DR GALVA

ELECTROPLATING GUIDE

for general use

V1.0

Contents

1 Basics of electroplating

The following section explains fundamental aspects of electroplating technology. Safety aspects and the disposal of the resulting waste are discussed.

1.1 Aspects of security

A galvanic electrolyte is a current-conducting liquid that is essential for electroplating. In addition to metal salts, such a galvanic metal electrolyte also contains acid or lye, water and other chemical additives, whereby the metal precipitate is deposited from the metal salt. In industrial electroplating, cyanide-containing electrolytes with free cyanide are often used, and attempts are increasingly being made to replace them. Such electrolytes are extremely toxic and are not suitable for use in the hobby, art and workshop sectors. For this reason, they are not considered further in this guide.

Instead, the focus here is on electrolytes that are cyanide-free. These are less dangerous to handle. Nevertheless, it should be noted that electrolytes should be handled with care and caution, as they are hazardous substances.

The various electrolytes from Dr. Galva are designed in such a way that any risks are kept as low as possible while at the same time focusing on the highest possible quality.

It is important that the electrolytes used are used exactly as described in the instructions. In principle, all chemicals should only be used in well-ventilated workplaces and kept away from foodstuffs. The electrolytes should never be filled into drinking bottles or similar containers in order to avoid confusion with foodstuffs.

You should always wear safety goggles when working with chemicals or carrying out galvanic work. Various other work steps also require you to wear protective gloves. Also try to avoid the formation of aerosols, i.e. fine droplets, often in the form of spray mist. This occurs when gases are produced during metal deposition. The higher the current, the higher the aerosol formation. With some electrolytes, a layer of foam forms > this also reduces aerosol formation. Ideally, you should close the container with a suitable plastic or glass plate so that the droplets cannot escape. In this way, you avoid the risk of inhaling the droplets, as they can be corrosive and/or cause damage to health. If you have a workstation with a fume cupboard or extractor function, you should use this.

In the event that you feel unwell at work or experience discomfort of any kind, you should always consult a doctor.

Before starting work, it is also important to read the instructions and safety information carefully and thoroughly.

1.2 Disposal of waste

With regard to the disposal of waste, particularly chemicals, the desirable goal is to prevent such waste from being produced in the first place. In other words: In the course of your work, always try to use only the amount of chemicals that you actually need.

However, if chemical waste is produced and needs to be disposed of, it should be collected by group and in separate containers. In almost all cities in Germany, chemical waste can be disposed of free of charge either at recycling centers or at municipal waste disposal companies. In some regions, there are also hazardous waste collection vehicles that collect chemical waste and ensure it is disposed of appropriately. Please enquire locally about your options. This information is usually available on the Internet.

In addition to government agencies, the market also offers private disposal service providers who specialize in the disposal of hazardous waste such as chemicals and enable uncomplicated collection.

You should always keep the original container so that you can inform the disposal point of the respective waste code number or the hazardous substances contained can be seen there directly. The number is also noted in the safety data sheet of the respective product (section 13). The safety data sheets are available as PDF files in the Dr. Galva store.

2 Preparation or pre-treatment

If you want to electroplate a workpiece, you must prepare or pre-treat it accordingly. You can find out which steps are necessary in the following sections of this book.

2.1 Pre-cleaning the workpiece

For the metal deposition process to be successful, it is essential to pre-treat the workpiece correctly.

The first step is to mechanically remove any rust as well as grease and dirt particles. You can use steel wool, abrasive fleece or sandpaper, for example. You can use commercially available brake cleaner to remove stubborn grease particles and grease residues.

In a second step, the thin layer of oxidation that is still on the workpiece must be removed. If the workpiece is made of nickel or copper, you will not be able to see this oxidation layer with the naked eye. Chemical pre-treatment is therefore necessary. As a rule, oxidation layers are removed with acidic pickling solutions. After pickling, you must rinse the workpiece with clear water so that any corrosive residues of the pickling solution are eliminated.

Nickel-Strike is recommended for pickling nickel, while the conditioner is suitable for copper and steel. Aluminum is much more complicated to coat here due to the oxide layer that forms very quickly. The Dr. Galva aluminum activator is available for this purpose. Please read chapter 4.2 for more information.

You can buy the following pre-treatment products directly from the Dr. Galva online store:

- Nickel-Strike - pre-treatment of stainless steel and nickel; electroplating activator
- Conditioner - pre-treatment of steel and copper; improves adhesion
- Aluminum activator - Pretreatment of aluminum with zincate

Tip:

After you have cleaned the surface of the workpiece accordingly, you should not touch the metal surface with your bare hands under any circumstances, as this will cause small grease stains on the workpiece, which will be excluded from the electroplating process. It is therefore essential that you wear gloves. If you were to touch the workpiece with unprotected hands, your fingerprints would be visible on the object after electroplating. The gloves should be unused, powder-free products. Ideally, you should use disposable latex or nitrile gloves.

