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(54) Title: PROCESS FOR THE PREPARATION OF A DECORATED SUBSTRATE

(57) Abstract: The present invention relates to a process for the preparation of a decorated substrate comprising the steps of: apply-
ing a radiation-curable coating composition at least partially to a substrate and/or a radiation-permeable film, pressing the substrate
and the radiation-permeable film together in such a way that the coating composition is sandwiched between them, curing the coat-
ing composition by irradiation through the film to obtain a coated substrate, removing the radiation-permeable film, covering the
surface of the substrate with a sheet comprising a decoration which is to be transferred to the surface of the substrate, and heating
the substrate and the sheet comprising the decoration to effect the transfer of the decoration from the sheet to the coated substrate.

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PROCESS FOR THE PREPARATION OF A DECORATED SUBSTRATE

FIELD OF THE INVENTION

5 High quality decorated substrates

The present invention relates to a process for the preparation of a decorated substrate. Specifically, it relates to the application of a high quality decoration on a substrate.

10 The substrate may, for example, be metal, flexible or hard plastic, ceramic, textile, or a cellulose-comprising substrate. Examples of products for which a sharp, clear-cut decoration, for instance a colour print, and a good quality coating are of high importance are flexible plastic substrates, for example polyester labels, and cellulose-comprising substrates such as book jackets,
15 posters, typical corrugated packaging materials such as B-flute, and micro-flute corrugated materials (which may be small-scale packaging material comprising a sandwich structure of paper layers with corrugation inside). The currently known processes for the application of a decoration on a substrate, however, need to be improved. Some of the currently used processes are, for example,
20 time consuming, expensive, and/or waste producing. The decorated substrate obtained after performing the currently used processes is not always satisfactory as, for example, the quality of the print may be hazy or blurred, the top surface may not have the desired gloss, and/or the mechanical and chemical properties of the top surface may be imperfect.

25

A special area in which the quality of the decoration on a substrate is of high importance is packaging. The final packaged products need to have a high quality decoration. But also the proofs made in order to decide what the final packaging should be, need to have a high quality decoration. In the present
30 context, the term "proof" represents a printed trial version of a graphic on the appropriate quality of substrate to see how it will look when produced in its final

form. The proofs preferably are made on a small scale. Normally it is difficult to obtain a good quality proof on a small scale with the same appearance as the large scale final product.

- 5 When making proofs for general packaging, for instance boxes, or for food packaging such as frozen food cardboard packaging and polyester film packaging such as confectionary wrappers, it is of importance to obtain a decorated substrate having the same quality and the same appearance as the packaging that would be obtained via production on an industrial scale. This
10 appearance may be glossy or matt (satin), dependent on the requirements.

Some substrates are difficult to decorate. One example of such a difficult to decorate substrate is a substrate that does not absorb ink very well. For example, some cellulose-comprising and some polymer-comprising substrates
15 do not absorb ink very well; they are not ink jet-receptive. In such a case, the ink is easily removed, and the print may not have a good appearance. Another example of a difficult to decorate substrate is a substrate that absorbs ink too readily. For example, some cellulose-comprising substrates absorb ink too readily; the ink penetrates too far into the substrate. An example of such a
20 substrate is carton board.

In the case of substrates which are not ink jet-receptive, it is sometimes possible to place a receptive coating on the substrate that does accept the ink of an ink jet printer in a satisfactory way. After the application of such a
25 receptive coating layer, it may be possible to obtain high quality decorated substrates using for example an Iris[®] printer (ex Iris), Matchprint[®] (ex 3M) or a digital Chromalin[®] printer (ex DuPont). Such special printers, however, are very expensive. Further, the printing process is relatively slow. Such an approach sometimes is useful when making proofs of substrates which are not ink jet-
30 receptive.

Another possibility for the preparation of proofs for substrates which are not ink jet-receptive may be to choose another type of substrate. For example, in the case of polymer-comprising packaging, e.g. polyester film food packaging, proofs may be made by preparing a decorated paper substrate instead of a decorated polymer-comprising substrate. A disadvantage of this commonly used process is that this does not result in the same appearance as would be obtained when the polymer-comprising substrate is decorated on an industrial scale using, for example, a printing press.

10 In the case of substrates that absorb too much ink, it is currently not possible to obtain a high quality decorated substrate by means of an ink jet printer. A common way to solve this problem is to apply a decoration to an ink jet-receptive substrate, for example an ink jet-receptive paper substrate, with a high quality printer, for example a digital Chromalin® printer. Subsequently, this decorated substrate is fixed, e.g. using a spray (applied) adhesive, to the substrate that cannot be printed (for example carton board).

Coated, or covered, high quality decorated substrates

After applying a decoration to a substrate, one may want to coat, or cover, the decorated substrate. For example, when making a proof print on a packaging board, it is desirable to apply a lacquer with the same or similar appearance and/or performance as the lacquer that will be applied when the decorated packaging boards are produced on an industrial scale. Currently, on an industrial scale high solids, usually 100% solids, UV-curable coating compositions, for instance acrylate coating compositions, tend to be used to coat decorated packaging boards. When making proofs, however, a water based or a solvent based coating composition that cures through physical drying, for instance a water borne acrylic composition, is applied. Current practice is to apply the coating composition by means of a wet proofing press such as a Korrex® or a FAG®. A disadvantage of a water borne or solvent borne coating composition according to current practice is that this does not result in

the same or a similar appearance and/or performance as would be obtained using a high solids or 100% solids UV-curable coating composition. Another disadvantage of such coatings is that with the apparatus normally used to apply these compositions, one needs to coat a large sheet, which is typically the same size as used on an industrial scale, such as B2 or A0, as it is not economically viable to coat only one or two sheets of a relatively small size such as A4. Hence, it is very time consuming, waste producing, and expensive to make a proof. This is especially the case when, for a trial, several proofs on different types of substrates, for example substrates having different colours, need to be prepared.

Another example of a process in which one may want to coat, or cover, the decorated substrate is when a proof on a paper substrate is made to resemble a polymer-comprising packaging, e.g. polyester film packaging such as confectionary wrappers. After the decoration is applied to the paper substrate, a coating or cover is applied. A disadvantage of this commonly used process is that this does not result in the same appearance as would be obtained when the polymer-comprising substrate is decorated on an industrial scale using, for example, a printing press, optionally followed by application of a coating layer on top of the decoration.

In an alternative process to prepare a coated, or covered, decorated substrate, the substrate is laminated after the decoration has been applied by, for instance, a Chromalin printer. A possible example of a substrate that is suitable for this process is board material. When making proofs on packaging boards, a disadvantage of laminating is that the laminated substrate does not have the same appearance as would be obtained using a high solids or 100% solids UV-curable coating composition, for example a 100% solids acrylate coating composition.

Another alternative process to prepare a coated, or covered, decorated substrate used nowadays is a process in which the substrate is pre-coated or pre-laminated, followed by applying the decoration. Possible examples of substrates that are suitable for this process are ceramic tiles and cellulose-comprising substrates. Current practice is to apply a two-component (2K) polyurethane composition, for instance by means of a roller coater or by spray-coating, or to apply a low viscosity, high solids, usually 100% solids, UV-curable lacquer by means of a roller coater. Alternatively, the substrate can be laminated before the decoration is applied. The decoration may then be applied to the pre-coated or laminated substrates by a dye sublimation process.

Dye sublimation can be performed using, for example, the Gs2 technology of Gencia. A disadvantage of this process, however, is that the obtained decorated substrates, using either a pre-coated substrate or a laminated substrate, do not have the same appearance as would be obtained using a printing process followed by coating with a high solids UV curable acrylate lacquer on an industrial scale. In particular, due to oxygen inhibition the use of a high solids UV-curable lacquer will result in decorated substrates with reduced mechanical and chemical properties. To prevent this, only industrial scale curing equipment must be used, which is neither economical nor safe or convenient in a small-scale environment.

SUMMARY OF THE INVENTION

The present invention relates to a process for the preparation of a decorated substrate, especially a proof on a packaging board, which provides a solution to the above-mentioned problems/disadvantages.

