AXC.133.02

Technical Leaflet

The Technology behind Car and Yacht Protective Finishes

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Introduction

Cars and yachts are probably the most valuable assets we may possess in our lives. They inspire us to travel to great places or are just used for day-to-day commuting. Independent of their function it is important for most people to keep them to appear shiny and new. Car and yacht manufacturers have recognized this and have come up with immaculate coatings with brilliant colours and high gloss. Protection of car and yacht coatings is a job of its own and specialised detailers and care companies apply finishes on top of the coating that move the aesthetics to the next level. These finishes are typically thin clear films that are applied by wiping and buffing.

At present, there are extensive different finishes available to improve the surface appearance, supported by a vast development of new technologies. Whereas in the past waxes on natural or synthetic basis were mainstream, today sol-gel systems and preceramic polymers are penetrating the market with great success.

Thanks to the modularity sol-gel systems and preceramic polymers, formulators can look beyond gloss and aesthetics only and are able to formulate brilliant permanent hydrophobic, easy to clean and self-cleaning finishes.

In this article an overview is given of different technologies currently used in protective finishes and will briefly describe the following types:

- Carnauba wax
- Polyethylene wax
- Fluoropolymers
- Silicones
- Sol-gel technology
- Preceramic polymers
- Graphene

Carnauba wax

Carnauba wax originates from the carnauba palm tree leaves and is harvested exclusively from Brazil.

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It is perhaps good to know that carnauba wax is extracted from the leaves by local producers, a process that does not harm the integrity of the tree or the environment. No tree is cut to produce carnauba wax!

Chemically speaking carnauba wax is based on aliphatic esters (40 wt%), diesters of 4-hydroxycinnamic acid (21.0 wt%), ω-hydroxycarboxylic acids (13.0 wt%), and fatty alcohols (12 wt%). Carnauba wax is favoured by car detailers as it deepens the colour of the car which is specifically noticed with dark colours like black or marine blue. Though chemically and UV resistant carnauba wax is not very durable. As wax it is not curing chemically and it will not protect the lacquer for long time against rain or washing.

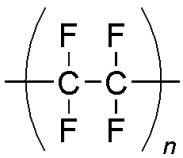
Polyethylene wax

Polyethylene is a man-made synthesized chemical. It is primarily known for uses as bags and packaging films. When formulated in the correct way it can be used in the form of a wax and can be applied as car or yacht polish. Its main advantage versus carnauba wax is its price and ease of application. Its disadvantage is the somewhat dull look and reduced gloss when compared to carnauba types.

Polyethylenes are high molecular weight materials. Chemically speaking polyethylene consists of repetitive $-(CH_2)_n$ units, where n is several thousands. It is known to be stable against chemicals and UV light. The polymer is chemically inert meaning it is relatively resistant to the elements and it has a low surface energy. Downside is that it does not bind very well to surfaces, the technology does not allow for chemical anchoring. This means that polyethylene waxes rain or wash off in time. Though economically attractive they do not last very long.

Fluoropolymers

Fluoropolymers have become important resins as they perform very well on hydrophobicity as well oleophobicity and generally have good antistick properties specifically appreciated in for example frying pan coatings. Besides, they have good chemical and temperature resistance.
Chemically fluoropolymers consist of polymer units with a combination of C-H and C-F bonds. The more C-F bonds, the more the fluorine properties will prevail, such as antistick, heat resistance and chemical inertness.
A downside of increasing the ratio of C-F reduces its substrate adhesion. As fluorine is antistick it also means it sticks less to the substrate.



A well-known fluoropolymer is PTFE (a structure depicted on the right) which is sold as Teflon® in the market. PTFE is the fluoropolymer with the lowest coefficient of friction and frequently used in car care formulations. PTFE provides nice gloss, scratch resistance and hydrophobicity.
PTFE is however costly and its durability is relatively limited due to its limiting surface anchoring capability; no chemical anchoring may be expected.

PTFE can conveniently be sourced as powder and formulated into care formulations. Sometimes it is used together with carnauba or polyethylene waxes to reduce the cost of the formulation.

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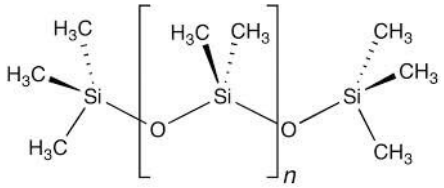
Silicone

Silicones are one the most diverse product groups in the chemical industry. They are also called polysiloxanes and can be classified as fluids, resins, or elastomers. They are based on polymers that



consist of chains made of alternating silicon and oxygen atoms. Silicones are rather flexible polymers and are predominately used in car care as additives to obtain good levelling and hydrophobicity. Especially prone to hydrophobic behaviour are polydimethylsiloxanes (PDMS) depicted in above chemical formula:

Since not very compatible with traditional formulations PDMS are often chemically modified with ethoxylates. This serves 2 goals, first the ethoxylate compatibilizes the PDMS and the other components of the formulation, and second it provides the molecule with surfactant properties. It means that during the application the ethoxylated siloxane moves to the surface to increase the hydrophobicity of the cured film. So while hardly used as the main resin, silicones are important coresins or additives in care formulations with the function to improve wetting, leveling or hydrophobation.

Sol-gel-technology

Sol-gel materials include a wide range of inorganic and hybrid organic/inorganic compounds which are prepared by a common synthesis method described by sol-gel-technology using nanotechnology.
Sol-gel-technology allows to start from wet chemistry (precursors) to form hard particles like SiO_2 and TiO_2 at nano scale (<100nm), which is referred to as the bottom-up process. So instead of putting lots of energy in milling particles to sub-micron level sol-gel-technology creates these particles in situ. In below scheme (Figure 1) the formation of a silica particle is depicted using sol-gel-technology.

