

## Experiments on electrolysis of organic salts having low conductivity

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### Abstract

Ordinary water, preferably distilled water is a very poor electrolyte. It contains a very low concentration  $H^+$  and  $OH^-$  ions and a large number of undissociated water molecules. Organic salts like  $C_{10}H_{14}N_2Na_2O_8 \cdot 2H_2O$ ,  $C_{10}H_{14}N_2Na_2O_8 \cdot 2H_2O$ , behave as an intermediate between strong and weak electrolytes i.e. the current conduction is less than strong electrolytes but more than weak electrolytes. If they are electrolyzed using metal electrodes like copper, aluminium, iron e.t.c. colored solutions are obtained at first. When electrolyzed for a considerable amount of time (it depends on the amount of water, concentration of the salt e.t.c.) precipitates are formed which resemble metal hydroxides in appearance. But their distinction from metal hydroxides can be easily seen by reacting the precipitate with  $Ba(OH)_2 \cdot 8H_2O$  (the solution must be heated). Ordinary metal hydroxides do not react while the said product turns white. It is mainly due to complex formation. In this paper we deal with electrolysis of  $C_{10}H_{14}N_2Na_2O_8 \cdot 2H_2O$ ,  $C_{10}H_{14}N_2Na_2O_8 \cdot 2H_2O$ ,  $(C_6H_5)_2NH$  (though it is very slightly soluble in  $H_2O$ ), using Cu, Fe, Sn, Al, electrodes and their interaction with heat and  $NO_3^-$  ion from a strong electrolyte (e.g.  $Ca(NO_3)_2 \cdot 2H_2O$ ).

**Keywords:** electrolysis, conductivity, complex, electrodes

### 1. Introduction

Distilled water is generally electrolyzed using strong electrolytes like dil.  $H_2SO_4$  using inert electrodes, mainly graphite.  $SO_4^{2-}$  does not get oxidized due to its position in the electrochemical series.  $OH^-$  get oxidized to  $O_2$  and  $H^+$  gets reduced to  $H_2$ . 2 drops of 98%  $H_2SO_4$  when mixed with 100ml. water conducts about 10 mA current when connected with a 9V D.C battery. Pure distilled water conducts only about 100  $\mu A$  while  $C_{10}H_{14}N_2Na_2O_8 \cdot 2H_2O$  conducts 900  $\mu A$  and  $C_{10}H_{14}N_2Na_2O_8 \cdot 2H_2O$  conducts between 950-1000  $\mu A$  i.e. slightly more than the sodium salt.

Cu, Al, Fe and Sn were used as electrodes.

Only after a few hours the distinction between the sodium salt and potassium salt can be easily verified. While the sodium salt gives a clear blue solution, the potassium salt gives a blue precipitate. This precipitate contains  $Cu(OH)_2$  as well as complex. This indicates that the solubility of the product in a potassium salt solution is less. The blue precipitate turns black when heated because  $CuO$  is formed. Fe gives a yellow solution and then a precipitate in both cases. Fe does not form any complex.

Al and Sn give white precipitate of  $Al(OH)_3$  and  $Sn(OH)_2$  respectively.

### Apparatus and Chemicals

1. Titriplex-III.
2. EDTA dipotassium salt.
3. Calcium Nitrate dehydrate.
4. Copper, aluminum, iron and tin rods for electrodes.

### Experimental

A. Salt used-  $C_{10}H_{14}N_2Na_2O_8 \cdot 2H_2O$  (titriplex-III)

Molecular weight - 372.24g/mol.

Quantity of water added -100 ml.

Mass of salt used – 2g (approx.)

Source of current - 9V battery

Electrode used – Cu

When electricity was passed, slowly the anode began to corrode and the solution started turning blue. After about 4 hours the solution turned bright blue. But no precipitate was obtained. Even 9 hours of constant electrolysis did not yield any precipitate.

Effect of  $Ba(OH)_2 \cdot 8H_2O$  addition

A very negligible amount of precipitate was obtained. This precipitate unlike  $Cu(OH)_2$  was bright blue. Most of the  $Cu^{2+}$  ions remained in solution.