The process according to the present invention for the preparation of a decorated substrate comprises the steps of:

- applying a radiation-curable coating composition at least partially to a substrate and/or a radiation-permeable film,
- pressing the substrate and the radiation-permeable film together in such a way that the coating composition is sandwiched between them,
- 5 - curing the coating composition by irradiation through the film to obtain a coated substrate,
- removing the radiation-permeable film,
- covering the surface of the substrate with a sheet comprising a decoration which is to be transferred to the surface of the substrate, and
- 10 - heating the substrate and the sheet comprising the decoration to effect the transfer of the decoration from the sheet to the coated substrate.

The part of the process of the current invention in which the radiation-curable coating composition is transferred from the film to the substrate is sometimes referred to as a "film transfer process". The part of the process of the current invention in which the radiation-curable coating composition is coated onto the substrate, the film is placed over the coated substrate, and the substrate and the film are irradiated together to cure the coating is sometimes referred to as a "casting process". The part of the process of the current invention in which the decoration is transferred from the sheet comprising a decoration to the coated substrate is sometimes referred to as a "dye sublimation process".

One advantage of a process according to the present invention is that it can be performed on a small scale. For instance, it is economically viable to make a proof print on only one or two sheets. Such sheets can have a large size, but also a size of A2 or smaller. The process can be performed relatively easily in a relatively short time. As single proof sheets can be prepared, a series of trial proofs is not very waste producing.

Another advantage is that the process is not restricted to a specific substrate. For example, one may want to try the effects of thicker or thinner substrates, differently coloured substrates (for instance applying the current process to a pink carton board and to a yellow carton board), different types of substrates (for instance carton board versus paper). The process is also very suitable to decorate metallised boards, often used for high value packaging. Furthermore, with the process according to the present invention a high quality decoration can be applied to a cellulose-comprising substrate. This process is also very suitable to decorate polymer-comprising substrates.

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Further, the process does not require a highly specialised ink jet printer or industrial coating apparatus to provide the sheet comprising the decoration. Commonly available ink jet printers using a cold ink jet head, such as a piezo ink jet printer from Epson® or Mimaki®, are suitable. This means that the process can be performed at relatively low costs. The process is even suitable to be performed in a small-scale environment such as at home or in the office or a design studio.

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Another advantage is that with the current process it is possible to make high quality proofs, for example proofs for packaging. It is even possible to obtain proofs for packaging having the same or similar quality and the same or similar appearance as the packaging that would be obtained via production on an industrial scale.

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Preferably, the process of the present invention includes film transfer. More particularly, a highly preferred process for the preparation of a decorated substrate comprises the steps of:

- providing a radiation-permeable film that has been coated at least partially with a radiation-curable coating composition,

- pressing a substrate and the radiation-permeable film together in such a way that the coating composition is sandwiched between them,
- curing the coating composition by irradiation through the film to obtain a coated substrate,
- 5 - removing the radiation-permeable film,
- covering the surface of the substrate with a sheet comprising a decoration which is to be transferred to the surface of the substrate, and
- heating the substrate and the sheet comprising the decoration to effect the transfer of the decoration from the sheet to the coated substrate.

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The process of the present invention including film transfer is most suitable to make high quality proofs, for example proofs for packaging. Preferably, the proofs are made using a radiation-permeable film that has been coated with a water borne UV curable coating composition. Also preferred is a process to

15 make proofs using a radiation-permeable film that has been coated with a radiation-curable acrylate coating composition, i.e. a coating composition comprising binders having acrylate functionalities.

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In an even more preferred process, the radiation-permeable film used has been coated at least partially with a radiation-curable water borne acrylate coating composition from which water has been removed after application of this coating composition to the film. Using such a pre-coated film it is possible to obtain a decorated substrate, even a proof for packaging, with the same appearance as would be obtained when packaging is produced on an industrial

25 scale.

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When an easily deformed substrate, such as corrugated board, is coated and decorated by means of a process according to the present invention, it is most advantageous to perform the film transfer part of the process with a film having

30 a tacky and/or soft and/or hot melt coating layer. One of the advantages of

such a tacky and/or soft and/or hot melt coating layer being transferred to the substrate is that the heat and/or pressure applied during the film transfer part of the process can be reduced. During the film transfer part of the process the coating layer is (fully) cured to obtain a coating layer with adequate physical properties for dye sublimation and for the end use of the decorated substrate.

BACKGROUND INFORMATION

Background information on film transfer processes

10 The part of the process of the current invention in which the radiation-curable coating composition is transferred from the film to the substrate is sometimes referred to as a "film transfer process".

15 An example of a film transfer process is described in US 4,388,137. This patent publication discloses a process in which a coating composition is applied to a film before the film and a substrate are pressed together. Next, the coating composition is cured, followed by the film being stripped from the coated substrate.

20 In WO 80/01472 a film transfer process is disclosed in which a film is coated with a radiation-curable coating composition, optionally followed by heating the coated film to evaporate non-polymerisable solvents from the coating. Subsequently, the coated film is applied to a substrate. The coating sandwiched between the film and the substrate is cured by UV radiation, after
25 which the film is removed from the coated substrate.

In WO 03/074198 a film transfer process is disclosed in which a film is coated with a radiation-curable water borne coating composition, and water is removed from the coating. The coated film is applied to a substrate and the film and the
30 substrate are pressed together in such a way that the coating composition is

sandwiched between them. The coating composition is cured by irradiation through the film to obtain a coated substrate and the radiation-permeable film is removed.

5 Background information on casting processes

The part of the process of the current invention in which the radiation-curable coating composition is coated onto the substrate, the film is placed over the coated substrate, and the substrate and the film are irradiated together to cure the coating is sometimes referred to as a "casting process".

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In US 4,113,894 a process is disclosed in which a substrate is coated with a radiation-curable coating composition before a film is placed over the substrate. The substrate and the film are irradiated together to cure the coating, after which the film is peeled from the substrate.

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Background information on dye sublimation processes

The part of the process of the current invention in which the decoration is transferred from the sheet comprising a decoration to the coated substrate is sometimes referred to as a "dye sublimation process".

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A dye sublimation process is known, for example, from patent application WO 96/29208, which is directed to a process and the relevant apparatus for making decorated, extruded, profiled elements.

25 In EP 14 901 a process for transfer printing (dye sublimation) of a substrate that can withstand heating to above 220°C is disclosed. In this process, the substrate is coated, followed by curing of the coating, next the substrate is heated to a temperature above 220°C and brought into contact with a support imprinted with sublimatable dispersion dyes, after which the dispersion dyes
30 are transferred to the coated substrate.

In EP 60 107 a process for dye sublimation is disclosed in which a substrate (a continuous length of strip) is coated with a thermosetting material, for example an alkyd, polyester, polyurethane or epoxy paint. Immediately after curing at a temperature between 190 and 250°C the substrate is brought into contact with a continuous strip of printed material. At a temperature between 180 and 280°C the printing ink is transferred to the strip by sublimation.

In WO 98/08694 a dye sublimation process is disclosed in which coated metal, coated plastic, or another coated material is decorated by heating the coated substrate, followed by dye sublimation of a decoration from a strip-like flexible support to the coated substrate.

In WO 00/32420 a dye sublimation process is disclosed that is suitable for decorating heat-sensitive substrates. The substrate is coated with a radiation-curable coating composition, followed by curing with electromagnetic radiation having a wavelength shorter than 400 nm until the coating has a T_g between 50 and 130°C and a scar resistance at 200°C of at least 3N. Then, the surface is covered with a sheet comprising a decoration, followed by heating of the substrate and the decoration to a temperature from 180 to 220°C to effect the transfer of the decoration from the sheet to the substrate. This document is mainly directed to applying dye sublimation to coated substrates that have been coated with a powder coating.

DETAILED DESCRIPTION OF THE INVENTION

As described above, the process according to the present invention for the preparation of a decorated substrate comprises the steps of

- film transfer and/or casting, and
- dye sublimation.

Examples of substrates that can be decorated by a process according to the present invention are metal, flexible or hard plastic, ceramic, textile, or cellulose-comprising substrates. Preferably, the substrate is a flexible plastic material or a cellulose-comprising substrate.

