What's in a can of paint?©

According to John Stauffer
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John, get me stated on what's in paint.

We think of paint as being divided between oil base and water base. As far as raw materials that we sell, certainly the lion's share of it is water base. We make acrylic resins and vinyl acrylic resins and various types of thickening agents or what we call rheology modifiers. There are two broad categories of those that we make. One is called ASR or alkali soluble resin, and the other type is a urethane type thickening agent. These are synthetic agents that thicken up the paint to give the right brushing, spraying, and rolling characteristics.

The old traditional types that we don't make are known as cellulosics and most of them are hydroxy-ethyl-cellulose which is a water-soluble powder made from any form of cellulose such as seaweed or cotton. These are made with alcohol or O_H groups to make them water soluble. We don't make them but we certainly use them in our formulating because many manufacturers are still using them. In the past they were used in interior and exterior paints, but now they are used primarily in exterior paints. In interior paints they have been replaced with synthetics.

Is they any testing procedure anywhere in that process to check for pesticide residues that may remain on the cotton?

Good question, I don't know. Anyway, these older-type thickeners are still used to a good extent and they make a relatively stiff paint that does not flow very well but does not sag either. These paints tend to spatter when you roll so a lot of interior paint over the past ten years have been diverted away from them over to synthetics, which do not spatter. The cellulosics are in a way synthetic too, but they're based on cellulose.

What are the modern synthetics derived from?

Basically they're acrylic polymers that are made water-soluble. They're basically acidics that neutralize in a paint base with ammonia and they thicken up in the water. They're supplied as an emulsion; they're milky-white thin liquids. And if you add a base to them they dissolve. The polymer goes from being a dispersed particle to being a dissolved molecule. And in that process they greatly increase the viscosity of the solution.

Then there are urethane-type thickeners which are non-ionic. They're mixable with water but they're already dissolved. What happens when you put them into a mixture of pigment and binder is that they grab onto an associate or one of the particles of binder and tend to thicken it *that* way. So urethanes are known as associative thickeners. The ASRs or alkali-soluble resins have some degree of associative thickening capacity, but not as much as the urethanes. The cellulosics are not associative at all. The associative thickeners give a much more uniform dispersion of pigment and binder so you get a much more uniform film. What this means in property is that you get better flow-out, more consistent gloss, and in a primer, better stain-blocking capability or rust inhibition. These thickeners are course are for waterbornes.

There can be thickening agents used in oil-base paints. They're more like gelling agents. They're more like pigments than something that goes into solution. If a latex paint formula had all the ingredients except the thickener, it would really be quite thin—impossible to use.

A perspective to keep is that latex paint is a dispersion of tiny particles. Some of the stuff is in solution but the pigments and binder in water base paint is a dispersion of discrete particles. The idea is to keep the dispersion as complete as possible—to keep the particles from agglomerating or collecting together. If the particles are completely dispersed and separated, the viscosity of the paint or thickness will be lowest, the gloss will be highest, and the color will be darkest if it's a tinted paint. If the pigment is completely disbursed, you'll get more surface area to deliver the color. This is one of the things we strive for in formulating paint and one of the ingredients we make is pigment disbursant—which is a soap or surfactant that is put into the batch and coats the pigment particles to prevent them from sticking to one another. If the particles start to agglomerate the viscosity tends to rise, but you can also get some clumping or settling too.

The biggest difference between oil and latex bases is the binder—which holds the pigment particles together as a paint film. It's normally vegetable oil or some sort of modified vegetable oil in oil base paints. Oils are called "drying oils" because they react to oxygen when they are exposed to the air. They cross-link and harden and develop their properties. Today, a modification of the oil is called "alkyd". The benefits of an alkyd over a straight oil is that they dry faster and they dry harder. Nearly all oil-base paints today are an alkyd of one sort or another. The oils that have traditionally have been used are linseed oil which is pressed from the flax seed, or tung oil which is oil pressed from the fruit of the China wood tree. Soya oil from soybeans is often used to make alkyds as well.

Oil base primers will often have a mixture of a pure oil and an alkyd. The pure oil will keep it more flexible—that's required of course for a primer that's going to be applied to bare wood. In latex the binder is completely different: it's a synthetic material which consists of microscopic particles that are in dispersion—not solution—they're discreet particles of solid material and they're mixed in the water—actually polymerized in water. We start with monomers which are the components used to make the polymer.

The monomers are typically clear, flammable, smelly liquids. They are quite reactive and they are pumped into a reactor filled partly with water. They react with the water and come together to make this plastic-like polymer in the form of very tiny spherical particles. The particles are of such a size that they scatter light fairly efficiently and therefore the liquid is milky white. For this reason we call this liquid "latex". It looks like the latex from a rubber tree plant. That's the only connection with real latex at all. People talk about the allergic reaction to latex in gloves such as contact with dentists gloves, and this comes from a protein that is in natural latex.

