particular for making individual layouts and for on demand printing, it would be necessary to be able to deposit the hygroscopic material as a curable ink via inkjet printing, valve jet printing, and liquid dispensing methods. For patterning via gravure printing the viscosity of the ink must be lower than 200 mPa•s at 20°C, and for flexo printing the viscosity of the ink must be lower than 500 mPa•s at 20°C. These are among favoured roll to roll printing techniques. It can be also necessary to have access to medium and low viscosity resins exhibiting the water scavenging properties.

SUMMARY ~~OF THE INVENTION~~

It is an object of the present ~~invention~~ disclosure to provide a photocurable composition containing oxide particles for making water scavenging layers, which is stable and flowable, so that it can be easily dispensed or printed for example via inkjet/valve jet printing or via gravure and flexoprinting.

It is a further object of the present disclosure ~~invention~~ to provide a method of manufacturing such a photocurable composition, which is simple, fast and economically viable.

It is a further object of the present disclosure ~~invention~~ to provide a method of manufacturing a water scavenging layer, which is simple, fast, economically viable and suited for opto-electric devices and applications.

It is a further object of the present disclosure ~~invention~~ to provide a method for manufacturing a light-emitting device or opto-electric devices, in particular an organic light emitting diode (OLED), which is simple, fast, economically viable, whereby the light-emitting device, in particular the organic light emitting diode (OLED), remains protected by moisture and water for very long time, and exhibits an improved barrier against atmospheric substances.

~~According to a first aspect of t~~The present disclosure ~~invention~~ provides a radiation curable, preferably photocurable resin composition ~~is provided~~ comprising:
(A) metal oxide particles;
(B) at least one photo initiator, preferably a radical photoinitiator, or any mixture thereof;
(C) at least one acrylate or methacrylate component with a clogP higher than 2, preferably higher than 4, more preferably higher than 5, or any mixture thereof;
(D) at least one monofunctional acrylate or methacrylate diluent component, preferably with a viscosity below 40 mPa•s at 20°C, or any mixture thereof;
(E) at least one acrylate or methacrylate component with functionality equal or higher than 3, preferably 3 or 4, or any mixture thereof, wherein
Mica is excluded from the group of (A) metal oxide particles.

According to a first aspect of the present disclosure, there is provided a radiation curable resin composition comprising:
(A) metal oxide particles;
(B) at least one photoinitiator, preferably a radical photoinitiator, or any mixture thereof;
(C) at least one acrylate or methacrylate component with a ClogP higher than 2, preferably higher than 4, more preferably higher than 5, or any mixture thereof;

(D) at least one monofunctional acrylate or methacrylate diluent component, preferably with a viscosity below 40 mPa•s at 20°C, or any mixture thereof;
(E) at least one acrylate or methacrylate component with functionality equal or higher than 3, preferably 3 or 4, or any mixture thereof; and
(F) a polybutadiene acrylate or methacrylate, a silicone acrylate or methacrylate, or a two-mole ethoxylated bisphenol A di(meth)acrylate, or any mixture thereof,
whereby such component (F) exhibits preferably two (meth)acrylate functionalities,
wherein the metal oxide particles A are alkaline earth metal oxide selected from the group consisting of CaO, BaO and MgO or mixtures thereof; and
wherein the metal oxide particles A exhibit an average particle diameter of 10 to 1000 nm, preferably 15 to 500 nm, more preferably 20 to 350 nm, or even 50 to 250 nm.

Such photocurable resin compositions are surprisingly stable and flowable and are surprisingly well suited for making water scavenging coatings that can be easily dispensed or printed via inkjet/valve jet printing or via gravure and flexoprinting. After curing, they give rise to water scavenging coatings characterized by exceptional water scavenging properties and transparency, and also by an exceptionally long life time. They are therefore surprisingly well suited for the manufacturing of water scavenging layers for opto-electric devices or light-emitting devices, in particular organic light emitting diodes (OLED).

Metal oxide particles can be also particle aggregates or agglomerates.