Examples of flexible plastic substrates that can be decorated by the process according to the present invention are labels, flexible flooring, plastic furniture foils, and flexible polymer-comprising substrates, especially polymer-comprising films like polyester-comprising flexible films. Especially polymer-comprising material, e.g. polyester-comprising material that can withstand temperatures of up to 130°C or even up to 220 °C is suitable for decoration by the process according to the present invention.

Examples of cellulose-comprising substrates that can be decorated by the process according to the present invention are wooden panels, veneer, fibreboards, paper, paper furniture foils, linoleum, carton board, packaging board, typical corrugated packaging materials such as B-flute, and micro-flute corrugated materials. In particular, the current process is very suitable for decorating substrates suitable for making book jackets, substrates suitable for making posters, cardboard packaging material, and especially food packaging material.

If a porous cellulose-comprising substrate needs to be coated and decorated, the current process is advantageous, as the amount of coating material required for coating the substrate is reduced, since less uncured coating material penetrates into the pores. Likewise, a minimum amount of coating material serves to prepare a smooth coating surface on a porous substrate when using a film with a smooth surface configuration on the side facing the substrate.

The surface of the substrate may be prepared before the application of the coating. For instance, the substrate may be cleaned using a well-known method for cleaning a surface. Depending on the type of substrate, the surface can be prepared by, for example, brushing, washing, de-greasing, corona
5 treatment, flame treatment, (high energy) UV treatment, phosphating, chromating, and/or sanding. The application of a primer can be included in this treatment. However, this is optional, for example, to improve the properties of the substrate surface such as by hiding its defects or to improve adhesion.

10 Detailed description of the film transfer and/or casting part of the process

In the film transfer and/or casting part of the process of the present invention, use is made of a radiation-permeable film. A radiation-curable coating composition is applied at least partially to a substrate and/or the radiation-permeable film. The substrate and the film are pressed together in such a way
15 that the coating composition is sandwiched between them, after which the coating composition is cured by irradiation through the film to obtain a coated substrate, and then the radiation-permeable film is removed from the coated substrate.

20 During the part of the process in which the coating composition is sandwiched between the substrate and a radiation-permeable film and subsequently cured, the surface configuration on the side of the film facing the coating layer can be imparted to the cured coating. This enables the manufacture of coated substrates with, in principle, any decorative effect. For example, it is possible to
25 make a high gloss coated substrate by using a high gloss film. Low gloss substrates can be manufactured by using low gloss films, which has the advantage that it is not necessary to add a matting agent to the coating composition. It is also possible to manufacture textured coated substrates, for example substrates with a leather- or wood-like structured surface.

Since the radiation-curable coating is cured in the absence of oxygen, a durable cured coating with good mechanical properties, such as scratch, scuff, and abrasion resistance, can be obtained. Also adequate chemical properties, such as stain resistance to, e.g., coffee, tea, wine, and shoe polish and
5 resistance to solvents and acids can be obtained.

The film transfer and/or casting process step(s) is/are very suitable for coating porous substrates. The coating composition requires only a relatively small amount of photoinitiator(s). Also, relatively high amounts of pigment(s) can be
10 present in the coating composition. Further, it is possible to coat two opposite sides of the substrate at the same time. If a water borne composition is used, the uncured coating composition may be allowed to re-flow after application and drying.

15 The coating sandwiched between the substrate and the radiation-permeable film is cured by irradiation through the film. If the coating is cured by electron beam, the film material is not critical, since penetration by the electrons can be assured by selecting a sufficiently high voltage. Consequently, in the case of cure by electron beam, the film can comprise, e.g., aluminium foil or an
20 aluminised layer, for instance an aluminised polyester film, plastic or paper. If the coating is cured by UV radiation, the film has to be sufficiently transparent to the UV radiation for the coating to be cured. Consequently, in the case of cure by UV radiation, the film may comprise quartz glass or a glass plate or a polymeric material, for example polyvinyl chloride, acetate, polyethylene,
25 polyester, an acrylic polymer, polyethylene naphthalate, polyethylene terephthalate, oriented polypropylene (OPP), polymethyl (meth)acrylate, or polycarbonate. The film may be rigid or flexible, and may be of any desired thickness, as long as it permits sufficient transmission of the radiation to result in a sufficient cure of the coating composition. Preferably, the film is non-
30 porous.

Ideally, a coating composition is used that shows good release properties from the transfer or casting film. When there is good film release, the film can be removed from the coated substrate with the coating remaining virtually undamaged. In order to ensure good release properties, the film may have
5 been treated before it is coated. The type of treatment of the film should be adjusted to the type of film and to the type of coating composition used in the process according to the present invention. The film may for instance be coated with a release coating. Such a release coating may contain silicone or a fluoropolymer such as polytetrafluoroethylene as release agent. US 5,037,668
10 for instance describes a silicone-free fluoropolymer comprising an acrylate-type release coating.

Within the framework of the present invention, a radiation-curable coating composition is a coating composition which is cured using electromagnetic
15 radiation having a wavelength $\lambda \leq 500$ nm or electron beam radiation. An example of electromagnetic radiation having a wavelength $\lambda \leq 500$ nm is UV radiation.

Radiation sources which may be used are those customary for electron beam
20 and UV. For example, UV sources such as high-, medium-, and low-pressure mercury lamps may be used. Also, for instance, gallium and other doped lamps may be used, especially for pigmented coatings. It is also possible to cure the composition by means of short light pulses.

25 In one embodiment of the present invention, especially when curing clear coats, the coating composition is cured using low-energy UV sources, i.e. by so-called daylight cure. The intensity of these lamps is lower than that of the aforementioned UV sources. Low-energy UV sources hardly emit UV C; they predominantly emit UV A, and radiation with a wavelength at the border of UV
30 B and UV A. Preferably, the coating composition is cured by radiation having a wavelength of $300 \text{ nm} \leq \lambda \leq 500 \text{ nm}$, more preferably $300 \text{ nm} \leq \lambda \leq 450 \text{ nm}$. For

some compositions low-energy UV sources emitting radiation having a wavelength of $370 \text{ nm} \leq \lambda \leq 450 \text{ nm}$ can be preferred. Commercially available daylight cure lamps are for instance solarium-type lamps and specific fluorescent lamps such as TL03, TL05 or TL09 lamps (ex Philips) and BLB UV
5 lamps (ex CLE Design).

Additionally or alternatively, the UV radiation is provided by at least one UV light emitting diode (UV-LED). The use of UV-LEDs in a process according to the present invention has several advantages. UV-LEDs allow instant on/off
10 switching of the UV radiation source. Furthermore, the service life of UV-LEDs generally is significantly longer than the service life of conventional UV sources, for example up to 50,000 hours for a UV-LED compared to about 1,000 hours for conventional UV lamps. Further, UV-LEDs generally have a narrow wavelength distribution and offer the possibility to customize the peak
15 wavelength. UV-LEDs are characterized by an efficient conversion of electric energy to UV radiation. This causes low heat generation and allows the omission of cooling elements or the use of only small ones. Another advantage of UV-LEDs is their relatively low working voltage compared to the higher voltages needed for normal UV lamps.

20

Individual UV-LEDs are often of a rather small size and emit a comparatively low level of UV radiation. Consequently, if such UV-LEDs are used as a source of actinic radiation, it is preferred that a plurality of UV-LEDs is grouped together in a so-called UV-LED array. The number of individual UV-LEDs in a
25 UV-LED array can be customized depending on the required size, shape, and UV radiation output required. A UV-LED array can comprise several hundreds or even thousands of individual UV-LEDs. The shape of the at least one actinic radiation outlet is not critical. It may be of any suitable shape.

30 In principle, any radiation-curable material or mixtures of materials can be used in the film transfer and/or casting process step in a process for the preparation

of a decorated substrate according to the present invention. The coating composition may, for instance, be a radiation-curable hot melt, a high solids radiation-curable coating composition, or a water borne radiation-curable coating composition.

5

Preferably, the coating composition is a water borne coating composition. The resins are present in amount of 20 to 95 wt.%, preferably 30 to 55 wt.%, calculated on the total weight of the coating composition. Water is present in an amount of 5 to 80 wt.%, preferably 45 to 70 wt.%, calculated on the total weight

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of the coating composition.

