(86) Date de dépôt PCT/PCT Filing Date: 2007/03/27
(87) Date publication PCT/PCT Publication Date: 2007/10/18
(85) Entrée phase nationale/National Entry: 2008/10/03
(86) N° demande PCT/PCT Application No.: EP 2007/002677
(87) N° publication PCT/PCT Publication No.: 2007/115678
(30) Priorité/Priority: 2006/04/08 (DE10 2006 016 642.6)

(51) Cl.Int./Int.Cl. C09D 133/06 (2006.01), B32B 27/08 (2006.01), B32B 27/30 (2006.01), C08K 3/00 (2006.01), C08K 5/00 (2006.01)

(71) Demandeur/Applicant: BAYER MATERIALSCIENCE AG, DE
(72) Inventeurs/Inventors: BUCKEL, FRANK, DE; MALEKA, ROBERT, DE; KOEHLER, WALTER, DE; MEYER, REINER, DE

(74) Agent: FETHERSTON-HAUGH & CO.

(54) Titre : COUCHE PROTECTRICE DURCISSABLE PAR UV POUR SUBSTRAT THERMOPLASTIQUE
(54) Title: UV-CURING PROTECTIVE COAT FOR THERMOPLASTIC SUBSTRATES

(57) Abrégé/Abstract:
The present invention relates to a multi-coat product comprising a first coat (S1) and a second coat (S2), S1 being obtainable from A) one or more aliphatic polymer precursors selected from at least one of the groups consisting of the components A.1 and A.2, A.1) being aliphatic oligomers containing urethane bonds or ester bonds and having at least two acrylate functions per molecule, or mixtures of such oligomers, and A.2) being aliphatic reactive diluents having at least two acrylate groups per molecule, or mixtures of such reactive diluents; B) one or more finely divided inorganic compounds; C) at least one organic UV absorber selected from the group consisting of triazine derivatives and biphenyltriazine derivatives, preferably at least one UV absorber from the biphenyltriazine derivatives; D) if desired, one or more free-radical scavengers of the HALS class; E) if desired, one or more flow control agents; F) if desired, one or more solvents; and G) at least one specific photoinitiator selected from the group consisting of acrylphosphate oxide derivatives and α-aminoalkylphenone derivatives, and the second coat being a thermoplastic polymer. The invention further relates to the composition of the UV-curable first coat, to a process for producing these multi-coat products, and to products which comprise the stated multi-coat products.
UV-hardening protective layer for thermoplastic substrates

Abstract

The present invention relates to a multi-layer product containing a first layer (S1) and a second layer (S2), wherein S1 is obtainable from

A) one or more aliphatic polymer precursors selected from at least one of the groups consisting of components A.1 and A.2, wherein

A.1) are aliphatic oligomers containing urethane bonds or ester bonds with at least two acrylate functions per molecule or mixtures of corresponding oligomers and

A.2) are aliphatic reactive diluents with at least two acrylate groups per molecule or mixtures of corresponding reactive diluents,

B) one or more fine-particle inorganic compounds,

C) at least one organic UV absorber selected from the group consisting of triazine derivatives and biphenyltriazine derivatives, preferably at least one UV absorber of the biphenyltriazine derivatives,

D) optionally one or more radical interceptors of the HALS class

E) optionally one or more flow control agents

F) optionally one or more solvents, and

G) at least one special photoinitiator selected from the group consisting of acylphosphine oxide derivatives and α-aminoalkylphenone derivatives,
and wherein the second layer is a thermoplastic polymer.

In addition, the invention relates to the composition of the UV-hardenable first layer, a process for the production of these multi-layer products and products which contain the named multi-layer products.
UV-hardening protective layer for thermoplastic substrates

The present invention relates to a multi-layer product, the first layer being a UV-hardened protective layer which contains SiO$_2$ nanoparticles, and the second layer containing a thermoplastic substrate. In addition, the invention relates to the composition of the UV-hardenable first layer, a process for the production of the multi-layer products and products, such as e.g. glazing products, which contain the named multi-layer products.

C. Roscher in Pitture e Vernici – European Coatings 2004, 20, 7–10, discloses UV-hardenable organic coating systems containing nanoparticles of silicon dioxide as a coating system which in comparison to corresponding filler-free coating systems have a clearly improved scratch resistance and abrasion resistance.

Mouldings made of polycarbonate have been known for some time. Polycarbonate, however, has the disadvantage that it is not itself inherently UV-stable. The sensitivity curve of bisphenol A polycarbonate has the highest sensitivity between 320 nm and 330 nm. Below 300 nm, no solar radiation reaches the earth, and above 350 nm this polycarbonate is so insensitive that no further yellowing takes place.

For a durable coating of a UV-sensitive plastic substrate, such as for example polycarbonate, thus a multi-layer product also suitable for long-lasting external application, an efficient UV protection is additionally required in the first layer.

Typical UV stabilisers which as is known are used in coatings, are UV absorbers such as 2-hydroxybenzophenones, 2-(2-hydroxyphenyl)benzotriazoles, 2-(2-hydroxyphenyl)-1,3,5-triazines, 2-cyanacrylates and oxalanilides, and radical interceptors of the HALS (hindered amine light stabilizer) type. These additional coating components, with a UV-harden binder, affect the radical crosslinking reaction started by UV light, competing with the photoinitiator for the UV light or by intercepting the initiator radicals or secondary radicals formed.
In the following, the prior art is combined with multi-layer products, with a first layer consisting of a matrix filled with organic nanoparticles formed by UV hardening and containing a UV absorber.

In EP-A 0 424 645 is disclosed a UV radiation-hardenable coating based on acrylates and colloidal silicon dioxide, in which UV absorbers, explicitly a benzophenone type, a cyanacrylate type and a benzotriazole type, and radical interceptors of the HALS type, are mentioned as possible additives. When UV light is used for radiation hardening, there is the problem of a hindering of hardening as a function of the quantity of UV absorber quantity. Regarding the photoinitiator for hardening, according to EP-A 0 424 645 there are no restrictions; explicitly mentioned are 2-hydroxy-2-methyl-1-phenylpropan-1-one (Danocure® 1173 from Ciba Specialty Chemicals) and 2,2-dimethoxy-1,2-diphenylethan-1-one (Irgacure® 651 from Ciba Specialty Chemicals).

In EP-A 0 576 247 is disclosed a coating hardenable by means of UV radiation based on colloidal silicon oxide, silyl acrylate, acrylate, 2,4,6-trimethylbenzoyldiphenyl phosphine oxide (Lucirin TPO from BASF AG) as photoinitiator and UV absorbers. Sterically hindered amines of the HALS type, fluoroacrylate and alkyl acrylate can optionally be used as additives. Three benzophenone types and two benzotriazole types are named with Cyasorb® UV-416, Cyasorb® UV-531, Cyasorb® UV-5411, Tinuvin® 328 and UnivoL® 400 explicitly as UV absorber.

In US 5,468,789 is disclosed a coating hardenable by means of UV radiation based on colloidal silicon oxide, alkoxysilyl acrylate, acrylate monomer and a special gel-forming inhibitor, wherein optionally UV absorbers such as resorcinol monobenzoate and 2-methylresorcinol dibenzoate can be contained.

To achieve an adequate protective function for the second layer, it is necessary that the first layer should as far as possible completely filter out or absorb the UV light harmful for the second layer primarily. In the case of polycarbonate as the second
layer, therefore, UV light with a wave length of 300 to 340 nm should be filtered out or absorbed as far as possible completely from the first layer. Both a corresponding quantity of a UV absorber with an as high as possible absorption coefficient in the first layer and also an adequately large layer thickness of the first layer are necessary for this. This high UV filter action of the UV absorber competes in the hardening of the first layer initiated by UV light with the photoinitiator for the light required for the formation of radicals. The additional use of radical interceptors such as HALS as light stabilisers is a further difficulty because they can intercept the radicals required for the radical start of crosslinking and formed from the initiator by UV radiation.

The present invention is based on the object of providing multi-layer products with a UV-sensitive substrate such as polycarbonate as the second layer and a UV-hardening scratch-resistant and abrasion-resistant protective layer as the first layer, which are distinguished by an effective UV protection and a high abrasion resistance.

This object is surprising achieved by a coating formulation containing at least one special photoinitiator selected from the group consisting of acylphosphine oxide derivatives and \( \alpha \)-aminoalkylphenone derivatives which after application and hardening forms the first layer of the multi-layer product. These special photoinitiators produce, optionally also in combination with other photoinitiators, the effective UV-initiated crosslinking necessary for the high abrasion resistance and scratch-resistance which is not impaired by the presence of the UV stabilisers such as for example triazine derivatives and optionally radical interceptors of the HALS class. The abrasion resistance of the multi-layer products according to the invention with implemented UV protection is on a comparable level to corresponding multi-layer products with siloxane-based protective coating systems.

