



# TIFOO

## Handbook for Plating

As at June 6th, 2016  
Version 1.2

# PREFACE

**Dear reader,**

In answer to our clients' and readers' requests we have decided to write this handbook as a useful guideline to plating. This guide is freely placed at our clients' disposal; over time we will be incorporating your and our experiences into this guide so that you will receive continually updated information and profit from further tips and suggestions. We welcome your criticism and ideas for improvement and take them very seriously.

This guide is directed towards all artists, plating amateurs and craftsmen who want to use plating for the finishing or restoration of raw material or works of art. Prior knowledge of plating is useful but not necessary. This guidebook does not presume to describe the whole complexity of plating in every detail, it rather offers a practical approach to these interesting creative techniques by explaining the basic steps in a simple and efficient way. For both beginners and professional users, this text is meant to ease the practice of plating and to provide important tips.

The areas of application in plating are manifold: a myriad of objects like, for example, wheel rims, tools, or cigarette lighters can be chromium-, gold- or silver plated by products of Tifoo. The metallization adds a high optical and material value to work pieces. Also non-conductive materials like glass, plastics and even flowers can be metallised and obtain thereby exclusivity and individuality.

**We wish you success, good luck and many interesting projects,**

Your authors

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# 1. Plating for everyone

## 1.1 What is plating – How does it work?

Short and simple definition: **Plating is a process by which electrically conductive surfaces are coated with metals.**

In order to deposit metal, a conductive object has to be immersed into a metal salt solution (electrolyte) and connected to a power source so that an electric current can flow. Only direct current, which can be generated, e.g. by battery or power supply unit, is used for electroplating. There are also power supplies which generate alternating power and bear the letters “AC”. Direct current power supplies are marked in turn by the letters “DC”. Direct current has always two poles, the (-)-pole (black connector), called **cathode**, and the (+)-pole (red connector) called **anode**.

The object, onto which the metal is supposed to be deposited, must always be connected to the (-)-pole, the cathode. The anode should either be made of the metal that is to be deposited, for example a copper sheet for copper plating; or the anode should be of a passive material, e. g. graphite for silver or gold plating. When using a regulated power supply unit, where you can control voltage and current, please adjust voltage (volt) to the highest possible setting. During the plating process, please adjust the current only with the current control (ampere). Turn this control completely to the left before the process so that no current will flow. By carefully turning to the right, you can set the desired current. Crucial to the success is a suitable electrolyte. This consists of a solution of metal salts and additives in water.

There are two important parameters concerning electricity: first voltage, which is measured in volt, and the current, measured in ampere. With an adjustable power unit, you can control voltage and current. If you use a battery, the voltage remains always the same. Compare, for example, electric power to the water flow rate in a water pipe: Voltage corresponds to the water pressure in the pipe. The higher the pressure, the easier it is for water to overcome an obstacle (e. g. a narrow point). The current strength can be compared to the amount of water flowing through the pipe.

Water pressure and water volume are always directly related. The higher the pressure, the more water will flow. It is the same with electric power. The higher the voltage (unit: volt), the more current (unit: ampere) will flow, therefore you cannot determine voltage and current strength independently of each other. The current is regulated by voltage. This follows Ohm's law:  $I = V / R$ , meaning that the current strength (in ampere) corresponds to the voltage (in volt) divided by resistance (in ohm). Another important piece of information is how much current flows per area. A copper sheet which measures 10 x 10 centimetres has a surface area of 100 cm<sup>2</sup> on the front side and 100 cm<sup>2</sup> on the back side.

The whole surface area is therefore 200 cm<sup>2</sup>. When a current of 1000 mA is flows, it corresponds to a current of 5 mA per cm<sup>2</sup>. This parameter (current density) plays the key role for the correct setting of the current strength.

## 1.2 What can be plated?

Generally, every electro-conductive object may be plated. Even non-conductive materials like glass, plastics or porcelain can be made conductive with Tifoo conductive copper or silver varnish and then metallised. Yet there is a limited set of metals which cannot be plated, or only with special methods, as we will briefly outline in the following text:



- Chromium
- Aluminium
- Titan
- Stainless steels with a high chromium content (e.g. 18/10)
- Tin
- Refractory metals (tungsten, etc.)

These metals form particularly stable oxide layers. They cause, on the one hand, exceptional corrosion resistance of these materials but, on the other hand, hinder or complicate direct plating at the same time. Chromium for example can be directly gold plated with a special gold electrolyte (gold electrolyte Flash).

## 2. Basics

### 2.1 Safety

The necessary electrolytes consist of metal salts, complexing agents and other chemical additives. For industrial use, electrolytes containing free cyanide are primarily found. Because these are very poisonous, we do not sell these products and we won't discuss them in greater detail in this guide for hobby and professional users.

Complexed cyanide is less dangerous to work with and only a few of our products contain a minor amount of it (e. g. gold electrolyte Flash). Luckily, there are often less toxic alternatives. The products of Tifoo have been optimised to offer highest quality at the smallest possible risk. It should be noted that an electrolyte presents a hazard and therefore has to be used according to the manual. Store chemicals apart from food and work at an extra designated, well-ventilated work place. Never fill electrolytes into water bottles or similar containers which can be confused with food products. It is a must to wear goggles during plating. If there are many individual steps during the plating process, protective gloves and protective clothing are recommended. Additionally, avoid the emergence of aerosols. These are small droplets in the air (spray mist), which form when gases emerge during metal deposition. It is sufficient to close the container with a glass or plastic sheet so that droplets are unable to escape from it. Otherwise, there is a danger that these droplets may be breathed in, which can be harmful to your health. Best work where there are fume hoods or other ventilation systems, if there is such a work place at your disposal. However, should problems occur, please consult the physician on duty.

Please read all your safety data pages and manuals carefully before proceeding and contact us if you have questions.

## *2.2 Waste disposal*

The overriding principle of chemical waste disposal says: “The best waste disposal is that where no waste is generated in the first place.” So take care to only use the actual amount of chemicals needed for your work.

For further information ask your municipal administration about the disposal of the different chemical substances.

