increase their solubility in a developer under the action of acid.

11. A radiation-sensitive composition according to claim 9, additionally to components (a1) or (a2) and/or (ax) and (b), comprising additives (c) and/or sensitizer compounds (d) and optionally further photoinitiators (e).

12. Use of a compound of formula I according to claim 1 as radiation-sensitive acid donor in the preparation of pigmented and non-pigmented surface coatings, adhesives, laminating adhesives, structural adhesives, pressure-sensitive adhesives, printing inks, printing plates, relief printing plates, planographic printing plates, intaglio printing plates, processless printing
plates, screen printing stencils, dental compositions, colour filters, spacers, electroluminescence displays and liquid crystal displays (LCD), waveguides, optical switches, color proofing systems, resists, photoresists for electronics, electroplating resists, etch resists both for liquid and dry films, solder resist, photoresist materials for a UV and visible laser direct imaging system, photoresist materials for forming dielectric layers in a sequential build-up layer of a printed circuit board, colour filters, chemically amplified resist materials, image-recording materials, image-recording materials for recording holographic images, optical information storage or holographic data storage, decolorizing materials, decolorizing materials for image recording materials, image recording materials using microcapsules, magnetic recording materials, micromechanical parts, plating masks, etch masks, glass fibre cable coatings, microelectronic circuits.

13. A coated substrate that is coated on at least one surface with a composition according to claim 9.

14. A method for the photopolymerisation or crosslinking of cationically or acid-catalytically polymerisable or crosslinkable compounds under the action of electromagnetic radiation or an electron beam, in which method a compound of formula I according to claim 1 is used as photolatent acid donor.

15. A method according to claim 14 in the manufacture of pigmented and non-pigmented surface coatings, adhesives, laminating adhesives, structural adhesives, pressure-sensitive adhesives, printing inks, printing plates, relief printing plates, planographic printing plates, intaglio printing plates, processless printing plates, screen printing stencils, dental compositions, colour filters, spacers, electroluminescence displays and liquid crystal displays (LCD), waveguides, optical switches, color proofing systems, resists, photoresists for electronics, electroplating resists, etch resists both for liquid and dry films, solder resist, photoresist materials for a UV and visible laser direct imaging system, photoresist materials for forming dielectric layers in a sequential build-up layer of a printed circuit board, colour filters, chemically amplified resist materials, image-recording materials, image-recording materials for recording holographic images, optical information storage or holographic data storage, decolorizing materials, decolorizing materials for image recording materials, image recording materials using microcapsules, magnetic recording materials, micromechanical parts, plating masks, etch masks, glass fibre cable coatings, microelectronic circuits.
**INTERNATIONAL SEARCH REPORT**

**International application No**

PCT/EP2008/062587

**A. CLASSIFICATION OF SUBJECT MATTER**

INV. C07D307/83  C07D333/22  C07D333/32  C07D333/34  C07D333/64

G03F7/004

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

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**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

C07D  G03F

Documented 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)

EPO-Internal, CHEM ABS Data, BEILSTEIN Data

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

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<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No</th>
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<td>EP 1 693 704 A (FUJI PHOTO FILM CO LTD [JP]) 23 August 2006 (2006-08-23)</td>
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<td>A</td>
<td>page 7; compounds BP-17</td>
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**D** Further documents are listed in the continuation of Box C

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* 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
- **IP** 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
- **B** document member of the same patent family

**Date of the actual completion of the international search**

4 December 2008

**Date of mailing of the International search report**

15/12/2008

**Name and mailing address of the ISA/**

European Patent Office, P B 5818 Patentlaan 2

NL - 2280 HV Rijswijk

Tel (+31-70) 340-2040

Fax (+31-70) 340-3016

**Authorized officer**

Jean jean, Fabien
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