Dr. Pampa Guha
Assistant Professor
Dept. Of Chemistry
City College, Kolkata

What is Surface coating?

Any mixture of film-forming materials plus pigments, solvents, and other additives, which, when applied to a surface and cured or dried, yields a thin film that is functional and often decorative. Surface coatings include paints, drying oils and varnishes, synthetic clear coatings, and other products whose primary function is to protect the surface of an object from the environment. These products can also enhance the aesthetic appeal of an object by accentuating its surface features or even by concealing them from view.

Objective of surface coating

- Protection from environment
- Corrosion resistance
- Adhesion or binding
- Opacity
- Colour; sheen(gloss); smoothness (or texture)

Objective of surface coating

- Specific mechanical and physical properties such as:
  - Wear resistance
  - Electrical properties
  - Thermal insulation
  - Oxidation resistance

Factors affecting selection

- Substrate type
- Objective of coating
- Durability
- Process of surface coating

Types of surfaces

- Metallic
- Non-metallic

Major Surface Coatings

- Conversion Coatings (phosphate coatings, oxidation, chrome coatings, anodizing)
- Thermal Coatings (diffusion, carburizing , flame spraying etc)
- Metal Coatings (electroplating, electroless)
- Deposition
  - Physical Vapor Deposition
  - Chemical Vapor Deposition
- Organic barrier such as paint, enamel etc

Major Surface Coatings :

Conversion Coatings

- Inorganic surface barriers produced by chemical or electro chemical reactions brought at the surface of base metal. Serve as excellent base for paint, lacquer, oil etc.

Conversion Coatings :
Phosphate Coating

- Chemical reaction of base metal, phosphate
  Fe, Mn or Zn with Phosphoric acid causes grov
  of a crystalline layer.

  Iron, Zinc or Manganese Phosphate layer forme

- Typically applied to C-steel, low alloy steel a
  cast irons

  Sometimes applied to Cadmium, Aluminum an

  Tin

Conversion Coatings :
Phosphate Coating

- Typically very thin ~2.5 mm, usually grey in colour.
- Used as primer coat for paint.
- Applied by either immersion, spraying or brushing.

Conversion Coatings :
Oxidation

- Treatment of base metal with alkaline oxidizing solution or gas
- Increased thickness of oxide film
- Corrosion resistant
- Good base for paint, oil etc but less absorptive power than phosphate coating
- Oxide coatings on steel with variety of colour ranging from straw yellow to blue.

Conversion Coatings :
Chrome Coating

- Immersion in a chromic acid bath (pH ~ 1.8) with other chemicals to coat surface
- Surface film consisting mixture of Cr(III)&Cr(VI)
- Known carcinogen chemicals(CrVI) used, so alternatives are currently under research
  - Molybdate chemicals currently best substitute for coatings of Al.

Conversion Coatings :
Chrome Coating

- Very good to minimize atmospheric corrosion
- Used for protection of Zn, Al, Mg
- applied to everyday items such as hardware and tools, and can usually be recognized by their distinctively iridescent, greenish-yellow color.

Conversion Coatings :
Anodized Coating

- Surface of non ferrous metals like Al,Zn,Mg & their alloys
- Anodic oxidation process on a base metal as anode
- Suspended in sulphuric, phosphoric , oxalic or chromic acid bath
- Thicker than natural oxide films hence shows improved resistance to corrosion and mechanical injury

Major Surface Coatings :

Thermal Coatings

- Surface Heat Treatment
- Diffusion Coating
- Hot-Dip Coatings
- Metal Spraying

Thermal Coating :
Surface Heat Treatment

- Basic concept is to heat the surface to austenitic range, then quench it to form surface martensite - example steel
- Heating Methods
  - Flame Treatment
  - Induction Heating

Thermal Coating :
Diffusion Coating

- With low carbon steel, the surface can be enriched by diffusion of C or N
- Carburizing
  - Heat steel to austenitic range (850-950 °C) in a carbon rich environment, then quench and temper

Thermal Coating :
Diffusion Coating

- Nitriding
  - Nitrogen diffusion into steels occurs around 500-560 °C to form a thin hard surface
  - Good for Cr, V, W, and Mo steels.