The subject matter of the invention is therefore a multi-layer product containing a first layer (S1) and a second layer (S2), the first layer being a coating obtainable from
A) one or more aliphatic polymer precursors selected from at least one of the
groups consisting of components A.1 and A.2, wherein

A.1) are aliphatic oligomers containing urethane bonds or ester bonds with at
least two acrylate functions per molecule or mixtures of corresponding
oligomers and

A.2) are aliphatic reactive diluents with at least two acrylate groups per
molecule or mixtures of corresponding reactive diluents,

B) one or more fine-particle inorganic compounds,

C) at least one organic UV absorber selected from the group consisting of triazine
derivatives and biphenyltriazine derivatives, preferably at least one UV
absorber of the biphenyltriazine derivatives,

D) optionally one or more radical interceptors of the HALS class

E) optionally one or more flow control agents

F) optionally one or more solvents, and

G) at least one photoinitiator selected from the group consisting of acylphosphine
oxide derivatives and α-aminoalkyphenone derivatives which are preferably
distinguished by a high photochemical reactivity and an absorption band in the
near UV range of > 300 nm, particularly preferably λ > 350 nm,

and the second layer being a thermoplastic polymer.

In a preferred embodiment, the components of the first layer (S1) are used in the
following quantity ratios:
based on the mixture of components A and B

20 to 95 wt.%, preferably 50 to 80 wt.% component A,

5 to 80 wt.%, preferably 20 to 50 wt.% component B and

0.1 to 10 wt.%, preferably 0.5 to 8 wt.%, particularly preferably 1 to 5 wt.% component G, are used.

The quantity of solvent (component F) is measured so that an experimentally determined solid content of 20 to 50 wt.%, preferably 30 – 40 wt.%, results for the mixture of components A, B and F.

Based on the solid content of the mixture of components A, B and F

0.1 to 20, preferably 0.5 to 10, particularly preferably 0.8 to 5 wt.% component C,

0 to 10, preferably 0.1 to 5, particularly preferably 0.2 to 2 wt.% component D and

0 to 5, preferably 0.1 to 1 wt.% component E are used.

**Components and structure of the first layer (S1)**

**Component A**

The aliphatic polymer precursors according to component A are selected from at least one of the groups consisting of components A.1 and A.2 wherein

A.1) are aliphatic oligomers containing urethane bonds or ester bonds with at least two acrylate functions per molecule or mixtures of corresponding oligomers and
A.2) are aliphatic reactive diluents with at least two acrylate groups per molecule or mixtures of corresponding reactive diluents.

Suitable polymer precursors according to component A with at least two acrylate groups per molecule are preferably those of the formula

\[ (R_1^2C=CR_2^2CO_2)_nR^3 \]  

wherein

\[ n \geq 2, \]

\( R^1 \) and \( R^2 \) independently of one another are \( H \) or \( C_1 \) to \( C_{30} \) alkyl, preferably \( H \), methyl or ethyl and

\( R^3 \) in the case of polymer precursors according to component A.1 is an \( n \)-valent organic radical which consists of aliphatic hydrocarbon units linked by urethane bonds or ester bonds, or

\( R^3 \) in the case of polymer precursors according to component A.2 is an \( n \)-valent organic radical, preferably with 1 – 30 hydrocarbons.

Production of the suitable oligomers according to component A.1 which belong to the class of aliphatic urethane acrylates or the polyester acrylates, and the use of which as coating binders are known and are described in Chemistry & Technology of UV & EB Formulation for Coatings, Inks & Paints, vol. 2, 1991, SITA Technology, London (P.K.T. Oldring (ed.) on pp 73–123 (Urethane Acrylates) or pp 123–135 (Polyester Acrylates). Commercially obtainable and suitable with the meaning according to the invention are here for example aliphatic urethane acrylates such as Ebecryl® 4858, Ebecryl® 284, Ebecryl® 265, Ebecryl® 264 (manufacturer Cytec Surface Specialities), Craynor® 925 from Cray Valley, Viaktin® 6160 from Vianova Resin, Roskydal® 2258 from Bayer MaterialScience
AG, Photomer® 6891 from Cognis or even aliphatic urethane acrylates dissolved in reactive diluents such as Laromer® 8987 (70% in hexanediol acrylate) from BASF AG, Roskydal® 2303 (80% in hexanediol diacrylate) from Bayer MaterialScience AG, Craynor® 945B85 (85% in hexanediol diacrylate) and Craynor® 963B80 (80% in hexanediol diacrylate) from Cray Valley or even polyester acrylates such as Ebecryl® 810 or 830 from Cytec Surface Specialties.

The production and use of suitable reactive diluents according to component A.2 are known and are described in Chemistry & Technology of UV & EB Formulation for Coatings, Inks & Paints, vol. 2, 1991, SITA Technology, London (P.K.T. Oldring (ed.) on pp 237–306 (Reactive Diluents). Suitable within the meaning according to the invention are here for example methanediol diacrylate, 1,2-ethanediol diacrylate, 1,3-propanediol diacrylate, 1,2-propanediol diacrylate, glycerol triacrylate, 1,4-butanediol diacrylate, 1,3-butanediol diacrylate, 1,2,4-butanetriol triacrylate, 1,5-pentanediol diacrylate, neopentyl glycol diacrylate, pentaerythritol triacrylate, pentaerythritol tetraacrylate, 1,6-hexanediol diacrylate, trimethylolpropane diacrylate, trimethylolpropane triacrylate, tricyclodecane dimethanol diacrylate, diethylene glycol diacrylate, triethylene glycol diacrylate, tetramethylene glycol diacrylate, dipropylene glycol diacrylate, tripropylene glycol diacrylate, trimethylol propane triethoxytriacrylate, dipentaerythritol pentaacrylate, dipentaerythritol hexaacrylate, dtrimethylolpropane tetraacrylate and the corresponding methacrylate derivatives. 1,6-hexanediol diacrylate, tricyclodecane dimethanol diacrylate, trimethylol propane triacrylate, pentaerythritol tetraacrylate and the methacrylate derivatives thereof are preferably used. 1,6-hexanediol diacrylate, tricyclodecane dimethanol diacrylate and the methacrylic derivatives thereof, in particular in mixture with component A.1 are particularly preferably used.

Component B

Component B comprises fine-particle inorganic compounds, these preferably consist of at least one polar compound of one or more metals of the 1st to 5th main group or 1st to 8th sub-group of the periodic system, preferably the 2nd to 5th main group or 4th
to 8th sub-group, particularly preferably the 3rd to 5th main group or 4th to 8th sub-group, or from compounds of these metals with at least one element selected from oxygen, hydrogen, sulfur, phosphorus, boron, carbon, nitrogen or silicon. Preferred compounds are for example oxides, hydroxides, aqueous oxides, sulfates, sulfites, sulfides, carbonates, carbides, nitrates, nitrites, nitrides, borates, silicates, phosphates, hydrides, phosphates or phosphonates.

Preferably the fine-particle inorganic compounds of oxides, phosphates, hydroxides, preferably of TiO₂, SiO₂, SnO₂, ZnO, ZnS, ZrO₂, Al₂O₃, AlO(OH), boehmite, aluminium phosphates, furthermore TiN, WC, Fe₂O₃, iron oxides, NaSO₄, vanadium oxides, zinc borate, silicates such as Al silicates, Mg silicates, one-, two- or three-dimensional silicates. Mixtures and doped compounds can also be used.

Hydrate-containing aluminium oxides (e.g. boehmite) and silicon dioxide are particularly preferred. Silicon dioxide is in particular preferred.

The fine-particle inorganic compounds within the sense according to the invention have a mean particle size (d₅₀) of 1 to 200 nm, preferably 5 to 50 nm, particularly preferably 7 – 40 nm. In particular, the fine-particle inorganic compounds have a narrow particle size distribution with a \(((d₉₀ – d₁₀)/d₅₀)\) of the distribution of less than or equal to 2, particularly preferably 0.2 to 1.0. Determination of the particle size is carried out by analytical ultracentrifuging, d₅₀ being the 90% value, d₁₀ the 10% value and d₅₀ the mean of the integral mass distribution of the particle size. The use of analytical ultracentrifuging for particle size determination is described in H.G. Müller Progr. Colloid Polym. Sci. 2004, 127, pages 9–13.

In a preferred embodiment, the surface of these fine-particle inorganic compounds is modified by means of alkoxy silane compounds. Alkoxy silane compounds of the formula

\[ \text{R}_m\text{Si(OR')}_{4-m} \]  

(II)

with
M = 1, 2 or 3 and

R and R' = a monovalent organic radical, preferably an alkyl chain with 1 to 30 carbon atoms,

are preferably used for this. Surface modification of the fine-particle inorganic compounds is particularly preferably carried out with acrylate-functionalised trialkoxysilane compounds according to

\[(R^1_2C=CR^2CO_2)\cdot R^4\cdot Si(OR^5)_3\]  

(III)

wherein

R^1 and R^2 independently of one another are H or C₁ to C₃₀ alkyl, preferably H, methyl or ethyl,

R^4 is a divalent organic radical, preferably an alkyl chain, with 1 to 30 carbon atoms and

R^5 is a monovalent organic radical, preferably an alkyl chain with 1 to 30 carbon atoms and particularly preferably methyl and ethyl.

The following acrylate-functionalised trialkoxysilane compounds are particularly preferably used for surface modification of the fine-particle inorganic compounds: (3-methacryloxypropyl) trimethoxysilanes, (3-acryloxypropyl) trimethoxysilanes, (3-methacryloxypropyl) trimethoxysilanes, methacryloxyethyl triethoxysilanes and methacryloxyethyl trimethoxysilanes.

