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HIGH-TEMPERATURE POLYMERIC ANTICORROSION COATINGS

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RusTec LCC
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ELECTRODEPOSITION COATING TECHNOLOGY

Electrodeposition is industrial technology to coat a surface of the articles made of electrical conductive materials with thin single-layer of paint and varnish materials (PVMs) for decoration and/or corrosion protection. To be commercially successful, modern electrodeposition technological process have to meet severe requirements for quality and safety, and to be environment friendly and cost-effective. Electrodeposition technique of surface coating is considered as the most economically effective among currently available. The method enables excellent quality coating of articles made of ferrous and non-ferrous metals and alloys, semiconductors and composites with high electrical conductivity, articles made of the materials with low electrical conductivity and plated with a continuous layer of electrical conductive material, and, also, of complex aggregates which component parts are made of above mentioned materials.

Waterborne PVMs based on water-soluble film-binders (epoxy resins) are known since 40s of the 20th century. Water is affordable environment friendly cheap solvent available everywhere. However, due to features of water as a solvent – low volatility, high surface tension, boiling at high temperature – the processing of waterborne PVMs into coatings has been difficult for a long time. The problem has been solved by development of electrodeposition technique and proper equipment that enabled serious expansion of waterborne PVMs coatings to industry.

The process of electrodeposition is performed by dipping an article into a bath with waterborne PVM. The bath is equipped with systems of stirring, thermo-stating of working solution, electrodialysis cleaning and DC power supply. Water-solubility of resin of film-binder degrades when DC current flows through waterborne PVM. Particles precipitate onto the surface of the dipped article which is one of the electrodes (anode or cathode) of the bath and form a dense thin coating over entire surface.

There are two types of electrodeposition methods: anodic (anaphoresis) and cathodic (cataphoresis).

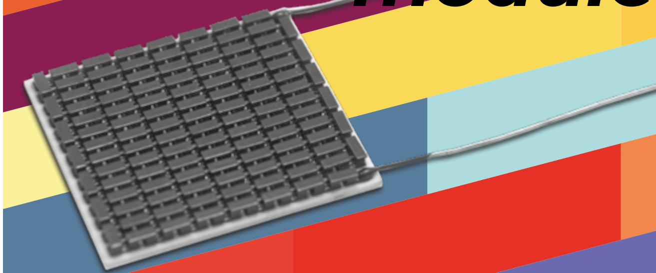
Anaphoresis differ on cataphoresis by enabling of cataphoresis to deposition of coatings with higher anticorrosive properties and ability simultaneous coating both of ferrous and non-ferrous metals. Additional attractive feature of cataphoresis is no significant chemical reactions with the bath's electrodes materials, that results in low level of uncontrollable impurities in coatings. Also, shelf lifetime of cataphoretic LPMs is longer (2 years). Therefore, cataphoresis is used nowadays as major technique for high-quality decorative and anticorrosion coatings in huge number of industrial applications.

Waterborne PVM is a suspension of chemicals and pigments in the solution of water-soluble film-binder resin of different types: alkyd resin, epoxy resin, epoxy-polyether resin, acrylic resin, etc. Chemically-synthesized film-binders for electrodeposition are unique, their usage for alternative coating techniques is not allowed. The cost of PVMs is quite high, however, because of low consumption of LPM and the excellent corrosion resistance provided by a single-layer coating, the great economic effect is achieved by replacing of traditional methods of coating with electrodeposition.

Water solutions of film-binder chemicals for electrodeposition are typical polyelectrolytes with properties of ionogenic superficially active substrates (SAS).

The principal reaction causes electrodeposition phenomenon is decomposition of water into ions that changes pH of chemical environment in the near-electrode space, and results acidized (pH→0) space near the anode and alkalinized (pH→14) space near the cathode. Precipitation is caused by the ability of polyelectrolyte to change solubility in water, depending on pH value of chemical environment in the near-electrode space. DC voltage supply to the article (first electrode) and opposite anode or cathode induces DC current through waterborne PVM that, in turn, degrades of water-solubility of film-binder and causes precipitation of PVM particles onto the surface of the article with formation a dense thin coating over entire surface. Areas of the article within zones of maximum density of electric current are coated first; as the insulating property of the deposited coating increases, the intensity of the electric field lines is redistributed over the surface and deposition process moves along the surface until that will be coated totally. Formation of coating is finalized in 1-3 minutes, depending on parameters of coating process and film thickness. Result is dense cladding, almost dehydrated, with content of non-volatile constituents of 98-99 % and uniform in thickness throughout the article surface. Very low water content in precipitate enables short drying and polymerization time and deposition of practically non-porous coating. Process of high-temperature polymerization occurs with three-dimensional cross-linking of film-binder providing high anti-corrosion properties, good elasticity and resistance of polymer coating to bending and impact.

