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High heat resistant coating systems

A look at the global market for high heat resistant coating systems. The first of a two-part series.

Certain organic binders, notably phenolics and epoxies, are tolerant of relatively high temperatures without modification, but coatings designed to provide protection against high service temperatures generally incorporate silicon in some form or another. Since the silicon bond requires much higher energy for its disruption than the corresponding carbon bonds in analogous molecules, it is much more resistant to thermal degradation.

Silicone is so effective in this respect that some degree of thermal resistance can be achieved simply by cold blending ten percent or more of a silicone resin with a conventional binder. The temperatures that such a coating will resist are limited to approximately 220°C. Copolymerization, even with modest levels of silicone resins, is more efficient, and can be achieved with, for example, alkyds, phenolics, epoxies, acrylics and saturated polyesters.

Silicone may also be utilized in the form of inorganic silicate coatings, which form a glassy layer on curing, and will react with both masonry and steel substrates to form a tight bond.

At the top end of the performance spectrum, silicone resins which will withstand temperatures above 800°C have been commercially available for more than 50 years. Systems which will withstand more than 1,000°C have been developed, originally for space vehicles, but now with applications in the chemicals industry. However, these pure silicone resins are expensive and their curing via condensation of the silanol groups requires high temperatures. Thus alkyl silicones or the copolymers discussed above are more widely used and are capable of meeting the majority of domestic and industrial requirements.

A means to avoid the time and expense of high-temperature stoving is to formulate "burn-off" coatings. These incorporate a binder system which cures at low or ambient temperatures, bonding the coating to the substrate. The organic binder decomposes when parts are exposed to service temperatures high enough to cure the silicone binder. The system is not ideal, in that its effectiveness will depend upon the conditions under which this secondary curing occurs, and air pollution during this phase is inevitable.

Table 1: High Heat Resistant Coating Applications

Cure Mechanisms	Resin Species	Number Coats	Solids	Filler Types
1 Heat	1 Fluoroploymers	1 Single	1 Low	1 Ceramic
2 Air Dry	2 Epoxies	2 Double	2 Medium	2 Aluminum
3 2k Ambient	3 Alkyds	3 Triple	3 High	3 TiO2
4 2k Heat assist	4 Acrylics			4 Other Inorg.
	5 Phenolics			
	6 Silicone			
	7 Polyesters			
	8 Hybrids of above			

A more sophisticated variation is to use, for example, titanium esters mixed with aluminum flake. The esters can be formulated into the binder system of stoving paints which will resist temperatures of up to 400°C. Above that temperature, burn-off occurs, depositing a titanium-aluminum complex coating which has good hardness and adhesion, and can resist temperatures of up to 800°C.

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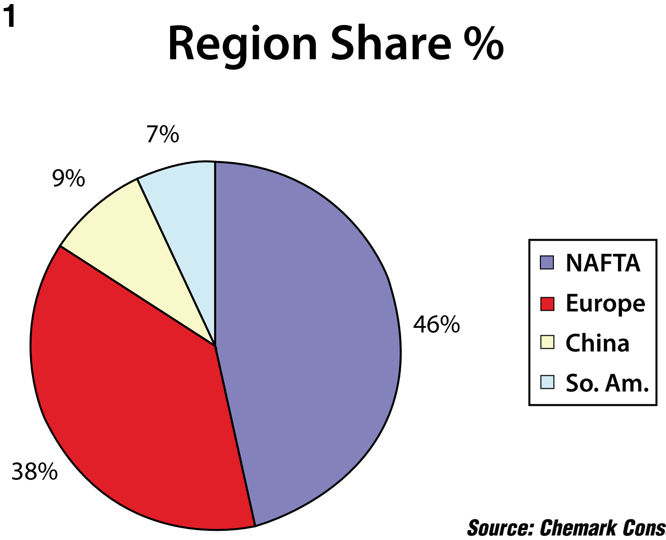
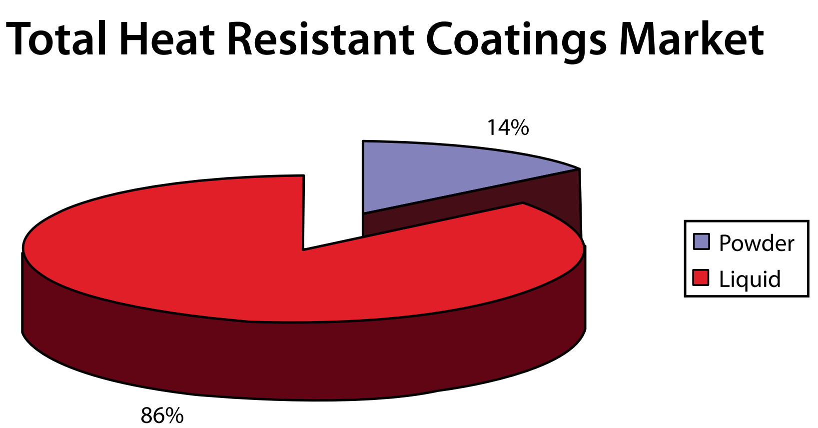
Powder coatings which will resist temperatures of 300-500°C, depending on formulation, have been on the market for several years and are used for applications such as barbecues, stoves and exhaust systems. An important consideration here is that powder coatings are often applied at relatively high film builds, but for these applications the film must be kept thin to minimize thermal stresses on heating.

Chart 1



Source: Chemark Consulting

Chart 2



Source: Chemark Consulting

IMPORTANCE OF PIGMENTATION

As has been noted in the example above, the pigment may react with the binder at high temperatures, making its choice critical. In general, however, there are two main issues:

- The pigment must itself be capable of resisting the service temperature; and
- Flake-form pigments may help to protect the resin system against oxidation.

Thus, leafing aluminum flake is widely used, though at temperatures above 500°C, ceramic frits are preferable. Black iron oxide and some other metal oxides are used in some applications, but care has to be taken not to choose materials that will lose water of crystallization and/or change their crystal form at service temperatures, as this results in a change of color and possible damage to film integrity.

MARKET SIZE & GROWTH RATES

There are 35 market segments representing 1,152 possible combinations serving this fast growing market (see *Table 1*).

The 35 segments that make up the global market for heat resistant coatings is valued at US$543.9MM and is expanding at an average growth rate of 5.78% annually.

Broken down in regional markets, NAFTA accounts for $246.6MM of the global market; all of Europe represents $199.9MM; China makes up $46.33MM; and South America accounts for the remaining $36.85MM (*see Chart 1*).

Although powder coatings have established a 14% foothold share in the heat resistant coatings market segment, it is not growing as fast as the liquid portion due to the greater technical flexibility with liquid systems versus powder (*see Chart 2*).

Chemark will address this market further in our second of a two-part series next month. ***CW***