Preferably, a radiation-curable water borne coating composition comprising a radiation-curable dispersion or a mixture of radiation-curable dispersions is used. This gives very good results when used in the film transfer and/or casting

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process step. For example, this coating shows a good release of the film from the coated substrate after curing of the coating composition. Further, such a coating composition can be used on a wide variety of substrates and in combination with a wide variety of films, including treated and untreated films.

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Within the framework of the present invention, a water borne coating composition is a coating composition which comprises at least 5 wt.% water, calculated on the total weight of the coating composition. Water-comprising coating compositions having a high solids content are included; these can be either heated or diluted with water before application. Such compositions are

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sometimes called water-dilutable coating compositions. Within the framework of the present invention, a dispersion or a dispersed system is an apparently homogeneous substance which consists of a microscopically heterogeneous mixture of two or more finely divided phases (solid, liquid or gaseous).

30

In view of present-day environmental concerns, the use of a water borne composition is preferred, as it comprises a low level of volatile organic

compounds or no volatile organic compounds at all. Preferably, the composition comprises < 450 g/l, more preferably < 350 g/l, even more preferably < 250 g/l, highly preferably < 100 grams of volatile organic compounds per litre of the composition. Ideally, the composition comprises no volatile organic compounds.

It was found that water borne dispersions are especially suitable in a process according to the present invention, in particular when a coated radiation-permeable film is used. This is because the viscosity of dispersions is independent of the molecular weight of the polymers that are dispersed. Thus it is much easier to use coating compositions based on water borne dispersions than solvent borne coating compositions to prepare a film comprising high-molecular weight polymers with sufficient film thickness after removal of the carrier liquid. And compared with solvent borne and high solids coating compositions it is much easier to prepare a low-viscosity composition comprising relatively high-molecular weight polymers. Additionally, the viscosity and rheology of a water borne dispersion can be adjusted with only small amounts of thickener and/or rheology modifier.

Furthermore, the water borne coating composition can be adjusted with respect to the tackiness of a coating layer after drying and before radiation curing. For some applications it is advantageous to make use of an uncured water borne composition that can be dried to a tacky film. For other applications it is advantageous to use an uncured water borne coating composition that can be dried to a non-tacky film. For example, the film used in the process according to the present invention may have been pre-coated with a non-tacky film. Such a pre-coated substrate and/or film can be stored under suitable storing conditions for use in due time. When a water borne dispersion is dried to a non-tacky film, it may not be re-dispersable. Thus, the dried dispersion may show less softening if it comprises a small amount of water or certain weak solvents, or if it is moistened due to the environmental conditions under which it is stored.

The water borne composition preferably used in the process according to the present invention is radiation-curable after application and evaporation of solvents and/or water. Combinations of IR and UV radiation are also suitable for curing the water borne composition.

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Water borne coating compositions comprising water borne radiation-curable binders based on urethane, polyester, acrylic or epoxy backbones were found to be very suitable for use in the process according to the present invention. Preferably, these water borne radiation-curable binders are acrylate binders, i.e. binders having acrylate functionalities. Suitable coating compositions with which the radiation-permeable film can be coated are described in WO 03/074198 and in EP 0 888 885.

Preferably, the water borne coating composition comprises a radiation-curable unsaturated polyurethane resin, for instance polyurethane acrylate, and/or an unsaturated polyurethane/polyacrylate copolymer. Also an unsaturated modified polyurethane, such as a polyester modified polyurethane, and/or an unsaturated modified polyurethane/polyacrylate copolymer are very suitable. Also preferred are coating compositions comprising a radiation-curable unsaturated polyester, for instance polyester acrylate, an unsaturated epoxy, for instance epoxy acrylate, an unsaturated acrylic, and/or an unsaturated polyether. An unsaturated polyester may be used together with for instance an epoxy acrylate or an unsaturated polyurethane resin. Either dispersions of the above-mentioned resins or water-dilutable resins of the above-mentioned type may be used.

Most preferably, the water borne coating composition comprises a radiation-curable unsaturated polyurethane dispersion, for instance a polyurethane acrylate dispersion, and/or an unsaturated polyurethane/polyacrylate copolymer dispersion.

Examples of polyurethane and polyurethane/acrylic disperions are: Halwedrol UV 14, Halwedrol UV 20, Halwedrol UV 140, Halwedrol UV 160, Halwedrol UV-TN 6306, Halwedrol UV-TN 6711, Halwedrol UV-TN 5960, Halwedrol UV 55, Halwedrol UV 65, Halwedrol UV 6731, Halwedrol UV 6732, Halwedrol UV 6670, Halwedrol UV-TN 6957, Halwedrol UV-TN 6958, Halwedrol UV-TN 7143, Halwedrol UV-TN 7157, Halwedrol UV-TN 7200 (all ex Huettenes-Albertus), Laromer LR 8949, Laromer LR 8983, Laromer LR 9005 (all ex BASF), Neorad R 440, Neorad R 441, Neorad R 445, Neorad R 450 (all ex Neoresins), Viaktin VTE 6155w, Viaktin VTE 6165w, Viaktin VTE 6169w, Viaktin VTE 5972w (all ex Solutia), Ucecoat DW 7770, Ucecoat DW 7773, Ucecoat DW 7825, Ucecoat DW7900 (all ex UCB), Akzo Nobel EPC 6896, Akzo Nobel Actilane 640 (ex Akzo Nobel), Syntholux DRB 1014-W, Syntholux DRB 1114-W, Syntholux DRB 1192-W, Syntholux DRB 1199-W (all ex Synthopol Chemie), Lux 101, Lux 102, Lux 241, Lux 280, Lux 308, Lux 338, Lux 352, Lux 399, Lux VP 285 (all ex Alberdingk Boley).

Examples of polyester acrylic dispersions are: Laromer PE 55 W, Laromer PE 55 WN, Laromer PE 22 (all ex BASF) and Viaktin VTE 6166w (ex Solutia). An example of an epoxy acrylic dispersion is Jaegerlux 3150W (ex Eastman Jaeger). Examples of acrylic dispersions are Primal E-3120 (ex Rohm & Haas), Lux 384 and Lux 584 (both ex Alberdingk Boley). An example of a water-dilutable urethane acrylic is Halwedrol UV 95 (ex Huettenes-Albertus). An example of a water-dilutable polyester acrylic is Syncryl 2000W (ex Galstaff). An example of a water-dilutable polyether acrylic is Syntholux DRB1077w (ex Synthopol Chemie). An example of a water-dilutable epoxy acrylic is Laromer LR 8765 (ex BASF).

Very good results have been obtained with coating compositions comprising 60-80 wt.%, calculated on the total weight of the coating composition, of a water borne radiation-curable, optionally modified polyurethane/polyacrylate copolymer dispersion having a solids content of about 40%, calculated on the

total weight of the dispersion, and 20-40 wt.%, calculated on the total weight of the coating composition, of a water borne radiation-curable unsaturated polyurethane dispersion having a solids content of about 40%, calculated on the total weight of the dispersion.

5

For pressure-sensitive substrates, such as corrugated board, very good results have been obtained with coating compositions comprising 60-95 wt%, calculated on the total weight of the coating composition, of a water borne radiation-curable unsaturated polyurethane dispersion having a solids content
10 of about 40%, calculated on the total weight of the dispersion.

The water borne coating composition may contain reactive diluents, for instance in an amount of 0-50 wt.%, and typically is 5-30 wt.%, calculated on the total weight of the coating composition. Preferably, the water borne coating
15 composition comprises less than 15%, more preferably less than 10%, most preferably less than 5% reactive diluents. Ideally, the water borne coating composition comprises no reactive diluents.

In view of present-day environmental concerns, a very good alternative is the
20 use of radiation-curable hot melt compositions, as these comprise a low level of volatile organic compounds or no volatile organic compounds at all. Additionally, hot melt compositions comprise a low level of reactive diluent or no reactive diluent at all.

25 In a film transfer process or a casting process, the use of a radiation-curable hot melt composition that emits substantially no volatiles during drying, cooling or curing has an additional advantage in that the coating does not have to be dried after application. Consequently, after applying the coating to the film and/or the substrate, the film and the substrate can be pressed together
30 (almost) directly. This is advantageous because it implies lower energy costs and a reduced processing time.

