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(54) A COMPOSITE MATERIAL COMPRISING A SUBSTRATE WITH A BARRIER LAYER

VERBUNDWERKSTOFF AUS EINEM SUBSTRAT UND EINER SPERRSCHICHT

MATERIAU COMPOSITE COMPRENANT UN SUBSTRAT MUNI D'UNE COUCHE BARRIERE

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- **CHEMICAL ABSTRACTS, vol. 129, no. 25, 21 December 1998 (1998-12-21) Columbus, Ohio, US; abstract no. 337789, SUZUKI, KAZUNORI ET AL: "Deposition of triazine dithiol organic thin films on Fe substrate and their evaluation" XP002093435 & IWATE-KEN KOGYO GIJUTSU SENTA KENKYU HOKOKU (1998), 5, 71-76 CODEN: IKGHFC;ISSN: 1341-0776,1998,**
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Description

[0001] The invention relates to a composite material comprising a substrate and at least one layer applied to the substrate. The invention relates in particular to an composite material comprising a substrate and a layer having permeability barrier properties on the substrate. The invention also relates to a process for the manufacture of a composite material comprising a substrate and a barrier layer applied to the substrate using vapour deposition.

[0002] A composite material comprising a substrate and a layer on the substrate was disclosed in US-A-3,442,686, This patent describes a composite film that includes an organic base sheet, a heat sealable top coating, and an intermediate barrier layer of an inorganic material. The disclosed barrier layer, preferably comprising an inorganic oxide or salt, is typically vapour deposited on the base sheet and then covered by an extruded top coating. The barrier layer, generally at least 0.02 μm thick, and more typically 0.06-0.6 μm thick, is provided to reduce the permeability of the composite film to gases and water vapour.

[0003] However, despite the use of "glassy state" inorganic materials, preferred over more crystalline materials, to form the layer, the disclosed inorganic barrier layers remain relatively brittle. This brittleness remained a drawback that allowed cracks to form in the barrier layer when the film was deformed. This cracking seriously degrades the barrier layer performance, allowing gases and water vapor to permeate the film. Another drawback associated with the disclosed inorganic layers are the high temperatures developed in the film during the vaccuum deposition process, usually above 100°C. These high temperatures seriously limit the use of the disclosed inorganic layers on temperature-sensitive substrates such as polymers with a low glass transition temperature. Moreover, further drawbacks associated with the disclosed films are their high cost, reduced optical clarity, and discoloration such as yellow (silicon oxide) or yellow-red (iron oxides).

[0004] In JP-A-09239938 a metal laminating film is disclosed including a thermoplastic resin film as a base material and a curable heat resistive layer containing a curable reacted substance of an epoxy resin laminated on at least one surface of the film.

[0005] GB-A-946,345 discloses composite structures or laminates comprising a polyurethane material and a substrate of metal or plastic material wherein the substrate is precoated with a resinous composition, for instance a melamine-formaldehyde resin.

[0006] The applicant has developed an improved composite material comprising a substrate and a triazine compound barrier layer obtainable by vapour deposition that overcomes some of the deficiencies associated with inorganic barrier layers. Accordingly, the invention is characterized in that the layer comprises a triazine compound selected from melamine, ammeline, ammelide, cyanuric acid, 2-ureidomelamine, melam, melem, melon and melamine salts.

[0007] In addition, the applicant has developed a process for manufacturing the improved composite material in which the triazine barrier layer is vapour deposited on heat-sensitive substrate materials. Accordingly, the process for manufacturing the improved composite material is characterized in that the layer that is vapour-deposited is a layer comprising a triazine compound selected from melamine, melam, melem, melon or a combination thereof.

[0008] The composite material according to the invention was found to provide a surprisingly durable barrier to gases, in particular oxygen, using a barrier layer comprising a triazine compound. Surprisingly, it was also found that composite materials according the present invention exhibits excellent sealability and further provides good paintability, printability and scratch resistance.

[0009] The composition material according to the present invention, utilizing a triazine compound barrier layer rather than an inorganic barrier layer such as silicon oxide, also exhibits improved resistance to mechanical damage. This means that materials prepared according to the present invention are better able to maintain their barrier properties after being subjected to deformation and increasing their utility as packaging materials.

[0010] A further advantage is derived from the lower temperatures required for applying the triazine compound layer to the substrate material. These lower temperatures allow a triazine compound layer to be applied to temperature-sensitive materials such as polyethylene that would not tolerate the temperatures necessary for application of an inorganic barrier layer.