## **3. Preparation**

### *3.1 Pre-cleaning*

Crucial to the success of the metal deposition is the suitable pretreatment of the work piece. Rust, dirt and grease must be removed carefully in a mechanical way. Fine steel wool is best suited for this. Cleaning alone however is not sufficient. Often a very thin oxide layer remains on the metal's surface. With copper or nickel, it is invisible to the naked eye, meaning you have to give the work piece a chemical pretreatment. Grease residue is best dissolved with Tifoo Degreaser: Simply immerse the work piece in the liquid for a few minutes. Oxide layers are removed by a suitable acidic pickling solution. The Tifoo copper cleaner is such a pickling solution, which both degreases as well as dissolves the oxide layer. After pickling, you remove the remnants of the corrosive pickling solution by rinsing the work piece with clear water.

Afterwards the metal surface is bare and clean and should only be touched at the edges and with gloves if it is really necessary. Do not use your bare hands, because otherwise thin grease stains would occur, which could not be plated. After plating you would see your finger prints! Additionally, the gloves have to be powder-free and unused. Thin nitrile or latex single use gloves are suitable. If your work piece is a sheet, you should only touch it at the edges. Generally, it is recommended to use tongs or tweezers. Then you can plate without touching the item. Always remember: Only a surface which is absolutely clean and grease-free will lead to great results.

### *3.2 Polishing*

After the removal of rust and corrosion, the metal must be absolutely bare. The object may still be matt and, for example, show small scratches. With certain methods you can polish dull metal to a bright shine. For smaller objects, we suggest using a tumbler (machine with a barrel for polishing). It consists of a barrel, which can be filled with small



with small stainless steel spheres and sticks. You put your object into the barrel where it rotates for 30 minutes up to several hours. Because of the mechanical effect of the bullets, the surface is pressed microscopically flat and your piece receives a high sheen. Flat surfaces, e. g. a sheet, can be polished to a shine by an agate. The agate has to glide so long over the flat surface until it is completely smoothed and has received a mirror finish. Agates are a special kind of quartz which are ideal for polishing because of their composition.

Polishing pastes like Tifoo Power Polish are very well-suited for providing metals with a high sheen. Please only use this polish after the plating process because it leaves a grease layer that is hard to remove.

## 4. Electroplating – Metallization with electricity

### 4.1 Methods: *Electroplating by tank, pen and barrel*

There are three fundamentally different methods to plate work pieces: bath, pen or barrel plating. For tank plating, work piece and anode are immersed in a suitable electrolyte. Then, for a certain amount of time, the current flows and the metal deposits onto the work piece. This is common practice in the industry where in big tanks, for example bathroom fixtures, wheel rims and many other things can be nickel or chrome or gold plated. The method is simple, big currents can flow and very thick metal layers can be deposited. A disadvantage is the high amount of electrolyte required to fill a tank. This is a problem especially for hobby platers, since they do not necessarily want to work with a high amount of electrolyte when gold plating a larger object.

For a higher number of small pieces, barrel plating is the method of choice. This functions along the lines of tank plating, except that the single objects to be plated lie loosely inside a barrel and a wire inside the barrel supplies electrical contact. A motor rotates the barrel and this movement causes the pieces to be coated regularly.

Pen or brush plating is best suited for very big or stationary objects. Here, a metal or graphite rod, at the tip of which a swab or brush of cloth is fixed, functions as the positive pole (anode). This brush or swab is immersed into the equivalent electrolyte until it is soaked. Like in tank plating, the work piece is connected to the negative pole (cathode). Now touch the work piece with the swab and the circuit is closed. Through this contact, the current can flow along the brush and after a few seconds a metal layer deposits at the contact point. With this method, high currents flow through a small contact area, which can easily lead to uncontrolled metal deposition. The point of contact becomes matt, may darken and lose its shine. Because of this, you have to move the pen on the work piece continuously around in circles when brush plating. The metal rod functions as anode at the same time and is attacked by the electrolyte, for example copper is attacked by copper electrolyte. This means that the rod must consist of (mostly) inert materials like (18/10) stainless, steel graphite, platinum, or of the material of the electrolyte (like copper for copper electrolyte). It is an advantage of pen plating that you can coat quite large areas with a small amount of electrolyte. It is a disadvantage that the layers produced

thereby are not as thick as with tank plating.

Method	Advantage	Disadvantage
<b>Tank plating</b>	<p>Thick layers are possible: From several micrometres to a few millimetres (1 millimetre = 1000 micrometres)</p> <p>Plating progresses automatically</p>	<p>Big baths (tanks) with electrolyte are needed, because the object has to be immersed completely</p> <p>Strong power supply units are needed</p> <p>Problematic for mass products (e. g. screws), each of which have to be clamped individually.</p>
<b>Barrel plating</b>	<p>Ideal for mass ware (jewellery, rings, screws, etc.)</p> <p>Regular coating because of continuous rotation</p> <p>Plating progresses automatically</p>	<p>Big baths with electrolyte are needed</p> <p>Strong power supply units are needed</p>
<b>Pen plating</b>	<p>Only a small amount of electrolyte is needed</p> <p>Weak power supply suffices because the current only flows at one contact pint</p> <p>Large areas are easily coated</p>	<p>Only few micrometres of layer thickness</p> <p>Plating does not progress automatically like in a bath</p>

Table 1: Advantages and disadvantages of tank, barrel and pen plating

## 4.2 Tank plating

### 4.2.1 Basic equipment

You need a regulated dc source for plating tanks, a laboratory power supply with a display for voltage (volt) and current (ampere). The tank plating requires a container in which the work piece is completely submerged. This should be made of an acid and alkali-resistant material. Glass and plastic are ideal for this. You need a cable to connect the power supply with the anode as well as with the work piece. In order to avoid confusion, the positive pole should always be connected with a red cable, while the negative pole should be connected with a black one.

Afterwards the metal surface is bare and clean and should only be touched at the edges and with gloves if it is really necessary. Do not use your bare hands, because otherwise thin grease stains would occur, which could not be plated. After plating you would see your finger prints! Additionally, the gloves have to be powder-free and unused. Thin nitrile or latex single use gloves are suitable. If your work piece is a sheet, you should only touch it at the edges. Generally, it is recommended to use tongs or tweezers. Then you can plate without touching the item. Always remember: Only a surface which is absolutely clean and grease-free will lead to great results.

