Paint \textit{[mass noun]} according to the Oxford dictionary is a coloured substance which is spread over a surface and dries to leave a thin decorative or protective coating. The next few pages attempt to explain a little more about paint, what it comprises of and its problems. To start with let’s have a look at what is in paint.

Resin or Binder, is the main constituent material that holds all the ingredients together, it forms the film and it is the only component that must be present; all other components are optional although rarely are no further compounds present as it is a combination of the components that produce the desired properties of the final paint film.

The function of binder is to give protection to the substrate and to the components within the film. It ensures that resin, fillers, pigments etc are homogeneously dispersed and strongly influences the key properties such as gloss, durability, flexibility and toughness.

The binder can be made up of one or more basic resin or polymer systems, either synthetic or natural resin systems. Typical types of binders include polyesters, polyurethanes, acrylics, polyesters, silicates, epoxies, oils, melamine resins, depending upon the substrate and cured performance required.

The binders can be categorized according to drying, or curing mechanism. The four most common are:
- Simple solvent evaporation
- Single component catalysed/cross linked polymerization
- Two component catalysed/cross linked polymerization
- Coalescence.

- There are of course others

It is worth noting that drying and curing are two different processes. Drying generally refers to evaporation of the solvent or thinner,[1] whereas curing refers to polymerization of the binder. Depending on chemistry and composition, any particular paint may undergo either, or both processes. Thus, there are paints that dry only, those that dry then cure, and those that do not depend on drying for curing.[3]

Solvent Evaporation
Paints that dry by simple solvent evaporation form a solid film over time as the solvent evaporates, this may be quick or take a number of hours, days or weeks depending upon film thickness, solvent type and resin construction. Classical examples of this are nitrocellulose paints used in the 60’s and 70’s automotive finishes and water colour paint used by children. A solid film forms when the solvent evaporates, and because the films can re-dissolve in solvent, they are not suitable for applications where chemical resistance is important.

Single component catalysed/cross linked polymerization
Single component materials contain all the ingredients needed to produce a cured material. They use external factors – such as moisture in the air, heat, or the presence of ultraviolet light – to initiate, speed, or complete the curing process.

Single component systems that cure by heat include epoxies, polyurethanes, polyimidies and usually consist of two pre-mixed components, which eliminates the need for metering and mixing, heat excites the polymer chains and the resulting chemical reactions cross link the material. The type of resin or polymer system chosen will determine the strength of the cross linked structure and greatly affect the final performance of the film.

Single component systems that cure by moisture, such as Cyanoacrylate do so by taking water from the atmosphere, or adsorbed water moisture from the substrate surface. Nonporous surfaces may not hold sufficient moisture to develop an adequate bond.

Anaerobics are also classified as chemically reactive single component materials, these materials cure by free radical polymerisation upon elimination of oxygen, in the presence of metal ions, such as iron or copper. Where it rapidly cures or hardens to form a tough cross-linked polymer that will bond to many metals.

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Two component catalysed/cross linked polymerization

Two component systems come in several versions, all consisting of a part A, normally the resin and a second part B which can be the hardener, or catalyst, (in which case the former is pre mixed with the resin).

Mixing ratios vary 1:1 to 10:1 as does the accuracy needed for mixing the two components depending upon the resin or polymer type.

Most two part material can cure at room temperature which makes application in the field possible for touch up and repairs, particularly on large structures, although some need an elevated temperature to achieve full cure.

Coalescence

Coalescence is a process in which two phase domains of the same composition come together and form a larger phase domain. Here latex type paint and glues arrive in water-borne dispersion polymer particles. The cure is initiated where first the water, and then the trace, or coalescing, solvent, evaporate and draw together and soften the latex binder particles and fuse them together irreversibly bound matrix structures, so that the paint will not redissolve in the solvent/water that originally carried it.

Plastisol works in a similar fashion, where PVC powders are mixed into a liquid plasticiser, when heated to around 180oc the PVC powder dissolves into each other forming a homogeneous film when cooled.

Recent environmental requirements restrict the use of volatile organic compounds (VOCs), and alternative means of curing have been developed, UV curing paints, is one example where the film is hit with UV light of predetermined wavelengths which excite the polymer matrix and cause a chemical reaction to cross link the binder. These materials often require some initial flash/evaporation of the solvents first.

With powder coatings there is little or no solvent, the material melts, flows, cross links to form a solid film after electrostatic application of the dry powder.

Pigments which give the colour and opacity or covering power are finely dispersed, with granular solids incorporated into the paint to contribute colour, they can add to toughness, texture or simply reduce the cost of the paint. They are different and distinct from dyes which can be used instead of or along with pigments. Dyes are soluble or are said to have an affinity[2]. Pigments can be classified as either natural or synthetic types. Natural pigments include various, mica, silicas, and talcs. Synthetics would include engineered molecules.

If we accept that a pigment is there only to provide a colour, then all other additions to the final paint film fall into two headings, Fillers and Additives.

Fillers are added to ‘Fill ’ the paint, maybe to thicken the film, support its structure or to simply increase the volume of the paint. Fillers are usually made of cheap and inert materials, such as Talcs. Not all paints include fillers, other quite large percentages.

With some paints the filler provides important functional properties in the cured film, materials such as Zinc or Aluminium loading as high as 50% by volume is used to give corrosion protection capabilities to the paint film by been sacrificial to the ferrous substrate. These are a key part of corrosion protection capability

Other high loading fillers are used for conductive paints, where the addition of Nickel, Copper and Silver is used. These precious metal fillers must be of sufficient density to provide contact to each other within the polymer matrix when the film is cured, to allow the formation of a Faraday cage effect around the enclosed electronics. These material are used typically on plastic substrates to provide EMC/RFI shielding protection.

Additives are added to paint to provide a wide range of modifications to the composition of the film and film properties. They are usually added in only small amounts, examples include additives to:

- Modify surface tension
- Improve flow properties
- Improve the finished appearance
- Improve paint stability to UV
- Reduce foaming
- Slow down reaction time
- Improve adhesion
- Flatten -mat finish
- Provide anti graffiti capabilities
- To give non stick surface to the paint film
- And many more

Solvent or liquid carriers are used to assist in the application of the paint, it typically reduces the viscosity of the binder/pigment/filler/additive mix to allow the material to be applied via dip or spray. Once on the substrate, the solvent will evaporate, leaving the film. The term liquid carrier is considered more appropriate as it may not be a true solvent for the binder, but acts as a carrier. This may be water or an organic solvent or both as is the case in Geomet®. This component however is optional as some paints do not require thinning for application.

[2] Chemical affinity is the electronic property by which dissimilar chemical species are capable of forming chemical compounds - Britannica 1911

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