[0011] In addition, the production costs of composite materials with a triazine compound barrier layer are lower than those associated with the production of equivalent composite materials using an inorganic barrier layer. Moreover, it has been found that composite materials incorporating a triazine compound barrier layer, even at thickness of 1 μm and more, maintains satisfactory transparency.

[0012] As stated before, the following triazines are used in the composite material of the present invention: melamine, ammeline, ammelide, cyanuric acid, 2-ureidomelamine, melam, melem, melon, melamine salts such as for instance melamine cyanurate, melamine phosphate, dimelamine pyrophosphate or melamine polyphosphate. The preferred triazine compounds are melamine, melam, melem, melon, or a combination thereof, melamine being particularly preferred. The temperature at which melamine or other triazine compounds can be vapour deposited is lower than 600°C, preferably lower than 400°C.

[0013] The invention can be applied with the layer comprising only one triazine compound, but it is also possible for the layer to comprise a combination of two or more triazine compounds. It is also possible for several distinct layers of one or more triazine compounds to be used, for example a melamine layer as well as a melam or melem layer, to form the barrier layer. The advantage of this procedure is that it allows the specific properties of the different triazine compounds to be combined.

[0014] According to the invention it is also possible for the barrier layer to contain compounds in addition the described triazine compounds. Preferably, a triazine compound, or a combination of triazine compounds, comprises the majority of the barrier layer in composite materials according to the invention. In particular, the barrier layer preferably contains at least 75 wt.%, and more preferably at least 90 wt.%, of the trizazine compound(s). In composite materials according to the invention, barrier layer thickness is preferably less than 50 μm, more preferably less than 10 μm, and most preferably less than 5 μm. The minimum barrier layer thickness, however, would provide a continuous monomolecular layer of the triazine, and more preferably, would have a thickness of at least 5 nm.

[0015] Suitable substrates for application of the triazine barrier layer according to the invention include, but are not limited to, polymers, glass, paper and preferably precoated paper, cardboard and preferably precoated cardboard, and metal. The type of substrate selected, as well as the shape and thickness of the substrate, will depend largely on the application intended for the final product and do not, therefore, act to limit the scope of the invention. Examples of polymers that may be utilized as a substrate include polyethylene, polypropylene, acrylonitrile-butadiene-styrene copolymer, polyethylene terephthalate, polyamide, polycarbonate, but the invention is not limited to these polymers either.

[0016] In particular, the applicant has developed a composite material comprising a substrate and a barrier layer, the barrier layer comprising a triazine compound. As used herein, a barrier layer refers to a layer that, when applied to a substrate, produces a composite material that exhibits greatly reduced gas permeability, particularly reduced oxygen permeability, when compared with an uncoated substrate.

[0017] The applicants have found that triazine compounds are particularly suitable for application to a wide variety of substrate materials to form a barrier layer. Further, it is preferred that all, or at least a portion, of the triazine compound used in the barrier layer has a crystalline structure. Without committing itself to any scientific theory, the applicant speculates that the preferred triazine compounds are able to form crystalline structures comprising a plurality of triazine ring interconnected by hydrogen bonds. The advantage of such a crystalline structure is reported by M. Salame; Journal of Plastic Films & Sheeting; vol. 2; October 1986.

[0018] The gas barrier performance of the composite material according to the present invention provides advantages for foodstuff packaging applications. In foodstuff packaging applications, the composite material according to the invention can be provided as a composite film. A variety of films, including for example polymers such as polyethylene, polypropylene, biaxially oriented polypropylene, polyethylene terephthalate, polybutylene terephthalate and polyamide, may be utilized as suitable substrates. The choice of substrate structure is not, however, limited to films but includes polymers or copolymers or polymer blends formed into plates, cartons, boxes, bottles, crates and other containers. Similarly, the range of suitable substrate compositions is not limited to polymers and copolymers, but includes paper and preferably precoated paper, cardboard and preferably precoated cardboard, and other common packaging. materials.

[0019] If the composite material according to the invention is intended for use as foodstuff packaging, it is advantageous to apply at least one more layer over the triazine compound barrier layer. In this preferred embodiment, the composite material comprises a substrate, an intermediate barrier layer comprising a triazine compound formed on the substrate, and a cover layer formed over the barrier layer. Selection of an appropriate cover layer material produces a composite material with improved moisture resistance. Suitable cover layer materials include polyethylene, polypropylene, biaxially oriented polypropylene, polyethylene terephthalate and polybutylene terephthalate. It is important that there is sufficient adhesion between the triazine compound barrier layer and the cover layer to avoid delamination. To ensure sufficient adhesion, an adhesive or adhesive layer is preferred for attaching the cover layer to the barrier layer. The triazine compound itself may act as the adhesive, or is at least a major component of the adhesive. Multilayer structures built up of repeating layers of films and triazine compounds are also possible to produce composite materials that are moisture resistant and have low gas permeability.

