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(54) **PANNEAU DE COFFRAGE ENDUIT DE PLASTIQUE**
(54) **PLASTIC-COATED CONCRETE FORM PANEL**

(57) Cette invention concerne un substrat recouvert d'une couche de plastique, tel qu'une planche de contreplaqué utile pour former un panneau en béton, comprenant une couche supérieure d'un prépolymère d'uréthane à terminaison isocyanate polymérisée par l'humidité dont la surface présente de spectaculaires indices de brillance et d'aspect lisse.

(57) Plastic-coated substrate, such as sheet of plywood useful as concrete form panel, having a topcoat of moisture-cured isocyanate-terminated urethane prepolymer with the surface of the topcoat having high degrees of specular gloss and smoothness.

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(54) Title: PLASTIC-COATED CONCRETE FORM PANEL

(57) Abstract

Plastic-coated substrate, such as sheet of plywood useful as concrete form panel, having a topcoat of moisture-cured isocyanate-terminated urethane prepolymer with the surface of the topcoat having high degrees of specular gloss and smoothness.

PLASTIC-COATED CONCRETE FORM PANEL

This invention relates to plastic-coated substrates, such as concrete form panels made from plywood sheets having a face coated with moisture-cured urethane isocyanate prepolymer and used in constructing molded concrete structures, such as walls and floors of buildings. In another aspect, it relates to a method of manufacturing such coated concrete form panels. In a further aspect, it relates to a coating system useful in said method of manufacturing.

Plywood is a basic kind of structural wood panel comprising a flat assembly of bonded thin sheets or plies of wood and such panels have been widely used for fifty years or so as a building or construction material. A large amount of plywood manufactured today by the lumber industry is used as concrete form panels in constructing concrete structures.

Concrete form panels are used generally as sheeting in temporary concrete formwork to mold freshly placed concrete poured into the formwork and retain it until it sets and gains sufficient strength. The formwork is thereafter removed and the panels stripped from the hardened self-supporting concrete structure. Economy is a major concern to the concrete contractor because the formwork costs alone may be from 35 to as high as 60 or 70 percent of the cost of the concrete structure.

Various techniques and modifications have been proposed or used to improve the quality and usefulness of plywood concrete form panels and save formwork costs. To these ends, principal attention has been focused on means to improve the durability of the panels to get their maximum reuse and to improve the smoothness and integrity of the face of the panel against which the concrete is hardened so that the panel may be readily stripped

therefrom without damage to the panel and without adversely affecting the smoothness and desired appearance of the finished concrete surface.

A number of oils and other materials have been applied to plywood concrete form panels as release agents to improve the strippability and other characteristics or properties of the panels -- e.g., see the study of release agents described by Thomas J. Reading in Concrete International, July 1985, pp. 15 to 22.

Another approach to improving strippability and reuse of plywood concrete form panels and the like is to apply various plastic coatings to the face of the panel. In this respect, see the related U.S. Patents 3,240,618, 3,468,690, and 3,703,394 of Charles B. Hemming and others describing smooth coated panels said to impart to the formed concrete a very desirable gloss and velvety smooth surface without staining. Said U.S. Patent 3,240,618 describes using "form oil," such as an SAE 10 to 30 paraffinic type hydrocarbon oil, to impregnate the plywood and then coating it with a moisture-curable isocyanate-terminated urethane prepolymer to form a porous polyurethane film adhered to the oil-coated surface. Said U.S. 3,468,690 describes a modification of the foregoing, wherein form oil is blended with the polymer, which can be made from Spenkel™ M86-50CX one-package moisture-cured urethane coating or a two-package, prepolymer/catalyst system, one such catalyst being Dabco™ 1,4-diaza(2.2.2)-bicyclooctane applied or added to the prepolymer. Said U.S. Patent 3,703,394 describes the further modification of dispersing microspheric particles of polyolefinic materials in the polyurethane film which can be applied by spraying resin and catalyst from separate spray guns mounted so that they mix at the panel surfaces. Reichhold Chemicals, Inc. describes in its Product Bulletin TD-84049 1/90 Spenkel™ M86-A6X-50 one-package

moisture-cure urethane prepolymer and suggest its use as coating for plywood concrete forms.

GB-A-1 126 094 describes moisture-curable isocyanate-terminated polyurethane prepolymer coatings which are particularly useful for the protection of wood to be used in concrete shuttering, and a process for coating substrates with the lacquer.

Other patents describing use of moisture-curable polyurethane or urethane prepolymer for concrete molds are U.S. Patents 3,427,178 (Zakimi et al.) and 3,650,795 (Willingham). Isocyanate-impregnated paper which is adhered as an overlay to plywood concrete form is described in U.S. Patent 3,666,593 (Lee). U.S. Patent 4,677,029 (Frisch et al) discloses coating a substrate, e.g. wood, with a composition comprising aliphatic polyisocyanate and tertiary amine "polyahl" and contacting the coated substrate with the vapor of a urethane catalyst, such as a tertiary amine.

FR-A-1 521 849 discloses a process for lacquering surfaces with polyurethane lacquers whereby a lacquer comprising a physically drying binder and a catalyst for the isocyanate polyaddition process is firstly applied to the surface and then a polyurethane lacquer, which is free from catalyst, is applied thereto.