If it is a sheet metal to be galvanized, you should only touch it at the edges. It is also advisable to use tweezers or crucible tongs. This will ensure that the entire workpiece is galvanized. Optimum results can only be achieved if the surface of the object is clean and free of grease.

2.2 Polishing the workpiece

After the workpiece has been pre-cleaned and rust particles etc. have been removed, it is possible that the object to be electroplated is not completely smooth and matt. For example, it may have small scratches. Ideally, the workpiece should be polished before electroplating. You can use certain methods to make matt metal shiny or bright.

- You can polish by hand, but it takes a lot of time and energy.

- For many smaller objects, it is advisable to use a drum polisher. As the name suggests, this type of machine has a drum containing small stainless steel rods and balls. When the workpiece is placed in the drum and the drum rotates, the balls and rods develop a mechanical effect that ensures that the surface of the workpiece appears smooth and highly polished. This rotation process can take between 30 minutes and several hours.

- Polishing with a polishing block is also possible and highly recommended. In this case, polishing is carried out with rotating disks made of fabric, felt or leather. The actual polishing agent is applied to the disk. This consists of greases, oils and fine particles. While the wheel rotates, the workpiece is gently pressed against the wheel and the surface is polished. Due to the high peripheral speeds and dusts, increased attention must be paid to safety here.

3 Coating using electroplating technology

In the following section, the various electroplating processes are presented, including the basic working equipment for the individual methods. In general, a distinction is made between three different electroplating processes, namely barrel electroplating, pin/tampon electroplating and bath electroplating.

3.1 Working temperature

To achieve the best possible results, the working temperature of the respective electrolyte should be observed. These can be found in the instructions for the various products. Many electrolytes already work optimally at room temperature. This means that no external heating medium is required.

In general, it can be said that almost no electrolyte works well below 15°C, so it is important to pay attention to the temperature if you notice problems with the electrolyte. The temperature of the workpiece must also be taken into account - especially in the case of pin electroplating.

3.2 Current density

A certain ratio between current and electrode surface is particularly important in electroplating. This is known as the current density. The current is specified in relation to the unit area and is expressed in A/dm^2. Higher current densities can be applied by increasing the temperature and moving the bath or workpiece.

The cathodic current density is important for the quality of the coating on the workpiece (cathode). For each electrolyte, there is an optimum current density range within which deposition is achieved with good results.

On the anode side, there is the anodic current density. This is particularly important for the stability of the electrolyte. As much metal should dissolve as is deposited at the cathode (workpiece).

Ideally, the anode dissolves just as quickly as the metal is deposited on the cathode, so the electrolyte would last a particularly long time. In practice, however, there is a deviation.

For example, acidic zinc electrolytes are enriched faster than metal is deposited, which leads to turbidity of the electrolytes after a longer period of time.

With nickel, the anode dissolves more slowly and the electrolyte slowly becomes poorer and poorer in nickel ions. In this case, suitable nickel salts could be added to increase the content again. However, nickel salts may not be sold freely due to the hazard classification. To improve anode solubility and reduce passivation, chloride ions are also added to the electrolyte by the manufacturer.

3.3 Anode material

As a rule, the metal of the specific electrolyte solution should be used as the anode material. If it is a copper electrolyte, for example, it is advisable to use a copper anode. The reason for this is that the anode dissolves during the electroplating process and the electrolyte solution is regenerated as a result. This significantly increases the range of the electrolyte, as the metal in the solution accumulates again.

Attention:

Chromium is an exception. Chromium anodes must not be used with chromium electrolyte (based on trivalent chromium), as this can produce highly toxic hexavalent chromium (chromium VI)! Furthermore, the electrolyte becomes unusable as a result. Please work with aluminum anodes. If you do not have an aluminum anode to hand, you can also use aluminum foil.

Incorrect anodes must be avoided at all costs, as they can contaminate the electrolyte and the electrolyte must then be discarded! In some cases, the electrolyte can be repaired by deposition if the interfering metal is deposited faster than the electrolyte metal.

If no anodes are available from the electrolyte material, the use of inert anodes such as platinum or graphite is an option. Care should always be taken to ensure that only suitable anodes are used. If no attention is paid to this aspect, it is possible that the deposited layers will become discolored or the electrolyte will be destroyed.

Caution: The anodes must be carefully cleaned before and after use. In addition, anodes that are not used should not remain in the electrolyte.

Expert tip:

With regard to graphite anodes, it should be noted that they are porous and the components of the electrolyte may be absorbed. For this reason, different graphite anodes should be used for different electrolytes.

If you only want to use one graphite anode for everything, it is essential to soak the anode in water at least two to three times for around 10 minutes. This ensures that the electrolyte components absorbed by the anode are rinsed out. If you do not rinse the anode, it is possible that the substances will be released into the subsequent electrolyte and this will become contaminated.

