How can the surface of a base metal be made more noble?

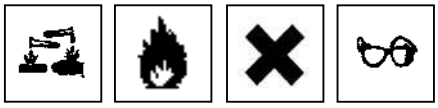
EEP 4.4 | S

Task

To demonstrate, in a model experiment, how a sheet of iron can be coated with a layer of copper.

Equipment

Plug-in board	06033.00	1
On/off switch	39139.00	1
Trough, grooved	34568.01	1
Copper electrode, 76 x 40 mm	45212.00	1
Iron electrode, 76 x 40 mm	45216.00	2
Connecting cable, 25 cm, red	07313.01	2
Connecting cable, 25 cm, blue	07313.04	2
Connecting cable, 50 cm, red	07314.01	1
Connecting cable, 50 cm, blue	07314.04	1
Crocodile clips, bare, 2 from 10	07274.03	(1)
Multi-range meter	07028.01	1
Power supply, 0...12 V-,6 V~, 12 V~	13505.93	1
Spoon, special steel	38833.00	1
Water, distilled, 5 l	31246.81	1
Copper-II sulphate, cryst, 250 g	30126.25	1
Sulphuric acid, 10%, tech. gr., 1000 ml	31828.70	1
Raw alcohol for burning, 1000 ml	31150.70	1
Emery paper, medium, 1 sheet from 5	01605.02	(1)
Cloth or absorbent paper		



Danger!

Methylated spirits is highly flammable. Extinguish all open flames.

Sulphuric acid is corrosive. Wear protective glasses!

Copper sulphate solutions are harmful to health. Do not swallow them!

Set-Up and Procedure

— Preparatory work: Clean the trough; thoroughly rub down the electrodes with emery cloth; wipe the iron electrodes with methylated spirits, then avoid touching them with your fingers (so that they remain fat-free).
— Fill the trough to about two thirds with distilled water; add about 2 spoonfuls of copper sulphate, under stirring, until the solution is saturated.
— Set up the experiment as shown in Fig.1, with the switch first open. Plug the electrodes in the trough and so connect them with crocodile clips and short connecting cables that the iron electrode is connected to the negative pole, i.e. is the cathode.
— Pour a little dilute sulphuric acid in the solution and stir it in.
— Select the 300 mA- measurement range, set the power supply to 0 V and switch it on.
— Close the switch and and increase the power supply voltage until about 150 mA has been reached.
— Observe the processes at the electrodes and note your observations.
— After about 3 minutes, open the switch, set the power supply to 0 V and switch it off.
— Rinse the iron electrode with water and take a close look at the part which was immersed; note what you see.
— Dry the copper electrode, properly dispose of the aqueous solution; clean the trough and wash your hands with soap and water.