The American Plywood Association (APA) permits its member mills to use APA trademarks on structural wood panels that have been manufactured to meet the requirements of APA performance standards. In APA's 1989 Source List on Plywood

Concrete Form Panels, descriptions are set forth of different grades of APA plywood for concrete form use, such as B-C Exterior, B-B Plyform, Medium Density Overlaid (MDO) Plyform and High Density Overlaid (HDO) Plyform. "Plyform" is an APA trademark for a plywood panel, treated with an oil in the mill, specifically manufactured for concrete forms, and generally reoiled initially and between uses in the field.

In the late 1960s and early 1970s, a moisture-cure isocyanate-terminated urethane prepolymer (Spenkel™ MC-2140 or Q-Thane™ MC-40) was used in the manufacture of primed plastic-coated plywood sheets sold as "Weyerhaeuser™ Concrete Form Panels/Release Coated" (see Weyerhaeuser Co. product literature PW-188, 8-72; PW-143, 2-75; PW-174, 2-69; PW-173, 1-69; PW-172, 1-69; PW-1012, 6-71). The moisture curing of the prepolymer coating was un-catalyzed and consequently the coated panels had to be racked in spaced-apart relationship overnight during mild or warm weather or during cold weather the racked coated panels were placed in an oven for 30 to 40 minutes and then held at ambient conditions overnight in order to complete curing of the prepolymer coating to a non-tacky state before the coated panels could be stacked. And though such factory prefinished panels were said to be relatively smooth and glossy, and had tough plastic faces which stripped with relative ease from hardened concrete and were reusable, sometimes reoiling of the panel surface was employed between pours (reuses) in an effort to extend panel life.

Briefly, in one aspect, this invention provides a process for manufacturing plastic-coated plywood panel useful as a concrete form panel for concrete formwork used in constructing concrete structures, such as cast-in-place walls, decks, columns, piers, and the like and pre-cast or pre-stressed concrete member components of structures. The plastic coating, durably adhered to a prepared substrate, such as sealed and primed plywood sheet, is a topcoat of moisture-cured isocyanate-terminated urethane prepolymer, the cure of which is catalyzed, e.g. with tertiary amine. The coated substrate or panel has a number of highly desirable characteristics or properties which are attributed to the nature of its plastic coating and the manner by which it is prepared. Two most significant characteristics are the surprisingly high degrees of specular gloss and smoothness of the surface of the plastic coating, which properties are manifested in the ready and clean release of the plastic coating from the face of the concrete hardened against it. Such characteristics together with the durability of the adhered plastic coating account for the long useful life of the coated panel. Correspondingly high specular gloss and smoothness are imparted to the face of the concrete structure hardened against the plastic coating of the panel, the face of the concrete needing reduced or minimal repair or finishing. The plastic-coated panel of this invention also has a high degree of reusability; for example, concrete formwork comprising sheeting made of such plastic-coated panels can be

reused for as many as ten to twenty or more "pours" of fresh concrete and without oiling the panels either initially or between pours, thereby significantly saving concrete formwork costs.

The method or process of preparing the improved concrete form panel is such that it can be carried out readily and economically by manufacturing the coated panels as prefabricated modular product on the continuous production line of a panel coating factory, such as that of a plywood manufacturer or custom coater finishing company, using commercially available chemical products and plywood sheets.

The coating system (a "catalyst undercoat system") used in this invention to provide the plywood with the superior plastic coating comprises (1) a film-forming coating solution of moisture-curable isocyanate-terminated urethane prepolymer in admixture with a lower molecular weight isocyanate applied as a thin topcoat, (2) a coating solution of a catalyst which is applied as a thin undercoat for the prepolymer topcoat to accelerate the moisture curing thereof, and, (3) a sealing and priming liquid applied as a thin coating to the substrate, e.g. sanded plywood sheet, to ensure that the topcoat surface has the aforementioned smoothness and gloss and to enhance the efficiency of continuous factory coating processes. The catalyst coating solution is applied and preferably dried just prior to coextensively applying a thin topcoat of the coating solution of prepolymer and polyisocyanate. (The catalyst may be added to the sealing and

priming liquid if it is compatible therewith, for example, if it does not gel the liquid.) The moisture cure of the prepolymer immediately begins to occur upon exposure of the coated substrate to ambient air (which contains moisture), the cure being rapidly accelerated by the catalyst, the topcoat becoming non-tacky or non-sticky in a desirably short time, e.g. within 15 minutes of applying the prepolymer coating solution, and becoming cured to a block-free state with 1 to 2 hours of the application of the prepolymer and polyisocyanate coating solution. Since the catalyst solution and prepolymer solution are separately applied, the coating system can be characterized as a liquid two-package system, the two applied compositions or components of which are apparently mixed by molecular diffusion, rather than by physical or mechanical mixing before application to the substrate. The resulting cured topcoat comprises a poly(urethane-urea)polymer and has the above-discussed gloss and smooth surface and durability. The cured coating system is essentially void- or bubble-free or non-cellular (at least to the unaided eye), water-impermeable, water-resistant, alkali resistant, abrasion-resistant, weather-resistant, and tough. Applying the catalyst as or in an undercoat for the prepolymer, as described above, not only permits retention of the desired working pot-life of the prepolymer solution but also results in a rapidly cured topcoat that is surprisingly superior in specular gloss and smoothness to that obtained by mixing the

catalyst with the prepolymer before application or by applying the catalyst over the prepolymer coating.

