ADHESION ON METALS

INTERFACIAL CHEMICAL KNOW-HOW FOR GOOD WETTING AND BONDING

KRÜSS

Advancing your Surface Science

WETTABILITY – A KEY TO HOMOGENEOUS, STABLE METAL COATINGS

- **Corrosion protection and coatings in automotive, marine, bridge and aircraft construction**
- **Electroplated finishes**
- **Housing coatings for household goods as well as entertainment and communication electronics**
- **Bonding with other materials such as plastics, glass and textiles**
- **Coating of metal prostheses and dental implants for biocompatibility**

Metal coatings protect against corrosion, refine the material, provide for coloring and smoothness or protect the surface against scratches. Often coatings must perform several of these tasks at the same time, so that the surface passes through a variety of coating operations with different objectives. The interfacial chemical properties of the metal and coating liquids have a significant influence on the adhesion and uniformity of the coating at each step.

Coatings in electroplating and conversion baths are only successful if there is good wetting

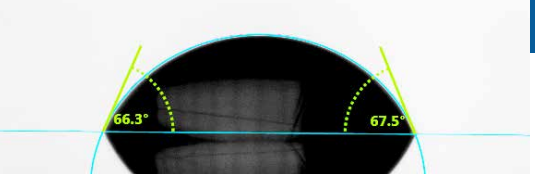
The first step of a metal coating is usually a wet-chemical treatment, which refines the surface or makes it inert (passivation). Finishing takes place in electroplating baths where the material is covered with a layer of corrosion-resistant metal using electro-chemical processes. Passivation as a pretreatment for multi-layer coatings and metal bonding is carried out in aqueous conversion baths , for example during phosphating or zircon treatment. In addition to corrosion protection, conversion is used to promote the adhesion of coatings or adhesives.

A good wetting of the material in the aqueous electroplating or conversion bath is required for this wet-chemical surface treatment of metals. Only then do the dissolved active substances have contact with the metal everywhere on the workpiece and are they able to trigger the desired chemical reactions.

Fats and oils reduce wettability and must be removed

The degree of wetting is closely related to the surface tension (SFT) of the fluid and material together, which for a solid is usually called surface free energy (SFE). SFE and SFT each consist of polar and disperse interaction components. Wetting is the better, the higher the SFE is and the more similar the SFE and the SFT are with regard to their polar and disperse components. Clean metal surfaces usually have a high SFE with a highly polar component and are well wetted in aqueous electroplating or conversion baths due to the likewise high polarity of the water.

If there are fats or oils on the metal surface, however, the SFE is determined by the surface properties of the impurities. These feature a low SFE and polarity, thus making the surface hydrophobic. Therefore, thorough and uniform cleaning of the workpiece before the wet treatment is one of the most important process steps.



The contact angle shows wettability and detects hydrophobic areas

Liquids form flat droplet shapes on clean, easily wettable metal surfaces. Drops on insufficiently cleaned and therefore hydrophobic metal surfaces tend towards round shapes. The contact angle, which, inter alia, is measured by means of optical procedures, is used as an objective identifier for the shape of the drop. Therefore, it directly mirrors the wettability of a metal surface. That is why this analysis method is successfully used for the inspection of cleaning steps.

Contact angle data for several widely distributed positions also help in the evaluation of the homogeneity of the surface. Uniformly cleaned surfaces generally show the same contact angle everywhere.

Coating leads to new surface properties which determine wetting and adhesion

Each coating step creates a new surface with a changed chemical structure and therefore leads to another SFE with other polar and disperse components. The same applys to the coating materials, which each time differ with regard to the SFT and its fractions. Therefore, the question of wettability due to the following layer is asked again and again.

In order to determine the SFE and its polar and disperse components, contact angles are measured with several liquids for which the interactive components of the SFT are known. Water as a strongly polar and diiodomethane as a purely disperse liquid are two commonly used test substances. With additional methods such as optical measurements of pendant drops, the SFT, with its polar and disperse components, can be determined. If these values are known, a detailed picture of the compatibility between the material and the coating substance is available.

Many coloring and sealing lacquer coats and metal adhesives adhere to the material because of physical interfacial interactions. In this case, the SFE of the solid and SFT of the liquid determine not only the wettability, but also how well the coating or the adhesive bonds. Adhesion is especially strong if the SFE is high and the polar and disperse fractions of the SFE of the solid material and the SFT of the liquid are similar. Combined analyses of the material and liquid thus allow predictions regarding the expected bond strength.

MEASUREMENT METHODS

A number of analytical methods characterize metals and the surfaces created in multi-step processes. In this way, they provide important information on the optimization of metal coatings and adhesives.

- Taking optical measurements of the contact angle (drop shape analysis), static and dynamic
- Taking mechanical measurements of the contact angle using a tensiometer
- Determining surface free energy and its polar and disperse components
- Measuring surface tension of liquids
- Calculating adhesion and interfacial tension
- Measurement of wettability by melts

KNOW-HOW FOR YOUR APPLICATION

If you would like more detailed information about your application, just get in touch with us. Our scientifically trained customer representatives have excellent knowledge of interfacial chemistry and process technology and share their expertise – comprehensively and competently.

We would also be happy to assist you with professional contract analyses from our laboratories. In addition, we provide scientific application reports on various topics which cover specific issues in research, development and quality assurance. With offers like these, we pass on a great deal of know-how for your application.

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