Title : Electro deposition

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5.5 Chemical equivalent or equivalent weight

- The chemical equivalent or equivalent weight of a substance can be determined by Faraday's laws of electrolysis and it is defined as the weight of that substance which will combine with or displace unit weight of hydrogen.
- The chemical equivalent of hydrogen is unity.
- Since valency of a substance is equal to the number of hydrogen atoms, which it can replace or with which it can combine, the chemical equivalent of a substance, therefore may be defined as the ratio of its atomic weight to its valency.

$$\text{The chemical equivalent} = \frac{\text{atomic weight}}{\text{valency}}$$

5.6 Terms connected with electrolytic processes

- Following terms are used in electrolytic processes:

1. Current Efficiency

- Due to impurities which cause secondary reactions, the quantity of the substance(s) liberated is slightly less than that calculated from Faraday's laws. This is taken into account by employing a factor, called the "Current efficiency".
- The current efficiency is defined as the ratio of the actual quantity of substance liberated or deposited to the theoretical quantity, as calculated from Faraday's laws.

$$\text{Current efficiency} = \frac{\text{Actual quantity of substance liberated or deposited}}{\text{Theoretical quantity of substance liberated or deposited}}$$

2. Voltage

- The voltage that is essentially required to pass the current through any electrolytic cell is equal to the sum of voltage drop in the resistance of the electrolyte and the voltage drops at electrodes.
- It is, therefore, desirable that these drops are made as small as possible. This can be achieved, in many cases, by adding special conducting agents to the electrolyte to make it (electrolyte) a good conductor.
- For example dilute sulphuric acid is added to copper sulphate bath in copper plating.
- The normal voltage required to pass current through most electrolytes is 1 to 2 V.

3. Energy efficiency

- Owing to secondary reactions, the voltage actually required for the deposition or liberation of metal is higher than the theoretical value which increases the actual energy required.

- The ratio of theoretical energy required to the actual energy required for depositing a given quantity of metal is known as energy efficiency.

$$Energy\ efficiency = \frac{Theoretical\ energy\ required}{Actual\ enerergy\ requied}$$

5.7 Applications of electrolysis

- The major applications of electrolysis are as under.

1. Electro-deposition
   - Electroplating
   - Electro-deposition of rubber
   - Electro-metallization
   - Electro-facing
   - Electro-forming
   - Electro-typing
2. Manufacture of chemicals
3. Anodizing
4. Electro polishing
5. Electro-cleaning or pickling
6. Electro-parting or electro stripping
7. Electro-metallurgy
   - Electro-extraction
   - Electro-refining

5.8 Electro-deposition

- The process of depositing a coating of one metal over another metal or non-metal electrically is called the electro-deposition.
- It is used for protective, decorative and functional purposes and includes such processes as electro-plating, electro-forming, electro-typing, electro-facing, electro metallization etc.
- As earlier discussed that, the compounds in the solution dissociate into positive and negative ions which when subjected to electric field travel towards respective electrodes then, one of the following events may take place:

i. In case the ion, after giving off electric charge to electrode, has stable existence and does not have chemical reaction with electrode material, it will be deposited on the electrode. This is the principle of electro-deposition and electro-extraction.

ii. The ion after giving off electric charge to electrode may undergo chemical reaction with electrode material, the product of reaction in turn is soluble in the electrolyte and the electrode is gradually eaten away. This principle is employed in Electro-refining.

iii. Ion if after giving off charge to electrode, does not react with the electrode material, or has any independent and stable existence, will react with the water of solution, thereby liberating oxygen or hydrogen.

- Factors on which quality of electro deposition depends.
  1. Nature of electrolyte:
     The electrolyte from which complex ions can be obtained (e.g., cyanides) provides a smooth deposit.
  2. Current density:
     The deposit of metal will be uniform and fine-grained if the current density is used at a rate higher than that at which the nuclei are formed. The deposit will be spongy and porous if the rate of nuclei formation is very high due to very high current density.
  3. Temperature:
     A low temperature of the solution favours formation of small crystals of metal and a high temperature, large crystals.
  4. Conductivity:
     The solution of good conductivity provides economy in power consumption and also reduces the tendency to form trees and rough deposits.
  5. Electrolytic concentration:
     By increasing the concentration of the electrolyte, higher current density can be achieved, which is necessary to obtain uniform and fine grain deposit.
  6. Additional agents:
     The addition of acid or other substances to the electrolyte reduces its resistance. Addition agents like glue, gums, dextrose, dextrin etc. influence the nature of deposit. The crystal nuclei absorb the addition agent added in the electrolyte; this prevents it to have large growth and thus deposition will be fine-grained.
  7. Throwing power:
     It is defined as the ability of the electrolyte to produce uniform deposit on an article of irregular shape and is one of the most important characteristics of plating or deposition bath.

Assignment:

1. Define chemical equivalent, current efficacy and energy efficiency.

2. Explain electro deposition.

3. State and explain factor affecting electro deposition.

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