

ELECTROCHEMISTRY: ELECTROPLATING

HAFIZAH

Hello, I'm Hafizah, a chemistry teacher from Muar Science School in Malaysia. We are going to discuss about an interesting chemistry topic related to electroplating but first let's take a look at these photos.

There are different types of houses as shown in the photos. Some are facilitated with gates while others without gates. Those with gates are houses found in Malaysia while the one without are in the United Kingdom. Unlike in the UK and America, houses in Malaysia are commonly facilitated with house gates, windows and door grills to ensure maximum safety of its residents. To exhibit the importance of installing house gates among Malaysian, let us look at this scenario of purchasing a house somewhere in Malaysia.

Dialogue between Fairus & Farid

Fairus : Hi, I'm Fairus

Farid : I'm Farid

Fairus : welcome to Denia Development. How may I help you?

Farid : I'm looking for a new house.

Fairus : Okay, then let me show you some new houses for sale then.

Farid : Okay, thank you.

Farid : Well.. I like this house but my main concern is about safety I don't think this house is suitable because there are no gates and grill installed.

Fairus : Don't worry Mr. Farid, usually clients prefer to install their own gates and grills according to their own preferences. That's why we didn't install any. We will suggest some design to them and let them choose. Let me show you some designs. See..there are many types of house gates, windows, and door grills that you can choose from.

Farid : I like modern and stylish design. Can you suggest some designs?

Fairus : Okay, with pleasure. There are three different types of gates with different prices here in this catalogue. We have chrome plated gate and ordinary iron gate. The most expensive would be chrome-plated gate.

Farid : I like chrome plated gate.

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Now students, why do you think Farid decided to get chrome plated gate? Why are the prices different for each type of gates? What sort of materials contain in each gate? Discuss the answer with your friends.

STUDENT ACTIVITY 1

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I see you have done your discussion and found the answer. Good job. So, that is the reason why Mr. Farid chose chrome plated gate for their house gate. Mr Farid choose chrome plated gate for their house gate because it is more resistant to corrosion and gives more attractive appearance. Chrome plated gate is more expensive because it went through electrolysis process by using iron and chrome as main substance. That is why chrome plated gate is more expensive and last longer. Tenant can use the chrome plated gate for many years because of it resistant to corrosion. Materials that contain in the chrome plated gate are iron and chromium while ordinary iron gate consist of iron, only.

VOICE OVER

Electrolysis is a process of breaking down a compound into its constituent elements by passing electricity through it.

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An electrolytic cell is a set of apparatus needed to carry out electrolysis process. It consists of battery, an electrolyte and two electrodes. Electrode connected to the positive terminal of a battery is called anode and electrode connected to the negative terminal of a battery is called cathode.

VOICE OVER

Electrolysis is a process by which electric current is passed through a substance to effect a chemical change. The chemical change is one in which the substance loses or gains an electron. The process is carried

out in an electrolytic cell, an apparatus consisting of positive and negative electrodes held apart and dipped into a solution containing positively and negatively charged ions. held apart and dipped into a solution containing positively and negatively charged ions. may constitute the solution, or may be dissolved in the solution. Electric current that is electrons enters through the negatively charged electrode which is cathode positively charged components of the solution travel to this electrode, combine with the electrons, and are transformed to neutral elements or molecules. The negatively charged components of the solution travel to the other electrode (anode), give up their electrons, and are transformed into neutral elements or molecules. If the substance to be transformed is the electrode, the reaction is generally one in which the electrode dissolves by giving up electrons. Electrolysis is used extensively in metallurgical processes, such as in extraction (electrowinning) or purification (electrorefining) of metals from ores or compounds and in deposition of metals from solution which is electroplating.

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Electrolysis is commercially highly important as a stage in the separation of elements from naturally occurring sources such as ores using an electrolytic cell. Beside that, electrolysis is also widely use in industry to purify the metal and to electroplate the metals and one of the end product of the electroplating metal is chrome plated house gate.