B. Salt used -  $C_{10}H_{14}N_2Na_2O_8 \cdot 2H_2O$  (EDTA dipotassium)

Molecular weight - 404.47g/mol.

Quantity of water added – 100ml.

Mass of salt used – 2g (approx.)

Source of current - 9V battery

Electrode used – Cu

The same thing happened except that a bright blue precipitate was obtained. This did not resemble  $Cu(OH)_2$  in appearance. Therefore the solubility of the  $Cu^{2+}$  salt formed in the two cases is different.

C. Salt used-  $C_{10}H_{14}N_2Na_2O_8 \cdot 2H_2O$

Electrode used- Al

As current passes the anode gets corroded and a white precipitate is formed. Bubbles are formed at the cathode. The Al compound is very slightly soluble and is  $Al(OH)_3$ . This is because it dissolves in NaOH forming  $NaAlO_2$ .

D. Salt used -  $C_{10}H_{14}N_2Na_2O_8 \cdot 2H_2O$

Electrode used- Al

The same products are obtained as in case of the sodium salt.

E. Salt used-  $C_{10}H_{14}N_2Na_2O_8 \cdot 2H_2O$

Electrode used- Sn

$Sn(OH)_2$  is formed which gets oxidized to  $Sn(OH)_4$ . A white precipitate settles at the bottom.

F. Salt used- Titriplex-III after heating to blackness.

Mass of salt- 2g (approx.)

Here the same process is repeated. The original solution before electrolysis is yellow. After electrolysis the solution is dirty green. So it can be concluded that the product is the same. Since blue and yellow on mixing produce green color, the resulting solution is green. Addition of  $\text{Ba}(\text{OH})_2 \cdot 8\text{H}_2\text{O}$  gives a negligible amount of precipitate. The precipitate resembles  $\text{Fe}(\text{OH})_2$  in color.

G. Salt used- Titriplex-III after heating to blackness.

Mass of salt- 2g (approx.)

Electrode used- Sn

Sn corrodes and slowly  $\text{Sn}(\text{OH})_2$  is formed which finally changes to  $\text{Sn}(\text{OH})_4$ . A white precipitate is thus obtained

H. Salt used- $(\text{C}_6\text{H}_5)_2\text{NH}$  (Di phenyl amine)

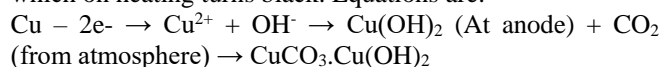
Electrode used- Cu

The salt is very slightly soluble in water. The water mixed with the salt behaves as ordinary distilled water. So  $\text{Cu}(\text{OH})_2$  (pale blue) is formed which changes to  $\text{CuCO}_3 \cdot \text{Cu}(\text{OH})_2$  (green). The product on heating gives  $\text{CuO}$  (black).  $\text{CO}_2$  is released which turns lime water milky.

If Al, Sn electrodes are used the respective hydroxides will be formed.

#### Effect of $\text{NO}_3^-$ ion on $\text{C}_{10}\text{H}_{14}\text{N}_2\text{Na}_2\text{O}_8 \cdot 2\text{H}_2\text{O}$ and $\text{C}_{10}\text{H}_{14}\text{N}_2\text{Na}_2\text{O}_8 \cdot 2\text{H}_2\text{O}$

$\text{Ca}(\text{NO}_3)_2$  was used. It is a strong electrolyte and ionizes almost completely in solution. However low concentration has no effect on the products of the electrolysis. High concentration gives  $\text{Cu}(\text{OH})_2$  and finally  $\text{CuCO}_3 \cdot \text{Cu}(\text{OH})_2$  which on heating turns black. Equations are:-



#### Effect of $\text{Ba}(\text{OH})_2 \cdot 8\text{H}_2\text{O}$

It has no effect. The products are the same as in the solution containing the salt only. On heating the solution with excess  $\text{Ba}(\text{OH})_2 \cdot 8\text{H}_2\text{O}$ , a white precipitate is obtained indicating that  $\text{Cu}^{2+}$  changes in to  $\text{Cu}^+$