Normally amines, such as triethanolamine or acrylated amines, are added to radiation-curable hot melt coating compositions. These amines can act as a synergist for the curing reaction. Sometimes amines are added when a high gloss surface needs to be obtained, as amines increase the surface curing. A disadvantage of amines, however, is that they cause yellowing. It has now been found that an additional advantage of the current process is that a high gloss coating can be prepared using less or even no amines. Preferably, the hot melt composition comprises less than 3 wt.%, more preferably less than 2 wt.%, even more preferably less than 1 wt.% of such amines, based on the total weight of the uncured hot melt composition.

In principle, any radiation-curable material or mixtures of materials can be used in the hot melt composition used in the film transfer and/or casting step in the process for the preparation of a decorated substrate according to the present invention, as long as the viscosity of the hot melt composition is or can be adjusted to a range of from 15 to 10,000 mPa.s in the temperature range of from 40 to 150°C. Radiation-curable resins can be present in an amount of 20 to 100 wt.% of the composition. Preferably, the resin is present in an amount of 30 to 95 wt.%, more preferred i an amount of 40 to 95 wt.%.

Polyester acrylate resins were found to be very suitable for use in the hot melt coating composition in the process according to the present invention. Examples of suitable commercially available polyester acrylate resins are: Craynor® UVP-215, Craynor® UVP-220 (both ex Cray Valley), Genomer® 3302, Genomer® 3316 (both ex Rahn), Laromer® PE 44F (ex BASF), Ebecryl® 800, Ebecryl® 810 (both ex UCB), Viaktin® 5979, Viaktin® VTE 5969, and Viaktin® 6164 (100%) (all ex Vianova). Very promising results were found when the composition comprised at least 40 wt.% of a polyester acrylate resin.

Epoxy acrylate resins can also be used in the hot melt coating composition in the process according to the present invention. Examples of commercially

available epoxy acrylate resins are: Craynor[®] UVE-107 (100%), Craynor[®] UVE-130, Craynor[®] UVE-151, CN[®] 104 (all ex Cray Valley), Photocryl[®] 201 (ex PC resins), Genomer[®] 2254, Genomer[®] 2258, Genomer[®] 2260, Genomer[®] 2263 (all ex Rahn), UVP[®] 6000 (ex Polymer technologies), and Ebecryl[®] 3500 (ex UCB).

Polyether acrylate resins can also be used in the hot melt coating composition in the process according to the present invention. Examples of commercially available polyether acrylate resins are: Genomer[®] 3456 (ex Rahn), Laromer[®] PO33F (ex BASF), Viaktin[®] 5968, Viaktin[®] 5978, and Viaktin[®] VTE 6154 (all ex Vianova).

Urethane acrylate resins can also be used in the hot melt coating composition in the process according to the present invention. Examples of commercially available urethane acrylate resins are: CN[®] 934, CN[®] 976, CN[®] 981 (all ex Cray Valley), Ebecryl[®] 210, Ebecryl[®] 2000, Ebecryl[®] 8800 (all ex UCB), Genomer[®] 4258, Genomer[®] 4652, and Genomer[®] 4675 (all ex Rahn).

Other examples of radiation-curable resins that can be used in the hot melt composition in the process according to the present invention are cationic UV-curable resins, for instance cycloaliphatic epoxide resins such as Uvacure[®] 1500, Uvacure[®] 1501, Uvacure[®] 1502, Uvacure[®] 1530, Uvacure[®] 1531, Uvacure[®] 1532, Uvacure[®] 1533, and Uvacure[®] 1534 (all ex UCB Chemicals), Cyracure[®] UVR-6100, Cyracure[®] UVR-6105, Cyracure[®] UVR-6110, and Cyracure[®] UVR-6128, (all ex Union Carbide), or SarCat[®] K126 (ex Sartomer), acrylate modified cycloaliphatic epoxides, caprolactone based resins such as SR[®] 495 (= caprolactone acrylate, ex Sartomer), Tone[®] 0201, Tone[®] 0301, Tone[®] 0305, Tone[®] 0310, (all caprolactone triols, ex Union Carbide), aliphatic urethane divinyl ether, aromatic vinyl ether oligomer, bis-maleimide, diglycidyl ether of bisphenol A or other glycols, hydroxy-functional acrylic monomer, hydroxy-functional epoxide resin, epoxidised linseed oil, epoxidised polybutadiene, glycidyl ester or partially acrylated bisphenol A epoxy resin, or trimethylol propane oxetane (UVR[®] 6000, ex Union Carbide).

Other radiation-curable compounds that are suitable for use in the hot melt-containing composition in the process according to the present invention are, e.g., vinyl ether-containing compounds, unsaturated polyester resins, acrylated
5 polyetherpolyol compounds, (meth)acrylated epoxidised oils, (meth)acrylated hyperbranched polyesters, silicon acrylates, maleimide-functional compounds, unsaturated imide resins, compounds suitable for use in photo-induced cationic curing, or mixtures thereof.

10 In the radiation-curable coating composition also use may be made of a radiation-curable mixture of (a) photo-induced radical curing resin(s) and (b) photo-induced cationic curing resin(s). Such systems are sometimes called hybrid systems and may comprise, for example, acrylic oligomers as photo-
15 induced radical curing resins, vinyl ethers as photo-induced cationic curing resins, and radical and cationic photoinitiators. In principle, all possible combinations of photo-induced radical curing resins and photo-induced cationic curing resins can be used in such hybrid systems.

In addition to the compounds mentioned above, the radiation-curable hot melt
20 composition used in the process according to the present invention can also comprise volatile organic compounds or reactive diluents, for example, to lower the viscosity of the composition. However, the amount of such compounds should be as low as possible. The composition can also contain up to 5 wt.% of water, calculated on the total weight of the coating composition.

25

The amount of volatile organic compounds in the hot melt composition normally is below 450 g/l and may for instance be between 0 and 40 wt.%. Preferably, the hot melt composition comprises less than 15%, more preferably less than 10%, most preferably less than 5% volatile organic compounds, calculated on
30 the total weight of the coating composition. Ideally, the hot melt composition comprises no volatile organic compounds.

The hot melt may contain reactive diluents, for instance in an amount of 0-50 wt.%, and typically is 5-30 wt.%, calculated on the total weight of the coating composition. Preferably, the hot melt composition comprises less than 15%,
5 more preferably less than 10%, most preferably less than 5% reactive diluents. Ideally, the hot melt composition comprises no reactive diluents.

Preferably, the hot melt coating composition comprises a mixture of a polyester acrylate and a urethane acrylate.

10

In principle, any radiation-curable materials or mixtures of materials can be used in a high solids radiation-curable coating composition used in the film transfer and/or casting process step in the process for the preparation of a decorated substrate according to the present invention, as long as the viscosity
15 of the coating composition is in a range of from 15 to 10,000 mPa.s at ambient temperature. By a high solids coating composition is meant a coating composition comprising less than 40 wt.% solvents on the total coating composition, preferably less than 30 wt%, more preferably less than 20 wt.%; most preferably, no solvents are present.

20

Suitable radiation-curable resins are those listed above for hot melt compositions. However, to be high solids the coating composition has to comprise a high amount of reactive diluent, for instance an amount of 30-100 wt.%, and typical is 40-80 wt.%, calculated on the total weight of the coating
25 composition.

Compounds suitable as reactive diluents in high solids coating compositions generally are ethylenically unsaturated compounds. The reactive diluent preferably has a molecular weight of from about 80 to 800, more preferably
30 about 100 to about 400. Compounds meeting the molecular weight requirement are suitable for lowering the viscosity of the coating composition.

Examples of monofunctional reactive diluents include the esters of acrylic and methacrylic acid such as octyl (meth)acrylate, isooctyl (meth)acrylate, nonyl (meth)acrylate, decyl (meth)acrylate, isodecyl (meth)acrylate, lauryl (meth)acrylate, stearyl (meth)acrylate, 2-(2-ethoxyethoxy)ethyl (meth)acrylate, and 2-phenoxyethyl (meth)acrylate.