Another disadvantage is that the resistance in the anode can increase significantly, making it unusable. Although graphite anodes can be used universally, we do not recommend them, as they do not dissolve chemically, but the oxygen development at the anode causes particles to enter the bath and cloud it. As the process progresses, these particles are also deposited and the surface produced becomes darker. Metal anodes are therefore preferable.

Alternatively, we can recommend platinum-plated anodes, which are suitable for almost everything. However, you should not buy anything too cheap, sometimes the layer is too thin or incomplete and the metal underneath can contaminate the electrolyte.

3.4 The procedures at a glance

A distinction is made between 3 processes for the electroplating of metals. These are bath electroplating, pin electroplating (also known as tampon electroplating) and barrel electroplating. Each of these processes has its advantages and disadvantages.

Procedure	Advantages	Disadvantages
Bath electroplating	• Automatic sequence of the electroplating process • Layer thicknesses from a few micrometers to several millimeters can be achieved	• Powerful power supply unit required • Large containers required • Large amount of electrolyte • Impractical for electroplating small parts
Pin electroplating / tampon electroplating	• Galvanizing of large areas feasible • Power supply unit with low power required, as current only flows at a small contact point • Small amount of electrolyte required	• Only low layer thicknesses achievable, therefore hardly any corrosion protection • Electroplating process is not automated • Very time-consuming • Exhausting
Barrel electroplating	• Excellent for electroplating small parts • Relatively uniform coating due to continuous rotation • Galvanization process runs automatically • Quick to fill	• Powerful power supply unit required • Large containers essential • Large amount of electrolyte • Workpieces receive small impact marks • A certain number of pieces required to ensure that the workpieces are permanently contacted • or suitable drum size

3.5 The bath electroplating process

Bath electroplating is a method in which the workpiece to be electroplated and the anode are immersed in an electrolyte. A current flow is also generated so that metal is deposited on the workpiece.

Bath electroplating is a process that is frequently used in industry. As a rule, workpieces are chrome-plated, gold-plated or nickel-plated in tanks of enormous size. Racks are often used for this on which the parts to be coated are suspended. In order to increase the possible current density and thus faster deposition, a bath movement is recommended here. This can be achieved by blowing in air, pumping or moving the rack.

The advantage is that the process is easy to carry out and large current flows can be generated, so that even thick metal layers can be deposited. The disadvantage is that large quantities of electrolyte are required to fill the baths. For this reason, bath electroplating is only suitable for smaller parts in the private or hobby sector.

3.5.1 Basic equipment required

A controllable direct current source, a tank or container and connecting cables are required to carry out the bath electroplating process.

The power source can be a laboratory power supply unit, for example, which should have both a volt and ampere display, i.e. voltage and current. The tank should be large enough so that the object to be electroplated can be completely immersed. It should be made of an alkali-resistant and acid-resistant material; in addition to plastic containers, glass containers are also very suitable. You will also need cables to connect the power supply to both the anode and the workpiece. To avoid confusion, always use a red cable for the (+) pole and a black cable for the (-) pole.

3.5.2 Anode area

As a general rule, the surface area of the anode should be as large as the surface area of the workpiece to be electroplated. However, if the anode surface is too small, it is possible that the layers will be deposited unevenly.

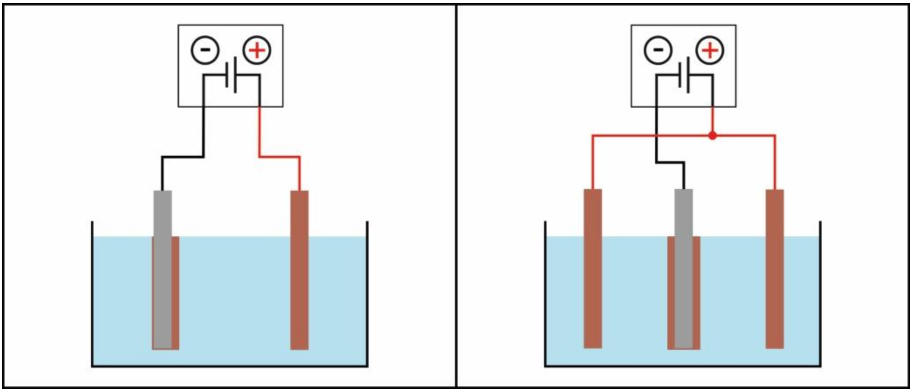
This effect occurs because the current is not evenly distributed in the electrolyte (scattering) and it takes the shortest path. This means that the current is higher in the area of the shortest path and the layer deposits thicker here. The anode shape and arrangement must also be suitable so that the current can be distributed evenly.

A larger anode does not have a negative effect on the result. However, due to an unfavorable anodic current density (anodic efficiency), a stronger passivation (depending on the electrolyte) can take place, which reduces the current flow. If this is the case, the anode should be cleaned.