- Metal Diffusion
  - Chromizing – Chromium diffuses into surface to form corrosion resistant layer.
  - Aluminizing – Used to increase the high temperature corrosion resistance of steels and superalloys

Thermal Coating :
Hot-Dip Coating

- These coatings are used for corrosion protection
- Galvanizing
  - Parts are dipped into a molten zinc bath, layer of $ZnCO_3$, used for protecting steel
- Galv-annealing
  - Galvanized parts are then heat treated to ~500 °C to form Fe-Zn inter-metallic
    - Used for metals that need spot welded to protect copper electrode from alloying with zinc and reducing its life.

Thermal Coating :
Hot-Dip Coating

- Aluminium coatings
  - Alloyed with Si
  - Coatings used on steel for high temperature applications that need a lustrous appearance
  - Example – Automobile exhaust

Thermal Coating :
Metal Spraying

- Typically used to improve wear resistance by creating a hard surface over a tough bulk body
- Process
  - **Molten particle deposition :** a stream of molten metal particles from spray gun are deposited on the substrate surface
  - **Two methods of spraying :** wire gun and powder metal

Thermal Coating :
Metal Spraying

- Process
  - **Wire gun :** metal wire melted in oxy acetylene flame and atomized by a blast of compressed air; widely used for common metals
  - **Powder metal:** finely divided powdered metal heated then passed through the flame of blow pipe, results into cloud of molten globules which are then adsorbed on base metal surface; used for low melting metals like Zn, Pb, Sn.

Thermal Coating :
Metal Spraying

- Process and its merit
  - Surface undergoes a bonding process with the molten particles.
  - Continuous but porous coating
  - Sealer oil or paint applied to provide smoothness
  - Greater speed of working
  - Ease of application
  - Adhesion strength less than hot dipping or electroplating method

Metal Coatings

- Electroplating
- Electroless Coatings
- Metallizing of Plastics and Ceramics

Metal Coatings :
Electroplating

- **Objectives of Electroplating : on Metals**
  - Used to increase wear and corrosion resistance
  - To improve physical appearance and hardness
  - To increase the decorative and commercial value

Metal Coatings :
Electroplating

- **Objectives of Electroplating : on non-metals**
  - To increase strength
  - To preserve objects like plastics, wood, glass etc
  - To make surface of light weight material conductive

Metal Coatings :
Electroplating : Main Features

- Electrochemical process used to create a thin coating bonding to substrate.
- Quite uniform film with little pinholes per unit area.
- Process is slow so coating thickness can be closely controlled (10-500 μm)

Metal Coatings :

Electroplating : Main Features

- **Applications:**
  - Tin and Zinc are deposited on steel for further working
  - Zinc and Cadmium are deposited on parts for corrosion resistance (Cadmium is toxic and can not be used for food applications)
  - Copper is deposited for electrical contacts
  - Nickel for corrosion resistance

Metal Coatings :

Electroplating : Main Features

- **Applications:**
  - Chromium can be used to impart wear resistance to dies and reduce adhesion to work pieces such as aluminum or zinc
  - Precious metals for decoration or electronic devices

Metal Coatings :

Electroplating :

Characteristics and factors of electrodeposit

- Thickness
- Adherence
- Hardness
- Brightness
- Protective value
- Decorative value
- Throwing power i.e. ability to give uniform thickness

Metal Coatings :

Electroplating :

Characteristics and factors of electrodeposit

- Temperature range : 35-60 °C
- Cleaning of substrate
- Composition of electrolyte bath
- Current density (low provides better diffusion, uniformity
- pH of bath 4-8 (lower – burnt deposit; higher- OH deposit