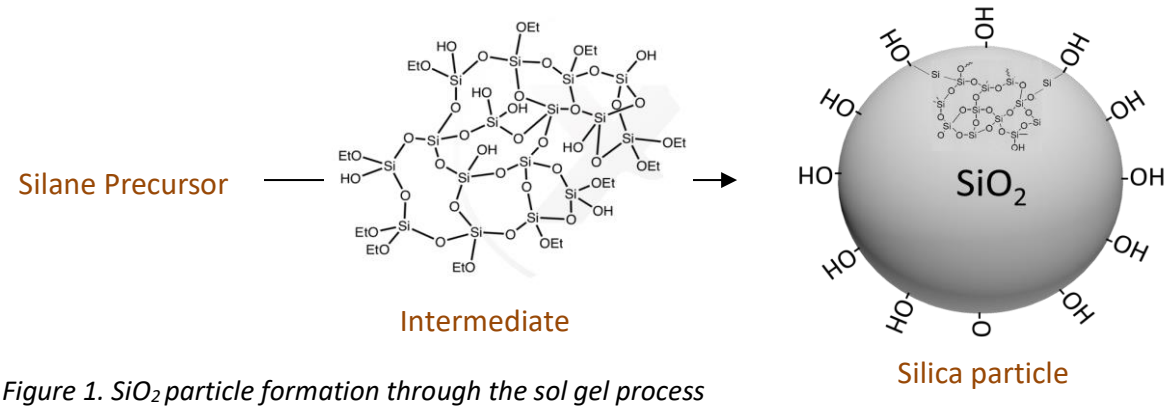


Figure 1. SiO_2 particle formation through the sol gel process

Through selection of the right precursors, sol-gel-technology can also be used to make particles with certain functionalities such as easy to clean, self-cleaning or superhydrophobicity. Another great advantage of sol-gel-technology is their ability to crosslink to surfaces making them more durable.
Sol-gel-technologies currently experience a strong industrial interest and find their way into the car industry. They are in particular used to provide durability, scratch resistance and easy to clean effects.

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Preceramic polymers

Ceramic finishes are preferred in the car industry as they aggressively improve scratch resistance due to their extreme hardness. Some ceramic finishes may deliver 8-9H pencil hardness and resist up to 20N load in scratch resistance tests. While in addition to that they provide very high gloss surfaces, it is no wonder that these finishes have gained wide attention in the last decade.

Preceramic polymers convert to a ceramic layer through reaction with moisture from the air (Figure 2). Moisture from the air hydrolyses the polymer which then internally reacts to form a metal oxide ceramic layer. While being covalently bound to the surface these ceramic layers account for very durable and resistant films.

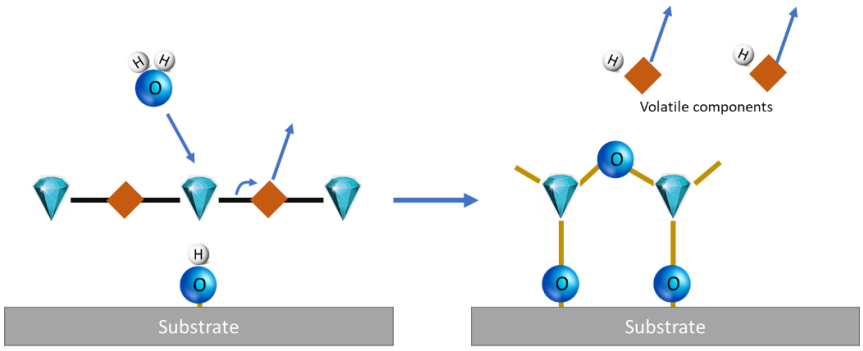
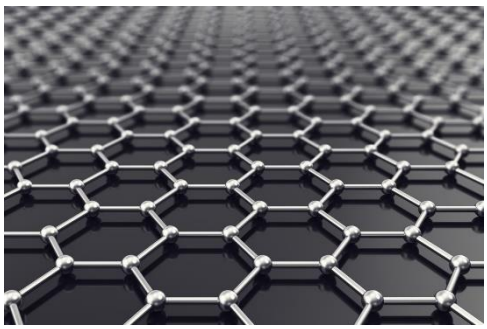


Figure 2. Conversion of preceramic polymer in ceramic layer

From all the developments in recent years it is probably the technology of preceramic polymers that has created the most impact in the car and yacht care industry. While not inexpensive, the technology used is in great demand because thin layers are used which reduce cost. Moreover, the polymers are easily altered with hydrophobic and oleophobic modifications to obtain for example easy to clean finishes.

Graphene



Graphene is often seen as the new wonder material that possesses many interesting properties. Being described as the thinnest 2D material presently around it provides properties such as electrical conductivity, mechanical robustness, transparency and hydrophobicity.

The production of graphene is relatively complex and involves amongst others chemical vapor deposition technique on Copper foils. Since difficult to scale up the quantities industrially produced product are still relatively small and amount for one of the reasons the material is up to this time very expensive.

While some formulators, used the material early on, therefore we see some car care polishes based on graphene. Though very similar in properties to ceramic systems graphene is said to reduce the heat pickup of the coating resulting in less water spotting.

About Axcentive:

Axcentive develops and promotes sol-gel and preceramic nanotechnology for the coatings industry. This technology base allows for chemical modifications on nano level to suite to a certain performance need. Smart and functional coatings with specific properties such as self-cleaning, easy to clean, anticorrosive, superhydrophobic or superhydrophilic properties can be formulated with this nanotechnology.

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