### 4.2.2 Electrode material

As a rule, the material of the anode should correspond to that of the electrolyte (a copper sheet in copper electrolyte) because during the plating process the anode is dissolved and the electrolyte solution can regenerate in this way. If no electrodes of the electrolyte's material are available, inert electrodes like graphite or platinum can be used. Additionally, no electrodes should be used which do not correspond to the electrolyte metal, because otherwise this results in the discolouration of the deposited layers or even in the destruction of the electrolyte. Please clean your electrodes thoroughly before and after each use. Do not let the electrodes remain in the electrolyte when not in use.

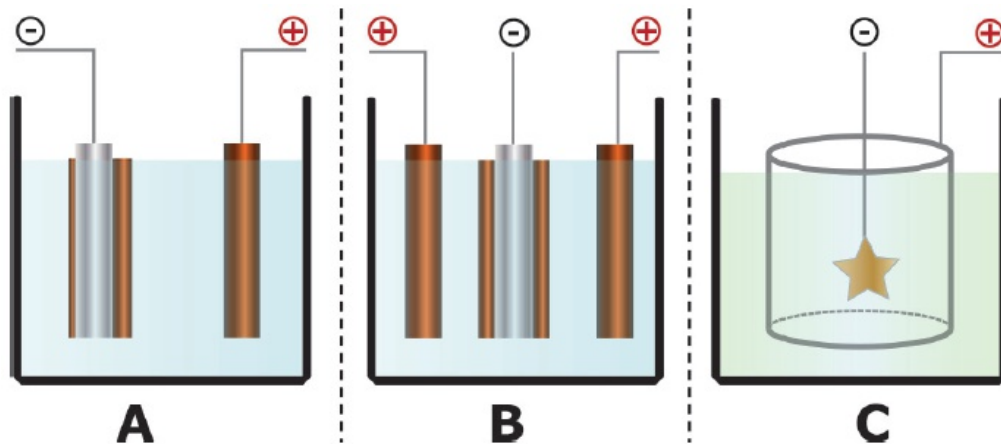
**We ask you to consider the following instructions with great care:** Graphite anodes are porous and can absorb electrolyte particles. This is why you should use a different graphite anode for every electrolyte (e.g. for silver and gold). Alternatively, you may take the same electrode, but it will have to be soaked in water several times. Let the graphite anode rest in clear water for at least 10 minutes, afterwards discard the water and repeat this process two or three times. In this way, the absorbed substances will be leached. If these are not cleaned out, they may be released in the next electrolyte and contaminate it.

### 4.2.3 Electrode area

The area of the anode should be at least as big as the surface of the object you want to plate. If the area of the anode is too small, the layers will not be deposited regularly. Larger anode areas don't lead to a negative result.

#### 4.2.4 Electrode assembly

It is important for tank plating that the object you wish to plate is surrounded by electrodes in a regular assembly, so that regular layers can be deposited. If the electrodes cannot be spaced in such a way, regular layers can be achieved by rotating the object. The distance between object and anode should be as large as possible.



**A:** The object is positioned opposite the anode. On the front, the object deposits significantly more metal than on its backside. The object has to be turned from time to time.

**B:** Object and two anodes (important: both anodes are connected to the same power supply unit). The object is set in the middle and surrounded by two anodes. The deposition happens in a much more regular way since there is no backside.

**C:** Object and ring anode. The best method. Here, the distance between anode and object is practically everywhere the same. A very regular layer thickness can be achieved without having to turn the object. This can be done by a pot of stainless steel for example, which is filled with electrolyte. Then the whole pot is connected to the (+)-pole. Beware: When you copper plate, do not connect a copper pot or copper cauldron as anode, because they will be attacked (corroded) and riddled with holes (perforated). This means that the electrolyte will leak (!). Only pots of stainless steel should be used for electrolytes which do not regenerate and dissolve (e.g. silver, gold); compare also the corresponding manuals.

Object and anode should in no case touch each other, since this would result in a short-circuit. It can cause the power supply to be overloaded or may lead to unsightly dark metal depositions at the contact point!

#### 4.2.5 Work temperature

Every electrolyte needs a certain work temperature which should be adhered to if you want to achieve optimal results. The exact operating temperatures of the electrolytes can be found in the respective manuals. All TIFOO electrolytes work ideally at room temperature so that you will not need external heating (exception: currentless processes).

## 4.3 Barrel plating

### 4.3.1 Basic equipment

You need the TIFOO barrel plating equipment. This consists of a barrel as well as a gear motor and corresponding mechanics. Small items are put into the barrel and then immersed in the bath and plated. You will need a power supply and cables analogous to tank plating (see above).

### 4.3.2 Electrodes

The requirements for electrodes are analogous to tank plating (see above). The anode is placed in the bath like in tank plating. The rotating barrel contains the cathode as a wire which contacts the work piece.

### 4.3.3 How to fill the barrel

The requirements for electrodes are analogous to tank plating (see above). The anode is placed in the bath like in tank plating. The rotating barrel contains the cathode as a wire which contacts the work piece.

## 4.4 Pen plating

### 4.4.1 Basic equipment

You need a regulated direct current source, a power supply used in laboratories with a display for voltage (volt) and current (ampere). Furthermore a pen electrode is needed, which can be connected to the positive pole of the power supply with a cable. The pen comes with a support for the anode (e.g. a graphite rod anode). A felt pad will then be attached to the anode and now the anode is ready for use. Like in tankplating, the (-)-pole is clamped to the work piece.

### 4.4.2 Electrodes

The requirements for electrodes are the same as for tank plating (see above); but for pen plating you will of course need round rod electrodes.

### 4.4.3 Pads

Pads are capped onto the electrode so that they soak up the electrolyte, which can then be spread onto the metal. Good swabs should have a high absorbing capacity. Furthermore, they should have no seams which could scratch the work piece. Additionally, the pads should not “tatter” and they have to be so thin that they are not insulating and the current can still flow.

### 4.4.4 Gelling agents

Gelling agents are thickeners which can be added to the electrolytes to make them more viscous. This way, the electrolyte will drip less and you will only need a small amount of it. On top of that, the working process is much cleaner.

