“Properties of inorganic polysiloxane hybrid coatings for the protective coatings industry”

The search for clean, green technologies, in all fields of the coating chemistry industry has never been more evident than over the last decade. The development and release of Polysiloxane coatings for the heavy duty market was seen as a breakthrough in technology as this system offered super low VOC with outstanding performance attributes.

Polysiloxane hybrid coatings can now be considered to be mature by world standards. The technology was introduced into the global market in 1993 and over this time greater than 3 million square meters of substrate has been painted with this product. The applications have been many and diverse i.e. OEM, maintenance, new construction, anti-graffiti. Since its introduction in the protective coatings industry, the polysiloxane hybrid coating has been used for the protection of more than 3 million square meters of steel, which includes large offshore new building and maintenance projects, the nuclear and mining industry, refineries, on shore plants, tunnels and bridges and a variety of OEM projects.

Inorganic coatings are predominantly formulated with silicon based binders, such as water and solvent based silicates, silicone resins, silanes and mixtures of organic binders with silicate and silicone binders. Commonly, all these traditional inorganic coatings use has been limited to very specific applications due to the characteristics of the binder system. Silicone resin based coatings require heat curing at levels of 230°C; silicate based coatings, which are formulated with high pigment contents, result in flat and rather porous coatings. The use of these inorganic coatings have been limited to specific applications, such as smoke and exhaust stacks and other structures exposed to high operating temperatures; tanks exposed to combinations of high temperatures and aggressive chemicals; nuclear industry structures exposed to high levels of radiation.

Organic resin based coatings have been used for many years as high performance and corrosion resistant maintenance coatings. From the protective coatings standpoint, each generic type of coating possessed certain unique features and benefits as well as certain limitations. Among the popular and durable organic coatings the problem with epoxies has been poor weatherability and low temperature curing, while the hybrid epoxy/acrylics have a problem with gloss retention and compatibility with other resin based coatings. Polyurethanes tend to be moisture sensitive and a health hazard due to the isocyanate curing system. Moisture cure polyurethanes besides their moisture sensitivity and health hazard also have problems with shelf life stability. Thus overall while the organic binders offer ease of processing, flexibility and toughness they fall far short of the inorganic binders in terms of weatherability and durability.

Through binder and formulation re-design, exploring the inorganic binder types with emphasis on the silicon based chemistry, organic-inorganic polysiloxane hybrid coatings have been developed during the last decades of the last century. This has resulted in the introduction of polysiloxane hybrid binders in the coatings industry, which has caused a breakthrough in the protective coatings industry. By the combination of organic and silicon based inorganic binder systems, high technology coatings have been introduced providing the durability and toughness of epoxy coatings whilst outranking the gloss and color retention of the best urethane based topcoats.

True hybrids are where inorganic and organic polymeric systems with mutual chemical bonds are formed. Specifically these true hybrids have been explored successfully for the development of new binders for use in high technology organic-inorganic polysiloxane hybrid coatings. By combining the inorganic polymeric structure of siloxanes with organic binder systems, coatings have been developed, which combine the inertness, weatherability and hardness of inorganics with the processability and toughness of organic binders.

The term polysiloxane reflects the nature of the polymeric structure that contains repeating silicon-oxygen groups as backbone. Organic-inorganic hybrids have been developed by chemical modification of the polysiloxane backbone with functional organic groups. By the versatility of the polysiloxane chemistry, a variety of functional organic groups can be attached to the inorganic siloxane backbone. This chemistry allowed the development of hybrid binder systems with varying reactivity and chemical and physical properties. The mutual chemical bond between the organic functional groups and the inorganic polysiloxane matrix represents the category of true hybrids.

The development of polysiloxane hybrid coatings based on a polysiloxane backbone constitutes a technological advancement, comparable to the introduction of inorganic zinc silicates in the middle of the last century. The chemical combination of aliphatic epoxies with polysiloxanes resulted in polymers with higher performance characteristics than can be achieved by the physical combination of both polymers.

The chemical combination provided the basis for the joined polymeric strength, weathering durability, radiation resistance, gloss and color retention and corrosion protective properties of the polymers, whilst overcoming the brittleness of inorganic structures.

Application

The epoxy polysiloxane is a two component coating with long pot life, which is applied at dry film thicknesses of up to 200 microns without sagging. The epoxy polysiloxane hybrid coating is easy to apply and does not require specialized equipment. It can be applied by airless and conventional spray systems, brush or roller. As no thinning is required for application, emissions of volatile organic compounds are controlled and no extra costs for thinners have to be incurred.

Health, Safety and Environment

By its high volume solids content of 90 percent in combination with its ease of application without the use of thinners, a significant reduction of solvent emissions and waste is achieved. By its low VOC, the polysiloxane coating is fully complying with the increasingly stringent environmental health and safety requirements without downgrading coating performance. The epoxy polysiloxane hybrid coatings represent a large improvement with respect to health, safety and environment compared to epoxy, epoxy acrylic and polyurethane coatings.

Weathering

The polymeric structure that contains repeating silicon-oxygen groups in the backbone of the epoxy polysiloxane hybrid coating provides the basis for the excellent weathering characteristics. As a consequence, the coating is hardly affected by sunlight, weathering or atmospheric oxidation in contrast to organic-based coatings, that eventually degrade under these exposure conditions.

Epoxy polysiloxane hybrid coatings retain their color and gloss far better than other topcoats in the protective coatings industry, such as polyurethanes, which show fading and loss of gloss in 3 to 5 years.

This is also demonstrated from the comparison of the epoxy polysiloxane hybrid coating with a wide range of polyurethane topcoats by Florida exposure tests carried out by ACQPA, France. After 12 months exposure, the epoxy polysiloxane hybrid coating outperformed the polyurethanes in colour and gloss retention.

Conclusion

The success of the polysiloxane hybrid coating is a result of the unique characteristics achieved by chemical modification of the inorganic polysiloxane backbone with functional organic aliphatic epoxy groups. This new technology provided the basis for a breakthrough in the protective coating industry, utilizing the greatly improved coating performance characteristics based on the epoxy polysiloxane hybrids binder systems.