Thermoelectric module



Thermoelectric module (L×W = 40 mm × 40 mm) with dices size 1.4 mm × 1.4 mm × 1.6 mm (without upper substrate) with electrodeposited coating of all conductive parts: side surfaces of thermoelectric dices, copper contact pads atop, copper interconnection lead wires on lower substrate and solder surfaces between them. Temperature difference between hot and cold sides for module for cooling is from -80 °C to +100 °C; and for module for generation is from 20 °C to 280 °C

COATING PROCESS INCLUDES THREE MAIN STAGES:

- Preparation of the surface of the articles by different cleaning techniques;
- Coating by cataphoretic electrodeposition;
- Dying and polymerization at high temperature.

Preparation of the surface to coating stage is pre-treatment of the surface before cataphoresis, more often, chemical treatment is used. Depending on contamination of the metal surface, technological process of the surface pre-treatment may include degreasing, etching, phosphating etc. The number of operations is determined during development of real electrodeposition process, considering the environment conditions of exploitation of articles. Articles are rinsed in main and distilled water in intervals between preparation operations.

The coating stage includes forming a single-layer film on the surface of the article by cataphoresis for 1-3 minutes, rinsing the coated article with main and distilled water, and its blowing with hot air to remove excess water from surface of the article.

The final stage is high-temperature drying and polymerization of deposited film. Polymerization of coating is carried out in a drying through-feed or box type oven at temperature of 125-200 ˚C during 15-60 minutes, depending on PVM type chosen for coating.

ADVANTAGES OF ELECTRODEPOSITION COATING TECHNIQUE

Electrodeposition technique is great progress in coating technology for engineering applications. Electrodeposition offers PVM coatings with the highest possible chemical resistance, mechanical toughness and corrosion protective properties per unit of coating thickness. Therefore, usage of electrodeposited coatings in different branches of industry enables decrease in number of layers in protective coating (often to single one) with simultaneous increasing in protection efficiency and life cycle of the coatings.

Electrodeposition provides deposition of thin (5-80 μm) intact single-layer coating over whole article surface, and it ensures superior throwing power of interior hard-to-reach surfaces of the articles including tightly creased areas, corners, as well as sharp edges. The method provides excellent uniformity of the coating with total thickness variations in 1-3 μm. New PVMs are free of heavy metals (lead), have low content of organic solvents (less than 2-3 % of the volume of working bath) and characterized by low loss in weight during drying and polymerization of the coating, that reduces significantly the amount of harmful emissions into the environment.

Advantage is that waterborne solutions for e-coating is of less chemical hazard compared to solutions used in galvanic methods. Weakly acidic (pH=5.5-6.5) or weakly alkaline (pH=7.5-8.5) waterborne solutions are used for cataphoresis and anaphoresis, properly, but strongly acidic (pH=2-4) or strongly alkaline (pH=10-12) solutions are used in galvanic processes. Electrodeposition technique is productive alternative to traditional galvanic coating methods:, cold galvanizing, anodizing etc.

Electrodeposited single layer replaces multilayer galvanic coating that results in shorter run-time of coating process. Electrodeposition is used environment friendly waterborne PVMs, process is

The major market segments of application the protective cataphoretic coatings are as follows:

- Automobile industry (carbodies, engine parts, wheels, accessories);
- Agricultural and construction equipment and machinery;
- Household appliances and electronics (refrigerators, vacuum cleaners, microwave ovens, etc.);
- Heating radiators (domestic and industrial);
- Parts and assembly units of computers and other electronic devices, including thermoelectric modules;
- Equipment for oil and gas production and processing;
- Equipment for chemical industry and biochemistry;
- Ship engines, reducers, transformers, compressors, generators, pumps, shock absorbers, etc.;
- Fastening and hardware products, etc.

fully automated, and explosion-proof and fire-proof. Technology enables launching a closed-circuit non-waste production that meets fully the criteria for state-of-the-art decorative and protection coating industry. Also, the content of volatile organic solvents in the working solution of PVM for electrodeposition is not more than 2 %. For example, waterborne PVMs for coating by dipping contain not less than 30 % of volatile organic solvents, and PVMs based on organic solvents - up to 70-80 %.

Cataphoretic PVM coatings exceed significantly of PVM coatings deposited by other techniques in chemical and corrosion resistance. According to accelerated tests, 17-20 μm thick cataphoretic PVM coating deposited on a phosphating treated metal surface has confirmed index of resistance against salt solution up to 2000 hours and similar coating with a thickness of 60-80 μm deposited by pneumatic spraying - less than 700 hours.

Consumption of PVM at deposition of single layer is only 60-80 g/m^2 in the supplied concentration (40-45 %), and at coating by pneumatic spraying and dipping equals to 200-300 g/m^2, by liquid paints and electrostatic spraying of powder – 150-200 g/m^2.