## 5. Plating of different metals

### 5.1 Overview

It is important in plating that the coating of metals happens in a certain sequence. It is for example not possible to gold plate zinc directly, due to the fact that different metals react in different chemical ways to the electrolytes. Additionally, so-called barrier layers (nickel or palladium) have to be built in, which hinder a mixing or respectively an alloy of the bordering layers. When e. g. copper is directly gold plated without a barrier layer, the gold and the copper layer will mix and this will gradually (days to months) lead to a reddening of the gold layer.

### 5.2 Copper, brass and bronze

Copper, brass and bronze form slightly dark oxide layers and so must be pickled with TIFOO copper cleaner before electroplating. Blank copper has a light red colour. A barrier layer of palladium or nickel (nickel electrolyte may only be sold to trade customers because of legal requirements) can be directly applied to copper and brass. After the nickel has been activated by acid (palladium without activation), every metal may be applied onto it. Bronze acts itself like a barrier layer and may be directly plated, for example with gold.

**Copper or brass -> nickel or palladium -> gold, silver, chromium**  
**Bronze -> gold, silver, chrome**

### 5.3 Zinc/iron

Base metals like zinc or iron are corroded by acidic electrolytes and therefore cannot be plated with these. Instead, first alkaline electrolytes like e.g. alkaline copper are applied onto these metals. Since alkaline electrolytes have noticeably weaker concentration than their acidic equivalents, you should only apply a very thin layer of alkaline electrolytes. Their efficiency is lower and much more time is needed to build up the layers. Yet it is absolutely essential that this thin layer has no cracks; otherwise, the layer underneath will corrode, when the acidic electrolytes are applied. A small crack may cause the whole coating to spall. You should therefore copper or bronze plate for at least 30 minutes in an alkaline bath. Afterwards, you can, for example, plate with acidic copper in order to form thick layers. Iron can also be directly zinc plated with a weakly acidic zinc electrolyte.

**Zinc or iron -> nickel -> gold, silver, chrome**  
**Iron -> copper -> palladium -> gold, silver, chrome**  
**Zinc or iron -> bronze -> gold, silver, chrome**  
**Iron -> zinc**

### 5.4 Silver

Silver has got a high tendency to oxidize (the typical blackening of silver). This silver patina must be removed completely before plating, e. g. with Tifoo Silver Cleaner. If you want to gold plate silver, you first have to apply a barrier layer of nickel or palladium to prevent the alloying and discolouration of gold (in this case green gold or rather light yellow gold). On top of the barrier layer, you can then again apply gold. After that, you may coat the silver with Tifoo Rhodium electrolyte, if you want to keep the light silver colour but prevent the blackening of silver.

**Silver -> nickel or palladium -> gold**  
**Silver -> rhodium**

### 5.5 Aluminium

Aluminium is a very oxygen sensitive metal (which oxidises immediately in the air) and thus protects or rather passivates itself. This protective oxide layer is not conductive and prevents a direct coating of the aluminium. Yet a currentless nickel plating with Tifoo Nickel-Star is possible for clean aluminum and many alloys.

**Aluminium -> currentless nickel -> gold, silver, chromium**

## 5.6 Chromium

Chromium forms, analogous to aluminium, a protective oxide layer, which prevents direct coating. The only exception: direct gold plating of chromium with a strong acidic cyanide gold(III)-electrolyte, for example the gold electrolyte Flash. In contrast to aluminium, there exists no simple process to pickle chrome. This means that chrome has to be stripped before plating (if you do not want to use gold). In general, chromium is applied industrially onto the nickel layers, which have to be exposed at first before plating them further. Chrome is removed with a special chrome remover. During the stripping of chrome, toxic chromium trioxide compounds develop, with which you must not contaminate yourself. Chromium trioxide compounds show an intensive yellow and are easily recognized. The chrome remover contains additives which neutralize the chromium trioxide compounds when they start to develop (colour changes from intensive yellow to weak light green) and makes working during dechroming more secure. Yet when the current is high, some chromium trioxide can develop. When working, the forming chromium trioxide compound must be intercepted and disposed of appropriately. Ascorbic acid (vitamin C powder) dissolved in water neutralises the chromate to a nearly non-toxic green chromium III. After an activation with acid, the exposed nickel can be directly coated with all metals.

**Chrome -> nickel -> copper, silver, gold**  
**Chrome -> gold**

## 5.7 Nickel

Nickel generates protective oxide layers. These oxide layers must be removed before you continue to work, e. g. with diluted hydrochloric acid. Afterwards, all metals may be deposited onto nickel.

**Nickel -> copper, silver, gold, chrome**

## 5.8 Tin

Tin has to be activated at first, because it is always covered by a thin oxide layer. This layer can be removed e. g. with a diluted hydrochloric acid. After activation, alkaline copper plating is possible or an immediate application of nickel. Bronze is also recommended.

**Tin -> (copper) -> nickel -> silver, gold, chrome**  
**Tin -> bronze -> silver, gold, chrome**



## 5.9 Stainless steel

Stainless steel is essentially iron which has been rendered resistant to corrosion by adding nickel and chrome. The average 18/10 stainless steel has chromium content of 18% and a nickel content of 10%. Because of the chromium content, this steel is mostly resistant to electroplating. A remedy here would be direct gold plating with a strong acidic cyanide gold electrolyte (gold electrolyte Flash). Direct nickel plating with a nickel electrolyte usually works quite well. Afterwards, you can continue coating with further layers like it is described above.