Preferred reactive diluents are those having more than one radiation-sensitive bond. Such compounds ordinarily are the esters of acrylic or methacrylic acid and a polyhydric alcohol, such as di(meth)acrylates, tri(meth)acrylates, tetra(meth)acrylates, and hexa(meth)acrylates. Further suitable reactive diluents are reactive diluents comprising polyethylene oxide. Examples of di(meth)acrylates include tripropylene glycol di(meth)acrylate, dipropylene glycol di(meth)acrylate, 1,6-hexane diol di(meth)acrylate, propoxylated neopentyl glycol di(meth)acrylate, polyethylene glycol di(meth)acrylate, and actilane 423. Examples of tri(meth)acrylates include ethoxylated trimethylolpropane tri(meth)acrylate, propoxylated glyceryl tri(meth)acrylate, trimethylolpropane tri(meth)acrylate, and pentaerythritol tri(meth)acrylate. Examples of tetra(meth)acrylates include pentaerythritol tetra(meth)acrylate, ethoxylated pentaerythritol tetra(meth)acrylate, propoxylated pentaerythritol tetra(meth)acrylate, and ditrimethylolpropane tetra(meth)acrylate. An example of hexa(meth)acrylates is dipentaerythritol hexa(meth)acrylate.

Preferably, the high solids radiation-curable coating composition comprises an epoxy acrylate and diacrylate and triacrylate reactive diluents.

Also, non-radiation-curable polymers can be incorporated into the coating compositions used in the process of the present invention. These polymers may be used to modify the viscosity, tack, adhesion, or film forming properties of the composition and/or to modify the general film properties of the cured coating.

Further, the composition can comprise a photoinitiator or a mixture of photoinitiators. Examples of suitable photoinitiators that can be used in the radiation-curable composition according to the present invention are benzoin, benzoin
5 ethers, α,α -dialkoxyacetophenones, α -hydroxyalkyl phenones, α -aminoalkyl phenones, acylphosphine oxides, methylbenzoyl formate, benzophenone, thioxanthenes, 1,2-diketones, and mixtures thereof. Commercially available examples are: Esacure[®] KIP 100F and Esacure[®] KIP EM (ex Lamberti), Genocure[®] CQ, Genocure[®] CQ SE, Genocure[®] EHA, Quantacure[®] BMS,
10 Quantacure[®] EPD (ex Rahn), Irgacure[®] 184, Irgacure[®] 651, Irgacure[®] 500, Irgacure[®] 369, Irgacure[®] 819, and Darocure[®] 2959 (ex Ciba), Speedcure[®] ITX, Speedcure[®] BKL, Speedcure[®] BMDS, Speedcure[®] PBZ, Speedcure[®] BEDB, and Speedcure[®] DETX (ex Lambson), Genocure[®] MBF (ex Rahn), and Lucirin[®] TPO (ex BASF).

15

However, the presence of a photoinitiator is not necessary. In general, when electron beam radiation is used to cure the composition, it is not necessary to add a photoinitiator. When UV radiation is used, in general a photoinitiator is added. Although the total amount of photoinitiator in the composition is not
20 critical, it should be sufficient to achieve acceptable curing of the coating when it is irradiated. However, the amount should not be so large that it affects the properties of the cured composition in a negative way. In general, the composition should comprise between 0 and 10 wt.% of photoinitiator, preferably from 0.5 to 5 wt.%, more preferably from 0.1 to 2 wt.%, calculated on
25 the total weight of the composition. As a rule, compared to the amount needed when the coating is applied to a substrate and subsequently cured, in the process according to the present invention a smaller amount of photoinitiator can be used to achieve acceptable curing. This effect might be due to the film on top of the coating that prevents the initiated radicals from being caught by
30 oxygen in the air.

When the coating composition is cured by a low-energy UV source, it is preferred to add an aminobenzoate co-initiator to the coating composition. The aminobenzoate co-initiator preferably absorbs radiation having a wavelength between 275 and 350 nm. Preferably, the aminobenzoate co-initiator is liquid at
5 room temperature.

The composition can also contain one or more fillers or additives. The fillers can be any fillers known to those skilled in the art, e.g., barium sulphate, calcium sulphate, calcium carbonate, silicas or silicates (such as talc, feldspar,
10 and china clay). Additives such as aluminium oxide, silicon carbide, for instance carborundum, ceramic particles, glass particles, stabilisers, dispersants, antioxidants, levelling agents, anti-settling agents, anti-static agents, matting agents, rheology modifiers, surface-active agents, amine synergists, waxes, or adhesion promoters can also be added. In general, the
15 coating composition used in the process according to the present invention comprises 0 to 40 wt.%, preferably 10 to 30 wt% of fillers and/or additives, calculated on the total weight of the coating composition.

The coating composition used in the process according to the present invention
20 can also contain one or more pigments. In principle, all pigments known to those skilled in the art can be used. However, care should be taken that the pigment does not show a too high absorption of the radiation used to cure the composition. In general, the coating composition comprises 0 to 40 wt.%, preferably 10-30 wt.% of pigment, calculated on the total weight of the coating
25 composition. Because the film on top of the coating prevents the initiated radicals from being caught by oxygen in the air, acceptable curing of a pigmented coating can be reached even when the coating comprises a relatively large amount of pigments.

30 In addition to the compounds mentioned above, the radiation-curable composition used in the process according to the present invention can also

comprise monomers or volatile organic compounds. However, the amount of such compounds should be as low as possible.

The coating composition, which preferably is a water borne or a hot melt
5 coating composition, can generally be prepared by mixing the components using any suitable technique. Normally, the components are mixed until a homogeneous mixture is obtained. The mixing can be done in air. Care should be taken to ensure that during the mixing of the components the shear stress and/or the temperature does not become so high as to cause degradation or
10 flocculation of any of the components. Needless to say, the mixing should be performed in the absence of any radiation that could initiate curing of the coating.

Equipment known to those skilled in the art can be used to apply the coating
15 composition to the radiation-permeable film and/or to the substrate, e.g. a roller coater, a bead coater, a spray gun or a curtain coater. Also suitable contact and non-contact printing techniques, as well as deposition coating techniques, can be used to apply these compositions.

20 In the case of a water borne coating composition, water is removed from the coating after it has been applied to the film and/or the substrate. For instance, the coating may be dried, either naturally or forced, to obtain a pre-coated film.

Normally, the application temperature of a hot melt coating composition in the
25 current invention is in the range of from 40 to 150°C. The preferred temperature range for applying the hot melt coating composition to heat-sensitive substrates or films is from 40 to 100°C, more preferably from 50 to 90°C. In a process according to the present invention, preference is given to the use of hot melt compositions that have a viscosity in the range of from 15 to
30 10,000 mPa.s at the application temperature (40 to 150°C). Optimum coating

properties are obtained if the viscosity of the composition is in the range of from 15 to 4,000 mPa.s, more preferably from 15 to 3,000 mPa.s, in the above-indicated application temperature ranges.

The viscosity of the composition at the application temperature should be
5 selected in accordance with the way the composition is applied to the film and/or the substrate. For example, for spray application the viscosity should be lower than for roller application.

Before or during application of a hot melt coating to the substrate and/or to the
10 film, the coating composition is heated to the application temperature. Equipment known to those skilled in the art can be used to heat and apply the coating, e.g. heated rollers, a heated spraygun or a heated curtain coater. It is also possible to heat the composition in a storage tank or vessel and/or to heat the composition in the hose that conveys it to an application apparatus and/or
15 in the application apparatus itself. The generation of hot-spots should be avoided by using suitable agitation. Heating can be performed by using direct or indirect heating, e.g., by heating elements, heated jackets, or using infrared radiation.

20 After a hot melt coating composition is applied to the substrate and/or the film, it is optionally cooled and/or dried, either naturally or forced. This process can also be used to prepare a pre-coated film.

It was found that by using hot melt compositions with viscosities within the
25 ranges mentioned above, excellent flow and levelling of the coating material are obtained. Further, it was found that the thickness of the coated film is easy to control. A coating film with a thickness of 5 μm can be applied without any special precautions being taken. On the other hand, it is also possible to apply a film with a thickness of 250 μm in one layer without sagging and with optimum
30 levelling properties.