The invention provides a sheet of plastic-coated plywood having a topcoat of polymer derived from a moisture-cured mixture of (a) 25 to 50 mole percent of isocyanate-terminated urethane prepolymer derived from polyoxypropylene polyol having a molecular weight in the range of 200 to 2,000 and a stoichiometric excess of polyisocyanate, and (b) 50 to 75 mole percent of lower molecular weight polyisocyanate with 3 to 5 isocyanate groups, said topcoat being coated onto an alkali-resistant seal-prime coat, and wherein said moisture-cure of said mixture was accelerated by a catalyst applied to said seal-prime coat as an undercoat for said topcoat.

The invention also provides a sheet of plastic-coated plywood having on one face a plastic topcoat of a poly(urethane-urea) polymer derived from a mixture of (a) 25 to 50 mole percent of moisture-curable isocyanate-terminated urethane prepolymer derived from polyoxypropylene polyol having a molecular weight in the range of 200 to 2,000 and a stoichiometric excess of polyisocyanate, and (b) 50 to 75 mole percent of lower molecular weight moisture-curable polyisocyanate with 3 to 5 isocyanate groups.

The invention further provides a method of making a sheet of plastic-coated plywood of the invention said method comprising applying to a base sheet of plywood a water-base sealing-priming liquid comprising a resin or resin precursor which when cured imparts alkali resistance to said topcoat,

drying said sealing-priming liquid, applying to the resultant seal-prime coat a coating solution of a catalyst dissolved or dispersed in an organic solvent or water which accelerates the curing of a moisture-curable isocyanate-terminated urethane prepolymer derived from polyoxypropylene polyol having a molecular weight in the range of 200 to 2,000 and a stoichiometric excess of polyisocyanate, in admixture with lower molecular weight polyisocyanate having 3 to 5 isocyanate groups, drying said solution of catalyst, coating the resulting dry catalyst with a solution of 25 to 50 mole percent of said prepolymer and 50 to 75 mole percent of said polyisocyanate, and allowing said solution of prepolymer and polyisocyanate to cure in ambient air.

The isocyanate-terminated urethane prepolymer used in the practice of this invention is a known type of urethane polymer formed by reacting a stoichiometric excess of polyisocyanate (either aliphatic or, preferably, aromatic), such as a commercial mixture of the 2,4- and 2,6-isomers of toluene diisocyanate, with a polyol, such as one with a medium molecular weight in the range of 200 to 2000 and hydroxyl functionality in the range of 2 to 5, preferably 2 to 3, e.g., polyoxypropylene glycol or triol. Commercially available polyols useful in making the prepolymers are PPG™ 1025 and 2025 polypropylene diols. Mixtures of the various polyols can be used to get desired physical properties in the cured prepolymer coating, such as hardness and elongation. The prepolymer upon reaction with moist air, e.g. with a relative

humidity greater than 30% at normal room temperature, to which the prepolymer is exposed, is converted predominantly or essentially to a polyurea. The isocyanate-moisture reaction also evolves carbon dioxide, which apparently generally diffuses from the prepolymer coating due to its thinness, since the cured topcoat appears clear and transparent (such that the grain of the underlying plywood surface can be seen) and the surface of the cured topcoat made by the above-described catalyst undercoat system is very smooth and has high gloss (almost like glass).

The prepolymer used in applying the topcoat of this invention is in the form of an organic solvent solution, suitable solvents for this purpose being, for example, common solvents used in coating formulations, such as esters, ketones, ether-esters, aromatic solvents, and petroleum distillates, e.g., methoxy propyl acetate, xylol, ethyl-3-ethoxy propionate, and mixtures thereof. The prepolymer coating solution does not have to be mixed or blended with form oil or other oil and is preferably oil-free.

Prepolymers useful in this invention are commercially available as solvent-free or in solution of solvents such as butyl acetate or Cellosolve™ acetate. Prepolymers and solutions thereof which can be used in this invention include those described in the aforementioned Hemming patents. A particularly useful commercially available aromatic moisture-cure urethane prepolymer is the aforedescribed Spenkel™ M86-A6X-50 which is available as a

49-51 weight percent non-volatile prepolymer solids solution in a 50/50 mixture of xylol and methoxy propyl acetate. Another such prepolymer is Spenkel™ M-26-X-64 which is available as 64 weight percent prepolymer non-volatile solids in xylol. Another moisture-curing prepolymer product which can be used is sold as Q-Thane™ MC49, which product has 40 weight percent non-volatile prepolymer solids in a mixture of ethyl 3-ethoxy propionate and xylol. Such products have short pot life in air and must be stored in tightly closed, moisture-free containers with a blanket of moisture-free inert gas such as nitrogen to prevent premature curing of the prepolymer with moist air.