**Stainless steel -> nickel -> gold, silver, chrome**  
**Stainless steel -> gold**

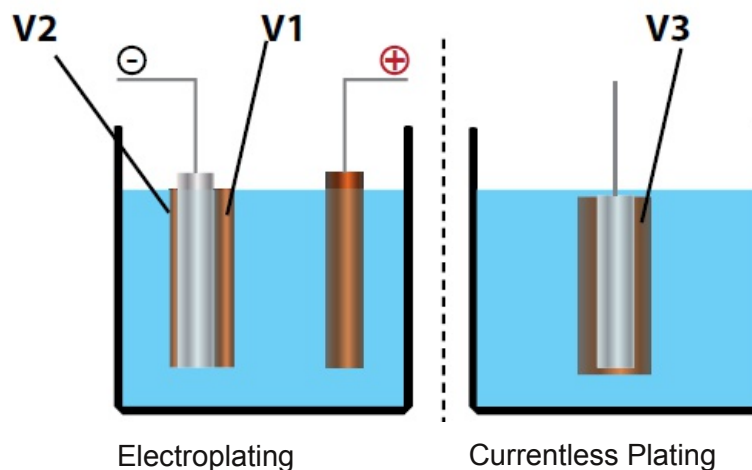
## 5.10 Other metal alloys

There are numerous different metal alloys which have, depending on their composition, different chemical and physical properties. As reference point you can choose for the plating of alloys the same process which you would choose for the main component of the alloy; for example cast iron should be treated like iron; some aluminium alloys can be coated like pure aluminium.

## 6. Metallization without electricity

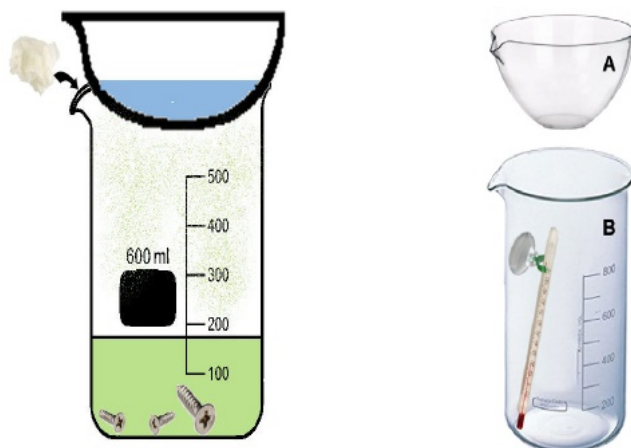
### 6.1 Electroplating and currentless plating compared

Electrodeposition and currentless deposition of metal: When using current, the metal deposits favour the side (V1) closest to the anode (+): "principle of the shortest path", similar to a lightning strike which always strikes the highest point (shortest distance from cloud to earth). Cavities, if they exist, are sometimes not plated at all. Currentless (V3), there is no such difference, the metal deposition is the same on all sides.



## 6.2 Basic equipment

Currentless processes need a simpler equipment than electroplating ones. A heatable container is necessary, the inside of which is ideally enameled. Stainless steel containing chrome (18/10) may also be used. We recommend the TIFOO Set for currentless baths. This consists of a glass tank, a thermometer and a condenser which efficiently hinders vapour from escaping.



## 6.3 Currentless baths in general

In addition to the electroplating process described above, there are also baths for which no current is needed at all. A so-called chemical reducing agent takes over the role of the current for these baths, or there is a chemical exchange at the surface. These processes are also known as “electroless silver”, “electroless gold” or “electroless nickel” (or chemical silver, chemical gold, chemical nickel). Currentless baths offer several advantages compared to baths with current:

Simple installation is possible, handling is simple.

The coating thickness is the same on all sides (when electroplating – with current – much material is applied to the outmost, exposed parts, while cavities or undercuts are less thickly coated).

Electroless rhodium protects silver objects from tarnishing (otherwise silver will be turning black in the course of time).

With electroless nickel plating, nickel phosphorus or nickel boron alloys are generated, which are, in contrast to pure nickel, harder and even more resistant to corrosion.

Electroless nickel also generates very thick layers, similar to electroplating.

Electroless baths nevertheless have some disadvantages compared to baths with current:

The baths are sooner used up than the electrolytes.

For gold and silver: only a very thin coating thickness is possible, often less than 0,3 µm; they are therefore only suitable for decorative uses (this does not apply to electroless nickel).

## *6.4 Electroless nickel (Nickel-Star)*

The bath most used is the electroless nickel bath (Nickel-Star). It is easy to use, very robust and generates very durable layers. During electroless plating, no pure nickel layer is generated but a nickel phosphorus alloy, which is chemically more robust, harder and more resistant to corrosion. Its layer thickness is dependent on the length of time spent in the tank. This weakly acidic bath must be heated to an elevated temperature (90 °C). When working, it absolutely must be assured that the tank is closed (in such a way that no pressure can build up); or the working is done beneath a fume hood, because nickel vapour is toxic! It is best to use the TIFOO set for currentless baths. Iron, nickel and steel with low amounts of chrome can be directly coated with electroless nickel. Copper and brass must first be activated with electroless palladium (palladium activator). Alternatively, copper can be activated by direct contact with an iron screw in the tank (not recommended) or a short current flow through the work piece with a nickel anode as counter electrode. Stainless steel with high chromium content cannot be coated.

**Iron -> nickel phosphorus**  
**Copper, brass, bronze -> electroless palladium -> nickel phosphorus**

## *6.5 Electroless silver (Silver-Star and Tifoo Silver gel)*

Tifoo Silver-Star and Tifoo Silver gel are ideally suited to silver plate brass and copper. During this process, a chemical exchange between the surfaces of copper and silver happens. Since this effects only the surface, it is only possible to cover a thin layer (ca. 0,2 µm) – yet those silver layers are relatively abrasion-resistant. The reaction happens during room temperature, but in problematic cases it may be started or sped up by heating to 30°C. The silver gel has the additional advantage that it does not drip (or does so only slowly), so that large copper areas may be plated.

**Copper or brass -> silver**

Deposited metal (product name)	Metal that can be plated	pH <sup>1</sup>	Working temperature in °C	Max. layer thickness	Use
Nickel phosphorus (TIFFO NICKEL-STAR)	Copper <sup>2</sup> , brass <sup>2</sup> , iron, nickel	4 – 5	90	20 µm and more	Protection against corrosion, barrier layer
Silver (TIFFO SILVER-STAR) TIFFO SILVER GEL)	Copper, brass	2 – 3 8 – 9	20 – 40	< 1 µm	Decorative
Gold (TIFFO GOLD-STAR)	Nickel, silver, copper, brass, bronze	7 – 8	60 – 90	< 1 µm	Decorative
Rhodium (TIFFO RHODIUM-STAR)	Silver	> 2	100	< 1 µm	Protection against the tarnishing of silver
Palladium (TIFFO PALLADIUM-ACTIVATOR)	Copper, brass, bronze	< 2	20	< 1 µm	Activation of copper and brass for electroless nickel

<sup>1</sup> pH 0 = acidic (e. g. 5% sulphuric acid), pH 7 = neutral (distilled water), pH 14 = alkaline ( e. g. 4% caustic soda solution); pH smaller than 2 or larger than 11,5 means danger of burns! Here it is a must to work with protective glasses and gloves.