[0020] The triazine compounds may be applied to a substrate according to the invention using known vapour deposition techniques and equipment. Vapour deposition of the triazine compound on the substrate may take place under elevated pressure or atmospheric pressure, but reduced pressures are preferred. Further, the process may take place in an inert atmosphere, such as a nitrogen atmosphere. For example, a vapour deposition process according to the invention can be conducted in a vacuum chamber having a pressure of less than 1000 Pa, preferably less than 100 Pa, and more preferably, less than 10 Pa. If an inert gas is present the inert gas, for instance nitrogen, refers to the gas or gases present in the deposition chamber other than the compound or compounds being vapour deposited.

[0021] In a typical vapour deposition process, the substrate and a supply of the triazine compound are placed in a vacuum chamber under an inert atmosphere. The pressure within the vacuum chamber is then reduced and the triazine compound is vapourized by heating. As the vapourized triazine compound contacts the substrate, which is maintained at a lower temperature, and solidifies to form a layer on the substrate. The temperature difference maintained between the vapourizing triazine compound and the substrate to promote deposition is preferably at least 100°C.

[0022] The temperature necessary to vapourize the triazine compound depends on both the type of triazine compound selected and the pressure at which the deposition is conducted. The rate at which the selected triazine compound is vapourized is temperature and pressure dependent, with higher temperatures and lower pressures providing increased vapourization. Through selection of appropriate temperature and pressure combinations, the vapourization rate, or sublimation rate, of the triazine compound can be adjusted to control the rate at which the barrier layer is formed on the substrate. The upper limit for the vapourization temperature will be that temperature at which the triazine compound will decompose.

[0023] The applicant has also found that the composite material according to the invention also exhibits improved scratch resistance as a result of the vapour deposited triazine layer.

[0024] The applicant has also found that the fracture properties of ceramic materials (glass) can be improved by depositing a layer of a triazine compound on the ceramic materials. Similarly, the applicant has found that the corrosion resistance of metals can be improved by depositing a layer of a triazine compound on a metal substrate. The triazine compound applied in this manner can eliminate the need for applying a zinc or chromium layer on susceptible metal surfaces to prevent corrosion.

[0025] The following specific examples are intended to further illustrate, rather than restrict in any way, the principles and practices of the present invention.

<u>Example 1</u>

[0026] In a test apparatus, melamine was vapour-deposited onto a glass plate substrate to form a triazine layer. The test apparatus included a vacuum chamber, a melting crucible into which the melamine to was placed, and a thermocouple for monitoring the temperature in the melting crucible. The pressure in the vacuum chamber was reduced to between 5×10^{-3} Pa and 1×10^{-2} Pa and the melting crucible was heated to vapourize the melamine. The glass plate was positioned relative to the melting crucible in such a way that the vapourized melamine was deposited on the glass plate.

[0027] Three experiments were executed with varying vapour-deposition temperature and the vapour-deposition time. The layer thickness and colour of each vapour-deposited layer was then measured. In addition, the IR spectrum of the vapour-deposited layers was measured using an IR spectrometer, specifically a Perkin Elmer® 1760X. The IR spectra thus obtained were compared with the IR spectrum of non-vapour-deposited melamine.

[0028] The results of the thickness measurements and colour determinations are presented in Table 1, Vapour-deposition conditions.

[0029] From the comparison of the IR spectra of the vapour-deposited melamine layers and the IR spectrum of the non-vapour-deposited melamine it was concluded that the vapour-deposition process does not alter the chemical structure of the melamine.

Table 1

Vapour-deposition conditions				
experiment	temperature (°C)	time (s)	layer thickness (nm)	colour
1	219	20	70	transparent
2	230	20	121	transparent
3	270	420	4300	white

<u>Example 2</u>

[0030] Several experiments were carried out in which a melamine layer was vapour-deposited on a 12 μm thick polyethylene terephthalate (PET) film using the same test apparatus described in example 1 and varying the thickness of the vapour-deposited melamine layer being formed.

[0031] The oxygen permeability of the composite materials obtained and of the uncoated PET substrate was then measured in duplicate according to standard DIN 53 380, part 3, and the results compared. The results of these measurements are presented in Table 2.

[0032] Table 2 shows that the oxygen permeability of a PET substrate with a vapour-deposited melamine layer is reduced by a factor of 50 to 100 compared with the uncoated PET substrate. Table 2 also shows that although a vapour-deposited melamine layer only a few tens of nanometres thick produces significant reductions in the oxygen permeability, the vapour deposition of additional melamine does not produce any significant reduction in the oxygen permeability.

