

What paint can do – Part 1

How can I not only visually enhance an object but also make it as durable as possible and enable it to be used as long as possible? The answer is simple: by painting it. The underlying science is much more complex, however. But that's exactly what makes the world of paints and coatings so fascinating and diverse.

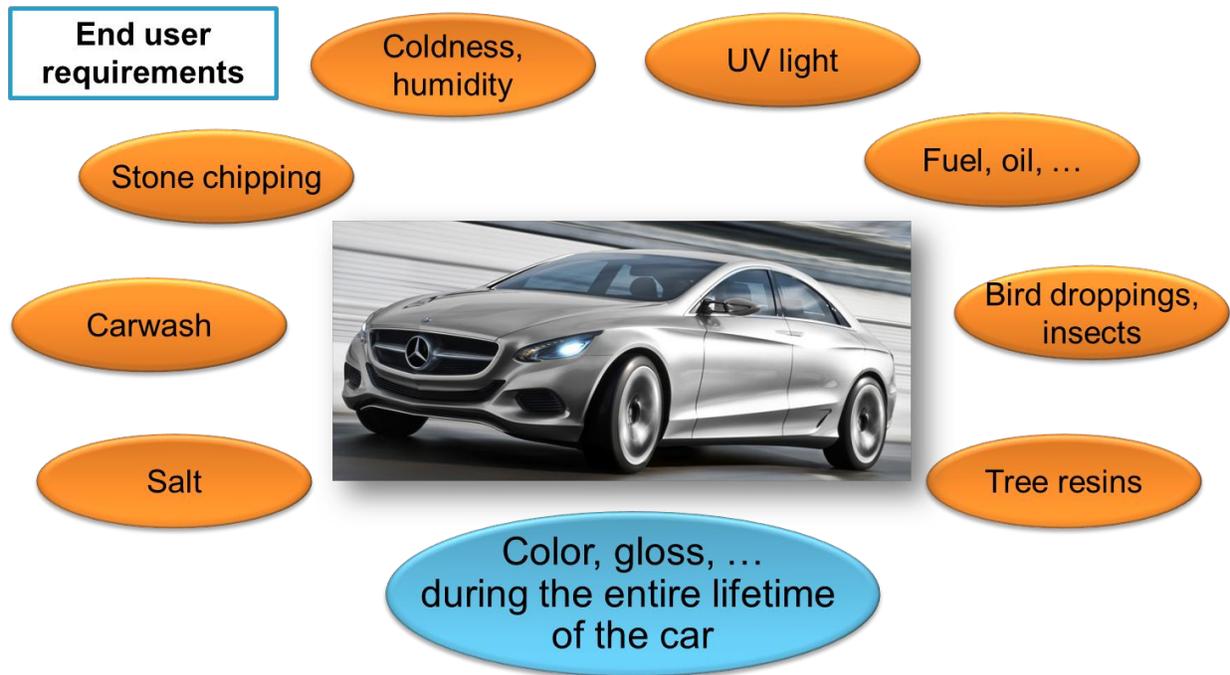
Protection and decor

Paints can decorate or protect materials. In some application areas, one or the other of these advantages is more important. For many applications, though, both properties are crucial. A car, for instance, needs long-term protection from rust and destruction caused by external influences. At the same time, its external appearance needs to suit the owner's taste.