<sup>2</sup> Copper and brass must be “activated” before, e. g. first treated with electroless palladium.

## 6.6 Electroless gold (Tifoo Gold-Star)

The chemical gold bath (Gold-Star) is used to gold plate both objects made of copper, brass or bronze as well as silver plated or nickel plated ones. The tank is heated to a high temperature (ca. 90 °C) and deposits decorative layers. Silver must additionally be treated with palladium activator. In order to prevent the inhalation of aerosols, you should work inside a fume hood, with a closed vessel or with breathing protection.

**Copper, brass, bronze, nickel, palladium -> gold**  
**Silver -> palladium activator -> gold**

## 6.7 Electroless Rhodium (Tifoo Rhodium-Star)

The chemical rhodium bath is used to plate silver with rhodium and therefore protect silver against the typical silver patina, similar to jewellery plated with rhodium. The silver object has to be put into a rhodium bath of 100 °C for about 5 minutes.

**Silver -> rhodium**

Silver ware which has been treated with chemical rhodium will display no tendency to turn black even after several years. The hue of chemical rhodium, however, is a bit darker (similar to stainless steel) than electroplated rhodium and silver.

# 7. Plating of non-conductive surfaces

## 7.1 Conductive varnishes in general

Surfaces like wood, plastic and similar synthetic materials cannot be directly plated, because these surfaces are not conductive. Non-conductive surfaces can be made conductive with the help of so-called conductive varnishes. These use special binding agents and particles which make the varnish conductive. Conductive varnishes may be applied by paintbrush or by spray. There are conductive varnishes based on silver, graphite and copper. Conductive silver varnishes possess the highest conductivity, but they are not inexpensive and are therefore only used for small to medium areas. Conductive graphite varnishes are less costly, but their conductivity is very poor. Ideally suited for the use of plating are conductive copper varnishes because they are low priced and have a high conductivity, which is necessary for electroplating.

## 7.2 Tifoo Conductive copper varnish

Before the conductive varnish is applied, the work piece has to be thoroughly cleaned and degreased. For this, Tifoo degreaser is particularly suitable. Then the object is painted with the conductive copper varnish or submerged. After the application, the conductive varnish has to dry for a short time (at least 10-15 minutes, better longer), and afterwards reinforced with the acidic copper electrolyte, because without reinforcement, the conductive varnish can be rubbed off. Copper plating may also be done with a bath or, when working carefully, also with brush plating. Important: The dried conductive varnish only becomes conductive when it comes into contact with the acidic electrolyte (1). It is therefore impossible to use it in electronics.

**Wood/plastic/glass -> conductive copper varnish -> copper -> nickel/palladium -> gold/silver/chrome**

## 7.3 Tifoo Conductive silver varnish and Conductive silver varnish spray

Conductive silver varnish also exists as spray and has numerous advantages. It is a bit more adhesive than conductive copper varnish (wiping-proof) and dries fast, when it is sprayed in thin layers. The object is immediately conductive. This makes the conductive silver varnish also suitable for electronics. When handled carefully, small areas of max. 10 x 10 cm area can be pen-plated directly.

For this purpose, a layer of bright copper has to be applied at first. This varnish is also very well suited for tank or barrel plating. The resistance against abrasion is especially important in barrel plating.

**Wood/plastic/glass -> conductive silver varnish -> copper -> nickel/palladium -> gold/silver/chrome**

## 8. Post-treatment and polishing

After electroplating, some objects (depending on the electrolyte) are still dull and may then be polished. This can be done e. g. by steel wool followed by TIFOO Power Polish. A tumbler is also very suitable for small parts (barrel plating), see also chapter "pre-treatment". If you wish to preserve the metal gloss or the rust-protective coat in the long run, further steps may still be necessary, depending on the metal:

**Copper, brass, bronze:** use cellulose varnish spray, otherwise these metals will darken

**Silver:** apply rhodium (e. g. rhodium-electrolyte or Rhodium-Star) or cellulose varnish spray

**Nickel:** chromium plate it.

**Palladium, gold, chromium:** no post-treatment necessary

**Zinc:** use trivalent chromium plating (passivates zinc against white rust).

Alternatively, the metals can also be patinated or artificially aged, if desired. Silver can be blackened permanently, e. g. with silver patination. Copper and brass turn black or dark brown because of patination. Cellulose varnish generates thin, completely transparent layers on every metal surface, so that even patinated surfaces can be protected permanently

## 9. Calculation of coating thickness

On our homepage you will find an online calculator to help you calculate the layer thickness of your electroplated layer (<http://www.tifoo.de/en-uk> => INFOMATERIAL => Calculator).

As an example we will show in the following passage how much area can be covered at the most by an electrolyte:

A frequently asked question: How much space can be covered by 100 mL gold electrolyte with a gold content of 1,0 gram per litre?

$$V (\text{electrolyte}) = 100 \text{ mL} = 0,1 \text{ litre}$$

$$m (\text{gold}) = 0,1 \text{ l} \times 1,0 \text{ g/l} = 0,1 \text{ g}$$

$$A = ?$$

$$A = L \times W$$

$$V (\text{gold layer}) = L \times W \times T$$

V = Volume  
m = mass ("weight")  
A = area  
L = length  
W = width  
T = thickness  
d = density (gold = 19,3 g/cm<sup>3</sup>)

$$d = m / V$$

$$d (\text{gold layer}) = m (\text{gold}) / V (\text{gold layer})$$

$$V (\text{gold layer}) = m (\text{gold layer}) / d (\text{gold layer})$$

$$V (\text{gold layer}) = 0,1 \text{ g} / 19,3 \text{ g/cm}^3$$

$$1000 \text{ mm}^3 = 1 \text{ cm}^3$$

$$V (\text{gold layer}) = 0,0052 \text{ cm}^3 = 5,2 \text{ mm}^3$$

Assumption: A decorative gold layer of 0,1 micron (= 0,1  $\mu\text{m}$  = 0,0001 mm)

$$T (\text{gold layer}) = 0,0001 \text{ mm}$$

L = W (area is as wide as it is long = quadratic area)

$$L \times L = V (\text{gold layer}) / T$$

$$L^2 = 5,2 \text{ mm}^3 / 0,0001 \text{ mm} = 52000 \text{ mm}^2$$

$$L = 228 \text{ mm} = 22,8 \text{ cm}$$

This means that a square area of 22,8 x 22,8 cm can be coated with one 100 mL bottle of gold electrolyte (1,0g/l) with a decorative gold layer of 1 µm.