Table 2:

Oxygen permeability of a PET substrate with a melamine layer vapour-deposited onto it as a function of the thickness of the vapour-deposited melamine layer		
Thickness of vapour-deposited melamine layer (nm)	oxygen permeability (cm^3/m^2 day bar)	
no layer vapour-deposited	110	110
36	1.4	2.5
1080	1.0	2.4
2100	1.1	1.2

[0033] The degree of adhesion between the vapour deposited melamine layer and the polymer film was tested by applying a band of adhesive tape to the melamine layer and then quickly tearing off the adhesive tape. From this test it was concluded that the melamine did not come loose from the polymer film.

Example 3

[0034] Using the same test apparatus described in Example 1, additional experiments were conducted in which melamine layers of various thickness were vapour-deposited onto a biaxially oriented polypropylene (BOPP) substrates.

[0035] The oxygen permeability of the composite products obtained and the uncoated BOPP substrate was measured in duplicate according to standard DIN 53 380, part 3, and the results compared. The results of these measurements are presented in Table 3.

[0036] Table 3 shows that the oxygen permeability of a BOPP substrate having a vapour-deposited melamine layer is reduced by a factor of 40 to 68 when compared with the uncoated BOPP substrate. Table 3 also shows that although a vapour-deposited melamine layer only a few tens of nanometres thick produces significant reductions in the oxygen permeability, the vapour deposition of additional melamine does not produce any significant reduction in the oxygen permeability.

Table 3:

Oxygen permeability of a BOPP substrate with a melamine layer vapour-deposited onto it as a function of the thickness of the vapour-deposited melamine layer		
thickness of vapour-deposited melamine layer (nm)	oxygen permeability (cm^3/m^2 day bar)	
no layer vapour-deposited	1600	1600
38	23.5	38.7
2100	32.5	39.7

[0037] The degree of adhesion between the vapour deposited melamine layer and the polymer film was tested by applying a band of adhesive tape to the melamine layer and then quickly tearing off the adhesive tape. From this test it was concluded that the melamine did not come loose from the polymer film.

Claims

1. Composite material, obtainable by the process of any one of Claims 7-10, comprising a substrate and a layer on the substrate, **characterised in that** the layer comprises a triazine compound selected from melamine, ammeline, ammelide, cyanuric acid, 2-ureidomelamine, melam, melem, melon and melamine salts or a combination thereof.

2. Composite material according to claim 1, wherein the substrate comprises a polymer, glass, metal, paper, precoated paper, cardboard or precoated cardboard.

3. Composite material according to claim 1, wherein the substrate comprises polyethylene terephthalate or biaxially oriented polypropylene.

4. Composite material according to claim 1, wherein the layer comprises a triazine compound selected from melamine, melam, melem, melon or a combination thereof.

5. Composite material according to claim 1, wherein the triazine compound is melamine.

6. Composite material according to any one of claims 1 - 5, **characterized in that** the composite material has another layer on top of the layer comprising the triazine compound.

7. Process for the manufacture of an composite materlal comprising a substrate and a layer on the substrate in which the layer is vapour-deposited, **characterized in that** the vapour-depositioning is done under atmospheric pressure or reduced pressure and that the layer that is vapour-deposited is a layer comprising a triazine compound selected from melamine, melam, melem, melon or a combination thereof.

8. Process for the manufacture of a composite material according to claim 7, wherein the pressure during the vapour-depositioning is less than 1000 Pa.

9. Process according to claim 7, **characterized in that** the layer that is vapour-deposited comprises melamine.

10. Process according to any one of the claims 7 -9, **characterized in that** the temperature difference between the vaporizing triazine compound and the substrate onto which the triazine compound is vapour-deposited is greater than 100 °C.

11. Use of a layer comprising a triazine compound and obtainable by vapour deposition under atmospheric pressure or reduced pressure as a gas barrier layer.

Patentansprüche

1. Kompositmaterial, erhältlich durch das Verfahren nach einem der Ansprüche 7-10, umfassend ein Substrat und eine Schicht auf dem Substrat, **dadurch gekennzeichnet, daß** die Schicht eine Triazinverbindung, ausgewählt aus Melamin, Ammelin, Ammelid, Cyanursäure, 2-Ureidomelamin, Melam, Melem, Melon und Melaminsalzen oder einer Kombination davon, umfaßt.

2. Kompositmaterial nach Anspruch 1, wobei das Substrat ein Polymer, Glas, Metall, Papier, vorgestrichenes Papier, Karton oder vorgestrichenen Karton umfaßt.