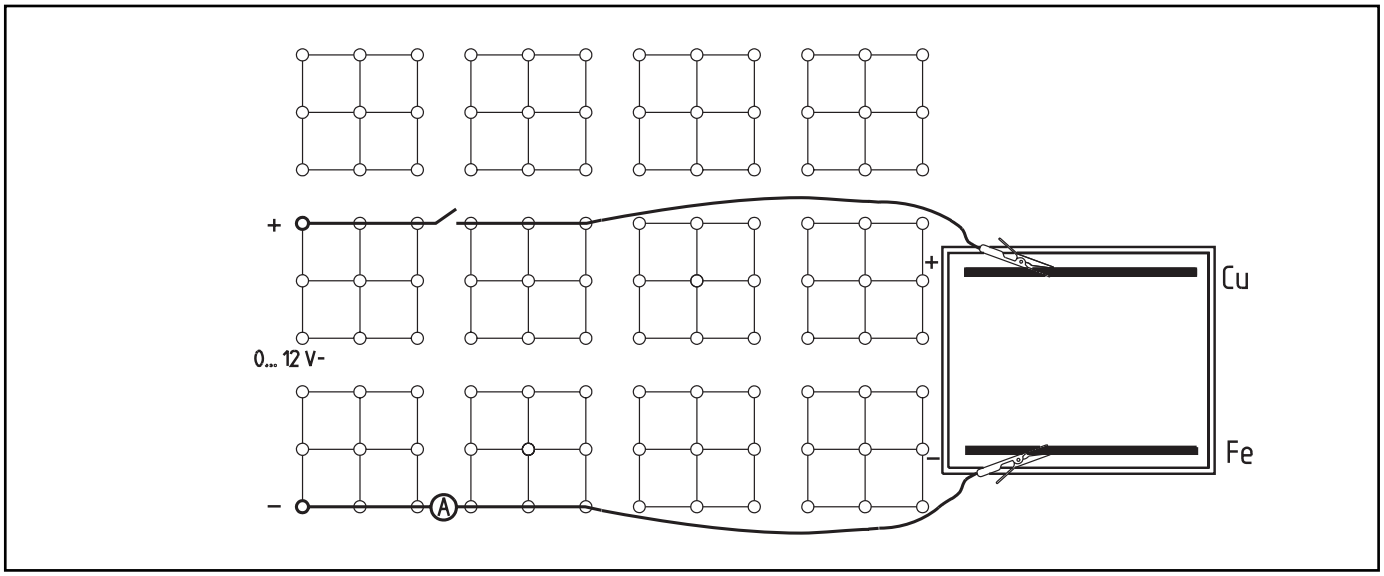
Waste disposal

Pour the galvanizing bath into an appropriately labelled container.

Pour left-overs of dilute sulphuric acid into the container for acid and alakaline wastes.

Pour copper sulphate solutions into the appropriately labelled container.

Fig. 1



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Observations
Processes occurring during the flow of current:
a) At the anode:

b) At the cathode:

Condition of the iron electrode at the end of the experiment:

Evaluation
1. How can the coating of the immersed part of the iron electrode with a layer of copper be explained?

2. The process by which the surfaces of conducting materials can be coated with a metallic layer by the passage of electric current through a salt solution is called galvanization. Name examples of galvanized products.

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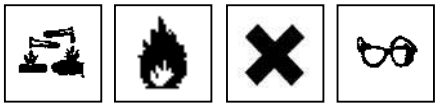
Items of practical use are frequently coated with a layer of nickel, chromium, silver or gold, for ethical reasons or as protection against corrosion. The coating process is carried out electrochemically, and is called galvanization.
The students are to coat part of a sheet of iron with a layer of metallic copper in a model experiment.

Notes on Set-Up and Procedure
Dilute sulphuric acid (approx. 10%) should be prepared in advance.
The limitation of the current to, e.g., 150 mA ensures, with a well prepared cathode surface, a copper coating which adheres relatively well, but is not wipe-resistant.
It is also important in this experiment that the teacher centrally organizes and superintends the waste disposal of the aqueous solutions, and also ensures that the necessary safety precautions are maintained during the whole of the experiment.



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Waste disposal
Collect the galvanizing baths in an appropriately labelled container. They cannot be held for long, however. Either quickly re-use them or precipitate the copper sulphate in basic or sulphide form and dispose of it as heavy metal waste.
Pour left-overs of dilute sulphuric acid into the container for acid and alakaline wastes.
Collect copper sulphate solutions in an appropriately labelled container and re-use them in similar experiments.

Observations
Processes occurring during the flow of current:
a) At the anode: The colour of the part of the copper electrode which is directed towards the cathode darkens.
b) At the cathode: The colour of the immersed part of the iron electrode becomes reddish-brown and small gas bubbles are formed on it.

Condition of the iron electrode at the end of the experiment: The immersed part of the electrode has been coated with a layer of copper which is very uniform on the side which was directed towards the anode.

Evaluation
1. Copper sulphate dissociates in water:
   $CuSO_4 \longrightarrow Cu^{2+} + SO_4^{2-}$;
   When the circuit is closed, Cu^{2+} ions migrate to the cathode, take up two electrons each there and deposit themselves on the surface of the immersed part of the cathode:
   $Cu^{2+} + 2e^- \longrightarrow Cu$.
2. Examples: Bathroom fittings, jewelry, keys, bicycle parts, spectacle-frames, wristwatch casings, ...

Remarks
Ascending bubbles result because an electrolysis of water occurs during galvanization.
This experiment is purposely simply designed as a model experiment. A much greater expenditure is required to obtain a wipe-resistant metallic electrocoating (refer to the corresponding literature)

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Room for notes