In a preferred embodiment, the fine-particle inorganic compound is used as a dispersion in at least one component selected from the group consisting of A) and F). Fine-particle inorganic compounds which are dispersible agglomerate-free in the coating formulation are preferred.
Component C

The UV absorbers within the meaning according to the invention are derivatives of triazine, preferably derivatives of biphenyltriazine. UV absorbers according to the following formula (IV) are preferably used

\[
\begin{align*}
    & X = \text{OR}^6, \text{OCH}_2\text{CH}_2\text{OR}^6, \text{OCH}_2\text{CH(OH)CH}_2\text{OR}^6 \text{ or OCH(R}^7\text{)COOR}^8, \text{ preferably OCH(R}^7\text{)COOR}^8, \\
    & R^6 = \text{branched or unbranched C}_1\text{-C}_13 \text{ alkyl, C}_2\text{-C}_20 \text{ alkenyl, C}_6\text{-C}_12 \text{ aryl or } -\text{CO-C}_1\text{-C}_18 \text{ alkyl,} \\
    & R^7 = \text{H or branched or unbranched C}_1\text{-C}_8 \text{ alkyl, preferably CH}_3 \text{ and} \\
    & R^8 = \text{C}_1\text{-C}_12 \text{ alkyl; C}_2\text{-C}_12 \text{ alkenyl or C}_5\text{-C}_6 \text{ cycloalkyl, preferably C}_8\text{H}_{17}. \\
\end{align*}
\]

A UV absorber according to formula (IV) with \( X = \text{OCH(R}^7\text{)COOR}^8 \), \( R^7 = \text{CH}_3 \) and \( R^8 = \text{C}_8\text{H}_{17} \) (UV absorber CGL479 from Ciba Speciality Chemicals) is particularly preferably used as component C.

In a preferred embodiment, the UV absorbers have a high UV absorption in the range of the greatest sensitivity of the second layer, particularly preferably the UV absorbers have a UV absorption maximum between 300-340 nm.

**Component D**

Component D within the meaning according to the invention are so-called HALS (hindered amine light stabilizer) systems. A further stabilisation is thereby achieved. The HALS systems are amines according to formula (V)

![Chemical Structure](V)

wherein

\[
Y = \text{H; } R^6 \text{ or } OR^6
\]

\[
R^6 = \text{branched or unbranched } C_{1-13} \text{ alkyl, } C_{2-20} \text{ alkenyl, } C_{6-12} \text{ aryl or } -\text{CO}-C_{1-}
\]

\[
C_{18} \text{ alkyl, and}
\]
\[ R^0 = Z - R^{10} - Z - R^{11}, \]

wherein

5 \[ Z = \text{a divalent functional group such as } C(O)O, \text{ NH or } NHCO \]

\[ R^{10} = \text{a divalent organic radical such as } (CH_2)_l \text{ with } l = 0 \text{ to } 12, \text{ C=CH-Ph-OCH}_3 \]

\[ R^{11} = \text{H or C}_1-\text{C}_{20} \text{ alkyl.} \]

10 This gives the following formulæ
wherein Y, Z, R^{10} and R^{11} have the above-mentioned meaning.

HALS systems according to the following formulae are preferably used

wherein Y and I have the above-mentioned meaning, and
wherein Y and \( R^{11} \) have the above-mentioned meaning.

HALS systems according to formulae (Vf) and (Vg) are particularly preferred

\[
\begin{align*}
\text{(Vf)} \\
Y - \text{N} - \text{O} - \text{C} - \text{O} - (\text{CH}_2)_6 - \text{C} - \text{O} - \text{N} - \text{Y}
\end{align*}
\]

with \( Y = \text{OC}_8\text{H}_{17} \) (bis(1-octyloxy-2,2,6,6-tetramethyl-4-piperidyl) sebacic acid ester; Tinuvin\textsuperscript{®} 123 from Ciba Speciality Chemicals) and
with $Y = \text{CH}_3((3,5$-ditert.-butyl-4-hydroxybenzyl)-butyl malonic acid-bis-(1,2,2,6,6-pentamethyl-4-piperidyl) ester; Tinuvin® 144 from Ciba Speciality Chemicals).

**Component E**

Component E within the meaning according to the invention are preferably all the flow control agents that facilitate good wetting of the coating formulation on the surface of the second layer and also a visually attractive surface of the first layer formed on curing of the coating formulation. Janos Hajas “Levelling Additives” in Additives in Coatings, Johan Beileman (ed.), Wiley-VCH Verlag GmbH, Weinheim 2000, pp 164-179 gives an overview of common flow control agents. For example and preferably, the flow control agent BYK® 300 from BYK Chemie is used.

**Component F**

Component F within the meaning according to the invention are solvents or solvent mixtures which must be compatible to an extent with the second layer and must to an extent facilitate dispersion, application and evaporation of the coating formulation that after UV hardening of the coating formulation to the actual first
layer a multi-layer product with high transparency and low haze is obtained. These can be for example and preferably alkanes, alcohols, esters, ketones or mixtures of those named. Alcohols (with the exception of methanol), acetic acid ethyl ester and butanone can particularly preferably be used. Very particularly preferred are solvents or solvent mixtures selected from at least one of the groups consisting of diacetone alcohol \((\text{CH}_3)_2\text{C(OH)CH}_2\text{C(=O)CH}_3\), acetic acid ethyl ester, methoxypropanol and butanone.

**Component G**

Component G is at least one photoinitiator selected from the group consisting of acylphosphine oxide derivatives and \(\alpha\)-aminoalkylphenone derivatives according to formula VI (acylphosphine oxides) or VII (\(\alpha\)-aminoalkylphenone),

\[
\begin{align*}
\text{(VI)} \\
\text{(VII)}
\end{align*}
\]

wherein

\[
R^{12} = \text{C}_1\text{-C}_{30} \text{ alkyl}, \text{C}_5 \text{ to } \text{C}_6 \text{ cycloalkyl optionally substituted by } \text{C}_1 \text{ to } \text{C}_4 \text{ alkyl, and/or chlorine, bromine, C}_6 \text{ to } \text{C}_{20} \text{ aryl, C}_6 \text{ to } \text{C}_{20} \text{ aryloxy or } \text{C}_7 \text{ to } \text{C}_{12} \text{ aralkyl, preferably phenyl, CH}_2\text{CH(CH}_3\text{)CH}_2\text{C(CH}_3\text{)}_3 \text{ or}
\]

\[
\begin{align*}
\text{CH}_3 & \\
\text{H}_3\text{C}
\end{align*}
\]

\[
R^{13} = \text{C}_1 \text{ -C}_{30} \text{ alkyl}, \text{C}_1 \text{ -C}_{30} \text{ alkoxy, C}_5 \text{ to C}_6 \text{ cycloalkyl optionally substituted by } \text{C}_1 \text{ to } \text{C}_4 \text{ alkyl, C}_1 \text{ to } \text{C}_4 \text{ alkoxy, C}_1 \text{ to } \text{C}_4 \text{ acyl and/or chlorine, bromine, C}_6 \text{ -C}_{20} \text{ aryl, C}_6 \text{ to } \text{C}_{20} \text{ aryloxy, C}_7 \text{ to } \text{C}_{21} \text{ aroyl or } \text{C}_7 \text{ to } \text{C}_{12} \text{ aralkyl, preferably OCH}_2\text{CH}_3, \text{ phenyl}
\]
R^{14} = C_1 to C_4 alkyl, C_1 to C_4 alkoxy, preferably CH₃ or OCH₃

n = 0 to 5, preferably 0, 2 or 3,

R^{15}, R^{16}, R^{17} and R^{18} independently of one another are C₁ to C₃₀ alkyl, optionally C₅ to C₆ cycloalkyl optionally substituted by C₁ to C₄ alkyl, and/or chlorine, bromine, C₆ to C₂₀ aryl or C₇ to C₁₂ aralkyl, preferably R^{15} is CH₂Ph or CH₃, R^{16} = CH₂CH₃ or CH₃, R^{17} = CH₃ and R^{18} = CH₃,

and wherein the radicals R^{17} and R^{18} can also be linked to a ring so that the nitrogen N shown in formula (VII) is part of a heterocyclic ring system

\[
\begin{array}{c}
\text{N} \\
\text{O}
\end{array}
\]

preferably part of morpholine

R^{19} = C₁ to C₃₀ alkoxy, C₁ to C₃₀ alkylthio, C₁ to C₃₀ dialkylamino, C₃ to C₆ cycloalkyl optionally substituted by C₁ to C₄ alkyl, and/or chlorine, bromine, wherein the C atoms of the ring can also be substituted by heteroatoms such as N, O or S,

\[
\begin{array}{c}
\text{N} \\
\text{O}
\end{array}
\]

preferably methylthio or
The following are preferably used as photoinitiators according to component G: bis(2,4,6-trimethylbenzoyl) phenyl phosphine oxide (Irgacure® 819 from Ciba Speciality Chemicals), (2,4,6-trimethylbenzoyl) diphenyl phosphine oxide (Lucirin® TPO Solid from BASF AG), bis(2,6-dimethylbenzoyl)(2,4,4-trimethylpentyl) phosphine oxide, bis(2,6-dimethoxybenzoyl)(2,4,4-trimethylpentyl) phosphine oxide, benzoylphosphonic acid bis(2,6-dimethylphenyl)ester (Lucirin® 8728 from BASF AG), 2,4,6-trimethylbenzoyl oxyphenoxyphenyl phosphine oxide (Lucirin® TPO-L from BASF AG), 2-benzyl-2-(dimethylamino)-1-(4-morpholinophenyl)-1-butane (Irgacure® 369 from Ciba Speciality Chemicals) and 2-methyl-1-[4-(methylthio)phenyl]-2-morpholino-1-propanone (see formula VIIa; Irgacure® 907 from Ciba Speciality Chemicals).