In order to avoid metal oxide (for example CaO) hydrolysis and the possibility of aggregation via hydrogen bonding, the curable matrix exhibits preferably a low water content - less than 1,000 ppm (by weight). For that reason, preferably compounds having a high hydrophobicity are used in order to prevent an elevated amount of internal water. A good indicator for the hydrophobicity is ClogP, i.e. the calculated logarithm of the octanol/water partition coefficient. A relatively high ClogP value indicates a relatively high hydrophobicity of the material. For the purpose of the present disclosure ~~invention~~ organic materials having a ClogP value of at least 2 are particularly suitable. The ClogP value is a well-known parameter and may be calculated for any given molecule from the knowledge of the structure of that molecule. There are a number of commercially-available computer programs performing this calculation. In the case of the present disclosure ~~invention~~ Osiris Property Explorer (http://www.organic-chemistry.org/prog/peo/.) was used, which is an integral part of Actelion's in-house substance registration system. The algorithm is implemented as an incremental system adding contributions of every atom, based on atom type, atom connectivity and chemical bonding. In addition, the curable matrix is preferably dried over activated 4A molecular sieves prior to the addition of the metal oxide or CaO particles.

The definition and way of calculation of ClogP can be found under the link http://en.wikipedia.org/wiki/Partition_coefficient; in Leo A, Hansch C, and Elkins D (1971) "Partition coefficients and their uses" Chem Rev 71 (6), 525–616; in Sangster, James (1997) Octanol-Water Partition Coefficients: Fundamentals and Physical Chemistry, Vol. 2 of Wiley Series in Solution Chemistry Chichester, John Wiley & Sons Ltd. pp. 178; in Hansch, Corwin Leo A (1979) Substituent Constants for Correlation Analysis in Chemistry and Biology New York, John Wiley & Sons Ltd. pp. 178; in Leo, Albert, Hoekman DH, Hansch C (1995) Exploring QSAR, Hydrophobic, Electronic, and Steric Constants Washington, DC, American Chemical Society.

In order to be flowable, and, in particular, for making inkjetable inks, which require very low viscosity resins (less than 30 mPa•s at printing temperature), a monofunctional acrylate or methacrylate diluent component (D) is used and the metal or calcium oxide concentration is preferably lower than 50% by weight, and more preferably lower than 20% by weight.

According to a preferred embodiment of the present disclosure ~~invention~~ the photoinitiator is a radical photoinitiator.

According to a preferred embodiment of the present disclosure ~~invention~~ the metal oxide particles are alkaline earth metal oxide particles, preferably CaO, BaO and/or MgO particles, and exhibit an average particle diameter of 10 to 1000 nm, preferably 15 to 500 nm, more preferably 20 to 350 nm, or even 50 to 250 nm.

The average particle diameter is calculated using the Dynamic Light Scattering technique. The apparatus used is a Malvern Zetasizer Nano ZS operating by Non Invasive Back Scatter mode for particle size measurement. Dynamic Light Scattering (also known as photon correlation spectroscopy or quasi-elastic light scattering) measures Brownian motion and relates this to the size of the particles using the Stokes-

Einstein equation. It operates by illuminating the particles with a laser and analyzing the intensity fluctuations in the scattered light.

Details of the used method to measure the average particle diameter in the present disclosure ~~invention~~ can be found under the link http://en.wikipedia.org/wiki/Dynamic_light_scattering, and in Berne, B.J.; Pecora, R. Dynamic Light Scattering, Courier Dover Publications (2000) ISBN 0-486-41155-9.

The metal oxide or CaO particle size is preferably in the nanometer range, in order to reduce sedimentation speed to a maximum, in particular for low viscosity resins. Nanometer range means calcium oxide fine particles having an average particle diameter (on volume basis) of 10 to 1000 nm, preferably 15 to 500 nm, more preferably 20 to 350 nm, and still more preferably 50 to 250 nm. In addition, a small particle size is highly desired for processes such as inkjet printing in order to avoid nozzle clogging, and also for making resins with a high degree of optical transparency. The problem is that the particles of calcium oxide are dried or prepared from a high temperature process (>500°C), and, as a consequence, are strongly agglomerated. A milling/grinding process has to be performed in order to pulverize the aggregates to the nanoscale. It is known from the grinding industry that nanoscale can be reached using very small milling balls. In our process, milling balls of 0.3-0.4 mm diameter were used. Smaller balls such as 50 µm or 100 µm would even be better suited, in particular for making transparent curable resins.

