SUMMARY AND CONCLUSION

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(1) A literature survey on the previous studies on electrochemical behaviours of copper, nickel and copper-nickel alloys in aqueous solutions is given, in the first part of the thesis, with particular emphasis on their behaviours in alkaline solutions.

(2) Cyclic voltammograms were constructed for copper, nickel and the three copper-nickel alloys (70%, 50% and 30% Cu) in sodium hydroxide solutions. The effects of cyclization, reversal potential, sodium hydroxide concentration and voltage scan rate on the obtained cyclic voltammograms were studied. It was found that:

(a) For copper electrode, the cyclization gives essentially similar voltammograms except that the peak current increases and the peak potential shifted to more negative. The cyclic voltammogram of copper in sodium hydroxide solution is characterized by four anodic steps before oxygen evolution and three cathodic ones. The successive oxidation steps correspond to the formation of Cu_2O; $Cu(OH)_2$; $HCuO_2^-$ and Cu_2O_3. The three cathodic steps correspond to successive reduction of the formed oxides to metallic copper.

(b) For nickel electrode, the cyclic voltammogram is characterized by four anodic steps before oxygen evolution and only one cathodic step. The successive oxidation steps correspond to the formation of α-$Ni(OH)_2$, β-$Ni(OH)_2$ and NiOOH. The reduction step is attributed to the reduction of NiOOH to irreducible β-$Ni(OH)_2$. The cyclization of electrode results in different voltammograms due to the presence of β-$Ni(OH)_2$ on the electrode surface at the end of the first cycle.

(c) For copper-nickel electrodes; the voltammograms of the three alloys have the same general features (namely, four anodic steps before the oxygen evolution and three cathodic ones). The cyclization of electrodes gives the same voltammograms except that the peaks currents increase slightly. The oxidation steps corresponding to the formation of α-$Ni(OH)_2$ together with Cu_2O; β-$Ni(OH)_2$ together with $Cu(OH)_2$; thickening of β-$Ni(OH)_2$ layer and NiOOH together with Cu_2O_3. The cathodic steps correspond to the reduction of the formed oxides to metallic copper and β-$Ni(OH)_2$. Generally, it was found that, alloy (I)(70% Cu) and alloy (II) (50% Cu) behave upon anodic oxidation and cathodic reduction in a manner similar that of pure copper. On the other hand, alloy (III) (30% Cu) behaves upon oxidation and reduction in sodium hydroxide solution, in the same manner of pure nickel electrode.

(3) Cyclic voltammograms for copper, nickel and the three copper-nickel alloys were constructed in sodium sulfide

solutions. The effects of cyclization, reversal potential, sodium sulfide concentration and voltage scan rate on the cyclic voltammograms were studied. From the abtained results it was concluded that:

(a) For copper electrode, the voltammogram is characterized by four anodic and two cathodic steps. The second and third sweeps gives essentially similar voltammograms which differ from that of the first sweep in some significant characteristics, namely, the disappearance of the last anodic peak as well as the two cathodic peaks with the appearance of another two new cathodic peaks instead of the original ones. It was concluded that, the four oxidation steps correspond to the formation of Cu_2S together with Cu_2O; CuS; thickining of Cu_2O layer and transformation of CuS to CuO. The two cathodic peaks of the first sweep correspond to the reduction of formed CuO. On the other hand the electrode was covered by CuS at the end of the subsequent sweeps.

(b) For nickel electrode, the voltammogram was characterized by five oxidation steps correspond to the formation of α-$Ni(OH)_2$; β-$Ni(OH)_2$; Ni_3S_2; NiS and Ni^{+2} ions together with sulfer. Two reduction peaks corresponding to reduction of Ni^{2+} ions are observed in the cathodic half-cycle. No oxygen evolution was noticed during the anodic half-cycle. The major characterestic of nickel-voltammogram is the presence of an isopotential point (y) under all experimental conditions. This point is the intercept of the forward and backword branches of the voltammogram indicating same surface structure.

(c) The copper-nickel alloys voltammograms are also characterized by the isopotential point (y). Its potential shifts to more noble direction as the copper content increased. There are five oxidation steps in the anodic half-cycle with no oxygen evolution. These steps correspond to formation of Cu_2S together with α-$Ni(OH)_2$; β-$Ni(OH)_2$; Ni_3S_2; CuS together with NiS; and CuO together with Ni^{2+} ions and sulfer. These compounds are reduced under two cathodic peaks during the cathodic half-cycle giving copper and β-$Ni(OH)_2$.

(4) The corrosion rates of copper, nickel and copper-nickel alloys were measured in sodium hydroxide in presence and absence of non-ionic surfactants as corrosion inhibitors, using potentiodynamic polarization and polarization resistance techiques. The corrosion rate of the tested electrodes increases in the order, Ni < Ni70 < Ni50 < Ni30< Cu. The presence of nickel reduces the rate of corrosion of copper through the improvement of its passive film characters. On the other hand, the presence of copper enhances the dissolution of nickel, due to their positions in the electromotove series.

In the presence of non-inoic surfactants, the corrosion rates of all electrodes were reduced due to the blocking and hydrophobic effects of surfactants. The effeciency of the inhibitors increases as the number of ethoxylated groups increases. The degree of inhibition of the five electrodes was found to be decreased in the following order:

Ni > Ni70 > Ni50 > Ni30 > Cu.

Pitting corrosion was studied for all electrodes in sodium hydroxide solution as a function of chloride ion concentration and addition of organic inhibitors (aniline and p-hydroxyaniline), using potentiodynamic anodic polarization. It was found that pitting potential for the five samples decreases according to the following order:

Cu > Ni > 30% Cu> 50% Cu > 70% Cu.

This sequence reflects the high resistivity of pure metals to pitting attack than the alloys composed of them. In addition, the pitting potential varies linearly with the logarithm of chloride ion concentration according to:

$$E_{Pit} = a - b \log C_{Cl^-}$$

The addition of aniline and P-hydroxyaniline as pitting corrosion inhibitors results in shifting of the pitting potentials for all electrodes to more noble direction. It was found that the effeciency of aniline is more than that of P-hydroxyaniline for all electrodes. In addition the inhibition effeciency of the two inhibitors at concentration $5X10^{-3}$ M, for the different electrodes are decreased in the following sequance:

Cu > Ni > Cu70 > Cu50> Cu30