Simpler than calculating yourself is using our online Calculator (see above).

## 10. Common mistakes and their solutions

The following points provide an overview of the most frequent mistakes in plating and show how they may be avoided or resolved. Plating is sometimes difficult, especially if the object is geometrically challenging (e. g. figures with several undercuts, etc.) or metals which are difficult to plate like aluminium. In general, for every problem there is a suitable solution. For further details please look into the corresponding product manuals.

### 10.1 Irregular coating and stains

One of the most frequent reasons for an applied metal layer to lack in quality is insufficient preparation. The preparation is practically the most important step. Without appropriate rust removal, pre-polishing, degreasing and activation, the applied layers will not adhere quite right or will deposit stains. For example, objects which are touched without gloves, will show finger prints after plating because these spaces cannot be coated. Copper coins which are not completely blank show, e. g. after copper or silver plating, still stains at places where the copper patina had not been removed completely. It is not enough that the object be simply “clean”. Copper coins for example, which you wash with soap, will become clean, but a thin surface patina will remain. This can only be removed by acid or TIFOO Copper cleaner. Otherwise, the layer applied next will be dull and dark.

**Remedy:** Clean all surfaces thoroughly and use the recommended resources to remove all grease residue and surface oxides – e. g. silver cleaner for silver and TIFOO Galvano-activator for nickel and stainless steel.

### 10.2 If the coating flakes after plating...

One of the worst mistakes that can happen is the flaking of the applied coating. If this happens, the applied layer must be completely removed mechanically, which demands great time and effort. So it is very important to absolutely avoid this mistake from the beginning. The origin of the flaking is always the same: insufficient connection of the applied metal to the underground. There are two reasons for this:



### 10.2.1 Flaking because of surface oxide

Some metals are protected by an invisible oxide layer. This is the case with stainless steel, nickel, chromium and aluminium. If these metals are plated without adequate preparation, the applied layer will flake. Thus, special care has to be taken when preparing these materials for plating. The oxide layer can be removed by acids, but it regenerates quickly.

**Especially affected:** aluminium, chromium, stainless steel, nickel

**Remedy:** Treat the model first with galvano activator or use suitable electrolytes (e. g. gold electrolyte Flash for chrome, stainless steel and nickel).

### 10.2.2 Flaking because of currentless reactions

The second most frequent reason is currentless deposition (immersion deposition). This happens very frequently when a nobler metal (e. g. silver) is applied onto a less noble one (e. g. copper). In this case metal is deposited without current. This is often a favoured outcome for currentless baths with a small layer thickness, but may lead to the flaking of thicker layers when electroplating. It is caused by a superficial erosion of the less noble metal. Such layers do not adhere well and are inclined to flake. Because of this, iron for example cannot be plated with bright copper immediately and must first be alkaline copper plated: otherwise, an immersion deposition will occur.

Even more problematic is the currentless deposition when working with silver. Here the base coat (e. g. nickel) must first be gold plated and then the gold layer can be silver plated. A direct silver plating of nickel leads to strong flaking.

**Especially affected:** iron, zinc, steel, copper

**Especially affected product:** TIFOO Silver electrolyte

**Remedy:** alkaline copper plating (iron, zinc, steel)

### 10.3 No sheen despite brightener

Brighteners are found in bright copper electrolyte and in nickel electrolyte. Without a brightener, these electrolytes deposit only dull and partially rough layers. Brighteners only react at certain current densities, therefore: please observe very carefully the recommended current densities according to each electrolyte. Too low current density does not lead to a generation of sheen. When this happens with, e. g. copper, only dull copper layers will deposit. Too high current densities lead to a formation of “spots”. The brighteners are used up after a certain time and must be added again. You can also order additional brighteners on request.

After a longer use it is possible that even this adding of brighteners has no effect any more. Then too many degradation products have been accumulated in the electrolyte. In this case the electrolyte has to be filtered. Use activated carbon as filter granulate and after filtering add new brightener.

**Remedy:** Increase the current flow or filter the electrolyte and add new brightener.

#### *10.4 Object does not metallise*

Frequent reasons: unsuited metal or mistaken metal (e. g. alkaline copper is used for iron, although the surface is chromed). Finished surfaces may also be a possibility. Please, also check the wiring, especially when pen plating and examine if the current is flowing (ampere display). When pen plating, check if the pad is sufficiently soaked with electrolyte, otherwise the appropriate level of conductivity will not be reached.

**Remedy:** Check closely your object's material.

#### *10.5 Development of crystallites or "spots"*

This happens when too much current is flowing, when using copper electrolyte for example. Then crystalline outgrowths ("spots") are generated on the parts of the object closest to the anode.

**Remedy:** Reduce the current flow.

#### *10.6 Development of "spongy", non-adhesive coatings*

It may happen during the bath that loose, non-adhesive ("sponge"-like) particles are forming on the object. Spongy depositions are dark and easily peeled away from the object. Should this happen, take the object immediately out of the bath and, with a cloth, remove loose metal. This mistake happens most often when too much current is flowing, e. g. when using silver electrolyte.

**Remedy:** Reduce the current flow.

#### *10.7 Development of "scorched looking" spots*

Dark coloured areas, "scorching", may develop, e. g. the black or brown areas during gold deposition. Like the spongy depositions above, they are caused by too high current flow. These may happen especially during pen plating. Scorchings can be polished away after plating, nevertheless they should better be avoided.