According to a preferred embodiment of the present disclosure ~~invention~~ the photocurable resin composition does not comprise any urethane (meth)acrylate, polyester (meth)acrylate, or polyethylene glycol (PEG) (meth)acrylate.

Components capable of metal oxide or CaO complexation and hydrogen bonding have to be preferably avoided, or used at very low loadings in order to avoid clumping of CaO particles and the progressive formation (only a few hours needed) of a solid-like gel which does not flow anymore. This phenomenon is aggravated as the particle size is decreased, due to the increase in surface area. Urethane acrylate building blocks, PEG (polyethylene glycol) building blocks, alkoxylated (meth)acrylates, (meth)acrylates with acidic or alcohol functionalities, polyols functionalized with (meth)acrylates are therefore preferably avoided.

According to a preferred embodiment of the present disclosure ~~invention~~ the photocurable resin composition exhibits a viscosity at 20°C below 500 mPa•s, preferably below 200 mPa•s, more preferably below 100 mPa•s, and/or exhibits a pot life at 60°C longer than 29 days, preferably longer than 43 days.

Pot life at a specific temperature is defined as the time after which the resin viscosity increases of 20% of the initial value of the resin viscosity, as measured at the time of the production of the resin.

The viscosity was measured using a Haake RS 80 rotational viscometer. This type of viscometer determines directly the absolute viscosity by measuring the resistance on a shaft rotating in the fluid of interest. The viscometer is composed of a cone attached to a rotating shaft. The cone is immerged in the fluid and rotated at a constant speed. The torque required to rotate the cone is measured and then related to the fluid viscosity.

The cone type used for our viscosity measurement was a 35 mm diameter with 2° angle, the rate was set at 100 s^{-1} and the measurement temperature was set at 20°C.

Details of the used method to determine the viscosity can be found under the link http://en.wikipedia.org/wiki/Viscometer#Rotational_viscometers and in the operating instructions of the used viscometer.

For making dispensable and printable inks (e.g. via gravure and flexoprinting), the viscosity must be lower than 500 mPa•s at 20°C, and preferably lower than 250 mPa•s for making dispensable inks. The curable resin has preferentially a viscosity lower than 60 mPa•s at 20°C for making inkjetable inks.

Non-flowable systems cannot be processed at all via printing techniques, such as inkjet, valve jet, gravure, and flexo printing or dispensing techniques, requiring low viscosity formulations.

Getter stickers are not practical for mass production at high speed compared to deposition of liquid resins.

It is very difficult to make thin coatings with high accuracy with high viscous pastes. A limited coating speed is achieved with viscous pastes, due to low levelling speed.

Thanks to the present disclosure~~invention~~, dramatic advantages are therefore achieved in the field of the application of water scavenging materials, which were unimaginable according to the prior art.

According to another preferred embodiment of the present disclosure ~~invention~~ the photocurable resin composition also comprises:
(F) a polybutadiene acrylate or methacrylate, a silicone acrylate or methacrylate, or a two-mole ethoxylated bisphenol A di(meth)acrylate, or any mixture thereof, whereby such component (F) exhibits preferably two (meth)acrylate functionalities.

Major components are preferably selected from polybutadiene (meth)acrylates, silicone (meth)acrylate, and other (meth)acrylate building blocks, preferably without PEG, acidic or alcohol functionalities.

According to a preferred embodiment of the present disclosure~~invention~~
component (D) exhibits a ClogP higher than 2,
component (E) exhibits a ClogP higher than 1,
and/or component (F) exhibits a ClogP higher than 4, preferably higher than 6 or 7.

According to a preferred embodiment of the present disclosure ~~invention~~ the component C is a 1,n-diol di(meth)acrylate of a diol of the formula $HO-(CH_2)_n-OH$, whereby n is higher than 3, preferably higher than 6, more preferably higher than 10.

