chromat

Solid Surface Handbook

Solid Surface

Solid surface is a generic name given to a polymerised decorative surfacing material which uses a single matrix for its entire make up. Such materials are made in a variety of nominal thicknesses, for example 3mm, 6mm, 12mm etc. depending on the type of applications and market requirements.

Solid surface is generally made, but not limited to, using an acrylic or polyester resin as bonding agent, solids such as Aluminium Trihydrate (ATH) and polymerised granules (chips) these are used for their fire retardant properties and enhancement of effect and colour. Paste pigments or dyes are also used for producing plain colours or in conjunction with chips for background colours.

Formulations of the matrix can vary widely depending on the desired effect, however, most solid surface producers tend to stay as close to the following typical model as possible:- Resin at 30% and Solids (ATH & Chips) at 70%.
This formulation is used as a guideline only and may be altered depending on the followings variables:

- Viscosity of the resin.
- Particle sizes of chips and ATH which affect the viscosity of the matrix.
- Percentage of the chips in the matrix which is adjusted to achieve the desired effect/colour.

Raw Materials

Aluminium Trihydrate
(ATH) is a primary ingredient in most solid surface materials, in some cases accounting for as much as 70% of the total make up of the product. ATH is a natural rock-form product which is excavated from quarries. In its raw form, ATH contains other impurities that can affect its colour and reduce its natural translucent properties. Not all ATH suppliers have a suitable ATH which can fulfil the colour requirements of solid surface casting.

Physical Properties of ATH:

- Powdery substance
- Odourless
- Non-carcinogenic
- Contains thermal characteristics that provide translucency and whiteness to solid surface materials.
- Non-smoking, low-toxicity, halogen-free flame retardant.

Good suppliers of ATH can provide a number of different grades of ATH which are commonly used in the production of solid surface. There are two main criteria which are normally considered when choosing ATH:-

- **Colour of ATH** – the colour and the clarity of ATH change depending on the quarry it comes from and the effectiveness of the purification process.
- **Size of and shape of ATH** – the particle sizes and shapes of ATH have an influence on the viscosity of the matrix. In general, the coarser the particle size the lower the viscosity and the better wetting properties it can provide.
- **Coated ATH** – some types of ATH are coated with titanium dioxide to provide a better whiteness. This grade is particularly suitable for when pigment alone cannot provide a brilliant white.

Other types are coated with a Silane material which is utilised to promote adhesion to the resin and to reduce the reception of ATH to moisture. For some applications it is also possible to obtain ATH which is coated with both Silane and titanium dioxide

Casting Plain Colours

When casting light plain colours, a particular attention should be made when choosing the ATH. Usually coated ATH grades such as TG35 would be ideal to enhance light colours. On the contrary, when casting dark plain colours a more neutral grade of ATH such as TA50 or TLV103 would be better suited.

Resin

Both acrylic and polyester resins are widely used in the production of solid surfaces. The choice in producing either acrylic or polyester based solid surfaces is normally made depending on the level of investment in the production plant, applications for which the end product is used for and the perception of the target market.

There are obviously differences between the solid surfaces made with these two types of resins. However, a well made product in either resin is equally suitable for the end user. Some of the differences are compared as follows:-

Type	Surface hardness	Colour Fastness	Water absorption	Fire resistant	Chemical resistant	Heat Resistant
Acrylic	Good	Better	Better	Good	Good	Good
Polyester	Better	Good	Good	Better	Better	Good

Determination of Formulations

There are no set formulations that are used in creating a solid surface product. Even one manufacturer would have to use different formulations depending on the desired design (colour and effect). It is likely that the different colours of blended chips will have different viscosities and this itself is a cause for having a slight change in the formulation of the matrix.

A resinous matrix and cloudy appearance of a cast product is the first sign of unbalanced formulation. A balanced formulation means that the matrix contains a correct ratio of solids to resin. If the resin content is too high the viscosity of the matrix will be too low. As a result solids in the matrix could sink. On the other hand, if the resin content is too low the viscosity of the matrix will be too high which would cause difficulty in the flow of the matrix throughout the mould and increase the likelihood of air bubbles and air entrapment. Air bubbles are introduced to the resin during mixing. However, in batch mixing the matrix can be made in a vacuum mixer which mixes it whilst removing the air. Alternatively (for larger volume production) continuous casting machines such as RESPECTA VacuCast® can be used.