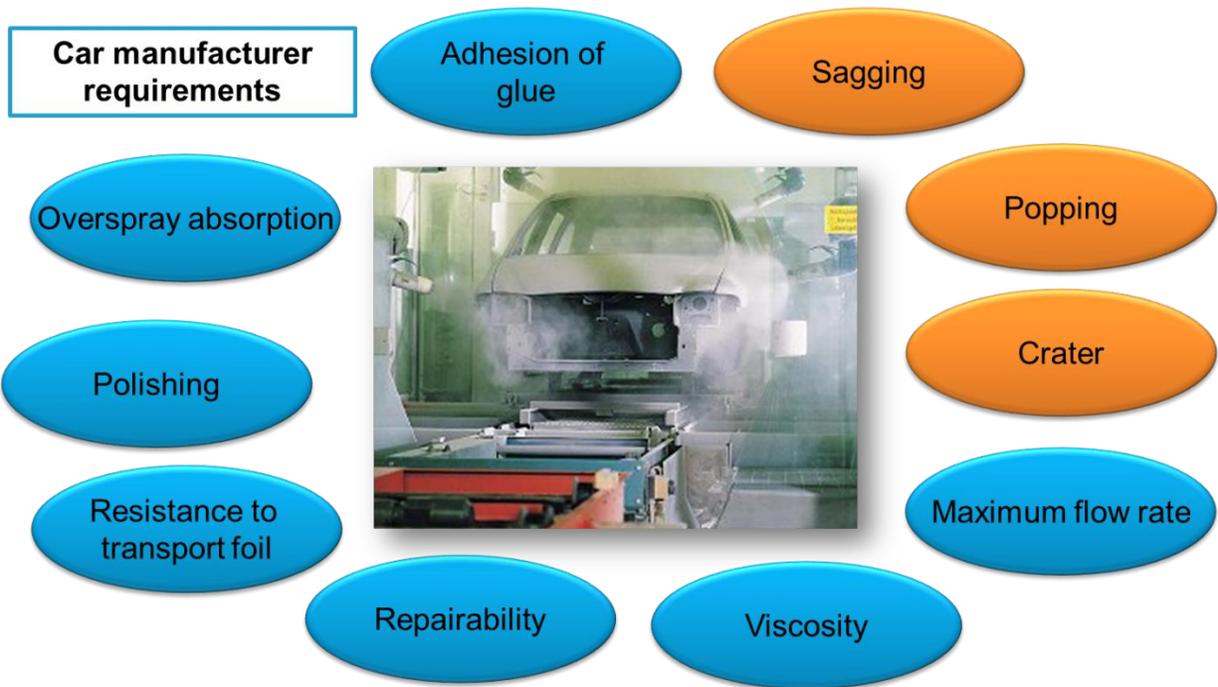
In other words, in most cases it is not possible to optimize just one of the paint system's functions. In order to fulfill the different requirements, you have to balance out the properties. In addition, the processing of the paint system also plays a central role, along with the type of application and of course the price.

Requirements for automotive coatings

When it comes to automotive coatings, the list of requirements for the paintwork's properties is long. Topping this list are obviously the buyer's expectations. The buyer's car will be subjected to all kinds of external influences in the course of its lifetime. The body needs to be protected from all weather conditions, whether in the polar regions, in the desert or in a tropical rain forest. The paint system therefore has to withstand a wide range of temperatures, UV radiation and high humidity. It also has to be resistant to all types of substances that may come into contact with the car's surface, such as road salt, gasoline, oil, sunscreen, tree sap and bird droppings. The paintwork also has to withstand mechanical stresses impacted by stone chipping or the brushes at the carwash. And while offering all this protection, it still needs to retain its color and gloss for the lifespan of the car.



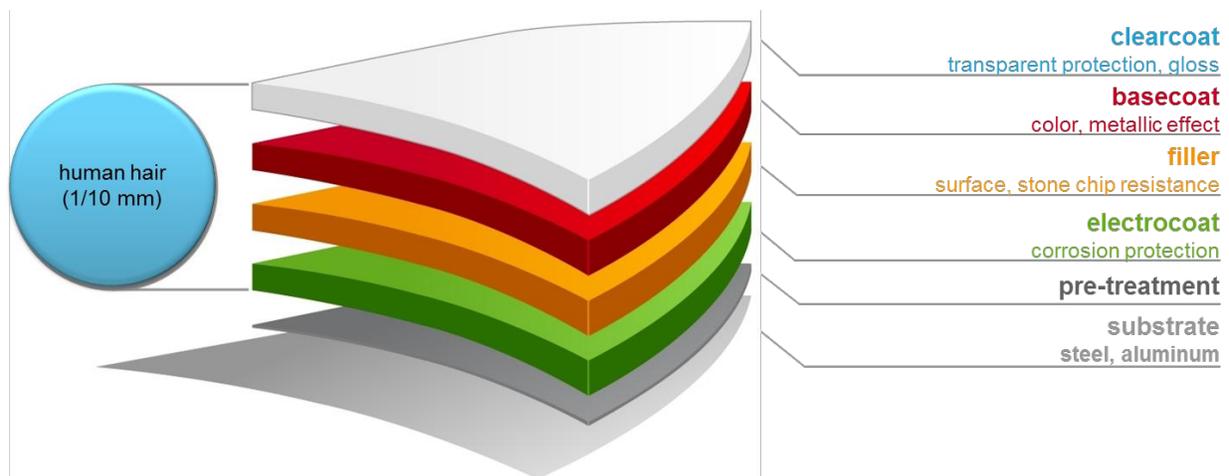
The wish list doesn't stop there, though, since the car manufacturers, too, have expectations for the paint system. They are also obviously interested in pleasing their customers – the car buyers. But at the same time, they have numerous requirements themselves, especially for the application process. They need paints that can be applied particularly quickly and efficiently. One objective is to consume as little energy as possible, since the high drying and baking temperatures make the application process one of the greatest energy consumers in the car manufacturing process. In addition, the paint needs to be resistant to various surface defects. Such defects may come about if solvents are unable to escape from the paint layer completely or in a controlled manner during drying, or if certain areas are not perfectly cross-linked due to minor contamination or dirt, ("cratering"). A car with a disfigured surface is unlikely to find a buyer. And this leads to the next point: a finish also needs to be repairable. After all, what good is the most attractive color if scratches to the finish cannot be repaired in the car's later life? Today, when cars are manufactured, many parts, such as the windshield, are bonded to the car body. Therefore, the paint system must also offer a good base for the adhesive. But at the same time, it must allow transport foils to be peeled off without leaving behind any residues.