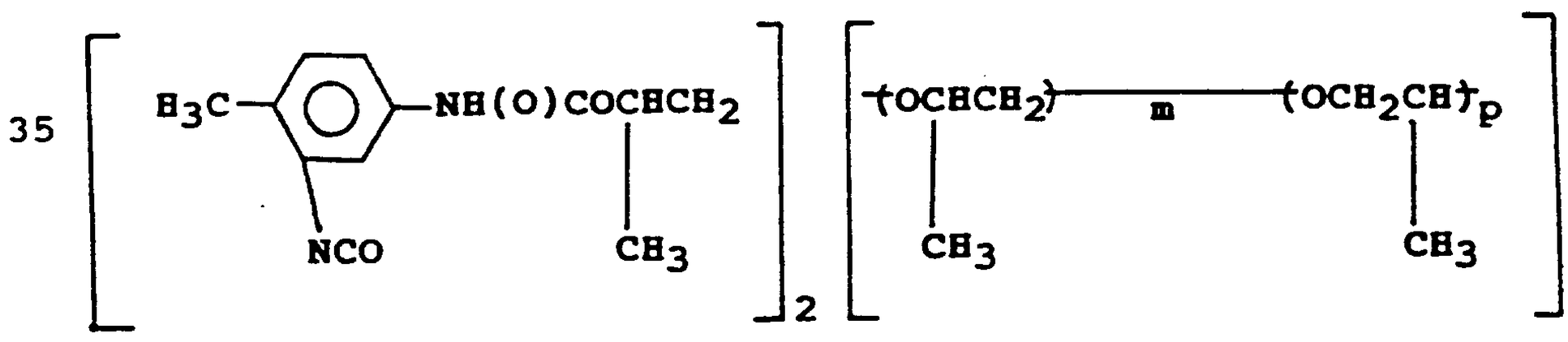
A general class of prepolymers which can be used in this invention can be represented by the formula:

$$Y_1 \left[-R-Y_2(N-NCO)_p \right]_z \qquad I$$

where Y_1 is an active hydrogen-free residue of a low molecular weight organic initiator compound having a

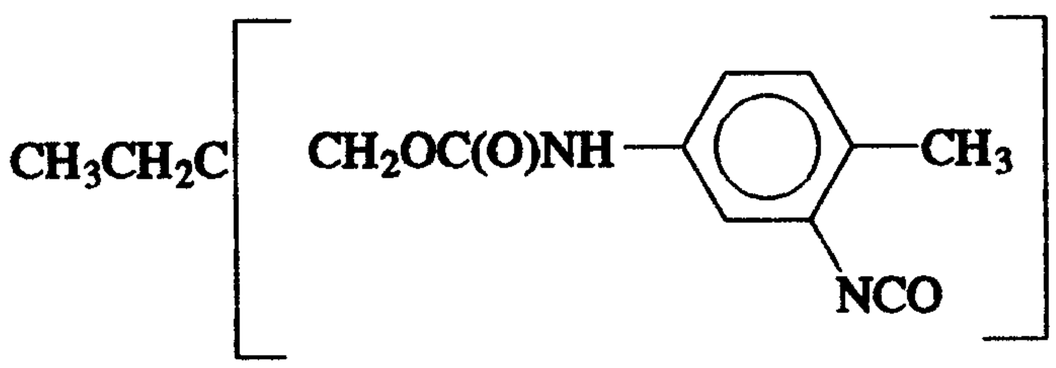
plurality (e.g., 2 or 3) of active hydrogen atoms, such as a polyhydroxyalkane, polyaminoalkane, or polyether polyol, e.g., ethylene glycol, ethylene diamine, glycerol, or 1,1,1-trimethylolpropane, which compound is, for example, an initiator from which polyoxypropylene diol or triol is made by reacting the initiator with propylene oxide; R is the active hydrogen-free residue chain of a high molecular weight polyol, such as said diol or triol, e.g. R is $(R'O)_o$ where R'O is a polyoxypropylene chain where the subscript o is the number of oxypropylene repeating units in the chain, which number is sufficiently low so that the resulting moisture-cured prepolymer is a relatively tough plastic; Y_2 is an organic linkage, for example, where the prepolymer is prepared by reacting polyoxypropylene triol with polyisocyanate, the prepolymer will be principally terminated with the group $-OC(O)NH-R''(NCO)_p$ where the -OC(O)NH- portion is a urethane group and R" is the organic residue of the polyisocyanate, e.g. R" is methylphenylene; the subscript p is 1 to 5 and typically is 1; and the subscript z is equal to the number of active hydrogen atoms in said initiator compound and is generally 2 to 6, preferably 2 or 3. Upon moisture curing of the prepolymer, the prepolymer is converted into polyurea polymer, which retains the urethane linkages of the prepolymer; thus the cured polymer also can be called a poly(urethane-urea).

A species of prepolymer (derived from polyoxypropylene triol and tolulene diisocyanate) can be represented by the formula:



II

where m + p = n (e.g. 12) and the depicted oxypropylene units are randomly distributed in the chain enclosed in the right-hand brackets. In order to get desired hardness or crosslinking, the moisture-cure isocyanate-terminated prepolymer such as that of Formula I, e.g. a diisocyanate prepolymer such as shown in Formula II, is mixed with a highly functional, related, lower molecular weight polyisocyanate with 3 to 5 isocyanate groups (or mixture thereof), e.g. a trifunctional isocyanate, a species of which is that represented by Formula III.