3.5.3 Arrangement of the anodes

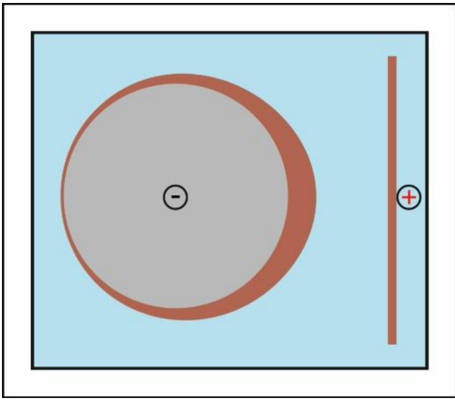
With regard to the anode arrangement, it should be noted that the workpiece to be electroplated should be evenly coated with anodes all around. This ensures that the layers are deposited evenly. At the very least, these should be present on two sides if possible.

If it is not possible to achieve such an anode arrangement, a uniform coating of the workpiece can be achieved by continuous turning. It is also important that the distance between the anode and the workpiece is as large as possible.

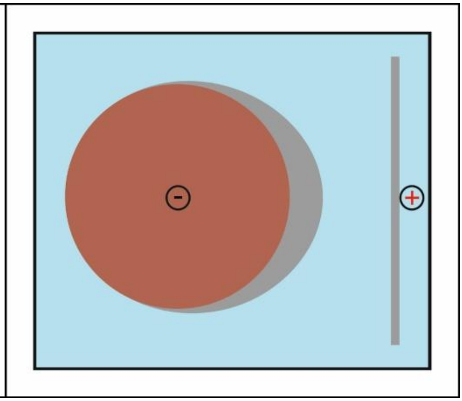


The anode and the workpiece are positioned opposite each other. More metal is deposited on the front side of the workpiece than on the rear side. The workpiece should be rotated at regular intervals.

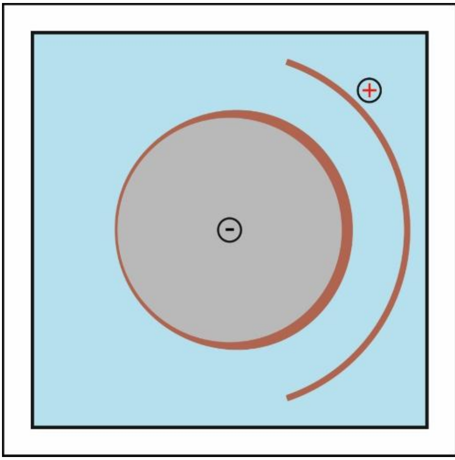
Two anodes and the workpiece are located in the tank. It should be noted that both anodes should be connected to the same power supply unit. The workpiece is placed in the middle, between the two anodes. This ensures a more even deposition.



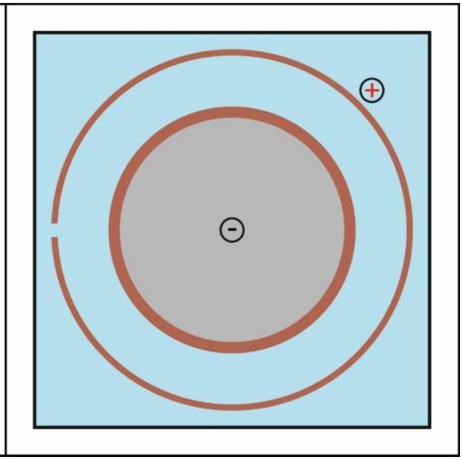
Good scattering (e.g. copper acid) when using a flat anode. The smaller the distance, the more current flows at these points and more metal is deposited there. Due to the good scattering, a thin layer is still deposited on the back.



Poor scattering (e.g. zinc weakly acidic). In this case, metal is only deposited on the side facing the anode. Practically no current flows on the reverse side and there is no or only minimal deposition there.



If the shape is adapted to the workpiece, the metal is deposited much more evenly. The layer is thinner on the side facing away from the anode. Overall, the layer is much more uniform compared to a flat anode.

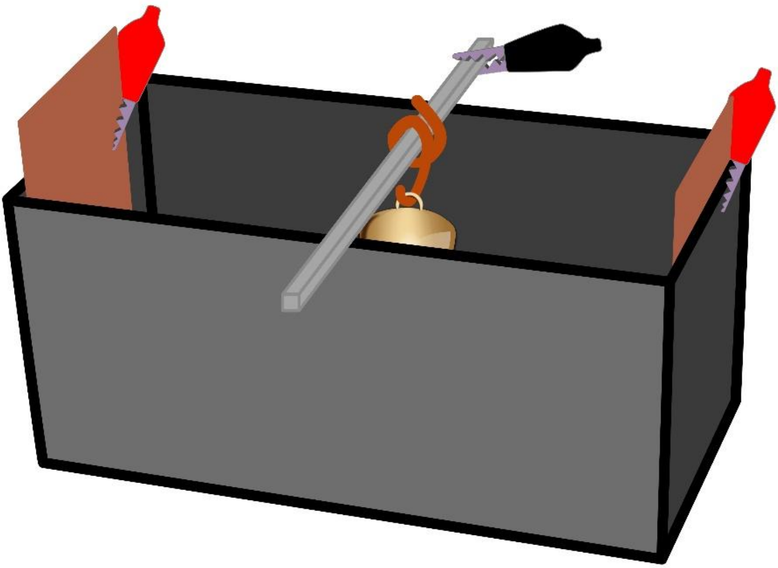


A ring anode and the workpiece are located in the galvanic bath. This ensures that the anode distance to the workpiece is the same all round. To achieve uniform deposition, it is not necessary to rotate the workpiece.

