

Electrochemical behavior of Zn in Carbonate Aqueous Solutions

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Introduction

Recently, utilization of a metal anode for rechargeable batteries has much attention because it is expected to show high capacity than chemical compound substances. Among them, Zn is known as one of the most promising candidates for aqueous rechargeable batteries because it is an abundance and a less toxic metal, and is compatible with the aqueous electrolyte even though its redox potential is below hydrogen potential. However, Zn has not been utilized as an anode material for secondary batteries because dendrite formation and shape change of Zn during charge-discharge cycles shorten the lifetime of the anode. Our previous study indicated that the use of conc. K_2CO_3 aq. is effective for suppressing the dendrite formation of Zn. In the present work, electrochemical behaviors of Zn in various concentrations of K_2CO_3 and KOH containing 5 M K_2CO_3 ($M = \text{mol dm}^{-3}$) aqueous solutions have been investigated.

Experimental

Cyclic voltammetry(CV) was applied to study the electrochemical oxidation and reduction behaviors of Zn in the carbonate-based aqueous solutions. A planar and a rotating disk Zn electrodes were used for electrochemical measurements. The mass change of Zn during CV was also monitored by EQCM. Potassium carbonates aqueous solutions of 0.5–6 M and 5 M K_2CO_3 aqueous solutions containing 0.05–1.0 M KOH were prepared by dissolving reagent grade K_2CO_3 and KOH into the deionized water of 18.2 $\text{M}\Omega \text{ cm}$.

Results and Discussion

The electrochemical oxidation and reduction of Zn are enhanced in concentrated K_2CO_3 aqueous solutions while they are suppressed in diluted K_2CO_3 aqueous solutions. In 5 M K_2CO_3 , Zn oxidation was significantly inhibited by the addition of small amount of KOH. It is also found that ZnO solubilities in K_2CO_3 aq. are smaller than that in KOH aq. of the same concentration. The the slopes of the linear relationship between logarithmic solubility of Zn and the solution pH indicated that Zn has dissolved in K_2CO_3 and KOH + 5 M K_2CO_3 aq. as $[\text{Zn}(\text{OH})_3^-]$ and $[\text{Zn}(\text{OH})_4^{2-}]$, respectively. The voltammograms taken by Zn RDE and the weight changes of Zn in 5M K_2CO_3 +0.5M KOH aqueous solutions(figs. 1 and 2) indicated that the oxidation of Zn in both solutions involves two anodic peaks A1 and A2. The peak A1 is attributable to the dissolution of Zn and might be affected by the difference in solubility of Zn in the solution.

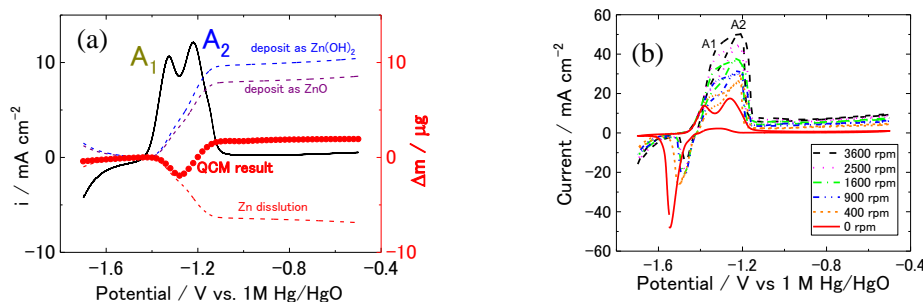


Fig.1 Cyclic voltammograms of (a) EQCM and RDE Zn in 5M K_2CO_3 +0.5M KOH aq. ($20 \text{ mV} \cdot \text{s}^{-1}$)

References:

- [1] T. Ishida, S.Nakata, S. Tsujimoto, H. Yamada, and K. Katakura, *Electrochemistry*, 83(10), 864–866 (2015)