III

The latter can be mixed with the species of Formula II in relative amounts of about 63 mole percent of II with 37 mole percent of III (such mixture being commercially available as Spenkel™ M86-A6X-50). Preferably such mixture of II and III is modified by mixing with it a further amount of the triisocyanate of Formula III to provide a mixture containing 40 to 44 mole percent of II and 56 to 60 mole percent of III. But broadly, to get the desired hardness or crosslinking, the relative mole percent ratio of the moisture-cure prepolymer to the lower molecular weight polyisocyanate is 25-50/50-75. representative of the lower molecular weight polyisocyanates,

in addition to that of III, which can be mixed with the isocyanate-terminated prepolymer to obtain desired hardness or crosslinking density in the moisture-cured polymer or plastic coating, are polymeric diphenylmethane diisocyanates, such as those sold under the trademark "PAPI," a mixture of 60-70

parts Spenkel™ M86-A6X-50 or Spenlite™ M27-X-63 with 30-40 parts PAPI™. Other representatives of the polyisocyanates which can be used are adducts made by reaction of diisocyanates, such as those listed in said U. S. Patent No. 3,666,593, with short chain polyols, such as the aforesaid trifunctional initiator compounds used in making the prepolymer of Formula I, commercially available adduct products including Mondur™ CB-72, CB-75, CB60, and CB-601, e.g. a mixture of 70 parts Spenkel™ M86-A6X-50 with 30 parts Mondur™ CB-72, --75, -60, or -601, and a mixture of 60-70 parts of Spenkel™ M26-X-64 with 30-40 parts Mondur™ CB-72 or -75. Further representatives of the polyisocyanates are triisocyanurates made by trimerizing the latter-mentioned diisocyanates of U.S. Patent No. 3,666,593, commercially available triisocyanurates including Desmondur™ IL and Z-4370, e.g. a mixture of 70 parts Spenkel™ M86-A6X-50 with 30 parts Desmondur™ IL or Z-4370. Other representatives and biurets made from diisocyanates such as hexamethylene diisocyanate, commercially available biurets including Desmodur™ N-100 and N-75, e.g. a mixture of 70 parts Spenkel™ M86-A6X-50 with 30 parts Desmondur™ N-100.

The above-described prepolymer-low molecular weight polyisocyanate mixtures, which result in a moisture-cured polymer with a relatively high degree of crosslinking (or higher glass transition temperature), are particularly useful if not required, where the plastic-coated plywood sheets are used as concrete form panels in the pouring of concrete under relatively warm or hot ambient temperatures e.g. 25°C and higher, such as encountered during summertime or in tropical or desert climates. Under such ambient conditions, the heat of hydration of curing concrete produces temperatures at the plastic coating-curing concrete interface, e.g. 50°C and higher, which will generally be high enough to soften the moisture-cured prepolymer if it has an insufficient

degree of crosslinking (or too low a glass transition temperature). Such softening may result in sticking of the plastic coating to the face of the concrete hardened against it, thereby impeding the ready and clean release of the plastic coating or concrete form panel and possibly requiring repair or finishing of the marred or rough face of the concrete. The relative amounts of the prepolymer and polyisocyanate to be used in making the moisture-cure prepolymer topcoat composition can vary, as can the particular prepolymer and polyisocyanate selected for such use, and these parameters can be determined empirically in light of the foregoing description by simple evaluation procedures, such as those described in working examples hereafter set forth.

In addition to the preferred toluene diisocyanate used to make the prepolymer, other isocyanates which can be used include aromatic or aliphatic polyisocyanates such as those described in said U.S. Patent 3,666,593.

The prepolymer solution used for the topcoat can also contain various coating adjuvants, such as levelling or flow agents, defoamers, and pigments or dyes, to impart a desired colour to the cured topcoat (which is otherwise usually clear and light amber). Silicone or fluorochemical surfactants, e.g. Fluorad^{TM} FC-430, can be used as levelling agents and defoamers can be used to minimize the formation of air or carbon dioxide bubbles in the cured topcoat.

The catalysts, when used in this invention, are catalysts known to accelerate the moisture curing of said prepolymers. Such are described, for example, in said U.S. Patent 3,703,394, 3,666,593, and 3,468,690, and are preferably tertiary amine catalysts, a particularly useful one being 1,4-diaza-(2.2.2)bicyclooctane, which is commercially available under the trademark Dabco^{TM}. The

catalyst can be dissolved or dispersed in an organic solvent to provide, for example, a 0.5 to 5 wt % solution, or in water to provide, for example, a 1 to 10 wt % solution. The amount of catalyst used can vary and will be that sufficient to accelerate the isocyanate-moisture, urea-forming reaction, such amount generally being about 0.5 to 5, preferably 1 to 2.5, parts by weight per 100 parts of non-volatile prepolymer solids in the prepolymer solution applied as topcoat. The catalyst solution will generally be coated on the seal-prime coat in a wet thickness of about 25 microns.

Coating compositions which can be used to seal and prime the unfinished face of the plywood sheets can be any of those normally used to treat such materials for such purpose and provide a less porous, scratch and water-resistant, smooth base for the subsequent coatings and enhance the smoothness of the prepolymer topcoat. An additional purpose of the seal-prime coat is to minimize or reduce migration of moisture in the wood into the applied prepolymer solution and thereby reducing moisture from participating in the isocyanate-moisture reaction and generating bubbles. The sealing-priming liquids are preferably of the quick-drying variety, such as solvent-base or water-base, e.g. those formulated with alkyds, urethanes, epoxies, acrylates, urea-formaldehyde resins, and mixtures thereof. Sealing-priming liquids particularly useful will be those formulated to resist the peeling and other deteriorating effects on the topcoat by the alkaline conditions presented by fresh concrete or hydraulic cement. Two or more sealing-priming coats can be applied with drying and sanding between the applications and after final application to provide a smooth base for the subsequently applied coating(s). Conventional pigments and fillers can be added to the sealing-priming liquid if desired.