In a next step, the substrate and the film are pressed together in such a way that the coating is sandwiched between them. Alternatively, the whole process starts with pressing a pre-coated film and a substrate together in such a way that the coating is sandwiched between them. The surface of the coating sandwiched between the substrate and the film may conform to the surface configuration on the side of the film facing the coating layer. It is also possible to emboss a flexible film in order to impart a pattern to the coating. Alternatively, the embossing can be done after the coating is sandwiched between the film and the substrate.

10

Preferably, the process of the present invention includes film transfer. More preferably, film transfer is performed using a pre-coated film. In an even more preferred embodiment, the pre-coated film is given a specific shape before the substrate is coated. For example, parts of the pre-coated film can be cut off or cut out using a cutting machine, for instance a tangentially controlled X-Y plotter equipped with one or more knives, e.g. Creator[®] ex Gencia. By using a film that does not cover the complete substrate, a coated substrate having uncoated areas can be prepared. Using the above-mentioned Creator[®] ex Gencia, the coated area can be in register.

20

It is also possible to prepare a coated substrate with uncoated areas by covering part of the substrate before the coating is transferred from the film to the substrate or before applying the coating on the substrate by casting. This can be done using any masking technique.

25

Uncoated areas on a coated substrate may be useful when, at a later stage, materials with a better attachment to the uncoated substrate than to the coating layer are applied. In a preferred embodiment, in the film transfer part of the process according to the present invention, a packaging material is coated with a pre-coated film with parts cut off or cut out, which results in uncoated areas. At a later stage, glue, or a bar code or a stamp, for instance with a date or the

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name of a shop, can be applied to these uncoated areas. For example, when making mock-up boxes, double-sided tape or glue is used to hold the box in its correct shape.

- 5 Alternatively, a coated substrate having high gloss and low gloss areas can be provided. This may be done by cutting up a high gloss film with, e.g., the above-mentioned Creator[®] ex Gencia. Low gloss film is then cut in the shape of the areas which have been removed from the high gloss film. Subsequently, the substrate is coated and the high gloss-low gloss film and the coated substrate
10 are pressed together in such a way that the coating is sandwiched between them. It is also possible to prepare a glossy substrate with matt areas by covering part of the coated substrate with low gloss film before the high gloss film and the coated substrate are pressed together in such a way that the coating is sandwiched between them. This can be done using any masking
15 technique. It is also possible to apply more than one coating layer to obtain a substrate with low gloss and high gloss areas. For example, during multilayer application, it is possible to first apply a high gloss coating layer by means of a high gloss film to the full surface of the substrate, followed by the application of a further coating which is applied using a low gloss film from which parts have
20 been cut out.

- Before, during and/or after the substrate and the film are pressed together, the film and/or the substrate can be heated in order to soften the coating until it will flow again. Such re-flow facilitates the surface configuration on the side of the
25 film facing the coating layer being imparted to said coating layer. Especially when a water borne coating composition is used, re-flow is preferred. The heating temperature preferably is between 40 and 100°C, more preferably between 40 and 90°C, even more preferably between 50 and 80°C. Preferably, the peak substrate temperature during the time that the substrate and the film
30 are pressed together is between 40 and 100°C, more preferably between 40 and 90°C, even more preferably between 50 and 80°C. Most preferably, the

substrate, the sandwiched coating layer, and the film all arrive at an elevated temperature, with a peak temperature between 40 and 100°C, more preferably between 40 and 90°C, even more preferably between 50 and 80°C. Preferably, a pressure is applied to the softened coating layer in order to force the softened coating to flow. For instance, the substrate and the film can be pressed together using conventional hot pressing means, such as a pair of heated calender rolls. This way the coating layer will re-flow.

In another embodiment, especially when the film is pre-coated with a tacky coating, e.g. a tacky coating made from a water borne composition or a tacky coating made from a hot melt composition, the substrate and the film can be pressed together using conventional pressing means, such as a pair of calendar rolls. Since re-flow is not necessary in this case, the pressing means do not have to be heated.

In a next step, the coating sandwiched between the substrate and the film is cured by irradiation through the film, followed by removal of the film from the coated substrate.

It is possible to coat two opposite sides of the substrate at the same time by pressing a film onto the substrate on either side. After curing of the two coating layers by irradiation through both films, the films are removed from the double-coated substrate.

In these film transfer or casting processes the film may be in the form of separate sheets or plates. Preferably, the film is flexible. The flexible film may constitute a reel of off-line pre-coated film when it is used for film transfer or a reel of uncoated film when it is used in casting. Alternatively, the film is left in place on the coated substrate to offer process protection until it is removed before dye sublimation takes place.

In these film transfer or casting processes the substrate may be in the form of separate sheets or plates. Alternatively, the substrate may be a flexible film or paper. In that case the substrate may be de-reeled before entering the film transfer or casting process and re-reeled after being coated.

5

With the process according to the present invention, it is possible to apply one or more coating layers to a substrate. The process is particularly useful for applying a top coat to an optionally coated substrate. In principle, there is no restriction as to the coating composition(s) that may be applied to a substrate, as long as there is good adhesion between the coating on top of the substrate and the (cured) composition. The same type(s) of coating composition(s) can be used for the optional pre-coating layer(s) as for the top coat layer, although the composition of this/these coating layer(s) and of the top coating composition need not be the same. The pre-coating layer(s) can be applied to the substrate by conventional means, such as by curtain coater, spray nozzle, roller coater, or flow coater. Also suitable contact and non-contact printing techniques, as well as deposition coating techniques, can be used to apply these compositions.

20 The coating has to be fully cured before the decoration is transferred to the substrate.

Notwithstanding the need to perform all process steps to be able to obtain a decorated substrate with the above-mentioned improvements, an advantage of the present process is the possibility of "in-between" storage. For example, the coated film can be stored before film transfer of the coating onto the substrate. Also, the coated substrate after being cured can be stored with or without the film in place. Storage does not affect the properties of the coated film or coated substrate.

30

Detailed description of the dye sublimation part of the process

After the coating has been applied to the substrate in one or more cycles, the dye sublimation part of the process of the present invention can be performed. In the dye sublimation part of the process, the coated surface of the substrate is covered with a sheet comprising a decoration which is to be transferred to
5 said surface, and the substrate and the sheet comprising the decoration are heated to effect the transfer of the decoration from the sheet to the substrate.

Preferably, the temperature during the transfer of the decoration to the coating is from 130 to 220°C. That is, the temperature of the surface of the substrate
10 and the sheet comprising the decoration during the transfer of the decoration to the substrate is from 130 to 220°C, preferably 150 to 200°C.

It was found that for a proper transfer of the decoration from the sheet to the coated substrate, the hardness of the coating at the temperature at which the
15 decoration is transferred to the substrate is important. If the hardness is too low, the release of the sheet from the substrate after the transfer of the decoration will be hampered. If the hardness is too high, an incomplete transfer of the decoration will be observed (or a longer time will be needed for the complete transfer of the decoration) and also the adhesion between the coating
20 and the surface will be lower.

The sheet comprising the decoration can be, e.g., a paper sheet provided with the decoration. For these decorations so-called "sublimatic pigments" or "dyestuffs" or "sublimatable dispersion dyes" are used. These decorated sheets
25 are well-known in the art.

Optionally, a (clear) top coat can be applied to the substrate after the transfer of the decoration. This can be done to obtain special decorative effects and/or to improve the properties of the decorated surface.

The invention will be elucidated with reference to the following examples. These are intended to illustrate the invention but are not to be construed as limiting in any manner the scope thereof.

Examples

The percentages in the coating compositions mentioned below are weight percentages based on the total weight of the composition.

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Example 1

A radiation-curable water borne coating composition having a solids content of 30-50% and a viscosity of 70-700 mPa.s at 21°C was prepared:

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Water borne radiation-curable polyurethane/polyacrylate copolymer dispersion (40% solids content)	65.1%
Water borne radiation-curable unsaturated polyurethane dispersion (40% solids content)	28.2%
Slip and flow additives	0.4%
Aminobenzoate co-initiator	3.0%
Photoinitiators	3.0%
Thickener	0.3%

20

The coating composition was applied to a substrate by means of a casting process or a film transfer process at ambient temperature.