#### Observations

The important observations have been summarized as under:-

- $\text{C}_{10}\text{H}_{14}\text{N}_2\text{Na}_2\text{O}_8 \cdot 2\text{H}_2\text{O}$  gives clear blue solution with Cu electrodes,  $\text{C}_{10}\text{H}_{14}\text{N}_2\text{Na}_2\text{O}_8 \cdot 2\text{H}_2\text{O}$  gives blue solution at first and finally gives blue precipitate. It turns white on heating with excess  $\text{Ba}(\text{OH})_2 \cdot 8\text{H}_2\text{O}$  forming  $\text{Cu}^+$  ion.
- $(\text{C}_6\text{H}_5)_2\text{NH}$  does not dissolve in water and proves to be a weak electrolyte. So the electrolysis gives the same products as in case of electrolysis of ordinary water.
- $\text{Ca}(\text{NO}_3)_2$  in low concentration has no effect on the products of the electrolysis. In high concentration  $\text{Cu}(\text{OH})_2$  is formed which finally changes to  $\text{CuCO}_3 \cdot \text{Cu}(\text{OH})_2$ .
- $\text{Ba}(\text{OH})_2 \cdot 8\text{H}_2\text{O}$  changes blue  $\text{Cu}^{2+}$  into white  $\text{Cu}^+$ .
- When a mixture of heated  $\text{Ca}(\text{NO}_3)_2$  and  $\text{C}_{10}\text{H}_{14}\text{N}_2\text{Na}_2\text{O}_8 \cdot 2\text{H}_2\text{O}$  is electrolyzed, a green solution is formed. It does not give precipitate on addition of NaOH.

#### Results and discussions

Titriplex-III and EDTA di potassium salt are intermediate between strong and weak electrolytes. The current conduction is between 900-1000  $\mu\text{A}$  for a 9V source.

Titriplex-III gives a clear blue solution with Cu electrodes, white insoluble  $\text{Al}(\text{OH})_3$  with Al,  $\text{Sn}(\text{OH})_2$  and  $\text{Sn}(\text{OH})_4$  both of which are white in color with Sn electrodes. Heated salts (formulae already mentioned) form a yellow solution which turns green on electrolysis.

In case of ordinary distilled water containing strong electrolyte like NaCl, KCl e.t.c.  $\text{Cu}(\text{OH})_2$  is the chief product. It is pale blue in color and finally changes in to  $\text{CuCO}_3 \cdot \text{Cu}(\text{OH})_2$  which is green and turns black on heating due the formation of  $\text{CuO}$ . The reaction is:-

$\text{CuCO}_3 \cdot \text{Cu}(\text{OH})_2 \rightarrow \text{CuO} + \text{CO}_2 + \text{H}_2\text{O}$  (equation is not balanced). So besides current conduction the product can be used to distinguish between a solution containing strong electrolytes like NaCl and moderate electrolytes like  $\text{C}_{10}\text{H}_{14}\text{N}_2\text{Na}_2\text{O}_8 \cdot 2\text{H}_2\text{O}$ . However this difference can not be seen if Al or Sn electrodes are used because in this case white precipitate of  $\text{Al}(\text{OH})_3$  and  $\text{Sn}(\text{OH})_2$  are obtained independent of the electrolyte used.

#### Conclusion

$\text{C}_{10}\text{H}_{14}\text{N}_2\text{Na}_2\text{O}_8 \cdot 2\text{H}_2\text{O}$  and  $\text{C}_{10}\text{H}_{14}\text{N}_2\text{Na}_2\text{O}_8 \cdot 2\text{H}_2\text{O}$  are intermediate between strong and weak electrolytes. When 2g of one electrolyte is added to 100ml. water the current is 900-1000  $\mu\text{A}$  for a 9V battery. The two solutions give a clear blue solution when electrolyzed for a long time of about 4 hours. EDTA dipotassium gives a bright blue precipitate if electrolyzed farther. This only indicates that the solubility of the  $\text{Cu}^{2+}$  compound is lower in the potassium salt. This helps to distinguish between strong and intermediate electrolytes because strong electrolytes give  $\text{Cu}(\text{OH})_2$  which is pale blue in color.

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#### References

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