A preferred sealing-priming composition used in this invention is a water-based composition comprising

resins and/or precursors thereof, such as those mentioned above, which in their cured state resist hydrolysis upon exposure to or contact with strongly alkaline aqueous solutions, e.g. saturated aqueous calcium hydroxide, such as in freshly poured concrete or hydraulic cement. The sealing-priming coating composition is applied to obtain a desired thickness, generally 10 to 46 microns, preferably 19 to 25 microns, which can be achieved with one heavy coat or two light coats, for example. Too thin a coating will likely result in inadequate sealing and consequent bubbling of the prepolymer coating, and too heavy a coating will likely result in adhesion failure between the poly(urethane-urea) topcoat and seal-prime coat and consequent delamination and blistering of the coating(s) upon exposure to the strongly alkaline conditions. The above-desired chemical composition of the sealing-priming liquid and said thickness thereof upon application result in a durable cured coating system, thus imparting reuseability of the coated concrete form panels of this invention.

The plywood sheets or panels coated in the practice of this invention can be any type or grade of plywood, e.g. APA grades A, B, C, D, etc., though pre-oiled or "mill-oiled" plywood, such as that sold under the trademark Plyform™, is not desirable or necessary, the plywood sheets generally useful as substrates in the practice of this invention being of the "exterior" type and non-oiled or oil-free. Preferred types of plywood are those made of Douglas Fir (a softwood) and other APA Group 1 species such as Southern Pine and Western Larch, and less preferred types are APA Group 2 species. Preferred grades are those rated by APA as B-B exterior grade or B-C exterior grade, with thicknesses which preferably are 9.5 to 25 mm, the area of such sheets normally being 1.2 meters x 2.4 meters. The more expensive hardwood plywoods, such as that with a face ply of grade N guatambu, can also be used in the

practice of this invention, and even though they are of higher cost, such cost does not generally significantly off-set the savings in concrete formwork otherwise realized in using the coated plywood panels of this invention for such constructions. Other types of wood panels, such as particle boards and oriented strand board, can be used, but they would not be preferred as sheeting for concrete formwork because of their relatively lower load-bearing strength and less durability in handling. Whatever wood or wood-based substrate is used, it generally and preferably is sanded to a desired smoothness. The edges of the substrate are also preferably seal coated with the coating system used for the face of the substrate or with any other coating used for that purpose, such as wax emulsions, to make the edges water-resistant or to minimize water absorption.

The coatings applied to the plywood in accordance with this invention can be carried out using conventional coating or finishing techniques used in the manufacture of coated panels and the like, using an O.E.M. continuous production line of semi-automated or nearly automated systems comprising conveying belts or the like to thus transport in tandem a series of panels from one station to another, e.g., sanding stations, coating stations and drying stations. Where the catalyst undercoat system or the modified catalyzed systems of the invention are used in coating the panels, the consequent rapid curing of the prepolymer coating, e.g. to a

tack-free state in less than 30 minutes, and typically in about 15 minutes, less racking equipment for holding the coated panels in spaced-apart relationship during curing is required, and the finished panels can be stacked (face-to-face or face-to-back) after the cure has progressed to the block-free state, which is generally reached in 1 to 2 hours. The equipment used in the coating stations can be fitted with automatic spraying equipment, roll coating equipment, or curtain coating equipment, and the equipment used in drying stations can be ambient or heated air blowing housing or tunnels or low temperature air ovens. The finished plastic-coated panels have a topcoat (the polyurethane-urea) which, as cured according to this invention, inherently has the aforementioned high degrees of gloss and smoothness (they are obtained without rubbing or polishing or otherwise further finishing the cured topcoat). The continuous O.E.M. or factory production line and factory applied coatings used in manufacturing the coated panels of this invention means not only that they can be made economically but also that purchasers or users are provided precision-finished modular panels that are processed through machines and equipment especially adapted to the uniform application of the thin coatings under controlled conditions. Such manufacture of prefabricated panels also eliminates imperfections and time-consuming work that would result when attempts are made by

relatively unskilled workmen to coat panels in the field, that is, at the construction site where they are used as concrete form panels.

EXAMPLE 1

A 5/8 inch (16 mm) thick, 150 mm by 300 mm, plywood panel (comparative specimens A) was prepared as follows. The panel specimen as cut from a sheet of APA B-C Douglas Fir plywood.

The sealing-priming liquids used for sealing-priming the plywood panel specimen comprised a mixture of 80 wt.% Reliance* Universal water base print sealer (comprising 24.1 wt.% acrylic polymer resin, 67.5 wt.% water, and 7.4 wt.% 2-butoxyethanol as coalescing agent) and 20 wt.% Beetle™ 65 resin (comprising 99 wt.% methylated urea-formaldehyde resin and less than 0.8 wt.% formaldehyde).

The catalyst composition used a solution of 2 wt.% Dabco™ 1,4-diaza-(2.2.2)bicyclooctane in n-butyl acetate.

The isocyanate-terminated prepolymer composition used was a mixture of 99 wt.% Spenkel™ M86-A6X-50 moisture-cure prepolymer product (comprising 50 wt.% isocyanate-terminated urethane resin derived from toluene diisocyanate (TDI) and polyoxypropylene polyol, 25 wt.% methoxy propyl acetate, 5 wt.% ethyl benzene, 20% xylene and less than 1 wt.% free TDI), 0.6 wt.% BYK™ 300 paint additive levelling (or flow) agent (comprising 50 wt.% polyoxyethylene-modified dimethylpolysiloxane copolymer, 40 wt.% xylene, and 10 wt.%

*Trade-mark

isobutyl alcohol), and 0.4 wt.% BYK™ 052 paint additive defoamer (comprising 28 wt.% foam destroying polymer-silicone free, 71 wt.% Stoddard solvent, and 1 wt.% 2-butoxyethanol).