3.5.4 How to set up the tray

The tray is assembled as follows. A traverse is included to hang the objects and make contact at the same time.

Enclosed is a graphic illustration:



3.6 The pin or pad electroplating process

If permanently mounted or large workpieces are to be electroplated, pin electroplating is the most suitable method. For this purpose, a metal rod is used as an anode (+) with either a cloth pad or a sponge at the tip (for simplicity's sake, we will only use the word pad). The pad is used to absorb the electrolyte and is completely soaked with the desired electrolyte. While the object to be electroplated is connected to the cathode (-), the workpiece is now contacted with the pad in a circular motion. This enables a current to flow and after a few seconds a metal layer is deposited at the corresponding contact points.

The circular movement is very important, as a high current flows over a small contact area. As soon as you stop with the tampon in one place, the area can become dull and can turn dark (burns), this effect occurs more quickly the higher the current flow. A little experience is therefore required here, but you will get it quite quickly. Moving the tampon back and forth is rather unsuitable, as the movement is briefly interrupted in between and burning can already occur at a high current density.

The anode should preferably consist primarily of inert materials such as platinum or graphite (and sometimes also stainless steel) or the material of the electrolyte used.

3.6.1 Basic equipment required

A controllable direct current source, i.e. a controllable power supply unit with digital voltage and current display, a pin anode with anode holder (electroplating pin), a cable set and a tampon or sponge are required to carry out the pin or tampon electroplating or pin electroplating process. The pin anode (or anode holder) must be connected to the (+) pole of the power supply unit using a cable. In addition, the anode must be fitted with a pad or sponge so that the complete electroplating pen is ready for use. The workpiece itself is connected to the (-) terminal as described above.

3.6.2 Sponge & tampon

If sponges or pads are used, these are attachments that soak up the electrolyte. This characteristic is essential as the electrolyte must be held between the anode and the workpiece during the electroplating process and must release the metal ions. Ideally, pad attachments for electroplating should have a very high absorption capacity and be robust. Electroplating pads should also not be too thin, as otherwise insulation effects could occur due to high pressure at certain points and the electric current could not be passed on. A pad for electroplating should also not have external seams, as this could cause scratches on the metal.

3.6.3 Thickener or gelling agent

A thickener, also known as a gelling agent, is a specific thickening agent. Thickeners are added to the electrolyte solution so that it becomes more viscous. There are special thickeners designed for the various galvanic electrolytes. If conventional agents are used or mixed in, the electrolyte usually becomes unusable. In principle, all types of electrolytes can be thickened using electroplating gel formers. Thickening the electrolyte ensures that the liquid does not drip, that work is cleaner and that electrolyte can be used sparingly. However, the electrolyte should not be too viscous.

To thicken an electrolyte, you should pour as much electrolyte as you expect to need into a container and add as much gelling agent while stirring evenly until the individually desired consistency or firmness is achieved. Proceed carefully and slowly. Make absolutely sure that there is no excessive dust formation when using powder. If you have thickened the electrolyte too much, you can make it more liquid again by adding unthickened electrolyte.

3.7 The barrel plating process

The barrel electroplating process is ideal for electroplating large quantities of small parts, especially for parts that cannot be mounted on racks or can only be mounted with great effort. Basically, the electroplating process corresponds to that of bath electroplating, whereby the workpieces to be electroplated are placed loosely in a slowly rotating drum. The workpieces are contacted using a centrally mounted contact rod, freely movable bobbins (cable with conductive cap) or via suitable contact points in the drum wall; the drum is set in rotation using a motor. The resulting uniform movement ensures a relatively even coating of the small parts, although there are subtle differences, as the uncontrolled mixing means that individual parts are contacted for longer and therefore receive a thicker coating, or this effect is also reversed (i.e. shorter contact time and thinner coating).

The advantage here is that it is quick to load, as the parts are simply fed in loosely. The disadvantage is that the workpieces always have small impact marks as they are mixed with each other, so this process is less suitable for mirror finishes, but this is irrelevant for screws etc.. A minimum number of pieces is also required to ensure that the parts are contacted throughout.