> Note: Other possibilities for settlement of solids; Long gel time which may be caused by inaccurate catalyst level or cold ambient temperature will allow the solids to sink before the matrix sets. This could happen even when the formulation of the matrix is well balanced.

Peroxide (Catalyst)

Peroxides are powerful oxidizing agents. They are unstable, releasing oxygen when heated. Peroxides may be formed directly by reaction of an element or compound with oxygen. Their direct contact with metal causes a vigorous reaction which could result in fire or even explosion. However, in liquids such as resin it is the cause of polymerization (cure).

Methyl Ethyl Ketone (MEKP) is the peroxide which is used for room temperature curing of polyester resins. A medium reactive MEKP is used at a typical ratio of 1.5% by weight to the weight of the resin. Ambient temperature will have a great impact on the gel time, cure time, hardness and other physical properties of the end product. Temperatures between 17°C to 25°C are considered to be the most suitable ambient temperature for casting of solid surface. Curing below 17°C may result in under-cured products.

Accelerator

Polyester resins usually use Cobalt as part or whole of the accelerating system. Cobalt is a silver-white, lustrous, hard, brittle metal which reacts by generating heat when exposed to peroxides.
A pre-accelerated resin has a considerably lower shelf-life than a resin which has not had the addition of the accelerator. The shelf-life of pre-accelerated resins can vary from 1 month to 6 months and perhaps more in cooler climates.
Acrylic resins (room temperature cure) usually use Calcium as part or all of the accelerating system.

Gel-Time

This is the length of time between pouring the catalysed matrix in liquid form into a mould and the time the matrix goes into a gel state. Gel-time is dependent on the type and the percentage of the catalyst, solid content of the matrix, ambient temperature, and thickness of the product and the moisture content in the solid[1].
It is important to achieve a reasonable gel time (a maximum of 15 minutes) to avoid settlement of the particles in the matrix. Particle settlement could lead to:

a) Incorrect representation (concentration) of the chips.
b) Bowing, as the matrix has lost its balance.

Cure Time

This is the length of time between the gel state of the matrix and the time that it becomes fully hardened. Cure time is dependent on:-

- the initial “kick off” of the gel time, (shorter gel time normally means shorter cure time)
- the wall thickness of the product (thicker wall thickness normally means higher exothermic reaction which in turn means faster cure time)
- The ambient temperature (warmer ambient temperature means faster gel time and faster cure time. In contrast, cold ambient temperature e.g. below 17°C would affect the gel time which in turn prolong the cure time, resulting in under cured end result.)

Temperature

Production of good quality solid surface will very much depend on whether a suitable ambient temperature is available or not. Solid materials such as chips and ATH should be kept at temperatures between 17-25ºC. More importantly, the resin that is destined for production should be preconditioned under such temperatures to ensure that not only the viscosity of the resin is fit for processing, but also that the catalyst is able to generate heat in a sensible time to kick off the gel and the curing process. A timely gel time will also ensure that the solids don’t settle before the resin sets. If the resin is well conditioned but the solids are still cold, the resin temperature would drop as soon as the solids are added. Conditioning of the moulds is equally important as the matrix would cool down as soon as the matrix comes in contact with the mould, inhibiting the start of the exothermic reaction.
In cold conditions ATH tends to absorb moisture and becomes very condensed. Moisture absorption in ATH is a contribution to the formation of micro-bubbles and slowing down the exothermic reaction. The flow of condensed ATH would be reduced which could cause major problems with the transportation of ATH where screw conveyors are used.