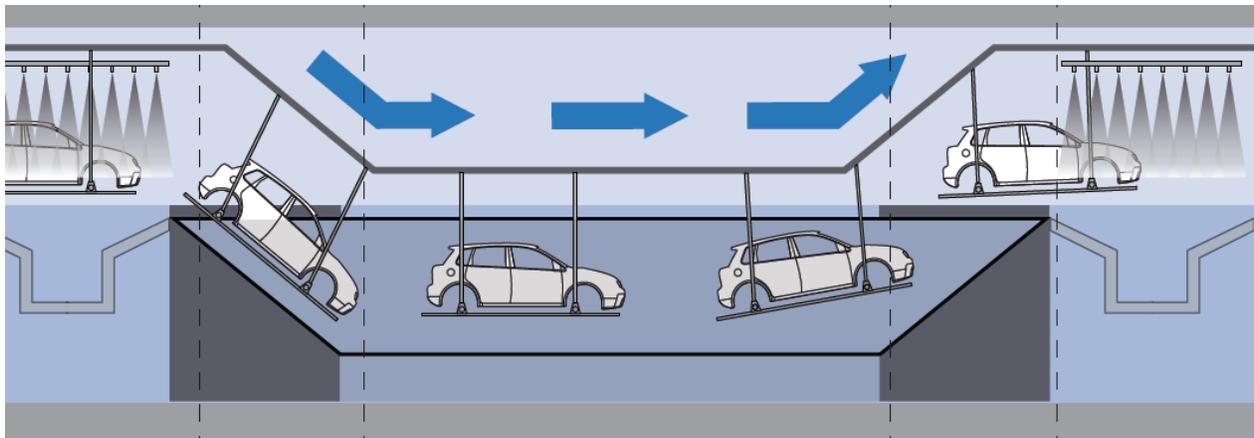
The list of requirements is long and there are certainly any number of other properties that can be added to it. Different manufacturers have different priorities. So the question is how to meet this long list of requirements in the first place.

Structure of an automotive finish

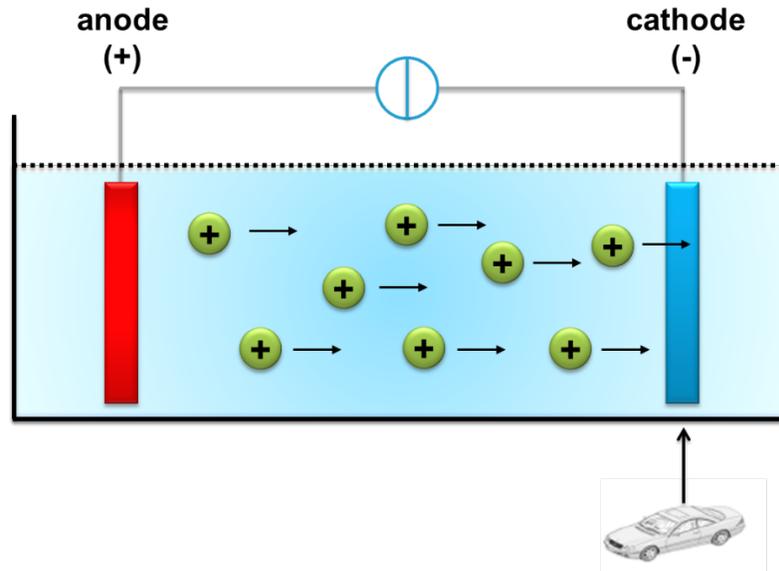
The different requirements for an automotive finish can be met only with a multilayer paint system. In this system, each of the individual layers has a special "job" and its properties differ from those of the other layers.