A thin coat of sealing-priming liquid was applied to the specimens by using a Graco™ Model 700 Sprayer with a #2 nozzle at an air pressure of about 60-80 psi (4.14-5.51 Pa). Two sealing-priming coatings were applied, the first coating being sanded with 240 grit sandpaper after 2 min. drying in an air oven at 150°F, (65.6°C), followed by spraying of the second coating which was also then dried 2 min. in said oven. The total or overall thickness of the seal-prime coat was about 0.75 to 1.0 mil (0.019 to 0.025 mm).

The catalyst solution was sprayed with the Graco sprayer onto the sealed-primed specimens to provide an undercoat for the prepolymer topcoat.

Five further plywood panel specimens (B to F) were prepared like Comparative Specimen A except that the prepolymer composition for specimens B to F additionally contained various amounts of Mondur™ CB-75 polyisocyanate and the sealing-priming liquid used as an initial coating was an acrylic-urea formaldehyde ("acrylic-UF") based liquid prepared as follows. In a 200 ml glass bottle, 60.8 g of AC-1024 acrylic latex (Rohm & Haas, 50% solids in water), 14.9 g. of Beetle-65™ ureaformaldehyde resin (American Cyanamid, 98% solids), 10 g. distilled water, 4.9 g methanol, 0.2 g

Drewplus* L-475 defoamer (Drew Chemical Co.), and .2 g Silwet* L-77 wetting agent (Union Carbide Chemical) were added with mixing. The pH of the mixture was adjusted to 7-8 with triethylamine. Just before use, the mixture was catalyzed by adding 1.14% by weight of para-toluenesulfonic acid as a 65% solution in water. The catalyzed sealing-priming was coated on the panel specimens A to F by spraying to give a dry film thickness of 20 to 30 micrometers.

Two further comparative panel specimens, C-1 and C-2, were also prepared. The first, C-1, was APA plywood grade Medium Density Overlaid Plyform* (MDO) which was oiled before each use (as is normally done in the industry with this product), the oil used being Nox-Crete Sparkle™ seal form oil. The second comparative specimen, C-2, was prepared as taught in U.S. Patent No. 3,468,690 using non-detergent motor oil (20W) as a primer and also mixing it with the moisture-curable urethane prepolymer composition formulated the same as used for Panel Specimens 1 and 3 in Example 1 except for the addition of the oil.

The panel specimens A-F, C-1, and C-2 were used as vertical walls in making 16 concrete molds, rectangular parallelepiped in shape, open at the top, with the coated sides of the panel specimens being interior surfaces of the mold. A concrete mix or "mud" was poured into each mold, vibrated, and cured in a sealed plastic bag for 20-22 hrs, half of them cured at 21°C and the other half at 66°C.

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After curing, the bags were opened and the molds were disassembled. If a mold could be disassembled by hand (without a tool), the panel specimens of that mold were considered as "easy" to strip, but if it was necessary to tap the end of a mold with a hammer to disassemble the mold, the panel specimens thereof were considered "hard" to strip. After disassembling each mold, the coated sides of the panel specimens were examined and rated for residual concrete (if any) adhering to the coated sides. After such disassembly and examination, the molds were reassembled, used again, disassembled, and reexamined. Each mold was reused, without cleaning between pours, for a total of 13 pours. The molds which were made with comparative panel specimens C-1 (the MDO specimens) were re-oiled between pours with Sparkle™ seal oil.

It was found that panel specimens B through F (made with a topcoat prepolymer composition containing the prepolymer and the additional polyisocyanate) were easy to strip after each use, both at 21°C and 66°C, whereas comparative panel specimens A (made of a topcoat without the additional polyisocyanate) though generally easy to strip after each pour and cure at 21°C, became hard to strip after about 2 to 4 pours. Comparative panel specimen C-1

(the MDO specimen) was easy to strip after the first pour and hard to strip after all subsequent pours. And comparative panel specimen C-2 (made with a topcoat containing prepolymer mixed with motor oil) was only easy to strip after the first 4 pours at 21°C and easy to strip after the first, second, fifth, sixth, and seventh pours, C-2 being otherwise hard to strip.

In examining the panel specimens for residual concrete, it was found that, for the concrete pour cured at 21°C, panel specimens B to F generally had no or very little residual concrete adhered after most of the pours except that panel specimens D and F had a little more residual concrete adhered after the 10th through

13th pours but only after the 12th and 13th pours was the amount significant to perhaps require cleaning of the panel specimens and/or finishing of the cured concrete face. For the concrete pours cured at 66°C, it was found that panel specimens B to F had no concrete adhered or essentially none adhered (though after the first pour, there was some concrete adhered, which was attributed to use of the panel specimen before the topcoat was fully cured). Panel specimen A was found to have no or very little concrete adhered after use in curing pours at 21°C except until after the 12th and 13th pours, but when panel specimen A was used in curing pours at 66°C, there was significant concrete adhered after the third pour. For comparison specimens C-1 and C-2, significant residual concrete was found to be adhered after all pours cured at 21°C and 66°C, except that C-2 specimens were found to have no adhered concrete or essentially none adhered, after each of the first 4 pours.