Correct performed electrodeposition provides coating that almost free of the most frequent defects, such as, sags, shagreen, poorly coated areas, nonuniform coating.

TAILORED TO CUSTOMER NEEDS. CUSTOMER SAVINGS

Electrodeposition coating process is practically independent on qualification of operator. Hand works are used only for hanging parts on hooks and manual handling of racks with processed parts, and, operator monitors also functioning equipment and check power supply with the aid of user friendly control panel or computer.

Customers yield of significant benefits with electrodeposition coatings: high production flexibility, processing of wider nomenclature of parts and output growth through increased density of parts per rack. More parts per rack result in more parts per minute, which in turn increase in production throughput.

Electrodeposition with waterborne PVMs is used not only in a large-scale production with conveyor system, but, also, for periodic coating of small-sized articles in small and medium-scale production. The range of sizes and shapes

of articles to be processed at such enterprises is often very wide, and requirements to quality and color of the coatings are different. Method is flexible as concerned pre-treatment of surface to coating, composing of production line and quick replacement of PVM composition in the bath for electrodeposition. This is feasible through the modular design of the electrodeposition production line, all baths can be standardized and placed on mobile trolleys.

Customer will save time and money with electrodeposited coatings due to:

- Tailored to customer needs PVM composition and production line size;
- Reduced PVM consumption;
- Short painting time;
- Decreased oven treatment time;
- Improved throughput;
- Increased density of parts per rack;
- Low waste;
- Energy savings

Market segments for electrodeposited PVM coatings are industrial, and in some sectors of industry this method of coating is simply indispensable..

RusTec INNOVATIONS

RusTec LLC offers novel PVM compositions for cataphoretic high performance coatings based on modified commercial PVMs. The innovation compositions consists of solutions of well-known film-binders and small additives of functional oligomers and highly dispersible polymers (one additive or a mixture of two). Compositions are formed by adding of special additives into the water solution of the commercial PVM directly in the electrodeposition bath followed by ordinary stirring. Polymeric modifying additive is added into PVM composition in the form of water latex, dispersion, highly dispersive powder or a solution compatible with water solution of the oligomer. The color of deposited coating is controlled by the color of pigment added.

Modifying of PVM composition, customer can deposit coating layers with improved corrosion resistance, increased hydrophobicity, increased diffusion capacity, high thermal and chemical stability, as well as, better wear resistance.

Innovations are patented PVM compositions based on waterborne solutions of commercial film-binder (epoxy resin) with new additives -

fluoroprene and/or polyorganosiloxane which enables deposition of cataphoretic films with significantly improved protective properties.

Using compositions of commercial PVMs and modifying fluoroprene additive (it is the triple copolymer of fluoro-olefines) results in coatings of higher oil-, atmospheric- and fire resistance, as well as, higher temperature stability and high resistance to water, water condensate, steam and to aggressive environment. Films are also very elastic in a wide range of temperatures, including temperatures below 0 ˚C, and resistant to great number of thermocycles «heating / cooling».

Using compositions of commercial PVM and modifying polyorganosiloxanes additive show superiority over coatings obtained with fluoroprene additive in concern resistance to high temperatures and significant temperature differences. Coatings are very elastic and resistant to great number of thermocycles «heating / cooling» and demonstrate strong hydrophobicity.

Customer is free to choose of innovative coating composition that best meets the requirements for specified environment conditions.

Summary data of synthetic cataphoretic coatings are given in Table for purpose to choose right composition which enables to deposit the best performance coating.

SUMMARY DATA OF SYNTHETIC CATAPHORETIC COATINGS

Coating composition Test parameter	Industrial PVM	Industrial PVM + fluoroprene	Industrial PVM + siloxane	Industrial PVM + fluoroprene + siloxane
Process parameters, Deposition time Polymerization time	2 min 15 min	2 min 15 min	2 min 15 min	2 min 15 min
Adhesion, Cross-hatch DIN EN ISO 2409	0 (the highest grade)	0 (the highest grade)	0 (the highest grade)	0 (the highest grade)
Dry film pencil hardness KOH-I-NOOR	H-3H	7H	8H	8H
Direct impact resistance, kG×sec/cm	50	50	50	50
Bending resistance, mm	< 3	1	1	1
Salt solution immersion resistance - 3% NaCl, hr	240	500	1000	800
Water immersion resistance, hr	500	1000	> 1200	> 2400
Muriatic acid immersion resistance – 10% HCl at 80 °C, hr	0,2	4	2	4
Resistance against gasoline, hr	96	> 1200	> 1700	> 1700
Resistance against engine oil, hr	96	> 1200	> 1700	> 1700
Max operating temperature	Up to 180 °C	Up to 180 °C	Up to 300 °C	Up to 300 °C
Abrasion resistance, kG/μm	1	5	4	6

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