Post-Cure
This process is essential to achieve the full mechanical properties of the resin. Dimensional stability, surface hardness and heat resistant of the product can only be realised after a successful post cure. The temperature and the period at which post curing is carried out would depend on the resin type used within the matrix and the thickness of the sheet. Some of the examples of post curing are mentioned as follows:

Method 1

After Curing	24 hours	8 hours
Post cure	After demoulding, leave to relax at normal ambient temperature 17-25ºC	Post cure at 60ºC

Method 2

After Curing	24 hours	4 hours
Post cure	After demoulding, leave to relax at normal ambient temperature 17-25ºC	Post cure at 80ºC

Method 3

After Curing	Immediately after cure	1 hour
Post cure	Normal ambient temperature 17-25ºC	Post cure at 120ºC

Chips
Polymerised granules (chips) are essentially made from a bonding agent such as polyester or acrylic resin, ATH, pigment and a hardener. Chips are an integral part of solid surface. As well as creating the aesthetics of the product, chips are also responsible for providing and/or affecting the physical properties in solid surface. Therefore, it is important that chips are of a good quality and consistency. Some chips that are available in the market have been processed from room temperature casting resin. It is important to ask the supplier whether they post cure their chips or the sheet materials that are used for making the chips. Poor quality chips can seriously compromise the quality of the end product. On the other hand, good quality chips should enhance the following properties in a solid surface product:-

- Scratch resistance; chips made from a hot cured system should produce surface hardness of approximately 55-60 barcol providing cast sheets are post cured.
- Heat resistance; as hot cured chips are processed in temperatures of circa 130ºC it will enhance the heat properties of the resin. • Fire retardant; hot cured chips have the least of free styrene monomers which makes them a suitable ally for the ATH to provide optimum fire retardant properties in a solid surface casting.
- Lustre; hot cured chips are stable solids and are able to hold their sheen. Providing that the solid surface product is post cured the surface will hold its lustre after sanding and polishing.
- Dimensional stability; as a stable product, hot cured chips, together with ATH, will form a dimensionally stable product providing that the end product is post cured.
- Good finish; hot cured chips are hard enough to enable a good finish after sanding and polishing. It is very difficult to achieve a good, crisp finish from a soft solid surface which uses soft chips.

Bulk Density and Specific Gravity
It is important to know the specific gravity of the resin and bulk density of chips and ATH in order to calculate costing and raw material requirement for the makeup of the matrix. The average bulk density of Chromat chips is 1080g/litre. However the bulk density of chips changes depending on

the design (percentage of different particle sizes used in the formulation of chips used in a design). In some colours with fine particles the bulk density may be as low as 800g/litre. In coarser particle sizes it may be as high as 1140g/litre.
Method of using bulk density and specific gravity to calculate weight and cost of a solid surface product:

Formulation Usage Unit cost Cost/item
Resin 1.10 (specific gravity) 36% 0.396 2.00 0.720
ATH 2.50 (bulk density) 39% 0.975 0.70 0.273
Chips 1.08 (bulk density) 25% 0.270 4.00 1.000
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1.641 kg 1.993 cost per kilo
This means a litre of matrix would actually weigh 1.621kg and would cost 3.22.

Therefore, the weight and the cost of a casting of $1m^2$ in the thickness of 12mm is determined as follows:
1 x 1 x 12 = 12
12 x 1.641 = 19.692 (weight)
19.692 x 1.993 = 39.246 (cost)

Taking the above numbers further to calculate the raw material requirement for the production of 100 units it would be calculated: 100 x 19.692 = 1969.20 kilos
Resin requirement: 1969.20 x 0.36 = 708.912 (kilos of resin)
708.912 x 2.00 = 1417.824 (cost of resin)
ATH requirement: 1969.20 x 0.39 = 767.988 (kilos of ATH)
767.988 x 0.70 = 537.592 (cost of ATH)
Chips requirement: 1969.20 x 0.25 = 492.300 (kilos of Chips)
492.300 x 4.00 = 1969.200 (cost of Chips)
Therefore the total cost of raw materials for producing 100 units of $1m^2$ each in the wall thickness of 12mm would be 3924.616.