In the casting process, the coating composition was applied to a substrate which was either a typical packaging board or a polyester film. Next, the coated substrate was dried using warm moving air. The dry layer thickness was in the range of 8 to 15 microns. Subsequently, a high gloss polyester film was pressed to the coated substrate, sandwiching the coating composition between the film and the substrate.

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In the film transfer process, the coating composition was applied to a high gloss polyester film. Next, the coated film was dried using warm moving air. The dry layer thickness was in the range of 8 to 15 microns. Subsequently, the coated high gloss polyester film was pressed to an uncoated substrate, which was
5 either typical packaging board or a polyester film, sandwiching the coating composition between the film and the substrate.

In the casting process as well as in the film transfer process, the coating composition was cured through the radiation-permeable polyester film using
10 low-energy UV lamps emitting radiation having a wavelength between 300 and 500 nm, and showing a maximum in the UV emission band at around 350 nm. Next, the polyester film was removed.

The coated substrate was subjected to dye sublimation using the Gencia Gs2
15 dye sublimation process. The coated side of the coated substrate was covered with a sheet of dye sublimation paper comprising a decoration that had to be transferred to said surface. The coated substrate and the sheet comprising the decoration were heated to a temperature in the range from 150 to 200°C for about 30 to 60 seconds.

20

It appeared that the decoration was successfully transferred to the coated substrate. After peeling off of the decorated dye sublimation paper, the paper had barely any ink left, which indicates that most of the ink had gone into the coated substrate. On the coated substrate, a sharp image with a very good
25 colour depth, i.e. having strong colours, was obtained.

Example 2

30 A hot melt composition was prepared:

	Tetra-functional polyester acrylate	~84%
	Tri-functional aliphatic urethane acrylate oligomer	~9%
	Slip and flow additives	<1%
	Aminobenzoate co-initiator	<3.0%
5	Photoinitiators	<3.0%

The hot melt composition was applied to a typical packaging board by means of a casting process or a film transfer process in the same manner as described for Example 1, except that the hot melt composition was applied to a substrate and/or to a film at a temperature between 60 and 80°C.

The film was removed and the coated substrate was successfully printed into using the Gencia Gs2 dye sublimation process. The temperature and the time used were in the range of 150 to 200°C for 30 to 60 seconds.

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Example 3

A high solids radiation-curable composition having a viscosity of approx. 500 mPas at 25°C was prepared:

	Bisphenol A epoxy acrylate oligomer	~30%
	Difunctional acrylate monomer	~55%
	Trifunctional acrylate monomer	~7%
25	Photoinitiators	<4%
	Aminobenzoate Co-initiator	<4%
	Slip and Flow additives	<1%

The radiation-curable high solids coating composition was applied to a typical packaging board by means of a casting process or a film transfer process in the

30

same manner as described for Example 1, except that the drying step was avoided.

The film was removed and the coated substrate was successfully printed into
5 using the Gencia Gs2 dye sublimation process. The temperature and the time used were in the range of 150 to 200°C for 30 to 60 seconds.

Example 4

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Examples 1 to 3 were repeated, except that instead of a high gloss polyester film a low gloss polyester film was used.

The process resulted in low gloss substrates, showing that the dye sublimation
15 steps do not affect the decorative effect of the coated substrate, irrespective of the coating composition used.

Example 5

20 A tacky radiation-curable water borne coating composition was prepared:

Water borne radiation-curable unsaturated polyurethane dispersion		
	(40% solids content)	93.3%
	Slip and flow additives	0.4%
25	Aminobenzoate co-initiator	3.0%
	Photoinitiators	3.0%
	Thickener	0.3%

The coating composition was applied to typical corrugated packaging board by
30 means of a casting process or a film transfer process at ambient temperature,

as described for Example 1. Special care was taken to ensure that the pressure applied was low enough so that the corrugated board was not deformed.

The film was removed and the coated substrate was successfully printed into
5 using the Gencia Gs2 dye sublimation process. The temperature and the time
used were in the range of 150 to 200°C for 30 to 60 seconds. Also in the dye
sublimation part of the process special care was taken to ensure that the
pressure applied was low enough so that the corrugated board was not
deformed.

Claims

1. A process for the preparation of a decorated substrate comprising the steps of:
 - 5 - applying a radiation-curable coating composition at least partially to a substrate and/or a radiation-permeable film,
 - pressing the substrate and the radiation-permeable film together in such a way that the coating composition is sandwiched between them,
 - curing the coating composition by irradiation through the film to obtain
10 a coated substrate,
 - removing the radiation-permeable film,
 - covering the surface of the substrate with a sheet comprising a decoration which is to be transferred to the surface of the substrate, and
 - 15 - heating the substrate and the sheet comprising the decoration to effect the transfer of the decoration from the sheet to the coated substrate.

2. A process according to claim 1, characterised in that the process comprises the steps of
 - 20 - providing a radiation-permeable film that has been coated at least partially with a radiation-curable coating composition,
 - optionally giving the pre-coated film a specific shape, for example by cutting off or cutting out parts of the pre-coated film,
 - pressing a substrate and the radiation-permeable film together in such a
25 way that the coating composition is sandwiched between them,
 - curing the coating composition by irradiation through the film to obtain a coated substrate,
 - removing the radiation-permeable film,
 - covering the surface of the substrate with a sheet comprising a decoration
30 which is to be transferred to the surface of the substrate, and

- heating the substrate and the sheet comprising the decoration to effect the transfer of the decoration from the sheet to the coated substrate.
3. A process according to any one of claims 1 to 2, characterised in that the
5 coating composition comprises a radiation-curable unsaturated polyurethane resin, an unsaturated polyurethane/polyacrylate copolymer, an unsaturated modified polyurethane, an unsaturated modified polyurethane/polyacrylate copolymer, a radiation-curable unsaturated polyester, an unsaturated epoxy, an unsaturated acrylic, and/or an
10 unsaturated polyether.
 4. A process according to claim 3, characterised in that the coating composition comprises a polyurethane acrylate, an unsaturated polyurethane/polyacrylate copolymer, a polyester acrylate, and/or an epoxy
15 acrylate dispersion.
 5. A process according to any one of claims 1 to 4, characterised in that the coating composition comprises an aminobenzoate co-initiator.
 - 20 6. A process according to any one of claims 1 to 5, characterised in that the coating composition is a hot melt.
 7. A process according to claim 6, characterised in that the hot melt coating composition comprises a polyester acrylate and a urethane acrylate.
25
 8. A process according to any one of claims 1 to 5, characterised in that the coating composition is water borne.

9. A process according to claim 8, characterised in that water has been removed from the water borne coating composition after application to the radiation-permeable film.
- 5 10. A process according to any one of claims 8 to 9, characterised in that the water borne coating composition comprises a polyurethane/polyacrylate copolymer dispersion and a polyurethane acrylate dispersion.
- 10 11. A process according to claim 10, characterised in that the coating composition comprises 60-80 wt.%, calculated on the total weight of the coating composition, of a water borne radiation-curable, optionally modified, polyurethane/polyacrylate copolymer dispersion having a solids content of 40%, calculated on the total weight of the dispersion, and 20-40 wt.%, calculated on the total weight of the coating composition, of a water borne radiation-curable, optionally modified, unsaturated polyurethane dispersion having a solids content of 40%, calculated on the total weight of the dispersion.
- 15 12. A process according to any one of claims 8 to 9, characterised in that the water borne coating composition comprises a polyurethane acrylate dispersion.
- 20 13. A process according to claim 12, characterised in that the coating composition comprises 60-95 wt%, calculated on the total weight of the coating composition, of a water borne radiation-curable unsaturated polyurethane dispersion having a solids content of about 40%, calculated on the total weight of the dispersion.
- 25 14. A process according to any one of claims 1 to 13, characterised in that the curing by irradiation is performed using a low energy UV source or a medium-pressure mercury lamp.
- 30

15.A process according to any one of claims 1 to 13, characterized in that the actinic radiation is provided by at least one UV light emitting diode (UV-LED).

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16.A process according to any one of claims 1 to 15, characterised in that the temperature of the surface of the substrate and the sheet comprising the decoration during the transfer of the decoration to the substrate is from 130 to 220°C.

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17.A process according to any one of claims 1 to 16, characterised in that the substrate to be decorated is a cellulose-comprising substrate or a polymer-comprising substrate.