![Formula VIIa](image)

Bis(2,4,6-trimethylbenzoyl) phenyl phosphine oxide (Irgacure® 819 from Ciba Speciality Chemicals), 2,4,6-trimethylbenzoyl oxyphenoxyphenyl phosphine oxide (Lucirin® TPO-L from BASF AG) and 2-methyl-1-[4-(methylthio)phenyl]-2-morpholino-1-propanone (Irgacure® 907 from Ciba Speciality Chemicals) are particularly preferably used.

The photoinitiators according to the invention have a high photochemical reactivity and an absorption band in the near UV range.

Also suitable are mixtures of these photoinitiators according to formulae (VI) and (VII) with one another and mixtures of the photoinitiators according to formulae (VI) and (VII) with other generally known photoinitiators such as for example α-hydroxyalkylphenones or phenylacetophenones. Mixtures of bis(2,6-dimethoxybenzoyl)(2,4,4-trimethylpentyl) phosphine oxide and
hydroxycyclohexyl) phenylmethaneone, preferably in a ratio of 25 : 75 (Irgacure® 1800 from Ciba Speciality Chemicals), or a mixture of bis(2,6-dimethoxybenzoyl)-2,4,4-trimethylpentyl) phosphine oxide and 2-hydroxy-2-methyl-1-phenyl-1-propanone, preferably in a ratio of 25 : 75 (Irgacure® 1700 from Ciba Speciality Chemicals) are preferably used.

**Structure of the second layer (S2)**

Thermoplastic polymers of the second layer within the meaning according to the invention are polycarbonate, polyester carbonate, polyesters (such as for example polyalkylene terephthalate), polyphenylene ethers, graft copolymers (such as for example ABS) and mixtures thereof.

The second layer is preferably polycarbonate, in particular homopolycarbonate copolycarbonate and/or thermoplastic polyester carbonate.

They have preferably mean molecular weights $M_w$ of 18,000 to 40,000, preferably 22,000 to 36,000 and in particular 24,000 to 33,000, determined by measuring the relative solution viscosity in dichloromethane or in mixtures of equal quantities by weight of phenol/o-dichlorobenzene calibrated by light scattering.

Hanser Verlag Munich, Vienna 1992, pages 117-299", for example, should be referred to for the production of polycarbonates.

The production of polycarbonates takes place preferably according to the phase interface process or the melt transesterification process and is described in the following for example on the phase interface process.

Compounds to be preferably used as starting compounds are bisphenols of the general formula (VIII)

\[
\text{HO-R-\text{OH}} \quad (\text{VIII})
\]

wherein R is a divalent organic radical with 6 to 30 carbon atoms which contains one or more aromatic groups.

Examples of such compounds are bisphenols which belong to the group of dihydroxydiphenyls, bis(hydroxyphenyl) alkanes, indane bisphenols, bis(hydroxyphenyl) ethers, bis(hydroxyphenyl) sulphones, bis(hydroxyphenyl) ketones and \(\alpha, \alpha'-\text{bis(hydroxyphenyl)-diisopropylbenzenes.}\)

Particularly preferred bisphenols which belong to the afore-mentioned compound groups are bisphenol A, tetraalkyl bisphenol A, 4,4-(meta-phenylene diisopropyl) diphenol (bisphenol M), 4,4-(para-phenylene diisopropyl) diphenol, 1,1-bis-(4-hydroxyphenyl)-3,3,5-trimethyl cyclohexane (BP-TMC) and optionally mixtures thereof.

Preferably the bisphenol compounds to be used according to the invention are reacted with carbon dioxide compounds, in particular phosgene, or in the melt transesterification process with diphenyl carbonate or dimethyl carbonate.

Polyester carbonates are preferably obtained by reaction of the already named bisphenols, at least one aromatic dicarboxylic acid and optionally carbon dioxide
equivalents. Suitable aromatic dicarboxylic acids are for example phthalic acid, terephthalic acid, isophthalic acid, 3,3'- or 4,4'-diphenyl dicarboxylic acid and benzophenone dicarboxylic acids. Part, up to 80 mol%, preferably 20 to 50 mol% of the carbonate groups in the polycarbonates can be replaced by aromatic dicarboxylic acid ester groups.

Inert organic solvents used in the phase interface process are for example dichloromethane, the various dichloroethanes and chloropropane compounds, tetrachloromethane, trichloromethane, chlorobenzene and chlorotoluene, preferably chlorobenzene or dichloromethane or mixtures of dichloromethane and chlorobenzene are used.

The phase interface reaction can be accelerated by catalysts such as tertiary amines, in particular N-alkylpiperidine or onium salts. Tributylamine, triethylamine and N-ethyl piperidine are preferably used. In the case of the melt transesterification process, the catalysts named in DE-A 4 238 123 are preferably used.

The polycarbonates can be consciously and controlled branched by using small quantities of splitter. Some suitable splitters are: phloroglucinol, 4,6-dimethyl-2,4,6-tri-(4-hydroxyphenyl)-heptene-2; 4,6-dimethyl-2,4,6-tri-(4-hydroxyphenyl)-heptane; 1,3,5-tri-(4-hydroxyphenyl)-benzene; 1,1,1-tri-(4-hydroxyphenyl)-ethane; tri-(4-hydroxyphenyl)-phenylmethane; 2,2-bis-[4,4-bis(4-hydroxyphenyl)-cyclohexyl]-propane; 2,4-bis-(4-hydroxyphenyl-isopropyl)-phenol; 2,6-bis-(2-hydroxy-5'-methyl-benzyl)-4-methylenol; 2-(4-hydroxyphenyl)-2-(2,4-dihydroxyphenyl)-propane; hexa-(4-(4-hydroxyphenyl-isopropyl)-phenyl)-orthoterephthalic acid ester; tetra-(4-hydroxyphenyl)-methane; tetra-(4-(4-hydroxyphenyl-isopropyl)-phenoxy)-methane; α,α',α''-tris-(4-hydroxyphenyl)-1,3,5-triisopropyl benzene; 2,4-dihydroxybenzoic acid; trimesic acid; cyanuric chloride; 3,3-bis-(3-methyl-4-hydroxyphenyl)-2-oxo-2,3-dihydroindole; 1,4-bis-(4',4''-dihydroxytriphenyl)-methyl)-benzene and in particular: 1,1,1-tri-(4-hydroxyphenyl)-ethane and bis-(3-methyl-4-hydroxyphenyl)-2-oxo-2,3-dihydroindole.
The 0.05 to 2 mol %, based on diphenols used, of splitters or mixtures of splitters optionally to be used can be used together with the diphenols or even added at a later stage of the synthesis.

Preferably phenols such as phenol, alkylphenols such as cresol and 4-tert.-butylphenol, chlorophenol, bromophenol, cumylphenol or mixtures thereof can be used as chain terminators in quantities of 1 – 20 mol%, preferably 2 – 10 mol% per mole bisphenol. Phenol, 4-tert.-butylphenol or cumylphenol are preferred.

Chain terminators and splitters can be added to the syntheses separately or also together with the bisphenol.

Production of the polycarbonates according to the melt transesterification process is described for example in DE-A 4238 123.

Polycarbonates preferred according to the invention for the second layer of the multi-layer product according to the invention are the homopolycarbonate based on bisphenol A, the homopolycarbonate based on 1,1-bis-(4-hydroxyphenyl)-3,3,5-trimethylcyclohexane and the copolycarbonates based on the two monomers bisphenol A and 1,1-bis-(4-hydroxyphenyl)-3,3,5-trimethylcyclohexane.

The homopolycarbonate based on bisphenol A is particularly preferred.

The polycarbonate can contain stabilisers. Suitable stabilisers are for example phosphines, phosphates or Si-containing stabilisers and other compounds described in EP-A 0 500 496. Triphenylphosphites, diphenylalkylphosphites, phenyldialkylphosphites, tris-(nonylphenyl)phosphate, tetrakis-(2,4-di-tert.-butylphenyl)-4,4'-biphenylene diphosphonite and triarylphosphate can be named for example. Particularly preferred are triphenylphosphine and tris-(2,4-di-tert.-butylphenyl) phosphate.
Furthermore, the polycarbonate-containing second layer of the multi-layer product according to the invention can contain 0.01 to 0.5 wt.% of the esters or partial esters of mono- or hexavalent alcohols, in particular glycerol, pentaerythritol or Guerbet alcohols.

Monovalent alcohols are for example stearyl alcohol, palmityl alcohol and Guerbet alcohols.

A divalent alcohol is for example glycol.

A trivalent alcohol is for example glycerol.

Tetravalent alcohols are for example pentaerythritol and mesoerythritol.

Pentavalent alcohols are for example arabitol, ribitol and xylitol.

Hexavalent alcohols are for example mannitol, glucitol (sorbitol) and dulcitol.