Pigment
Pigments are essentially organic powder materials that are used for the purpose of colouring. Whilst in powder form, they are also at their strongest, most concentrated phase and difficult to handle. In order to use pigments in a more controllable manner, they are blended with various base liquids such as polyester, acrylic, plasticizer or others depending on the applications in which they are used.
There are two main differences between organic and inorganic based pigments:-
Although organic pigments can in some cases produce more vivid colours with higher intensity, they may contain heavy metals such as cadmium. The use of solid surface materials for food applications has been condemned in most European countries. As a result, most pigment manufacturers have a wide range of inorganic pigments to be able to comply with such regulations. Care should be taken to ensure inorganic pigments are used for the colouring of solid surface products. Furthermore, a certificate should be sought from the supplier of chips to certify that all their chips colours are made only with inorganic pigments.

The obvious reason for using pigments in solid surface is to produce plain colours. However, pigments are also used in other instances such for example,

- In conjunction with small percentage of chips to create a uniform background colour,
- As enhancement of background colours in room temperature cure acrylic systems which tend to cancel out the intensity of dark colours.

A few typical formulations where pigments are used:

1. White Plain Colour

    Resin 30%
    ATH 70%
    White pigment 2% (of resin by weight)

2. Black Chips with White Background

    Resin 33%
    ATH 65%
    Chips 2%
    White pigment 1% (of resin by weight)

3. Nightsky in Polyester

    Resin 35%
    ATH 35%
    Chips 30%

4. Nightsky in Acrylic

    Resin 35%
    ATH 35%
    Chips 30%
    Black Pigment 0.5% (of resin by weight)

You will notice that although the same chips design is used in examples 3 and 4, additional black pigment is required in the example 4 to enhance the blackness which is lost by using acrylics accelerator system.

Colour

Colour consistency and colour matching from batch to batch is a known concern to all manufacturers who use colouring for their products in one shape or form and solid surface manufacturers are not immune to this matter. In order to minimise the colour inconsistency, here we have outlined the possible variables in the materials and the process which could cause this problem.

- ATH – changing the grade of ATH or the particle size in the same grade can change the colour.
- Resin – each resin has its own colour after cure and this may change from batch to batch when received from suppliers. With volumetric measuring systems ensure the resin is conditioned as the viscosity can reduce the accuracy of the measuring causing colour variance.
- Temperature – low temperature increases the viscosity of the resin and makes the solids less flowing. Similarly high temperatures will reduce the viscosity of the resin. Such differences can cause colour inconsistency.
- Catalyst – catalyst reduces its reactivity in the cold temperatures. If increase in the catalyst level is used for compensation of the low temperatures this could result in varying the colour.
- Cure Time – low temperature has a major impact on the cure time. Any cure time (slow – good – fast) will produce a different colour. If the cure time is maintained there is less likelihood of colour inconsistency. Bear in mind that products made in cold temperatures are likely to be under cured.
- Chips - depending on the size of granules used in the colour there may be a settlement of granules due to transportation. This could cause colour and pattern inconsistency.

- Measuring/metering – instruments need to be calibrated regularly to ensure raw materials are measured accurately.
- Season – change of season could impact on viscosity and cure time. To overcome the effect of seasons, the workplace has to be air conditioned.

Release Agents

There are a number of substances used to prime the moulds for release purposes. Wax is most commonly used across the industry. However, this can create a problem with wax build-up which actually prevents an easy release thus making this product a less efficient way of releasing products from a mould. A more advanced and time saving method is to use a semi permanent release agent such as the ZYVAX® system which also has a good resistance to the heat generated during the exothermic reaction.

Glossary

- Slabs: referred to a sheet of material used for crushing to produce granules (chips) for solid surface.
- Gel time: time between pouring of matrix in liquid form and the time the matrix sets and goes in to a gel state.
- Cure time: time between pouring of matrix in liquid form and the time that the matrix is fully hardened.
- Pinholes: small form of air bubble.
- Micro-bubbles: the smallest form of air bubble, not normally detected by naked eye.
- Air entrapment: largest form of air bubble, usually as a result of the matrix folding when it's being poured into a mould.
- Matrix: mixture that is used for moulding a solid surface product, usually made up of resin, chips, ATH, pigment.
- Wall thickness: thickness of the sheet to a product that is being moulded.
- Conditioning: bringing the raw material to a workable room temperature (17-25ºC)
- Wetting properties: ability and speed of a solid to mix with resin.