Corrosion resistance modeling of a new titanium alloy in acid environments

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Introduction

Though is very resistant in many aggressive environments, the titanium presents a low corrosion resistance in concentrated acidic solutions at high temperatures [1]. In order, to optimise the titanium behavior in these conditions, the main method is alloying. It was found that molybdenum [2, 3] and nickel [4] can have beneficial effects by a considerable inhibition of the anodic dissolution reactions and increase in the thermodynamic stability. The stable structures can be obtained by the special thermal treatments [5, 6]. It results that, the simultaneous alloying of the titanium with molybdenum and nickel could be efficiently.

Corrosion resistance modeling of a new ternary titanium Ti-0.5Mo-1Ni alloy (in casting Ti-0.5Mo-1Ni_c or forging Ti-0.5Mo-1Ni_f state) in comparison with the base metal in ortho- and meta - phosphoric acid solutions of different concentrations and temperatures was studied.

Experimental

The experiments were performed in 30% orthophosphoric acid – H_3PO_4 and 10% and 30% metaphosphoric acid – $(HPO_4)_n$. The solution temperature was kept at 23^0, 50^0, $75^0 \pm 1^0$C.

The potentiostatic and potentiodynamic electrochemical polarization measurements were carried out in order to determine: the corrosion potential E_{corr}, the critical passivation potential E_{cr}, the passivation potential E_p, the passive potential range ΔE_p, the transpassive potential E_T, the critical passivation current density i_{cr}, and the dissolution current density in the passive range, i.e., passive current density i_p. The linear polarization method was used to obtain the corrosion current density $i_{corr} = k(di/dE)_{Ecorr}$ from Stern formula considering k=26.8 mV. The potentiostatic polarization measurements started from –0.8V to +4.0V (vs. SCE) using a rate of 50mV at every 2min.; the potentiodynamic cyclic polarization was performed starting from –0.8V to +2.0V with a scan rate of 2mV/sec.; the linear polarization were applied for ± 10mV around the corrosion potential.

Results and Discussions

Corrosion resistance in orthophosphoric acid

The corrosion potentials of the ternary alloy Ti-0.5Mo-1Ni (casting or forging) are nobler than of the base metal due to the beneficial effects of the alloying elements. On the anodic curves of the titanium and ternary alloys appear two peaks for the critical passivation current density; for ternary alloy, these peaks are lower than the base metal (Fig. 1). Correspondingly, can be observed two values for the critical passivation potential, which are nobler for alloy than for titanium. This behavior can be explained [7] by the formation at the first critical passivation potential of the titanium trioxide Ti_2O_3 or pentoxide Ti_2O_5 and at the second critical passivation potential, these oxides are converted to the compact and protective titanium dioxide, TiO_2.

The alloy passive current density is higher than that of the titanium, due to the molybdenum dissolves transpassive in this potential range. Also, an incorporation of the molybdenum oxide, MoO_3 or nickel oxide Ni_3O_4 in the passive film can take place [8]; these oxides increase the ionic conductivity of the film and the dissolution rate.

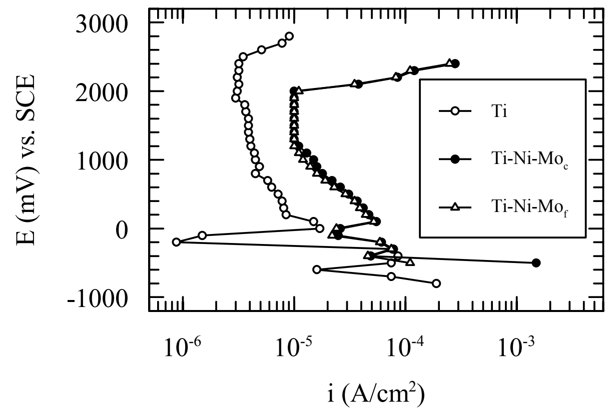

Fig. 1. Polarization curves for Ti and Ti-0.5Mo-1Ni alloy in 30% H_3PO_4 solution at 25^0C.

Corrosion resistance in metaphosphoric acid

This acid has a lower acidity than orthophosphoric acid. The anodic curves for titanium (Fig. 2) present an active dissolution potential range with a high critical passivation current density. For ternary alloy (Fig. 2), the corrosion potential is more electropositive and the critical passivation current density is lower than for the titanium, because of the positive effect of the alloying elements.

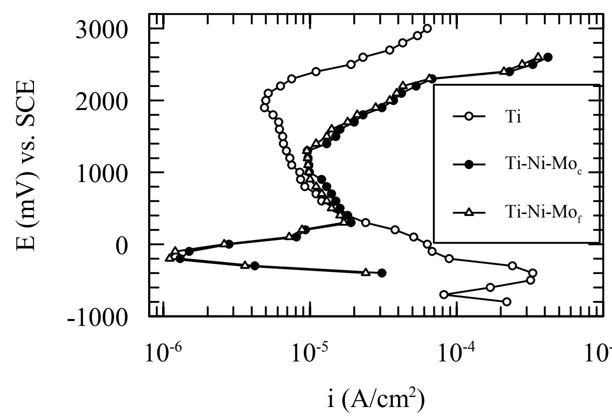

Fig. 2. Polarization curves for Ti and Ti-0.5Mo-1Ni alloy in 30% $(HPO_3)_n$ solution at 75^0C.

Corrosion rates, determined by linear polarization revealed that the ternary alloy (in casting and forging state) are more resistant than the base metals; the forging alloy has a better stability than the casting alloy.

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