So the beauty of this stuff is that when it dries the particles come together and fuse into a tough, continuous film. The process is called coalescing. The particles coalesce into a tough adhering film which binds the pigment particles. In the training programs we do we apply straight latex and allow it to dry and it goes from being quite milky white to perfectly clear and glossy and tough. This provides the benefit of water cleanup, yet once it dries it 's water resistent.

Within the category of latex polymers there's different basic categories. In North America, 100% acrylic is one category, vinyl acrylic is another, and there are some styrene acrylic polymers. The basic difference is that 100% acrylics are considerably more expensive than vinyl acrylics, but they do offer a number of benefits which are particularly helpful for exterior paints: they have maximum adhesion under wet conditions, blistering resistance, alkalinity resistance on masonry surfaces, and more water resistance which means they will dry out quicker from dew or rain and they also support less mildew growth as well as attracting less dirt than a vinyl acrylic in an exterior context. Sometimes top-of-the-line interior paints are made from 100% acrylics.

Styrene acrylics are used in direct-to-metal paints and some masonry sealers. Styrene helps minimize the cost, and also it's hydrophobic—which means that it's water unloving. So it's put into masonry sealers for that reason. But too much styrene will cause the topcoat paint to chalk if it's in an exterior topcoat because it absorbs UV and is broken down by it.

As far as pigments go, we have pretty much the same range of pigments for both oil and latex. Titanium dioxide is a pigment with a uniquely high refractive index. It scatters light much more efficiently than other pigments. So it's very helpful getting whiteness into paint. So it's in all white, light colored, and mid-toned paints, but not the real dark colors. If you're looking at a range of available paints such as an interior latex semi-gloss line, you may have a white, a pastel base, a medium base, a deep base, and sometimes even deeper ones called accent bases. The deep and accent bases will have no titanium dioxide.

The scattering of light is what gives whiteness and lightness. When we use the term scattering we're talking about whiteness. What happens with other pigments is that they absorb selectively. So if you have a blue pigment, the pigment is absorbing everything but the blue. A black pigment absorbs *all* the light—it's the opposite of scattering light.

In the paint industry the term pigment is given a broad definition. Some people would define it as something that provides color through the selective absorption of light. Certainly reds, whites, blues, and greens and so forth are classed as pigments. In paints they all start as dry powders—they're not dyes, they're powders. A dye would be on a molecular scale. Pigments are particles that you can see under a microscope. Even the liquid colorants that you see in the store start as dry pigments. And those pigments can be natural or they can be synthetic. They can be organic or they can be inorganic. There's quite a range. The brighter colors can be organic, and all the organic colors are synthetic. Then you have the oxide colors or earth tones. Some of them are natural and some are synthetic. there's red iron oxide and brown iron oxide, and they typically are synthetic oxide colors. Then you have ochres and umbers, some of which are mined materials with impurities that render a certain tone to them. But they are inorganic colors. Typically the inorganics are very light stable and stand up much better in sunny situations whereas brighter organics tend to not last as well in sunny areas that get a lot of UV.

There are other components such as powders that are used in paints that are called extender pigments. These are fillers or inert material that have effects determined by what the formulator chooses. Examples are calcium carbonate, clays, and talc. These extenders provide bulk and influence properties. In exterior paint they influence the chalk rate, gloss and color retention, and mildew resistance.

In interior paints extenders influence scrub, burnish, and stain and block resistance. They also serve to control the cost of a formulation. For highly pigmented paints the extenders provide what we call dry hide. Once the paint dries there is a lot of extender on the surface that scatters light to give whiteness and hiding. But this is a type of hiding that is subject to loss if some liquid gets onto the paint—water or cooking oil or something like that. If the surface gets wet you greatly reduce the efficiency of the extenders, so that's sort of a downside. The kind of paint that contractors typically apply to new residential construction is typically of this nature. They have a lot of dry hiding, but a low binder content so they don't stand up to scrubbing well and they're also subject to the loss of hiding if they get wet.

All latex paints are made with a preservative because water base paint is subject to growing bacteria. They're all non-metallic organic compounds. Mercury and mercurial compounds were typically used but they're not anymore. We make a class of compounds known as isothyazilones that are used as a preservative. They are very low levels—just enough to discourage bacteria.

For exterior paints, mildewcides are typically used, especially in the higher quality paints. Not all exterior products are made with mildewcides, but certainly the higher quality ones are. Their role is to discourage mildew from growing on the surface. They don't prevent anything from growing in the substrate. There are similar compounds to some of the preservatives that are used such as the reactive pigment zinc oxide which is used to discourage mildew growth. But most exterior paints are not made with zinc oxide. Way back before the days of titanium dioxide, lead compounds were used, and they also served as mildewsides. In addition to giving whiteness, they also helped oil based paints remain flexible. Otherwise, mildew would feed on the linseed oil in the paint.

John Stauffer is a chemist and Rohm and Hass is one of the largest manufacturers of paint resins in the world, with approximately 20,000 employees.To read more about Stauffer and the Paint Quality Institute, see my December 2002 column Down on the Farm with Deb and John. This interview with Stauffer was conducted late summer 2002.