Selective dissolution of Brass in Salt Water

The dezincification of brass is a problem of considerable industrial importance. The process occurs by selective dissolution of zinc which is the active component of the alloy leaving behind a highly defective surface layer which is enriched in copper which is the noble component). It leads to deterioration of the surface and mechanical properties of the alloy. The mechanisms involved in this process are different and more complex than those encountered in the dissolution of pure metals(1-3).Thus in addition to its industrial importance, the selective dissolution of alloys poses several questions of basic academic significance(4-11).

This work aims to investigate the selective dissolution behavior of brass in salt water. Several approaches are proposed to achieve this objective, i.e. measurement of the polarization curves and the electrochemical impedance spectra of the alloy/electrolyte interface and measurement of the concentrations of the Zn and Cu ions in the electrolyte and calculation of the dezincification factor under various conditions.

The extent of dezincification can be determined by calculating the dezincification factor, Z, which is given by (2,5):

$$Z = \frac{[Zn^{++}]/\chi_{Zn}}{[Cu^{++}]/\chi_{Cu}}$$

(1)

where [Zn++] and [Cu++] are the molar concentrations of the respective ions in solution while χ_{Zn} and χ_{Cu} are the mole fractions of the respective components in the alloy. The factor Z may also be expressed in terms of the partial currents of dissolution of the respective components (2). A value of Z > 1 indicates that the active component dissolves preferentially although the more noble component is also dissolving. Note that Z varies with potential, time and compositions of the alloy and electrolyte.

Results and Discussion

We have performed extensive measurements, in buffered media of pH 6, on commercial alpha brass electrodes which have been homogenized at 873K in vacuum. In addition to measurements of the polarization curves and the electrochemical impedance diagrams of the interface, we monitored the concentration of both Cu and Zn ions in the electrolyte as functions of time, chloride concentration and potential. From these transients, one can determine the partial currents for the dissolution of the individual components of the alloy, which cannot be directly measured. These can be used to calculate the extents of dezincification under various conditions and to construct the polarization curves of each component in the alloy.

Fig. 1 illustrates the polarization curves obtained in presence of increasing concentration of chloride ions, from left to right. Clearly the concentration of chloride has a significant effect on the shape of the polarization curve. The impedance spectra were measured at various times and under various conditions. An illustrative example of the Nyquist plots is shown in Fig.2.On the other hand,Fig.3 illustrates the variation of the charge passed with time for a brass electrode polarized at 60 mV(Ag/AgCl) in 0.58 M NaCl of pH 6.The slope of the strait line is the partial current for each component.

Acknowledgement

1- H. W. Pickering, Corros. Sci., 23, 1107 (1983).
2- H. Kaiser, in Corrosion Mechanisms, F. Mansfeld, Ed., Marcel Dekker, New York (1987); H. Kaiser, Corros., Sci., 34, 683 (1993); Werkst and Korr., 40, 1 (1989).
3- A.C. Van Orden, in Corrosion Tests and Standards: Application and Interpretation, R. Bobian, ed., ASTM, Philadelphia (1995).
4- Henry Leidheiser, Jr., 1979, The Corrosion of Copper, Tin and their Alloys, p. 82, Robert E. Krieger Publishing Co., Huntington, New York.
5- E.A. Ashour and B.G. Ateya, Electrochim. Acta, 42, 243 (1997).
6- V. Subramanian and W.J. van Ooij, Surface Engineering, 15, 168 (1999).
7- F.M. Al-Kharafi and W.A. Badawy, Corrosion Prevention & Control, 45, 57 (1998).
8- C.K. Lee and H.O. Shih, Corrosion, 52, 690 (1996).
9- B.-S. Kim, T. Piao, S.N. Hoier and S.-M. Park, Corros. Sci., 37, 557 (1995).
10- R.L. Martin, Corrosion, 51, 482 (1995).
11- G.T. Burstein and G. Gao, J. Electrochem. Soc., 141, 912 (1994).
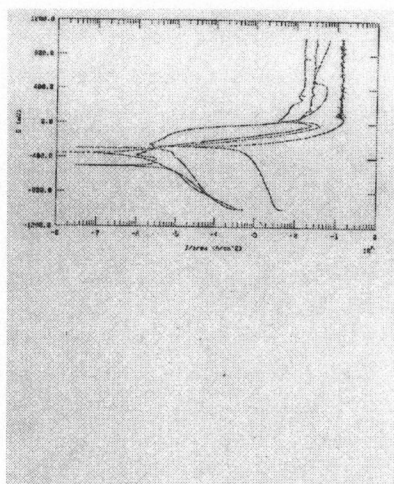
Fig.1 Illustration of the polarization curves of brass in presence of various concentrations of chloride ion, see text.
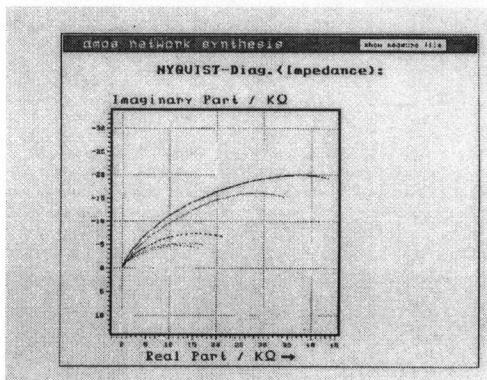

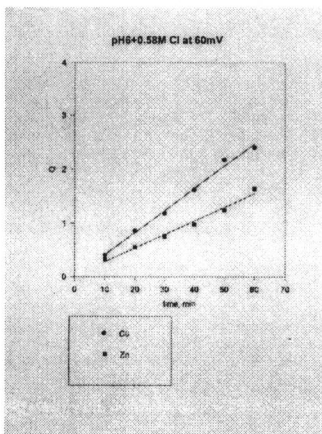Fig.2;Nyquist plots of the brass interface at various times, see text.

Fig.3:Variation with time of the charge(amount of metal ions) passed from the brass surface, see text.