According to an advantageous embodiment of the present disclosure ~~invention~~ the photocurable resin composition, after curing, is transparent, preferably the cured resin, as a film of 20 micrometer thickness, has a light transmission at 600 nm of > 90%,
and/or exhibits a water uptake after storage for 80 hours at 40°C in 90% relative humidity of less than 2% of its initial weight.

According to a preferred embodiment of the present disclosure~~invention~~, the resin composition comprises at least:
(A) 1 - 30 % by weight of CaO, BaO and/or MgO particles (component A);
(B) 0.1 - 10 % by weight of the photo initiator B;
(C) 30 - 80 % by weight of component C, which preferably exhibits two (meth)acrylate functionalities;
(D) 5 - 40 % by weight of the monofunctional (meth)acrylate diluent component D;
(E) 5 - 30 % by weight of the (meth)acrylate component E with functionality equal or higher than 3; and optionally
(F) 0.1 - 30 % by weight of component F;
based on the total weight of the composition.

According to a most preferred embodiment of the present disclosure~~invention~~, the resin composition comprises at least:
(A) 4 - 20 % by weight of CaO, BaO and/or MgO particles (component A);
(B) 0.1 - 5 % by weight of the photo initiator B;
(C) 40 - 70 % by weight of component C, which exhibits preferably two (meth)acrylate functionalities;
(D) 10 - 30 % by weight of the monofunctional (meth)acrylate diluent component D;
(E) 7 - 20 % by weight of the (meth)acrylate component E with functionality equal or higher than 3; and optionally
(F) 0.3 - 25 % by weight of component F;
based on the total weight of the composition.

According to a second aspect of the present disclosure ~~invention~~ a method is provided for preparing a photocurable resin according to the present disclosure~~invention~~, comprising the steps of:

h) mixing and stirring together components C, D, E, and optionally F, in order to produce a mixture h, which is optionally dried;
i) incorporating optionally dehydrated calcium, barium and/or magnesium oxide (component A) into the produced mixture h, so as to obtain a mixture i;
j) Milling and/or grinding the produced mixture i, preferably via bead milling under dry nitrogen, in order to downsize the average diameter of calcium, barium and/or magnesium oxide particles, so as to produce a mixture j;
k) Adding the photoinitiator B to the produced mixture j, so as to obtain a mixture k, which is preferably stirred under dry nitrogen atmosphere.

Such method exhibits the exceptional surprising advantage that the photocurable resin according to the present disclosure ~~invention~~ can be prepared with a one step milling process and without the use of any solvent, so that the preparation of the resin is simple, fast, inexpensive and practical.

The use of solvents and/or of a heating step for evaporating the solvent or for curing might not be compatible with the system in which the desiccant is applied. For instance, a heating step might be a critical issue when depositing the desiccant layer on a heat sensitive substrate, such as an OLED. Solvent residues might be trapped in the matrix and contaminate the system.

The dispersion of CaO in a solvent prior to dispensing the resin adds cost to the manufacturing process. In addition, it is not environmentally friendly.

The incorporation of CaO nanoparticles just before use requires the customer to be equipped with dispersing equipment, which is costly and requires expertise. A simple mixing step would not be sufficient to disperse the CaO particles to the nanometer scale.

A high number of preparation steps increases the risk of contamination of the CaO particles with humidity and, as a consequence, of the loss of water scavenging properties.

The method to prepare the photocurable composition according to the present disclosure ~~invention~~ solves surprisingly all such problems and issues.

According to another preferred embodiment of the present disclosure~~invention~~, during the milling step j) the average particle diameter of the CaO, BaO and/or MgO particles is reduced to the range of 10 to 1000 nm, preferably 15 to 500 nm, more preferably 20 to 350 nm or even 50 to 250 nm, and the produced photocurable resin k exhibits a water content less than 1000 ppm by weight.

Preferably, the CaO powder is dried, handled and milled with the resin under inert atmosphere (using inert gas with a water content of not more than 10 ppm (by mol)), in order to avoid CaO hydrolysis and the possibility of aggregation via hydrogen bonding. In the liquid curable matrix, the calcium oxide fine particles exhibit preferentially a calcium hydroxide content of less than 5% by weight and a calcium carbonate content of less than 1% by weight.