3. Kompositmaterial nach Anspruch 1, wobei das Substrat Polyethylenterephthalat oder biaxial gestrecktes Polypropylen umfaßt.

4. Kompositmaterial nach Anspruch 1, wobei die Schicht eine Triazinverbindung, ausgewählt aus Melamin, Melam, Melem, Melon oder einer Kombination davon, umfaßt.

5. Kompositmaterial nach Anspruch 1, wobei die Triazinverbindung Melamin ist.

6. Kompositmaterial nach einem der Ansprüche 1 bis 5, **dadurch gekennzeichnet, daß** das Kompositmaterial eine weitere Schicht oben auf der Schicht, umfassend die Triazinverbindung, aufweist.

7. Verfahren zur Herstellung eines Kompositmaterials, umfassend ein Substrat und eine Schicht auf dem Substrat, wobei die Schicht aufgedampft wird, **dadurch gekennzeichnet, daß** die Dampfabscheidung unter Atmosphärendruck oder vermindertem Druck durchgeführt wird und daß die Schicht, die aufgedampft wird, eine Schicht ist, umfassend eine Triazinverbindung, ausgewählt aus Melamin, Melam, Melem, Melon oder einer Kombination davon.

8. Verfahren zur Herstellung eines Kompositmaterials nach Anspruch 7, wobei der Druck während der Dampfabscheidung weniger als 1000 Pa beträgt.

9. Verfahren nach Anspruch 7, **dadurch gekennzeichnet, daß** die Schicht, die aufgedampft wird, Melamin umfaßt.

10. Verfahren nach einem der Ansprüche 7 bis 9, **dadurch gekennzeichnet, daß** der Temperaturunterschied zwischen der verdampfenden Triazinverbindung und dem Substrat, worauf die Triazinverbindung aufgedampft wird, mehr als 100°C beträgt.

11. Verwendung einer Schicht, umfassend eine Triazinverbindung und erhältlich durch Dampfabscheidung unter Atmosphärendruck oder reduziertem Druck, als eine Gassperrschicht.

Revendications

1. Matériau composite pouvant être obtenu par le procédé selon l'une quelconque des revendications 7 à 10, qui comprend un substrat et une couche sur le substrat, **caractérisé en ce que** la couche comprend un dérivé de la triazine choisi parmi la mélamine, l'amméline, l'ammélide, l'acide cyanurique, la 2-uréidomélamine, le melam, le melem, le melon et les sels de mélamine, ou une combinaison de ceux-ci.

2. Matériau composite selon la revendication 1, dans lequel le substrat comprend un polymère, du verre, du métal, du papier, un papier pré-enduit, un carton ou un carton pré-enduit.

3. Matériau composite selon la revendication 1, dans lequel le substrat comprend du poly(téréphtalate d'éthylène) ou du polypropylène à orientation biaxiale.

4. Matériau composite selon la revendication 1, dans lequel la couche comprend un dérivé de la triazine choisi parmi la mélamine, le melam, le melem, le melon ou une combinaison de ceux-ci.

5. Matériau composite selon la revendication 1, dans lequel le dérivé de la triazine est la mélanine.

6. Matériau composite selon l'une quelconque des revendications 1 à 5, **caractérisé en ce que** le matériau composite possède une autre couche par-dessus la couche qui comprend le dérivé de la triazine.

7. Procédé de fabrication d'un matériau composite comprenant un substrat et une couche sur le substrat, dans lequel la couche est déposée en phase vapeur, **caractérisé en ce que** le dépôt en phase vapeur est effectué sous la pression atmosphérique ou sous pression réduite, et que la couche qui est déposée en phase vapeur est une couche comprenant un dérivé de 1a triazine choisi parmi la mélamine, le melam, le melem, le melon ou une combinaison de ceux-ci.

8. Procédé de fabrication d'un matériau composite selon la revendication 7, dans lequel la pression pendant 1e dépôt en phase vapeur est inférieure à 1000 Pa,

9. Procédé selon 1a revendication 7, **caractérisé en ce que** la couche qui est déposée en phase vapeur comprend de la mélamine.

10. Procédé selon l'une quelconque des revendications 7 à 9, **caractérisé en ce que** la différence de température entre le dérivé de la triazine déposé en phase vapeur et le substrat sur lequel le dérivé de la triazine est déposé en phase vapeur est supérieure à 100°C.

11. Utilisation, en tant que couche à effet de barrière aux gaz, d'une couche comprenant un dérivé de la triazine et pouvant être obtenue par dépôt en phase vapeur sous la pression atmosphérique ou sous pression réduite.