The esters are preferably the monoesters, diesters, trimesters, tetraesters, pentaesters and hexaesters or mixtures thereof, in particular statistical mixtures, of saturated aliphatic C_{10} to C_{36} monocarboxylic acids and optionally hydroxymonocarboxylic acids, preferably with saturated, aliphatic C_{14} to C_{32} monocarboxylic acids and optionally hydroxyl-monocarboxylic acids.

The commercially obtainable fatty acid esters, in particular of pentaerythritol and glycerol, can due to production contain <60% different partial esters.

Saturated, aliphatic monocarboxylic acids with 10 to 36 C atoms are for example capric acid, laurie acid, myristic acid, palmitic acid, stearic acid, hydroxystearic acid, arachidic acid, behenic acid, lignoceric acid, cerotic acid and montanic acids.
Preferred saturated aliphatic monocarboxylic acids with 14 to 22 C atoms are for example myristic acid, palmitic acid, stearic acid, hydroxystearic acid, arachidic acid and behenic acid.

Particularly preferred are saturated aliphatic monocarboxylic acids such as palmitic acid, stearic acid and hydroxystearic acid.

The saturated aliphatic C\textsubscript{10} to C\textsubscript{36} carboxylic acids and the fatty acid esters are either known as such in the literature or producible by processes known in the literature. Examples of pentaerythritol fatty acid esters are those of the particularly preferred monocarboxylic acids named above. Particularly preferred are esters of pentaerythritol and glycerol with stearic acid and palmitic acid. Particularly preferred are also esters of Guerbet alcohols and glycerol with stearic acid and palmitic acid and optionally hydroxystearic acid.

The multi-layer product according to the invention can comprise other layers, in particular a further UV protective layer (S3) which contains a UV stabiliser according to formula (IV). The sequence of layers is in this case (S1)-(S2)-(S3) and layers (S1) and (S3) can have the same or different compositions.

The multi-layer products according to the invention can contain organic dyes, inorganic coloured pigments, fluorescent dyes and particularly preferably optical brighteners.

The subject matter of the invention is also a coating obtainable from

A) one or more aliphatic polymer precursors selected from at least one of the groups consisting of components A.1 and A.2, wherein

A.1) are aliphatic oligomers containing urethane bonds or ester bonds with at least two acrylate functions per molecule or mixtures of corresponding oligomers and
A.2) are aliphatic reactive diluents with at least two acrylate groups per molecule or mixtures of corresponding reactive diluents,

B) one or more fine-particle inorganic compounds which are preferably present in the coating formulation dispersed agglomerate-free,

C) at least one organic UV absorber selected from the group consisting of triazine derivatives and biphenyltriazine derivatives, preferably at least one UV absorber of the biphenyltriazine derivatives,

D) optionally one or more radical interceptors of the HALS class

E) optionally one or more flow control agents

F) optionally one or more solvents, and

G) at least one special photoinitiator selected from the group consisting of acylphosphine oxide derivatives and \( \alpha \)-aminoalkylphenone derivatives which are preferably distinguished by a high photochemical reactivity and an absorption band in the near UV range of \( > 300 \) nm, particularly preferably \( \lambda > 350 \) nm,

which is suitable for the production of at least one layer of a multi-layer product.

The subject matter of the invention is also a process for the production of a multi-layer product wherein

(i) in a first step, the first layer S1 is applied in the form of a coating formulation to the second layer S2 in which this is preferably a plastic moulding of any shape produced from the thermoplastic polymer according to S2 by means of injection moulding or extrusion, and
(ii) in a second step, the coating formulation of the first layer is hardened.

Preferably, in the first step (i) the coating formulation is applied to the surface of the second layer by flow coating, dipping, spraying, roll coating or centrifuging and then evaporating at room temperature and/or elevated temperature (preferably at 20 – 200°C, particularly preferably at 40 – 120°C). The surface of the second layer can be pre-treated by cleaning or activating.

Preferably, in the second step (ii) hardening of the first layer is carried out by means of UV light wherein a mercury vapour lamp or even correspondingly doped variants (for example with gallium or iron) are preferably used as the UV light source.

Other subject matters of the invention are the production of the multi-layer products and the products constructed of the multi-layer products. Also, the subject matter of the present invention is the use of afore-mentioned multi-layer products, in particular for external applications with constantly high requirements regarding the visual impression, such as for example glazing.

The subject matter of the invention is in particular also multi-layer products which contain as layer S2 a plastic moulding which is produced preferably from thermoplastic polymer by means of injection moulding or extrusion and is coated with the coating according to S1 and optionally even with a further layer S3. This multi-layer product is for example a glazing product such as for example architectural glazing, automotive glazing, spotlight glazing, lenses or helmet visors.
**Examples:**

**Component AB:**

**Component AB-1:** Nanocryl® xp21/1372 from Hanse Chemie AG containing Viaktin® 6160, an aliphatic urethane hexaacrylate from Vianova Resin, and a solid content of 40 wt.% fine-particle SiO₂ with a mean particle size (d₅₀) of 23.5 nm and a ((d₉₀-d₁₀)/d₅₀) of 0.66

**Component AB-2:** Nanocryl® xp21/1468 (Hanse Chemie AG) containing Ebecryl® 4858, an aliphatic urethane diacrylate from Cytec Surface Specialities, and a solid content of 40 wt.% fine-particle SiO₂ (d₅₀ = 24.3 nm; (d₉₀ – d₁₀)/d₅₀ = 0.43)

**Component AB-3:** Nanocryl® xp21/1930 (Hanse Chemie AG) containing Ebecryl® 810, a polyester tetraacrylate from Cytec Surface Specialities, and a solid content of 50 wt.% fine-particle SiO₂ (d₅₀ = 27.7 nm; (d₉₀-d₁₀)/d₅₀) = 0.61

**Component AB-4:** Nanocryl® xp21/1447 (Hanse Chemie AG); Laromer® 8987, an aliphatic urethane triacrylate with 30% 1,6-hexanediol diacrylate as reactive diluent from BASF AG, and a solid content of 40 wt.% fine-particle SiO₂ (d₅₀ = 24.1 nm; (d₉₀-d₁₀)/d₅₀) = 0.49

**Component AB-5:** Nanocryl® xp21/2344 (Hanse Chemie AG); Roskydal® 2308, an aliphatic urethane triacrylate with 20% 1,6-hexanediol diacrylate as reactive diluent from Bayer MaterialScience AG, further diluted with 1,6-hexanediol diacrylate (HDDA) to
25% HDDA, and a solid content of 50 wt.% fine-particle SiO₂ 
\(d_{50} = 24.0 \text{ nm}; (d_{90}/d_{10})/d_{50}) = 0.58\)

Component AB-6: Nanocryl® xp21/3032 (Hanse Chemie); Ebecryl® 4858, an 
aliphatic urethane diacrylate from Cytec Surface Specialities, 
diluted with tricyclodecane dimethanol diacrylate as reactive 
diluent to a ratio of 70 to 30, and a solid content of 40 wt.% 
fine-particle SiO₂ \(d_{50} = 24.1 \text{ nm}; (d_{90}/d_{10})/d_{50}) = 0.47\)

Component C: UV absorber CGL479 from Ciba Speciality Chemicals

Component D:

Component D-1: HALS system Tinuvin® 123 from Ciba Speciality Chemicals

Component D-2: HALS system Tinuvin® 144 from Ciba Speciality Chemicals

Component E: Flow control agent BYK® 300 from BYK Chemie

Component F:

Component F-1: Diacetone alcohol

Component F-2: Methoxypropanol

Component G:

Component G-1: Irgacure® 184 from Ciba Speciality Chemicals (reference)

Component G-2: Irgacure® 819 from Ciba Speciality Chemicals
Component G-3: Irgacure® 1800 from Ciba Speciality Chemicals
Component G-4: Darocure® 1173 from Ciba Speciality Chemicals (reference)
Component G-5: Irgacure® 651 from Ciba Speciality Chemicals (reference)
Component G-6: Lucirin® TPO-L from BASF AG
Component G-7: Irgacure® 907 from Ciba Speciality Chemicals

Test procedure (general description):

a) Production of the coating formulation:

The quantity given in Table 1 in the column headed “Coating basic formulation” of the named type of component AB from Hanse Chemie AG was dissolved in the given quantity of component F-1 or F-2. The solid content was then determined experimentally using the solid tester MA40 from Satorius as described below.

Experimental determination of the solid content with the solid test MA40 from Satorius:

A quantity of approx. 2 g of the coating solution produced is placed in an aluminium dish and the exact weight m (initial weight before the heating phase) determined. The coating solution is then heated to 105°C and kept at 105°C to constant weight. When constant weight has been reached, the weight m (final weight at constant weight) is read off. From quotient m (final weight at constant weight) to m (initial weight before the heating phase) is obtained the experimentally determined solid content.