All the components have to be compatible for avoiding phase separation during the milling process.

According to a third aspect of the present disclosure a method is provided for manufacturing a multi layer barrier stack against water and oxygen penetration and diffusion, comprising the steps of:

m) Depositing a first inorganic layer, preferably silicon nitride or oxide, exhibiting preferably a thickness between 50 and 300 nm;
n) Depositing onto said first inorganic layer, preferably via ink jet printing, a first organic layer of the photocurable resin according to the present disclosure or produced with a method according to the present disclosure;
o) exposing said first organic layer to ultraviolet (UV) radiation, so as to solidify said first organic layer and to produce a transparent layer exhibiting water scavenging properties;
p) applying onto said first solidified organic layer, preferably via ink jet printing, a second organic layer of a photocurable resin not containing metal oxide particles;
q) exposing said second organic layer to UV radiation, so as to solidify said second organic layer and to produce a transparent layer exhibiting planarization properties;
r) Depositing onto said second solidified organic layer a second inorganic layer, preferably silicon nitride or oxide, exhibiting preferably a thickness between 50 and 300 nm.

~~According to a third aspect of t~~The present disclosure ~~invention~~ also provides a method ~~is provided~~ for manufacturing a multi layer barrier stack (30) against water and oxygen penetration and diffusion, comprising the steps of:

m) Depositing a first inorganic layer (32), preferably silicon nitride or oxide, exhibiting preferably a thickness between 50 and 300 nm;
n) Depositing onto said first inorganic layer (32), preferably via ink jet printing, a first organic layer (34) of the photocurable resin according to the present disclosure ~~invention~~ or produced with a method according to the present disclosure~~invention~~;
o) exposing said first organic layer (34) to ultraviolet (UV) radiation, so as to solidify said first organic layer (34) and to produce a transparent layer exhibiting water scavenging properties;
p) applying onto said first solidified organic layer (34), preferably via ink jet printing, a second organic layer (36) of a photocurable resin not containing metal oxide particles;
q) exposing said second organic layer (36) to UV radiation, so as to solidify said second organic layer (36) and to produce a transparent layer exhibiting planarization properties;
r) Depositing onto said second solidified organic layer (36) a second inorganic layer (38), preferably silicon nitride or oxide, exhibiting preferably a thickness between 50 and 300 nm.

The first organic layer (34) exhibits advantageously a thickness between 10 and 100 micrometers, preferably between 20 and 80 micrometers.

The second organic layer (36) exhibits advantageously a thickness between 10 and 100 micrometers, preferably between 20 and 80 micrometers.

According to a fourth aspect of the present disclosure a method is provided for manufacturing an opto-electric device, in particular an organic light emitting diode (OLED), comprising the steps of:
- providing an opto-electric element and/or layer,
- providing an encapsulation comprising a multi layer barrier stack produced according to the method according to the present disclosure.

~~According to a fourth aspect of t~~The present disclosure ~~invention~~ also provides a method ~~is provided~~ for manufacturing an opto-electric device, in particular an organic light emitting diode (OLED), comprising the steps of:
- providing an opto-electric element and/or layer (10),
- providing an encapsulation comprising a multi layer barrier stack (30) produced according to the method according to the present disclosure~~invention~~.

According to a fifth aspect of the present disclosure a multi layer barrier stack or opto-electric device, in particular OLED, is provided, which is obtained by a method according the present disclosure or a resin according to the present disclosure.

~~According to a fifth aspect of t~~The present disclosure ~~invention~~ also provides a multi layer barrier stack (30) or opto-electric device, in particular OLED~~, is provided~~, which is obtained by a method according the present disclosure ~~invention~~ or a resin according to the present disclosure~~invention~~.

Such organic opto-electric device or OLED comprises advantageously:
- an opto-electric element,
- a protective enclosure for protecting the opto-electric element against atmospheric substances, said protective enclosure comprising a multi-layered protective layer or multi layer barrier stack, in which a first inorganic layer, a first organic layer comprising a metal oxide, a second organic layer free from getter material and a second inorganic layer are stacked in the order named. The first organic layer is produced with the resin according to the present disclosure ~~invention~~ or with a method according to the present disclosure~~invention~~.