**Remedy:** Reduce the current flow.

## *10.8 The electrolyte is muddy and dull, “dirty” coats are deposited*

During the electrolyte bath, decomposition products may be generated of the brighteners; furthermore, particles can dissolve from the anodes, which then cloud the electrolyte. A cloudy electrolyte does not deposit bright and well-adhering layers any longer, because the particles disrupt the layer generation or rather get included in the layer as well.

**Remedy:** Filter the electrolyte (with paper filter or fluted filter and funnel) and clean the anodes thoroughly after each use; do not let the anodes sit in the electrolyte for a longer amount of time.

## *10.9 The pH-value is no longer correct – electrolyte deposits badly*

For certain electrolytes, the pH-value (this is a measure for the acid or the base concentration) may slowly be changing during the electroplating. This can be determined by a pH-electrode or a pH-indicator paper. After longer use, the pH-value must be corrected with acid or base for the following electrolytes:

**Nickel electrolyte:** this electrolyte becomes more alkaline when it is used, green clouds and flakings are generated. Remedy: add very little of thinned battery acid (sulphuric acid) in drops and stir well. The precipitate will slowly dissolve. Important: Don't let it become too acidic, otherwise the electrolyte will stop working! The pH-value should be about 5.

**Silver electrolyte:** this electrolyte becomes acidic during the operation and may decompose spontaneously. After a longer period of use, add a minor amount of sodium bicarbonate (natron). The pH-value should be about 4,5.

## *10.10 The electrical current decreases very fast during plating*

If the set current is decreasing during plating, the reason may be that the anode has become “passive”. This means the anode has covered itself with a protective film of insoluble salts and can no longer conduct well or is even no longer conductive at all. This may happen, for example, when you copper plate with a brush.

**Remedy:** Clean the anode (grind it); reduce the current density.

## 11. Useful tips and tricks

In this chapter you will find some “special effects.”

### 11.1 “Pseudo” gold plating

It is relatively simple and cheap to achieve a coat of brass which resembles gold plating quite closely. To this end, the object is at first thickly copper plated with TIFOO bright copper electrolyte. Then it is polished until the sheen is as bright as desired. Now a thin layer of TIFOO zinc electrolyte is plated on it (max 0,2  $\mu\text{m}$ !). Then the zinc layer is polished (if desired) and the zinc plated object is heated in the oven at 180-230 °C. After ca. 10 minutes, the zinc coat will turn golden yellow. Don't let it remain too long in the oven, otherwise the coat will darken. This beautiful “gold coat” may be conserved with cellulose varnish. The brass is generated when zinc diffuses in copper (brass is a copper/zinc alloy).

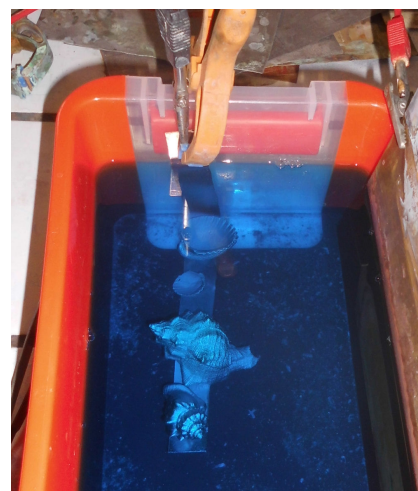
Alternatively: When the bright copper layer has been applied, tilt the object in a boiling suspension of zinc dust (1-2 grams per litre) in caustic soda solution (20 g sodium hydroxide / litre) continuously so that the zinc dust is swirled up. After a short time the object is electrolessly (chemically) plated with a thin zinc layer. Afterwards you can heat up your object as described above.

### 11.2 Iridescent rainbow patina

Let a freshly bronzed piece soak in the bronze electrolyte without current for about 15 minutes (rinse afterwards). When it is now exposed to the air, a blue-green, iridescent rainbow patina will form. This may then be protected with a cellulose varnish.

### 11.3 A sheet bar for cathodes to plate several pieces at once

There are cases where neither tank nor barrel plating will work out in a satisfying way. This concerns especially delicate objects like mussels, Lego bricks, etc. which have been treated with conductive varnish beforehand. They would be damaged if you fixed them in the bath with a crocodile clip. Inside the barrel, the conductive varnish would be rubbed off because the pieces are too sharp-edged. There is a simple trick which is very useful for bright copper (or other low-priced electrolytes). Take a long thin copper sheet (or cut out an adequate piece of a larger sheet) and bend it on one end at 90 degrees. Then connect the shorter end to the cathode with a crocodile



clip. The rest of the sheet is immersed in a bright copper electrolyte. Now put the delicate work pieces (e. g. mussels with conductive varnish) onto the sheet cathode. Since they simply lie on the cathode sheet, the objects are connected and plated electrically in a way which limits damages. The cathode sheet will of course be plated as well as the object, but this is a regular side effect and should not trouble you. Move the objects gently from time to time to avoid their merging with the cathode sheet.



### *11.4 An “ideal” way to gold plate non-conductive objects*

The most beautiful gold plating of non-conductive like mussels, Lego bricks, plants and many other objects will be achieved by the following method: The pieces are sprayed with conductive silver varnish and then in a bath thickly copper plated with bright copper. Without polishing the pieces are then put into a nickel bath and plated with bright nickel. The advantage of the nickel bath is found in the fact that the generation of sheen is less dependent on geometry. This means that undercuts and cavities receive enough sheen, which is not always successfully achieved when using a copper bath. Areas with a matt layer can now become bright, too. The nickel plating process should last for quite some time (30 minutes to 2 hours). The final step is gold plating with gold electrolyte Flash. The gold electrolyte Flash on the one hand deposits slower than gold electrolyte Midas, on the other hand it generates the most beautiful gold sheen without needing a final polishing. Because of this reason, the nickel layer is then gold plated for at least 10 minutes. The object will become bright golden with this method. It is also particularly recommended for objects which are hard to polish (watch bands, delicate chains, flowers, etc.).

## **12. About Tifoo**

Tifoo is the market specialist in Germany for hobby-, art- and craft plating. We develop and produce new and innovative products for both electroplating and currentless surface coating and expand our portfolio by respecting the feedback and wishes of our clients. This way, we can continue to improve our product range and therefore offer our clients best quality at a very good price.



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