3.7.1 Basic equipment required

To carry out the barrel electroplating process, you need an electroplating barrel. In addition to a barrel, the basic components are a geared motor and the mechanical system, which together make up a barrel electroplating system. As with the bath electroplating process, a sufficiently powerful, adjustable power supply unit and a cable set are also required.

3.7.2 Filling the electroplating drum

As a general rule, the electroplating drum should be filled with workpieces to a maximum load of between 40 and 50 percent. This ensures that the components can move freely; at the same time, jamming, jamming or even blocking is prevented. If this were to happen, the contact points would prevent ideal coating and thus uniform electroplating. It is essential to ensure that these are also in contact with the contact pin.

Expert tip: Balls are the ideal filling material, as they cannot tilt, free movement is guaranteed, as is an ideal electroplating result.

3.8 Corrosion protection of the layers

Good corrosion protection is only achieved with a sufficiently thick layer or an appropriate combination of layers. A thin layer of chrome on iron will offer virtually no protection, so at least a combination of nickel and chrome is used. The nickel layer underneath offers a further advantage, as the nickel (bright nickel) enhances the shine. If you also want to improve corrosion protection in a reducing atmosphere, use the copper-nickel-chromium coating combination, as the copper does a better job here.

In general, therefore:

Corrosion protection varies greatly depending on the metal formed. There are also major differences depending on the different types of electrolyte. Quite a few types deposit with microscopically fine pores - the protection is not present in these areas. Higher layer thicknesses are required to close the pores. A combination of several layers significantly improves protection. The different layers complement each other and the corrosion protection increases exponentially, true to the motto "1+1=5".

Examples of corrosion protection:

<u>Nickel:</u>

A pure nickel layer only has good corrosion protection from 25µm, but the protection is greatly improved in the layer combination nickel-chromium or copper-nickel-chromium.

<u>Zinc:</u>

A layer thickness of around 10µm is recommended for zinc. Zinc has a long-range effect, which also provides cathodic protection for uncovered areas of iron (e.g. pores or mechanically damaged areas).

<u>Zinc-nickel:</u>

This is where the combination of 2 protective elements comes together. On the one hand, the active zinc and the passive nickel. Both elements form a common layer with increased protection. The average layer thicknesses are between 5µm and 10µm. The coatings are also corrosion-resistant at temperatures of up to 180°C, which is why zinc-nickel coatings are ideal for protecting combustion engine components.

The example shows a chrome-plated frame with an obviously inadequate coating thickness or unsuitable design of the base coat:

4 Electroplating of various metals

The following section focuses on the various metals that can be coated, such as copper, iron, silver, etc.

4.1 Fundamentals

The coating of metals in the course of electroplating should always follow a specific process. For example, the gold plating of zinc cannot be carried out directly. This is due to the different chemical behavior of the various metals in relation to the electrolytes. In addition, the installation of so-called barrier layers is essential, as they prevent alloying or mixing of boundary layers. Such barrier layers consist of either palladium or nickel. If, for example, no barrier layer is installed when gold-plating copper, but the copper workpiece is gold-plated directly, then the copper and gold layers mix, so that the gold layer turns reddish after a certain period of time. This process can take anywhere from a few days to several months.

4.2 Aluminum

Aluminum is a base metal. Aluminium oxidizes immediately when exposed to air, which is a protective or passivation process. The protective oxide layer of aluminum is detrimental to the adhesive strength. This means that a direct aluminum coating is prevented, as the subsequent coating is easily removable.

In order for aluminium to be electroplated, a metallically pure surface must be created. Only if this is the case is strong adhesion and good quality of the coating possible. However, as the oxide layer forms within a very short time, processes must be used that remove the oxides and build up a layer in the same step without exposing the workpiece to air. We have the Dr. Galva aluminum activator for this purpose. The workpiece is immersed in the aluminum activator at room temperature, the oxides are removed and a zinc layer is deposited at the same time. This process is also known as the zincate process. Unfortunately, the zinc layer that forms is matt, which means that it can either be smoothed and polished by further electroplating or the subsequent layer can be polished.

The pores in the aluminum surface are problematic in this respect. The solution could collect in these and further corrode the aluminum after coating - bubbles can form on the surface later. Pores should therefore be kept to a minimum and can be removed by sanding, for example. The Dr. Galva aluminum activator has a lower viscosity in order to reduce the inclusion of the solution in porous casting moulds. In general, the aluminum activator should first be rinsed off with water and then with diluted citric acid after use (alkaline solutions are generally difficult to remove). This neutralizes any residues.

The zinc layer that has now formed is now copper-plated with our "alkaline copper electrolyte". Make sure that the layer is not too thin. If the layer is too thin, very fine open areas (pores) could remain through which an acidic electrolyte could attack the underlying zinc layer and reduce adhesion or even form bubbles later, as the acidic electrolyte can be trapped in them during electroplating. This layer can either be built up thicker and polished or made shiny directly with our "bright copper electrolyte".