The foregoing results or examinations show advantages of this invention and that it is desirable to use a topcoat prepolymer composition which contains sufficient polyisocyanate, such as Mondur CB-75™, to ensure easy and clean stripping of the concrete form panels of the invention, particularly where they are used in warm or hot climates.

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TABLE 1

Topcoat composition wt% solids

Panel Specimens	Initial coating	Prepolymer	Mondur™ CB-75	Motor oil
C-1	Sparkle™ seal	0	0	0
C-2	motor oil	90.5	0	9.5*
A**	acrylic-UF	100	0	0
B	acrylic-UF	80	20	0
C	acrylic-UF	70	30	0
D	acrylic-UF	60	40	0
E	acrylic-UF	50	50	0
F	acrylic-UF	40	60	0

* all the oil was considered as non-volatile solids.

Various modifications and alterations of the invention will become apparent to those skilled in the art without departing from the scope and spirit of this invention.

** a comparative panel specimen.

THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. A sheet of plastic-coated plywood having a topcoat of polymer derived from a moisture-cured mixture of (a) 25 to 50 mole percent of isocyanate-terminated urethane prepolymer derived from polyoxypropylene polyol having a molecular weight in the range of 200 to 2,000 and a stoichiometric excess of polyisocyanate, and (b) 50 to 75 mole percent of lower molecular weight polyisocyanate with 3 to 5 isocyanate groups, said topcoat being coated onto an alkali-resistant seal-prime coat, and wherein said moisture-cure of said mixture was accelerated by a catalyst applied to said seal-prime coat as an undercoat for said topcoat.

2. The plastic-coated plywood of claim 1 wherein said catalyst is a tertiary amine.

3. The plastic-coated plywood of claim 1 wherein said catalyst is 1,4-diaza-(2.2.2)bicyclooctane.

4. A sheet of plastic-coated plywood having on one face a plastic topcoat of a poly(urethane-urea) polymer derived from a mixture of (a) 25 to 50 mole percent of moisture-curable isocyanate-terminated urethane prepolymer derived from polyoxypropylene polyol having a molecular weight in the range of 200 to 2,000 and a stoichiometric excess of polyisocyanate,

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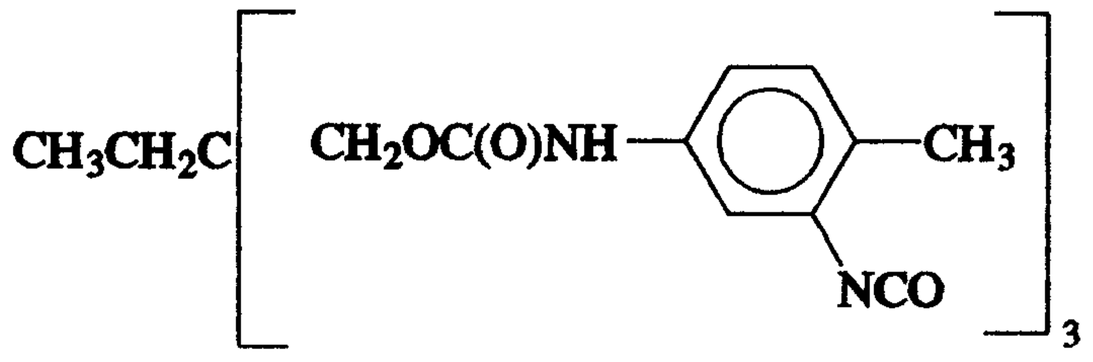
and (b) 50 to 75 mole percent of lower molecular weight moisture-curable polyisocyanate with 3 to 5 isocyanate groups.

5. The sheet of plastic-coated plywood of claim 4 wherein the moisture curing of said mixture of prepolymer and polyisocyanate was accelerated by a catalyst undercoat.

6. The sheet of plastic-coated plywood of claim 5 wherein the catalyst undercoat was applied to an alkali-resistant seal-prime coat.

7. The sheet of plastic-coated plywood of claim 5 wherein said polyisocyanate has 3 isocyanate groups.

8. The sheet of plastic-coated plywood of claim 7 wherein said polyisocyanate is represented by the formula:



and said catalyst is 1,4-diaza-(2.2.2)bicyclooctane.

9. The sheet of plastic-coated plywood of claim 7 wherein said polyol has a hydroxyl functionality of 2.

10. A method of making a sheet of plastic-coated plywood according to claim 1, said method comprising applying to a base sheet of plywood a water-base sealing-priming liquid comprising a resin or resin precursor which when cured imparts alkali resistance to said topcoat, drying said sealing-priming liquid, applying to the resultant seal-prime coat a coating solution of a catalyst dissolved or dispersed in an organic solvent or water which accelerates the curing of a moisture-curable isocyanate-terminated urethane prepolymer derived from polyoxypropylene polyol having a molecular weight in the range of 200 to 2,000 and a stoichiometric excess of polyisocyanate, in admixture with lower molecular weight polyisocyanate having 3 to 5 isocyanate groups, drying said solution of catalyst, coating the resulting dry catalyst with a solution of 25 to 50 mole percent of said prepolymer and 50 to 75 mole percent of said polyisocyanate, and allowing said solution of prepolymer and polyisocyanate to cure in ambient air.

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