An important function of the finish entails protecting the body from rust and other external influences over the entire lifetime of the car. This job is carried out by the lowest paint layer – the cathodic e-coat – which is applied to the pretreated steel. In order to apply the e-coat in an electrochemical application process, the body is moved through a tank and turned around several times. This ensures that all of the cavities are coated as well. Even very tiny spots without sufficient corrosion protection could be enough to cause extensive damage, because the rust could migrate from this spot underneath the finish.



When electric current is applied, the body serves as a minus pole (cathode). The paint components in the tank are for their part positively charged and therefore move toward the body and are deposited on it. This process continues until a certain film thickness has been achieved, which then has an insulating effect. After it is removed from the tank, the body is moved into an oven, where chemical cross-linking gives the paint layer the stability it requires.



In the standard paint system of an automotive OEM finish, filler is applied over the e-coat by means of spray application. In keeping with its name, the filler fills these minor irregularities in order to smooth out the surface. The material is relatively soft, which allows it to cushion the blow of some mechanical stresses such as stone chipping. The filler also has to be baked in the oven afterward.

In the next step, the appearance of the finish, which up to now has been rather plain, is significantly improved, since basecoat is applied to the filler. Not only does the basecoat provide the desired color, it can also evoke different effects such as metallic, pearlescent or iridescent color effects. Here we can see how important the decorative function of the finish is, since the color and effect, combined with the body's design, is usually an important factor in a customer's decision to buy a car.

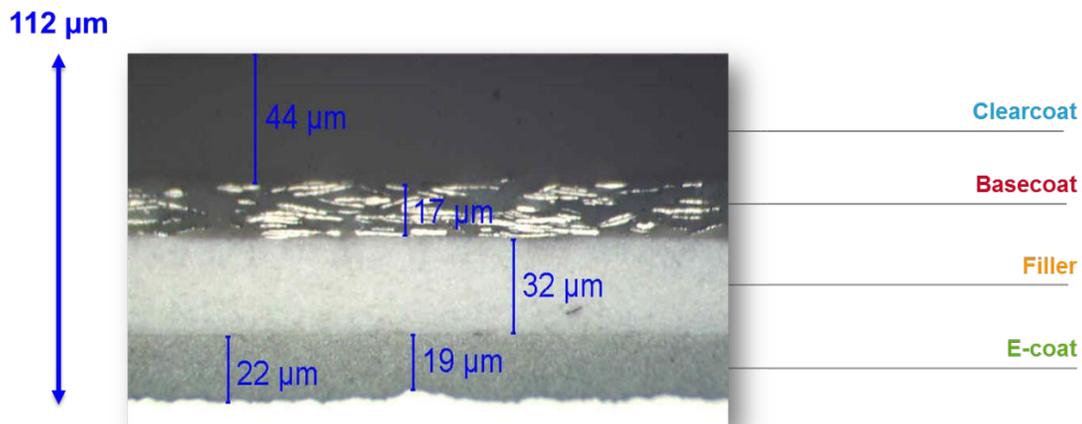
Despite the color impression, however, the multilayer paint system still appears very mat and dull. The car does not take on its characteristic gloss until the topmost layer is applied: the transparent clearcoat. In addition to its visual property, it also protects the underlying layers and the body from all kinds of potential external influences. These include different weather conditions such as rain, UV radiation and extreme temperatures, as well as substances occurring in nature such as bird droppings or tree sap, and also mechanical stress, such as that encountered at the carwash.

While the finish looks as though it is a single entity, it actually consists of several layers. Each layer features different properties. In order to fulfill the entire list of requirements, the interaction between the individual paint systems is key. Certain challenges can only be overcome through teamwork.



	Phosphatization	E-coat	Filler	Basecoat	Clearcoat
corrosion protection	●	●			
adhesion	●	●	●	●	●
stone chip protection		○	●	○	○
elasticity		○	●	●	●
protection against wetness		●	●	●	●
leveling		●	●	○	●
color (including e.g. flop effect)				●	○
gloss					●
hardness				○	●
protection against UV light			○	○	●
scratch resistance					●
acid resistance					●
protection against chemicals					●
protection against solvents					●

At the same time, the entire finish is extremely thin, at 100-150 μm on average, just slightly thicker than the diameter of a human hair. This demonstrates that automotive coatings are true high-tech products that have been continually refined over time.



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