APPLICATIONS OF PRIMERS AND VINYL PLASTISOLS

Primers

If good adhesion to metal is required, the parts should be primed prior to coating with vinyl plastisols.

Primers are a combination of resins in solution in solvents, or water. Solvent-based primers can generally be thinned with methyl ethyl ketone (MEK). Introduction of foreign material, into the primer, will eventually destroy its adhesive characteristics.

Primer will give a good adhesion to most types of vinyl plastisols to most types of metal. For optimum adhesion, the primer-coated metal should be pre-baked at oven conditions that will bring the primer coat and adjacent metal surface to 375ºF (191ºC) for five (5) minutes or longer. Shorter bake times and lower bake temperatures can provide good and sufficient adhesion. However, if the part is exposed to moisture for a length of time, the adhesion may be lost.

Optimum adhesion is obtained on clean metal surfaces that are free of rust, grease, dirt, scale, etc. Sand blasting or acid etching generally give excellent adhesion because they remove rust and scale, as well as roughening the surface of the part, thus increasing surface area and increasing adhesion. Surfaces should be washed afterwards. Excessively rough surfaces can result in poorer adhesion because of a thin prime coat on the peaks and the possibility of air inclusion in the valleys. Freshly cleaned metal surfaces are more active and better adhesion is generally obtained. Better adhesion is obtained to certain non-ferrous metals by chemical treatment (phosphating, chromating, or anodizing).

Poorer adhesion results if the vinyl plastisol is underfused. When poor adhesion is obtained and it is known that adhesion is generally good with a given plastisol, primer and metal combination, one should generally look first for impurities on the metal surface. Secondly, check for primer contamination.

If the primer pulls loose with the plastisol from the metal surface, one should suspect insufficient primer bake or one of the above problems. If the plastisol pulls from the primed metal, one should suspect insufficient plastisol fusion or excessive primer bake.

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Vinyl Plastisols

Vinyl plastisols have typically been considered as 100% solids. In reality, plastisols will typically exhibit an approximate 2% emissions loss during fusion, with vinyl organosols exhibiting a higher emission loss. At a temperature of 140ºF (60ºC) to 180ºF (82ºC), depending upon the gel rate of the plastisol, solvation of the solid resin by the liquid plasticizers occurs, causing the plastisol to deposit on the preheated metal.

The viscosity of the plastisol increases gradually with aging. This is especially true if the aging plastisol is subjected to elevated temperatures, such as might be encountered in hot storage areas or dip tanks that tend to increase in temperature during use. Plastisol can be thinned with solvents such as Aromatic 150, Odorless Mineral Spirits (OMS), or low viscosity plasticizers such as phthalates or TXIB™. The supplier should be consulted before thinning, as each material has a practical limit on its usage level.

With a given plastisol, coating thickness is increased by:

- Increasing the pre-heat temperature of the part, and
- Increasing immersion (dip) time (when heat is completely transferred from the part, this ceases to be a factor).

The coating is properly fused when the plastisol and adjacent metal surface reaches optimum fusion temperature. For most compounds this temperature is about 350ºF (177ºC). A thin coating over a thin piece of metal can be fused in just a few minutes, whereas, a thick coating over a massive piece of metal may take up to an hour.

It is important that the pre-heat and fusion ovens have relatively uniform temperatures in all areas of the oven. As the consistency of both coating thickness and proper fusion will be affected. With a lack of oven temperature uniformity, it is possible to degrade the plastisol in hot areas without proper fusion in cold areas.

Degradation occurs with excessive fusion. Degradation is evidenced by discoloration, with the color shift generally starting with yellow, subsequently changing to brown and then black. Continued excessive heat exposure, or over-fusion, will result in full degradation of the polymer with eventual liberation of hydrogen chloride (HCl) and blistering. Occurrence time and temperature depend upon the compound, plastisol, metal mass, and oven conditions. A 1/32 inch (0.8 mm) coating on thin aluminum sheeting using a colored plating rack type vinyl plastisol will generally discolor in about 20 minutes and blister in about 40 minutes, in a circulating air oven operating at 375ºF (191ºC).

Plastisol Applications

The use of vinyl plastisol in applications such as coating, molding, dipping, and casting has greatly increased because of the ease and economy with which plastisol formulations can be varied to achieve the desired end results. Each application takes advantage of the ease of conversion from the liquid plastisol to the fused homogeneous thermoplastic solid.

Application: Dip Coating

When the vinyl plastisol coating becomes a functional part of the mold itself, the process is called dip coating. The metal substrate may or may not require an adhesive primer.

Hot Dip Coating is by far, one of the most common plastisol processing techniques. In hot dipping, the item to be coated is preheated before immersion into the room temperature plastisol. The inherent heat gelling characteristic of a plastisol causes the coating to gel on the hot form. The thickness of the coating is dependent upon the mass of the part, the preheat temperature and the time the hot part is allowed to remain in the dip tank. Plastisol viscosity is not a major controlling factor with regards to film thickness.