To the quantity of coating solution reduced by the quantity taken for determination of the solid are added consecutively
2.2 wt.% (based on the experimentally determined solid content) of component C, optionally 1 wt.% (based on the experimentally determined solid content) of component D (see Table 1, column headed “UV stabiliser package”),

5 wt.% (based on the quantity of component AB used) of component G wherein the type and composition with mixtures can be taken from Table 1, and

0.5 wt.% (based on the coating solution consisting of components AB and F) of component E

with stirring and completely dissolved.

b) **Coating of the substrates with the UV-hardening coating formulation:**

The injection-moulded polycarbonate (PC) sheets used in the optical grade of Makrolon® 2808 (Bayer MaterialScience AG; medium-viscosity bisphenol A-polycarbonate, MVR 10 g/10 min according to ISO 1133 at 300°C and 1.2 kg, without UV stabilisation), size 10 x 15 x 0.32 cm, were heat-treated for 1 h at 120°C, rinsed with isopropanol, evaporated, UV-pre-treated (with a laboratory UV radiator KTR 2061 from Hackemack; web speed 3 m/min and with a UV dose (Hg lamp) of 1.7 J/cm², measured with an eta plus UMD-1) dosimeter and then treated with ionised air. The UV-hardening coating formulation of a) was then applied in the flow coating process under the conditions as described in Table 1, column headed “Hardening conditions”. The coated sheets are subsequently evaporated and then hardened at a web speed of 4 m/min in a laboratory UV radiator KTR 2061 from Hackemack at a UV dose (Hg lamp) of 2.6 J/cm², measured with an eta plus UMD 1 dosimeter. The thickness of the transparent coating thus obtained was determined by means of an Eta SD 30 from Eta Optik GmbH (for values see Table 1, column headed “Layer thickness”).
c) Testing of the adhesion of the UV-hardening protective layer to the PC substrate:

The following adhesion tests were carried out:

5

(a) adhesive tape tear-off (adhesive tape 3M 898 used) with and without cross-hatch adhesion (as in ISO 2409 or ASTM D 3359), and

(b) adhesive tape tear-off after 10 days' storage in approx. 65°C hot water (as in ISO 2812-2 and ASTM 870-02).

In reference examples 1, 2 and 8 in which the surface of the coating layer was still tacky after UV radiation (see column headed Adhesion multilayer structure in Table 1), the adhesion test was not necessary.

15
d) Measurement of the abrasion resistance and determination of the relative Taber value:

The initial haze value of the PC sheet coated with the UV-hardened first layer (obtained from b)) was first of all determined according to ASTM D 1003 using a Haze Gard Plus from Byk-Gardner. The coated side of the sample was then scratched by means of a Taber Abraser model 5131 from Erichsen according to ISO 52347 or ASTM D 1044 using the CS10F wheels (type II; colour pink). A \( \Delta \text{haze value} \) (sample) was established by determining the end haze value after 1000 rotations. Directly thereafter, a PC sheet coated with siloxane coating SHP401 / AS4000 from GE Bayer Silicones was scratched under the same conditions, a \( \Delta \text{haze value} \) (reference) being obtained. From this is obtained the relative Taber value given in Table 1 for the multi-layer product of

\[
\text{relative Taber value} = \frac{\Delta \text{haze value (sample)}}{\Delta \text{haze value (reference)}}
\]
Within the meaning according to the invention, the first layer should have a sufficiently high scratch resistance. This criterion is achieved within the meaning according to the invention if the relative Taber value is less than or equal to two.

In Examples 1, 2 and 8 in which the surface of the coating layer was still tacky after UV radiation (see column headed Abrasion resistance rel. Taber value), this test was not necessary.

e) Determination of the extinction of the UV-hardened coating:

Using a Cary 50 UV-Vis spectrophotometer from Varian Inc., the UV spectrum of the coating, thus the first layer of the multi-layer product, was established using the uncoated polycarbonate sheet as a background spectrum for measurement of the coated polycarbonate sheet, thus the multi-layer product. The extinction value, measured at a wavelength of 340 nm, for the first layer is listed in Table 1 together with the layer thickness of this first layer at exactly the extinction measuring point.

Within the meaning according to the invention, it was the object to achieve an extinction of $\geq 1.5$ for the first layer measured at 340 nm and layer thicknesses of approx. 5 $\mu$m.

Results:

The results are shown in Table 1.

The compositions of reference examples 1, 2 and 8 gave tacky layers, the other compositions of (reference) examples 3 – 7 and 9 – 32 fulfil the adhesion test carried out, i.e. there was no tear-off of the coating of any kind (rating “0” according to ISO 2409 or “5B” according to ASTM D 3359).

Reference examples 1, 2, 8, 9, 10, 13, 14 and 19 do not fulfil the requirement on the scratch resistance and abrasion resistance of the first layer of the multi-layer
product. There is an efficient crosslinking or hardening of the first layer resulting in a high scratch resistance and abrasion resistance if the multi-layer product after 1000 rotations with CS10F wheels (Taber Abraser test) exhibits an increase in haze in the form of a relative Taber value of \( \leq 2 \), the siloxane-based hardcoat (AS4000 from GE Bayer Silicons) being regarded as reference regarding abrasion resistance. Generally known photoinitiators such as 2,2-dimethoxy-2-phenylacetophenone (Irgacure© 651 from Ciba Speciality Chemicals; component G5) or even the representatives of the \( \alpha \)-hydroxyalkylphenone class, such as for example 1-hydroxycyclohexyl-phenyl ketone (Irgacure© 184 from Ciba Speciality Chemicals, component G1) and \( \alpha \)-hydroxy-\( \alpha \)-dimethylacetophenone (Darocur© 1173 from Ciba Speciality Chemicals; component G4) alone do not with the coating formulations used here with high UV filter action (extinction \( \geq 1.5 \) for the first layer measured at 340 nm and layer thicknesses of approx. 5 \( \mu \)m) lead to an efficient hardening (reference examples 1, 2, 8, 9, 10, 13, 14 and 19).