The metal oxide is preferably CaO, BaO or MgO particles and is distributed advantageously in the first organic layer as nanometer sized particles with a density in the range of 4 to 20 wt%. The second organic layer has advantageously a thickness in the range of 10 to 100 micrometer.

Nanometer sized particles, hereinafter also denoted as nanoparticles, are understood to be particles having dimensions less than 100 nm. The getter-material distributed as nano-particles with a density in the range of 4 to 20 wt% provides for an efficient binding of moisture in the first organic layer of the OLED. In typical embodiments the density is in the range of 5 to 10 wt%, for example 5 wt%.

Despite the small size of the original getter particles, these particles tend to form clusters having a size of several micrometers. It has been surprisingly found that milling of the getter particles results in a distribution having a small average cluster size, so that the layer comprising the particles exhibit a good transparency and can be used in the manufacturing of a OLED for example. Transparency is a physical property necessary

for films to be used in organic opto-electric devices or OLED. Despite such small average cluster size, it appeared that the presence of large clusters could not be fully ruled out. Accordingly, when applying a second organic layer over the first organic layer, having a conventional thickness in the range of 0.1 to 3 µm, these clusters may protrude through the second organic layer and the particles at the surface of the clusters tend to cause defects in the inorganic layer. The second organic layer has therefore advantageously a thickness substantially greater than the thickness that is conventionally applied. The first and the second inorganic layer encapsulate the first and the second organic layer so that a lateral ingress of moisture is prevented.

In a preferred embodiment the thickness of the second organic layer is at least 20 µm. This exhibits the advantage that even if tolerances in the manufacturing process cause variations in the thickness of the second organic layer then the remaining thickness is

still larger than the required minimum of 10 µm. For a flexible product it is preferred that the thickness of the second organic layer is less than 100 µm. In a typical embodiment the second organic layer exhibits a thickness of about 70 µm.

In an embodiment the first organic layer has a thickness in the range of 10 to 100 µm. A substantially smaller thickness, e.g. less than 5 µm, would exhibit an insufficient getter capacity, while a substantially larger thickness, e.g. more than 200 µm, would be undesirable for a flexible product.

In an embodiment the getter particles are of an alkaline earth metal oxide. Alkaline earth metal oxides, in particular CaO, provide for a very efficient binding of water.

In an embodiment the opto-electric element is an OLED, having an opto-electric layer arranged between a cathode and an anode, and the cathode faces the multi-layered protective layer. The cathode side of the OLED is the most vulnerable part to moisture, against which the multi-layered protective layer provides an efficient and still transparent protection. At the opposite side of the OLED another protective layer may be arranged, for example a metal foil. The metal foil may also serve as a conductor for the cathode or the anode. In another embodiment the opto-electric element has a multi-layered protective layer or stack as described above on both sides.

As explained, the first organic layer is produced by curing a photocurable resin according to the present disclosure~~invention~~.

The advantage of using such photocurable resins to produce the described organic opto-electric device or OLED is that the resin is stable and flowable and can be easily applied in the form of a thin film with controlled thickness. Curing time is almost instantaneous by photocuring and layers can be produced with exceptional water scavenging properties and transparency.

COMPONENTS OF THE RESIN

The photocurable resin according to the invention comprises components (A), (B), (C), (D), (E) and optionally (F):

(A) metal oxide particles

The metal oxide particles with the function of getter are advantageously CaO, BaO or MgO particles, preferably CaO nanoparticles.

Also other getter materials may be used. Other alkaline earth metal oxides for this purpose which are particularly suitable are barium oxide (BaO), magnesium oxide (MgO) and strontium oxide (SrO). As an example, MgO nanopowder (Catalog Nr.12-1400) from Strem may be obtained having the following specifications: Specific Surface Area (BET): ≥ 230 m^2/g; True Density: 3.2 g/cc; Crystallite Size: ≤ 8 nm; Mean Aggregate Size: 3.3 µm; Average Pore Diameter: 50 Å; Loss on Ignition: ≤ 8%; Total Pore Volume: ≥ 0.2 cc/g; Moisture Content: ≤ 1%; Bulk Density: 0.6 g/cc Mg Content (Based on Metal): ≥ 95%.