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Why is the house gate in photo 1 rusty? Why is the chrome plated house gate in photo 2 not rusty? How is electroplating done? State the material as an anode. State the material as a cathode. Can you help me to solve these questions?

STUDENT ACTIVITY 2

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The house gate in photo 1 is rusty because the iron metal is exposed to oxygen and water.

VOICE OVER

Figure shows an electrochemical mechanism for corrosion of iron. The surface of the iron and a water droplet constitute a tiny galvanic cell in which different regions of the surface act as anode and cathode

while the water droplet serves as the electrolyte. iron surface in the centre of a water droplet acts as the anode (negative terminal) iron surface at the edge of the water droplet serves as the cathode (positive terminal) At the anode, iron atoms lose electrons to form iron (II) ions. Iron (II) ions dissolve in water. Electrons flow to the edge of the water droplet (cathode) (cathode) and are received by oxygen and water molecules to form hydroxide ions. The Fe^{2+} ions combine with OH^- ions to form iron (II) hydroxide. The iron (II) hydroxide is then further oxidised by oxygen to form hydrated iron (III) oxide, (brown substance known as rust), whereby x varies.

HAFIZAH

The house gate in photo 2 still looks beautiful and new even after 10 years because it is plated with chromium, therefore the metal is not exposed to oxygen and water. As a conclusion, rusting of iron requires oxygen and water hence it must be electroplated with another metal to protect it from rusting. Do you know how the process of plating is done? Let me explain to you.

VOICE OVER

A simple example of the electroplating process is the electroplating of iron nail in which the metal to be plated which is copper is used as the anode, iron nail is used as the cathode and the electrolyte solution contains the ion of the metal to be plated (Cu^{2+} in this example). Copper goes into solution at the anode as it is plated at the cathode. A constant concentration of Cu^{2+} is maintained in the electrolyte solution surrounding the electrodes. At the anode: $\text{Cu(s)} \rightarrow \text{Cu}^{2+}(\text{aq}) + 2\text{e}^-$ At the cathode: $\text{cathode: Cu}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Cu(s)}$.

HAFIZAH

Now, let's perform an experiment. You will need these materials, apparatus and procedures. The materials are: Iron nail or any small utensil or tool made of iron. Copper rod, 2 mol/dm³ copper (II) sulphate solution. The apparatus are: beaker, connecting wires with crocodile clips, ammeter, rheostat, batteries, sandpaper, and switch. The procedures are: First, clean of iron nail with sandpaper. Second, set up the apparatus using the iron nail as the cathode and a copper rod as the anode. Third, turn on the switch and adjust the current to 0.2 A using the rheostat. Forth, turn off the switch after 30 minutes. Fifth, record all the observations. Sixth, repeat steps 1 to 5 by interchanging the position of the iron nail and copper rod.

STUDENT ACTIVITY 3

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Let us discuss the importance of the experiment you just did. When the iron nail is connected to negative terminal it is known as a cathode and copper metal is connected to positive terminal it is known as anode. At the anode: Copper metal dissolves to form Cu^{2+} ions. It will be presented in this half equation: $\text{Cu} \rightarrow \text{Cu}^{2+} + 2\text{e}^-$. At the cathode: Cu^{2+} ions are discharged to form copper atoms that are deposited on the surface of the object to be plated, forming a thin layer of shining copper. It will be presented in this half equation: $\text{Cu}^{2+} + 2\text{e}^- \rightarrow \text{Cu}$. A brown solid is deposited on the iron nail. When the copper metal is turned to cathode and iron nail is turned to anode. At the anode: Iron nail dissolves to form Fe^{2+} ions. It will be presented in this half equation: $\text{Fe} \rightarrow \text{Fe}^{2+} + 2\text{e}^-$. The iron nail appears to be thinner due to corrosion activities at anode. Fe^{2+} ion will be dissolved with the other ions (Cu^{2+} ion and H^+ ion) in the solution. At the cathode: Copper atoms are deposited on the surface of copper metal, forming additional layer of copper. Cu^{2+} ions are selected to be discharged compared to H^+ ion and Fe^{2+} ion because its position is more lower in the Electrochemical Series. It will be presented in this half equation: $\text{Cu}^{2+} + 2\text{e}^- \rightarrow \text{Cu}$. Perform the experiment with the guidance from your teacher and record all the result from your observation. I will get back to you later.