4.3 Bronze, copper & brass

Bronze, copper and brass are metals that must be treated with copper cleaner or pickled (conditioner) before electroplating. The reason for this is that the metals form light dark oxidation layers

Either a nickel or palladium barrier layer can be applied to copper and brass. While palladium does not need to be activated, nickel must be activated with Nickel-Strike. Copper and brass can then be coated with any metal.

On the other hand, a metal can be applied directly to bronze, as it acts as a barrier layer itself.

Additional knowledge: Copper and electroplating technology

Copper is a relatively soft metal that is easy to process. With regard to copper and electroplating, a distinction must be made between the plating of copper itself and the plating of other metals with copper.

In principle, copper can be electroplated with a variety of different metals, with chrome, nickel and aluminum being among the most commonly used.

If a copper workpiece is to be electroplated, it must first be conditioned. This means that the workpiece must be ground, polished and brushed. In addition, the oxidation layer of the copper must be removed; it must be etched. The surface must then be degreased and cleaned.

In order to chrome plate copper, the workpiece must first be nickel-plated. In some cases, this step must be repeated as part of the electroplating process. This influences the surface quality of the copper workpiece so that the chrome adheres better.

4.4 Chrome

As with aluminum, it is also difficult to apply a direct coating to chrome, as it also forms an oxide layer for protection. Unlike aluminum, which can be pickled, this process cannot be applied to chrome. For this reason, chrome must be removed before it is electroplated. In industrial electroplating, chrome is applied to nickel layers. These must be exposed in advance. A special chrome remover is used to remove the chrome. Toxic chromium compounds develop during the removal process. Contamination must be avoided at all costs, as these are chromium (VI) compounds. Once the nickel layer has been exposed and activation with acid has taken place, the workpiece can be coated directly with the desired metal. The gold plating process is an exception, as this can be carried out directly, i.e. the chromium does not have to be removed.

Additional knowledge: Chromium (VI) compounds

In general, chromium(VI) compounds are clearly visible to the naked eye due to their intense yellow color. Chromium(VI) compounds are extremely toxic and have both carcinogenic and mutagenic effects. Aqueous chromium(VI) solutions are highly corrosive. If chromium(VI) is swallowed, it causes indigestion, cramps, paralysis and kidney damage. 0.6 grams of orally ingested chromium(VI) can be fatal. Therefore, please do not try any simple recipes from the Internet and take care of your health.

High-quality chromium removers contain additives that neutralize the harmful compounds as they are formed. This reaction can be recognized by the color change, whereby the intense yellow color changes to a light green color. This ensures greater safety during the process.

Nevertheless, it is possible that chromium(VI) is produced, especially at high strengths. The chromium(VI) compounds should be collected and disposed of properly. Conventional vitamin C powder (aqueous ascorbic acid) can be used for this purpose, as the chromate is neutralized to green, almost non-toxic chromium(III).

4.5 Stainless steel

Stainless steel is generally iron that has been made corrosion-resistant with the help of nickel and chromium. The typical nickel content is around 10 percent and the chromium content is 18 percent; this is where the name "18/10 stainless steel" comes from.

Due to its chromium content, stainless steel is virtually resistant to galvanic coatings. The subsequent layer could peel off, as stainless steel forms a protective oxide layer that reduces adhesion. In order to coat stainless steel, it must therefore first be either direct nickel-plated (nickel strike) or direct gold-plated (gold strike). Stainless steel can then be coated. If stainless steel is to be silver or chrome plated, a nickel layer should be applied as a base. A nickel layer can, but does not necessarily have to be applied beforehand for gold-plating stainless steel (pre-treatment with nickel strike is still necessary).

4.6 Iron & Zinc

Some metals are so-called base metals. These include iron and zinc, for example. Base metals are not suitable for electroplating with strongly acidic electrolytes, as they can be attacked or corroded by them.

Alkaline electrolytes have a significantly lower concentration compared to acidic electrolytes. With alkaline electrolytes, only a thin layer should be applied during the electroplating process. It should be noted that the layer build-up takes longer with alkaline electrolytes and is also less efficient. When electroplating, make absolutely sure that the applied layer does not have any imperfections; if in doubt, it is better to apply a slightly thicker layer. If this were the case, the coating would - to put it crudely - be undermined during subsequent electroplating with acid electrolyte. In other words: If the first coating only has a small, defective area, the entire layer can flake off or (delayed) bubbles can form. For this reason, the first step is to bronze or copper plate iron or zinc workpieces in an alkaline bath. In a second step, thicker layers can then be built up in an acid bath.

It is also possible to galvanize iron directly using weakly acidic zinc electrolyte.

Additional knowledge: Precious metals, semi-precious metals and base metals

Base metals are those that react with oxygen from the air under normal conditions. This reaction is known as oxidation. Metals such as iron and zinc, but also aluminum and lead etc. are base metals.

In addition to base metals, there are also so-called precious metals, which do not react with oxygen from the air under normal conditions. Precious metals include gold, silver and platinum metals such as rhodium.