The object according to the invention regarding a relative abrasion value of the sample (relative Taber values of \( \leq 2 \)) compared with a standard (siloxane-based hardcoat (AS4000 from GE Bayer Silicons) determined in accordance with the Taber Abraser method according to ISO 52347 or ASTM D 1044 and at the same time a high UV filter action (extinction \( \geq 1.5 \) for the first layer measured at 340 nm and layer thicknesses of approx. 5 \( \mu \)m) is fulfilled by the multi-layer products according to the invention (Examples 3 – 7, 11, 12, 15 – 18 and 20 – 32).
<table>
<thead>
<tr>
<th>No.</th>
<th>Coating base formulation(^1)</th>
<th>UV stabiliser package(^2)</th>
<th>Photoinitiator(^3)</th>
<th>Hardening conditions(^4)</th>
<th>Layer thickness(^5)</th>
<th>Adhesion multi-layer structure(^6)</th>
<th>Abrasion resistance rel. Taber value(^7)</th>
<th>Extinction at 340 nm (^8) layer density thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (ref.)</td>
<td></td>
<td>2.2% C</td>
<td>5% G-1</td>
<td>2.3-5.6 μm</td>
<td>-</td>
<td>tacky</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>2 (ref.)</td>
<td></td>
<td>2.2% C &amp; 1% D-1</td>
<td></td>
<td>2.1-5.2 μm</td>
<td>-</td>
<td>tacky</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>2.2% C &amp; 1% D-1</td>
<td>5% (G-1/G-2</td>
<td>2.2-5.3 μm</td>
<td>OK</td>
<td>1.5</td>
<td>2.0 @ 6.4 μm</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>5% G-2</td>
<td>H1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>2.2% C</td>
<td>5% G-3</td>
<td>2.1-5.9 μm</td>
<td>OK</td>
<td>0.9</td>
<td>2.6 @ 6.4 μm</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>12 g AB-1; 22g F-1 &amp; 0.18g E</td>
<td>5% G-3</td>
<td>H1</td>
<td>2.5-4.4 μm</td>
<td>OK</td>
<td>1.4</td>
<td>2.3 @ 7.3 μm</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
<td>2.2% C &amp; 1% D-1</td>
<td>5% (G-4/G-2</td>
<td>2.8-4.8 μm</td>
<td>OK</td>
<td>1.1</td>
<td>2.1 @ 6.2 μm</td>
<td></td>
</tr>
<tr>
<td>8 (ref.)</td>
<td></td>
<td>2.2% C &amp; 1% D-1</td>
<td>5% G-4</td>
<td>2.2-5.7 μm</td>
<td>OK</td>
<td>1.5</td>
<td>2.0 @ 5.6 μm</td>
<td></td>
</tr>
<tr>
<td>9 (ref.)</td>
<td></td>
<td>5% G-5</td>
<td>H1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 (ref.)</td>
<td></td>
<td>5% (G-1/G-5</td>
<td></td>
<td>1.9-5.4 μm</td>
<td>-</td>
<td>tacky</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td></td>
<td>5% (G-1/G-6</td>
<td></td>
<td>2.1-4.9 μm</td>
<td>OK</td>
<td>&gt; 2.0</td>
<td>1.7 @ 4.8 μm</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td></td>
<td>5% (G-1/G-7</td>
<td></td>
<td>2.2-6.0 μm</td>
<td>OK</td>
<td>&gt; 2.0</td>
<td>1.5 @ 4.8 μm</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>5% (G-1/G-7</td>
<td></td>
<td>2.2-5.4 μm</td>
<td>OK</td>
<td>2</td>
<td>1.9 @ 6.2 μm</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>5% (G-1/G-7</td>
<td></td>
<td>2.9-5.4 μm</td>
<td>OK</td>
<td>1.5</td>
<td>2.1 @ 5.8 μm</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13 (ref.)</td>
<td>14 (ref.)</td>
<td>15</td>
<td>16</td>
<td>17</td>
<td>18</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6g AB-2; 11g F-1 &amp; 0.09g E</td>
<td>6g AB-3; 11g F-2 &amp; 0.09g E</td>
<td>2.2% C &amp; 1% D-1</td>
<td>2.2% C &amp; 1% D-1</td>
<td>2.2% C &amp; 1% D-1</td>
<td>2.2% C &amp; 1% D-1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.2% C</td>
<td>2.2% C &amp; 1% D-1</td>
<td>2.2% C</td>
<td>2.2% C &amp; 1% D-1</td>
<td>2.2% C &amp; 1% D-2</td>
<td>2.2% C &amp; 1% D-2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5% G-1</td>
<td>5% G-3</td>
<td>5% G-1</td>
<td>5% G-3</td>
<td>5% G-2</td>
<td>5% G-2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1-3.2 μm</td>
<td>1.4-2.6 μm</td>
<td>H2</td>
<td>1.3-3.2 μm</td>
<td>1.4-2.6 μm</td>
<td></td>
<td>1.3-3.9 μm</td>
<td>1.4-2.4 μm</td>
<td></td>
</tr>
<tr>
<td>OK</td>
<td>OK</td>
<td>0.7</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; 2.0</td>
<td>1.8 @ 2.8 μm</td>
<td>1.1</td>
<td>&gt; 2.0</td>
<td>1.9 @ 2.8 μm</td>
<td>2.0 @3.2 μm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.9 @ 3.0 μm</td>
<td>1.8 @ 2.8 μm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19 (ref.)</td>
<td>20</td>
<td>21</td>
<td>22</td>
<td>23</td>
<td>24</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6g AB-3; 11g F-2 &amp; 0.09g E</td>
<td>2.2% C</td>
<td>2.2% C &amp; 1% D-1</td>
<td>2.2% C</td>
<td>2.2% C</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.2% C &amp; 1% D-2</td>
<td>5% G-1</td>
<td>2.2% C &amp; 1% D-1</td>
<td>5% (G-1/G-6 (80/20))</td>
<td>5% G-1</td>
<td>5% G-3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.4-4.5 μm</td>
<td>4.1-7.1 μm</td>
<td>H3</td>
<td>4.2-8.0 μm</td>
<td>5.1-7.6 μm</td>
<td>5.4-7.9 μm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OK</td>
<td>OK</td>
<td>0.7</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; 2.0</td>
<td>1.9 @ 6.5 μm</td>
<td>1.5</td>
<td>&gt; 2.0</td>
<td>0.4</td>
<td>0.6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.5 @ 5.4 μm</td>
<td>2.3 @ 9.7 μm</td>
<td>2.1 @ 8.7 μm</td>
<td>2.2 @ 9.3 μm</td>
<td>2.3 @ 9.9 μm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>26</td>
<td>27</td>
<td>7.7g AB-4; 11g F-1 &amp; 0.09g E</td>
<td>2.2% C &amp; 1% D-1</td>
<td>2.2% C &amp; 1% D-1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.2% C &amp; 1% D-2</td>
<td>2.2% C &amp; 1% D-2</td>
<td>2.2% C &amp; 1% D-1</td>
<td>2.2% C &amp; 1% D-1</td>
<td>2.2% C &amp; 1% D-1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5% G-3</td>
<td>5% (G-1/G-6 (80/20))</td>
<td>5% G-3</td>
<td>5% G-3</td>
<td>5% G-3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.5-5.0 μm</td>
<td>2.7-5.1 μm</td>
<td>H4</td>
<td>2.5-5.0 μm</td>
<td>2.5-5.0 μm</td>
<td>2.7-5.1 μm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OK</td>
<td>OK</td>
<td>0.9</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.0 @ 6.2 μm</td>
<td>2.4 @ 7.7 μm</td>
<td>0.9</td>
<td>2.0 @ 6.2 μm</td>
<td>0.9</td>
<td>2.4 @ 7.7 μm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.35g AB-5: (80/200)</td>
<td>24.8 F-1 &amp; 0.21g E</td>
<td>12g AB-6: (80/200)</td>
<td>0.18g E</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----</td>
<td>---------------------</td>
<td>-------------------</td>
<td>-------------------</td>
<td>--------</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>G-1/G-6 5%</td>
<td>D-1 5% C &amp; 1%</td>
<td>G-1/G-6 5%</td>
<td>D-1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>H5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>H5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>32</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Ref. = reference example
(1) Coating base formulation (still without UV protective package and photoinitiator). In Examples 28 – 30 with component AB-5, no UV pre-treatment of the substrate (Makrolon® 2808) was carried out before coating.

(2) Data in wt.% based on the experimentally determined solid content of the coating solution (see general example description).

(3) Data in wt.% based on the quantity of Nanocryl (component AB) used.

(4) Hardening conditions of the first layer after application to the second layer.

H1; H2; H4; H5 and H6 evaporate for 30 min at RT; 30 min at 110°C and UV-harden with an Hg lamp (web speed 2 x 4 m/min; UV dose 2.6 J/cm²); H3 evaporate for 30 min at RT; 30 min at 50°C and UV-harden with an Hg lamp (web speed 2 x 4 m/min; UV dose 2.6 J/cm²).

(5) Layer thickness measured in direction of flow at the top or at the bottom (each approximately 2 cm from the edge of the sheet) with an Eta SD 30 from Eta Optik GmbH.

(6) Adhesion test for the multi-layer structure (a) tape test with and without cross-hatch adhesion in accordance with ISO 2409 or ASTM D3359 and (b) tape test on the cross-hatch adhesion after immersion in water of the sample in 65 +/- 2°C hot water in accordance with ISO 2812-2 or ASTM 870-02 (the test is passed if on the 10th day of immersion in water no delamination according to the tape test occurs on the cross-hatch adhesion; “OK” means that in both tests (a) and (b) no delamination occurs, i.e. in test a) rating “0” according to ISO 2409 or “5B” according to ASTM D 3359).

(7) Taber Abraser test according to ISO 52347 or ASTM D 1044, 1000 rotations each with CS10F wheels type 2 (colour pink), then the increase in haze is determined; a PC sheet coated with the siloxane coating SHP401 / AS4000
from GE Bayer Silicons which is scratched directly before or after under the same conditions at 1000 rotations and examined for an increase in haze is used as an internal reference; the relative Taber value is then defined by:

\[
\text{relative Taber value} = \frac{\text{haze (sample)}}{\text{haze (reference)}}
\]

(8) Extinction only of the coating (uncoated Makrolon® 2808 as reference); after that is the layer thickness at the measuring point (located on the edge of the sheet (sometimes directly on the draining edge, which is why here some larger layer thicknesses are measured compared with the measurement in (5)).
Claims

1. Multi-layer product containing a first layer (S1) and a second layer (S2), S1 being obtainable from

A) one or more aliphatic polymer precursors selected from at least one of the groups consisting of components A.1 and A.2, wherein

A.1) are aliphatic oligomers containing urethane bonds or ester bonds with at least two acrylate functions per molecule or mixtures of corresponding oligomers and

A.2) are aliphatic reactive diluents with at least two acrylate groups per molecule or mixtures of corresponding reactive diluents,

B) one or more fine-particle inorganic compounds,

C) at least one organic UV absorber selected from the group consisting of triazine derivatives and biphenyltriazine derivatives, preferably at least one UV absorber of the biphenyltriazine derivatives,

D) optionally one or more radical interceptors of the HALS class

E) optionally one or more flow control agents

F) optionally one or more solvents, and

G) at least one special photoinitiator selected from the group consisting of acylphosphine oxide derivatives and α-aminoalkylphenone derivatives,

and wherein the second layer is a thermoplastic polymer.
2. Multi-layer product according to Claim 1, wherein based on the mixture of components A and B

20 to 95 wt.% component A,

5 to 80 wt.% component B and

0.1 to 10 wt.% component G are used, and

a quantity of component F is used, so that an experimentally determined solid content of 20 to 50 wt.% for the mixture of components A, B and F results, and

based on the solid content of the mixture of components A, B and F

0.1 to 20 wt.% component C,

0 to 10 wt.% component D and

0 to 5 wt.% component E are used.

3. Multi-layer product according to one of Claims 1 or 2, wherein the aliphatic reactive diluent (component A.2) is 1,6-hexanediol diacrylate, tricyclodecane dimethanol diacrylate, trimethylol propane triacrylate, pentaerythritol tetraacrylate and the methacrylate derivatives thereof.

4. Multi-layer product according to one of Claims 1 to 3, wherein component B is silicon dioxide with a mean particle size \((d_{50})\) of 1 to 200 nm.