STUDENT ACTIVITY 4

Were you surprised that the nail was electroplated with silver and not copper? For $0.001 \text{ mol dm}^{-3}$ silver nitrate solution, in the early stage silver ion will be selected to be discharged because silver ion is lower than H^+ ion and Cu^{2+} ion in the electrochemical series. Besides that, silver ion is adjacent to the cathode and the copper ions still have to travel through the gap. Initially the silver has to be the one deposited due to diffusion rate factor. When the silver ion has been used up, copper ion will take place and will be discharged at the cathode. So two layers have been formed, a first layer is a shiny grey solid metal (i.e silver metal) on the iron nail. Later it will be covered by shiny brown solid metal which is copper metal. As a comparison with 2 mol/dm^3 silver nitrate solution, only one layer was formed that is a shiny grey solid metal due to the higher concentration of silver ion in the solution.

Sodium chloride (salt) solution consists of sodium ion and hydrogen ion but at the same time copper metal at the anode will corrode and ionize to copper ion. Iron nail will select copper ion because copper ion is easier to receive electron at the cathode. No chemical reaction occurs when sugar solution is used as an electrolyte due to no free moving ion. Sugar solution is a covalent compound, so it cannot conduct electricity. The shorter the distance between the iron nail and copper metal the faster the layer forms at the iron nail. This is due to the less resistance with the distance. Besides the house gate, there are many other examples of items which use electroplating method. For example, keys, jewelry, coins, silverware and many more. Now, watch this next video.

VOICE OVER

First, clean the surface of a copper plate with sand paper to remove metal oxide. Second, draw a picture according to the student's own design on the copper plate with an oil based marker. Third, Connect the copper plate (used as the cathode) to the negative pole of a 9-V battery and a graphite rod (as the anode) to the positive pole of the battery. The electrical circuit is set up in the manner as shown in the diagram below. Fourth, pour 200 ml of concentrated Nickel Chloride Solution into the beaker. Fifth, put two electrodes into the solution and connect the circuit with a 9 V battery. Sixth, allow the process to run for 30 minutes or more, disconnect the 9-V battery, take out the copper plate and rinse it with sufficient amount of water. Seventh, use acetone to remove the marking trail to furnish the end product.

HAFIZAH

You have watched the video. Now, try to answer this question, Why are the lines drawn on the copper plate were not plated with nickel? Discuss with your friends in group and I will get back to you afterwards.

STUDENT ACTIVITY 5

HAFIZAH

The metal cannot be plated on the oil surface because oil prevents adhesion of the coating. Congratulations. Good effort students. Now you can see that electroplating plays an important role in our life. You can see there are many beautiful and stronger chrome plated gate and grills in Malaysia. By using electroplating method, the gate

and grills are more resistance to corrosion, their life span increase, better insulated and better appearance. Hope you enjoy the lesson.

TEACHER'S GUIDE

The objectives of this lesson are for students to, state the uses of electrolysis in industries, explain the electroplating of metals involving electrolysis in industries, write chemical equations to represent the electrolysis process in the industries, justify uses of electrolysis in industries. The lessons will be conducted in class and students are to work on the questions given in the lesson in small groups. The simple experiment will be conducted by the students in the class. Teacher has to guide the students to explore new ideas during their group activities. Students should be encouraged to try out making electroplated nail on their own. Other than iron nail, students could also use iron spoon or any small utensil or tool made of iron. Other than iron nail, students could also use iron spoon or any small utensil or tool made of iron. Hopefully, through this learning approach, students will enjoy learning and will be able to construct new knowledge.