CLAIMS

1. A radiation curable resin composition comprising:
(A) metal oxide particles;
(B) at least one photoinitiator, preferably a radical photoinitiator, or any mixture thereof;
(C) at least one acrylate or methacrylate component with a ClogP higher than 2, preferably higher than 4, more preferably higher than 5, or any mixture thereof;
(D) at least one monofunctional acrylate or methacrylate diluent component, preferably with a viscosity below 40 mPa•s at 20°C, or any mixture thereof;
(E) at least one acrylate or methacrylate component with functionality equal or higher than 3, preferably 3 or 4, or any mixture thereof; ~~wherein~~ and
~~Mica is excluded from the group of (A) metal oxide particles~~
(F) a polybutadiene acrylate or methacrylate, a silicone acrylate or methacrylate, or a two-mole ethoxylated bisphenol A di(meth)acrylate, or any mixture thereof,
whereby such component (F) exhibits preferably two (meth)acrylate functionalities,
wherein the metal oxide particles A are alkaline earth metal oxide selected from the group consisting of CaO, BaO and MgO or mixtures thereof; and
wherein the metal oxide particles A exhibit an average particle diameter of 10 to 1000 nm, preferably 15 to 500 nm, more preferably 20 to 350 nm, or even 50 to 250 nm.

~~2. A resin composition according to claim 1, wherein metal oxide particles A are alkaline earth metal oxide particles, preferably CaO, BaO and/or MgO particles,~~
~~and exhibit an average particle diameter of 10 to 1000 nm, preferably 15 to 500 nm, more preferably 20 to 350 nm, or even 50 to 250 nm.~~

~~3~~2. A photocurable resin composition according to ~~any of the preceding claims~~claim 1, which does not comprise any urethane (meth)acrylate, polyester (meth)acrylate, or polyethylene glycol (PEG) (meth)acrylate.

~~4~~3. A photocurable resin composition according to any of the preceding claims, which exhibits a viscosity at 20°C below 500 mPa•s, preferably below 200 mPa•s, more preferably below 100 mPa•s,
and/or which exhibits a pot life at 60°C longer than 29 days, preferably longer than 43 days, wherein pot life at a specific temperature is defined as the time after which the resin viscosity increases of 20% of the initial value of the resin viscosity, as measured at the time of the production of the resin.

~~5. A photocurable resin composition according to any of the preceding claims, which also comprises:~~
~~(F) a polybutadiene acrylate or methacrylate, a silicone acrylate or methacrylate, or a two-mole ethoxylated bisphenol A di(meth)acrylate, or any mixture thereof,~~
~~whereby such component (F) exhibits preferably two (meth)acrylate functionalities.~~

~~6~~4. A photocurable resin composition according to any of the preceding claims, wherein component (D) exhibits a ClogP higher than 2,
component (E) exhibits a ClogP higher than 1,
and/or component (F) exhibits a ClogP higher than 4, preferably higher than 6 or 7.

~~7~~5. A photocurable resin composition according to any of the preceding claims, wherein component C is a 1,n-diol di(meth)acrylate of a diol of the formula $HO-(CH_2)_n-OH$, whereby n is higher than 3, preferably higher than 6, more preferably higher than 10.

~~8~~6. A photocurable resin composition according to any of the preceding claims, which, after curing, is transparent, preferably the cured resin, as a film of 20 micrometer thickness, has a light transmission at 600 nm of > 90%,
and/or exhibits a water uptake after storage for 80 hours at 40°C in 90% relative humidity of less than 2% of its initial weight.

97. A resin composition according to any of the preceding claims comprising at least:
(A) 1 - 30 % by weight of CaO, BaO and/or MgO particles (component A);
(B) 0.1 - 10 % by weight of the photo initiator B;
(C) 30 - 80 % by weight of component C, which preferably exhibits two (meth)acrylate functionalities;
(D) 5 - 40 % by weight of the monofunctional (meth)acrylate diluent component D;
(E) 5 - 30 % by weight of the (meth)acrylate component E with functionality equal or higher than 3; and optionally
(F) 0.1 - 30 % by weight of component F;
based on the total weight of the composition.