A subsequent fusion step may be required. The necessity of a subsequent fusion step will be determined by the thickness of the coating and the temperature of the plastisol furthest from the substrate will determine this. Often, subsequent fusion of the coating will be required to obtain the maximum physical performance for the coating.

Cold Dip Coating requires no preheat of the metal part. The amount of plastisol pickup by the part is largely dependent upon the viscosity and thixotropic ratio of the plastisol. In the case of cold dip molding, a subsequent fusion step is always required.

Application: Slush Molding

Slush molding is used to produce hollow, flexible items by filling a female mold with plastisol, heating sufficiently to gel a layer of plastisol on the inner mold surface, and then draining the excess plastisol. The gelled layer is then subsequently fused and stripped from the mold. Parts produced via the slush molding process are open parts, such as interior automotive parts, doll heads, etc.

Application: Rotational Molding

Rotational molding is a process whereby hollow flexible or rigid forms, having complex shapes, can be molded efficiently. Parts produced via the rotational molding process are generally closed parts, such as play balls. However, open parts can also be produced either through insulating select portions of the mold, or by trimming fused material in selected areas of the finished part. Rotational molding consists of a two part mold filled with a predetermined weight of plastisol, inserted into a heated oven, and rotated on the mold wall in two planes simultaneously.

Application: Dip Molding

Dip molding refers to the process of dipping a solid male mold, or mandrel, gelling a plastisol layer, fusing the gelled plastisol and then stripping the hollow parts. Dip molding follows the same processing procedures and principals as dip coating.

Application: Open Molding

Open molding is a process of molding directly in, or onto, a finished article such as automotive air filters. After pouring the room temperature plastisol into the room temperature mold, the part is fused.

Application: Cast Coating

Cast coating is a process where plastisol is applied to a substrate, either permanent (fabric scrim or metal) or temporary (casting paper), through a number of processes. Typically cast coating techniques include knife and reverse roll.

The plastisol is cast onto a substrate. The substrate can either be temporary material, such as release paper, or can be an integral part of the product, such as a fabric scrim.

Coating thickness is controlled by the application rate of the plastisol at the coating head. After the substrate is coated, the material is fused, and embossed, if desired. Cast coated products are typically flat, but can have some three dimensional detail, and are often produced in rolled form, such as artificial leather, conveyor belting and resilient flooring.

Safety And Handling

As with all chemicals, employees should review and understand the MSDS for each PolyOne product they handle.

Additional information, on vinyl plastisol handling and processing, can be obtained through the review of other PolyOne Vinyl Plastisol Technical Assistance Briefs.

During the fusion process, if the vinyl plastisol is exposed to excessive temperatures for extended periods of time, degradation of the material may occur. The early stages of degradation are characterized by color changes, usually to yellow, then brown and then black. Severe polymer degradation can be accompanied by the release of HCl, which is a somewhat toxic and noxious irritating gas. Material degradation can occur with both manufactured parts and with material that may be spilled in the oven, or on manufacturing equipment and molds.

Adequate ventilation and appropriate employee protective equipment are recommended. It is recommended that all companies develop and follow good manufacturing procedures, to minimize employee exposure, not only fumes and smoke, but also to the liquid raw materials.

Emissions generated during the fusion of plastisols should be removed from the workplace with localized ventilation. In the absence of adequate ventilation, an industrial hygiene survey should be conducted to ascertain air quality. An organic vapor air-purifying respirator equipped with a dust / mist pre-filter can be used to protect workers from nuisance levels (below regulatory personnel exposure limits) of plastisol emissions. Should emissions be above regulatory exposure limits, the advice of a certified industrial hygienist should be sought.

Certain lacquers and primers may contain flammable raw materials and solvents that are somewhat toxic. These materials should be used with adequate ventilation to prevent user exposure and to keep flammable / solvent concentrations below lower explosive limits. The flash points of the flammable / solvent components may be below room temperature. Precautions must be taken to prevent static discharge and exposure to flames, sparks and any equipment that may generate the same.

Table 1: General Vinyl Plastisol Properties

Processing Characteristics	
Viscosity	100 cps. to paste-like
Gelation Temp.	140°F - 200°F (60°C – 93°C)
Fusion Temp.	275°F - 400°F (135°C – 204°C)
Density	8.5 - 16 lbs./gal. (4,950 – 9,320 kg/m^3)
Physical Property Characteristics	
Hardness	Shore A5 – D80
Tensile Strength	50 – 5,000 psi (0.34 – 34 N/mm^2)
Elongation	50 – 550%
Specific Gravity	0.98 – 2.0
Low Temp. Flex	< 70°F (21°C)
Dielectric Strength	Max. 500 volts/mil @ 25 mils (19,700 MV/m @ 0.635 mm)
Flammability	Self extinguishing
Abrasion Resistance	Excellent
Impact Resistance	Excellent
Toxicity	Some compounds acceptable for use under FDA, USDA and NSF standards
Outdoor Exposure	Some compounds exhibit no significant change after 10 years; color stability varies
Other Properties	
Color Range	Virtually unlimited
Adhesive Property	Self bonding are available
Gloss Retention	Good
Relative Cost	Excellent vs. nylon, epoxy, polyester or acrylic