5. Multi-layer product according to Claim 4, wherein the silicon dioxide has a particle size distribution with a \(\left(\frac{(d_{90} - d_{10})}{d_{50}}\right)\) of the distribution of less than or equal to 2.
6. Multi-layer product according to one of Claims 1 to 5, wherein component C is a compound according to the following formula (IV)

\[
\begin{align*}
\text{(IV)}
\end{align*}
\]

wherein

\[X = \text{OR}^6, \text{OCH}_2\text{CH}_2\text{OR}^6, \text{OCH}_2\text{CH(OH)CH}_2\text{OR}^6 \text{ or } \text{OCH}(\text{R}^7)\text{COOR}^8\]

\[\text{R}^6 = \text{branched or unbranched C}_{1-13} \text{ alkyl, C}_{2-20} \text{ alkenyl, C}_{6-12} \text{ aryl or } -\text{CO-C}_{1-18} \text{ alkyl}\]

\[\text{R}^7 = \text{H or branched or unbranched C}_{1-8} \text{ alkyl, and}\]

\[\text{R}^8 = \text{C}_{1-12} \text{ alkyl, C}_{2-12} \text{ alkenyl or C}_{5-6} \text{ cycloalkyl}\]

7. Multi-layer product according to one of Claims 1 to 6, wherein component D is one or more compounds of the following formula (V)

\[
\begin{align*}
\text{(V)}
\end{align*}
\]

wherein
Y = H; R⁶ or OR⁶

R⁶ = branched or unbranched C₁-C₁₃ alkyl, C₂-C₂₀ alkenyl, C₆-C₁₂ aryl or -CO-C₁-C₁₈ alkyl, and

5

R⁹ = Z-R¹⁰-Z-R¹¹,

wherein

10

Z = a divalent functional group such as C(O)O, NH or NHCO

R¹⁰ = a divalent organic radical such as (CH₂)₁ with 1 = 0 to 12, C=CH-Ph-OCH₃

15

R¹¹ = H or C₁-C₂₀ alkyl.

8. Multi-layer product according to Claim 7, wherein component D is bis(1-octyloxy-2,2,6,6-tetramethyl-4-piperidyl) sebacic acid ester and/or (3,5-di-tert.-butyl-4-hydroxy-benzyl)-butyl malonic acid-bis-(1,2,2,6,6-pentamethyl-4-piperidyl) ester.
9. Multi-layer product according to one of Claims 1 to 8, wherein component F is selected from at least one of the groups consisting of alkanes, alcohols, esters and ketones.

10. Multi-layer product according to one of Claims 1 to 9, wherein component G is selected from at least one of the groups consisting of formula VI (acylphosphine oxide) and formula VII (α-aminoalkylphenone),

\[ \text{(VI)} \quad \text{(VII)} \]

wherein

\[ R^{12} = C_1 - C_{30} \text{ alkyl, } C_5 \text{ to } C_6 \text{ cycloalkyl optionally substituted by } C_1 \text{ to } C_4 \text{ alkyl, and/or chlorine, bromine, } C_6 \text{ to } C_{20} \text{ aryl, } C_6 \text{ to } C_{20} \text{ aryloxy or } C_7 \text{ to } C_{12} \text{ aralkyl} \]

\[ R^{13} = C_1 - C_{30} \text{ alkyl, } C_1 - C_{30} \text{ alkoxy, } C_5 \text{ to } C_6 \text{ cycloalkyl, } C_6 \text{ to } C_{20} \text{ aryl, } C_6 \text{ to } C_{20} \text{ aryloxy, } C_7 \text{ to } C_{21} \text{ aroyl or } C_7 \text{ to } C_{12} \text{ aralkyl, optionally substituted by } C_1 \text{ to } C_4 \text{ alkyl, } C_1 \text{ to } C_4 \text{ alkoxy, } C_1 \text{ to } C_4 \text{ acyl and/or chlorine, bromine,} \]

\[ R^{14} = C_1 \text{ to } C_4 \text{ alkyl, } C_1 \text{ to } C_4 \text{ alkoxy,} \]

\[ n = 0 \text{ to } 5, \]

\[ R^{15}, R^{16}, R^{17} \text{ and } R^{18} \text{ independently of one another } C_1 - C_{30} \text{ alkyl, } C_5 \text{ to } C_6 \text{ cycloalkyl optionally substituted by } C_1 \text{ to } C_4 \text{ alkyl, and/or chlorine, bromine, } C_6 \text{ to } C_{20} \text{ aryl or } C_7 \text{ to } C_{12} \text{ aralkyl,} \]
and wherein the radicals $R^{17}$ and $R^{18}$ can also be linked to a ring so that the nitrogen N shown in formula (VII) is part of a heterocyclic ring system,

$$R^{19} = C_1 \text{ to } C_{30} \text{ alkoxy, } C_1 \text{ to } C_{30} \text{ alkylthio, } C_1 \text{ to } C_{30} \text{ dialkyamino, } C_5 \text{ to } C_6 \text{ cycloalkyl optionally substituted by } C_1 \text{ to } C_4 \text{ alkyl, and/or chlorine, bromine, wherein the } C \text{ atoms of the ring can also be substituted by heteroatoms such as } N, O \text{ or } S.$$

11. Multi-layer product according to Claim 10, wherein component G is selected from at least one of the groups consisting of bis(2,4,6-trimethylbenzoyl)phenyl phosphine oxide, (2,4,6-trimethylbenzoyl) diphenyl phosphine oxide, bis(2,6-dimethylbenzoyl)(2,4,4-trimethylpentyl) phosphine oxide, bis(2,6-dimethoxybenzoyl)(2,4,4-trimethylpentyl) phosphine oxide, benzoyl phosphonic acid bis(2,6-dimethylphenyl) ester, 2,4,6-trimethylbenzoyl ethoxyphenyl phosphine oxide, 2-benzyl-2-(dimethylamino)-1-(4-morpholinophenyl)-1-butane and 2-methyl-1-[4-(methylthio)phenyl]-2-morpholino-1-propanone (see formula VIIa, wherein Me = methyl).

![VIIa](image)

12. Multi-layer product according to one of Claims 1 to 9, wherein component G is a mixture of bis(2,6-dimethoxybenzoyl)(2,4,4-dimethylpentyl) phosphine oxide and (1-hydroxycyclohexyl)phenylmethane or a mixture of bis(2,6-dimethoxybenzoyl)(2,4,4-trimethylpentyl) phosphine oxide and 2-hydroxy-2-methyl-1-phenyl-1-propanone.

13. Multi-layer product according to one of Claims 1 to 12, wherein the second layer is selected from at least one from the group consisting of
polycarbonate, polyester carbonate, polyester, polyphenylene ethers and graft copolymers.

14. Multi-layer product according to one of Claims 1 to 13 containing a further UV protective layer (S3) which contains a UV stabiliser according to formula (IV)

\[
\begin{align*}
\text{X} & \quad \text{OH} \\
\text{N} & \quad \text{N} \\
\text{C} & \quad \text{C} \\
\text{H} & \quad \text{H} \\
\text{R}^6 & \quad \text{R}^7 \\
\text{R}^8 & \quad \text{R}^9
\end{align*}
\]

(IV)

wherein

\[ X = \text{OR}^6, \text{OCH}_2\text{CH}_2\text{OR}^6, \text{OCH}_2\text{CH(OH)CH}_2\text{OR}^6 \text{ or } \text{OCH(R}^7\text{)COOR}^8 \]

\[ \text{R}^6 = \text{branched or unbranched C}_1\text{C}_{13} \text{ alkyl, C}_2\text{C}_{20} \text{ alkenyl, C}_6\text{C}_{12} \text{ aryl or } -\text{CO-C}_1\text{C}_{18} \text{ alkyl} \]

\[ \text{R}^7 = \text{H or branched or unbranched C}_1 \text{ to C}_8 \text{ alkyl, and} \]

\[ \text{R}^8 = \text{C}_1\text{C}_{12} \text{ alkyl; C}_2\text{C}_{12} \text{ alkenyl or C}_5\text{C}_6 \text{ cycloalkyl,} \]

and wherein the layer sequence is (S1)-(S2)-(S3) and layers (S1) and (S3) have the same or different compositions.

15. Coating obtainable from
A) one or more aliphatic polymer precursors selected from at least one of the groups consisting of components A.1 and A.2, wherein

A.1) are aliphatic oligomers containing urethane bonds or ester bonds with at least two acrylate functions per molecule or mixtures of corresponding oligomers and

A.2) are aliphatic reactive diluents with at least two acrylate groups per molecule or mixtures of corresponding reactive diluents,

B) one or more fine-particle inorganic compounds which are preferably present in the coating formulation dispersed agglomerate-free,

C) at least one organic UV absorber selected from the group consisting of triazine derivatives and biphenyltriazine derivatives, preferably at least one UV absorber of the biphenyltriazine derivatives,

D) optionally one or more radical interceptors of the HALS class

E) optionally one or more flow control agents

F) optionally one or more solvents, and

G) at least one special photoinitiator selected from the group consisting of acylphosphine oxide derivatives and \( \alpha \)-aminoalkylphenone derivatives which are distinguished preferably by a high photochemical reactivity and an absorption band in the near UV range of \( >300 \) nm, particularly preferably \( \lambda > 350 \) nm,

which is suitable for the production of at least one layer of a multi-layer product according to one of Claims 1 to 14.
16. Process for the production of a multi-layer product according to one of Claims 1 to 14, wherein

(i) in a first step, the first layer S1 is applied in the form of a coating formulation to the second layer S2, and

(ii) in a second step, the coating formulation of the first layer is hardened.

17. Use of the multi-layer products according to one of Claims 1 to 14 for external applications with constantly high requirements regarding the visual impression, in particular for glazing.

18. Multi-layer products according to one of Claims 1 to 14 which contain a plastic moulding as layer S2.

Fetherstonhaugh
Ottawa, Canada
Patent Agents