108. A resin composition according to any of the preceding claims comprising at least:
(A) 4 - 20 % by weight of CaO, BaO and/or MgO particles (component A);
(B) 0.1 - 5 % by weight of the photo initiator B;
(C) 40 - 70 % by weight of component C, which exhibits preferably two (meth)acrylate functionalities;
(D) 10 - 30 % by weight of the monofunctional (meth)acrylate diluent component D;
(E) 7 - 20 % by weight of the (meth)acrylate component E with functionality equal or higher than 3; and optionally
(F) 0.3 - 25 % by weight of component F;
based on the total weight of the composition.

119. Method for preparing a photocurable resin according to any of the claims 1 to 108, comprising the steps of:

h) mixing and stirring together components C, D, E, and optionally F, in order to produce a mixture h, which is optionally dried;
i) incorporating optionally dehydrated calcium, barium and/or magnesium oxide (component A) into the produced mixture h, so as to obtain a mixture i;
j) Milling and/or grinding the produced mixture i, preferably via bead milling under dry nitrogen, in order to downsize the average diameter of calcium, barium and/or magnesium oxide particles, so as to produce a mixture j;
k) Adding the photoinitiator B to the produced mixture j, so as to obtain a mixture k, which is preferably stirred under dry nitrogen atmosphere.

1210. Method for preparing a photocurable resin according to claim 119, wherein during the milling step j) the average particle diameter of the CaO, BaO and/or MgO particles is reduced to the range of 10 to 1000 nm, preferably 15 to 500 nm, more preferably 20 to 350 nm or even 50 to 250 nm, and/or
wherein the produced photocurable resin k exhibits a water content less than 1000 ppm by weight.

1311. Method for manufacturing a multi layer barrier stack (30) against water and oxygen penetration and diffusion, comprising the steps of:

m) Depositing a first inorganic layer (32), preferably silicon nitride or oxide, exhibiting preferably a thickness between 50 and 300 nm;
n) Depositing onto said first inorganic layer (32), preferably via ink jet printing, a first organic layer (34) of the photocurable resin according to the inventionany one of claims 1 to 8 or produced with a method according to the inventionany one of claims 9 or 10;
o) exposing said first organic layer (34) to ultraviolet (UV) radiation, so as to solidify said first organic layer (34) and to produce a transparent layer exhibiting water scavenging properties;

p) applying onto said first solidified organic layer ~~(34)~~, preferably via ink jet printing, a second organic layer ~~(36)~~ of a photocurable resin not containing metal oxide particles;

q) exposing said second organic layer ~~(36)~~ to UV radiation, so as to solidify said second organic layer ~~(36)~~ and to produce a transparent layer exhibiting planarization properties;

r) Depositing onto said second solidified organic layer ~~(36)~~ a second inorganic layer ~~(38)~~, preferably silicon nitride or oxide, exhibiting preferably a thickness between 50 and 300 nm.

~~14~~ 12. Method for manufacturing a multi layer barrier stack ~~(30)~~ according to claim ~~13~~11, whereby the first organic layer ~~(34)~~ exhibits a thickness between 10 and 100 micrometers, preferably between 20 and 80 micrometers, and/or
whereby the second organic layer ~~(36)~~ exhibits a thickness between 10 and 100 micrometers, preferably between 20 and 80 micrometers.

~~15~~ 13. A method for manufacturing an opto-electric device, in particular an organic light emitting diode (OLED), comprising the steps of:
- providing an opto-electric element and/or layer ~~(10)~~,
- providing an encapsulation comprising a multi layer barrier stack ~~(30)~~ produced according to the method of claim ~~13~~ 11 or ~~14~~12.

~~16~~ 14. A multi layer barrier stack ~~(30)~~ or opto-electric device, in particular OLED, obtained by a method according to claim ~~13~~11, ~~14~~ 12 or ~~15~~13.