There are also semi-precious metals. Compared to precious metals, they corrode more quickly in air and semi-precious metals dissolve quickly in oxidizing acids. This means that semi-precious metals are less resistant to corrosion than precious metals.

4.7 Nickel

If a nickel workpiece is to be electroplated, it should be noted that nickel also forms protective oxide layers. As with other oxidizing metals, the oxide layer must be removed before further processing. The use of Dr. Galva Nickel-Strike is ideal.

Once the oxide layer has been removed, all metals can be applied to nickel.

The nickel should now be coated again quickly. After a few hours, the oxide layer is fully formed again and the nickel should be treated again with Nickel-Strike.

Nickel forms a very good diffusion barrier layer and is therefore used in a variety of applications in electroplating. The barrier layer prevents copper, for example, from diffusing into gold and discoloring the gold over time. To replace nickel, palladium is also used as a barrier layer, but this is considerably more expensive.

4.8 Silver

Silver is a precious metal with a high tendency to sulphidation, i.e. a tendency to turn black. If a silver workpiece is to be electroplated, this layer, also known as silver patina, must be removed.

If a silver workpiece is to be gold-plated, the first step is to apply a barrier layer of palladium or nickel. This prevents discoloration and alloying of the gold. Once the barrier layer has been implemented, it is possible to apply gold.

If, on the other hand, the sulphidation of silver is to be prevented without changing the color, the silver workpiece can be coated with rhodium, for example.

4.9 Tin

Tin also has a thin oxide layer, so a workpiece made of tin must first be activated. Dr. Galva conditioner can be used for this purpose. After activation, tin can either be nickel-plated directly or alkaline copper-plated. Coating with bronze is also possible.

4.10 Other metal alloys

In practice, there are almost countless metal alloys. Depending on their specific composition, the different metal alloys also have different physical and chemical characteristics. As a rule, the procedure used for electroplating a specific metal alloy is the same as that used for the main components. For example, if it is an aluminium alloy, the process for electroplating aluminium would be used. If it is an iron alloy, on the other hand, the process for electroplating iron would be used.

5 Galvanizing non-conductive surfaces

In principle, not only workpieces with conductive surfaces can be electroplated, but also objects with non-conductive surfaces. The following section provides general information on this topic and explains electroplating using silver conductive paint and copper conductive paint in more detail.

5.1 General information on conductive coatings

Workpieces with surfaces that are electrically non-conductive cannot be electroplated directly, regardless of whether they are made of plastic, synthetic material or wood, for example. However, it is possible to make non-conductive surfaces electrically conductive. So-called conductive lacquers are used for this purpose. In addition to specific binders, components of these lacquers include tiny particles that make the lacquer conductive.

Generally, conductive coatings are available in the form of lacquer, but also in the form of sprays. In other words, conductive lacquers for electroplating can either be sprayed or brushed on. Conductive lacquers are also available on a copper, graphite or silver basis. While silver conductive lacquers have the highest conductivity, graphite conductive lacquers have the lowest conductivity. This is also reflected in the price of the two types of conductive varnishes, as silver conductive varnishes are significantly more expensive than graphite conductive varnishes. The third category, copper conductive varnishes, are relatively inexpensive and also have relatively good conductivity. Copper conductive varnishes are therefore ideal for electroplating.

Due to their low conductivity, graphite conductive varnishes are not considered further in this electroplating guide. Instead, silver conductive varnishes and copper conductive varnishes are discussed in more detail.

5.2 Electroplating with silver conductive paint

Silver conductive lacquer for electroplating is available in the classic form of lacquer, but also as a spray. Silver conductive lacquer and silver conductive lacquer have various advantages: Silver conductive lacquer is smudge-proof, i.e. it holds better than copper conductive lacquer. If it is sprayed on in relatively thin layers, it also dries quickly. In addition, the workpiece treated with silver conductive lacquer is immediately conductive. For this reason, silver conductive lacquers are also ideal for use in electrical engineering.

If only small areas are to be electroplated, they can be coated directly using the pin electroplating process if handled with care. The maximum size of the area to be coated is around 10 x 10 centimetres. However, the surface must first be treated with bright copper.

Silver lacquer is also very suitable for the barrel electroplating process, as it guarantees high abrasion resistance.

5.3 Electroplating with copper conductive lacquer

If a workpiece is to be made suitable for electroplating using copper conductive lacquer, the first step is thorough cleaning and degreasing (see section 2.1 Pre-cleaning the workpiece). In a second step, the workpiece can be coated with copper conductive lacquer or immersed in copper conductive lacquer. The lacquer layer should then dry for at least 10 to 15 minutes, but ideally longer.

The workpiece can then be copper-plated using either the bath electroplating process or, with a careful approach, the tampon electroplating process.

Caution: Copper conductive lacquer only becomes highly conductive when coated with acidic copper electrolyte. For this reason, it cannot be used in the field of electronics.