Morphology and structure of electrolytically produced zinc dendrites from the alkaline electrolyte

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The alkaline electrolytes of zinc are widely used in a Zn-air secondary batteries which represent promising candidate for energy storage with many advantages relative to the other types, such as Li-air, Al-air, and Mg-air batteries [1]. These advantages are related with an abundance of Zn, low toxicity, and low cost, as well as by the fact that Zn posses a relatively high specific energy density [1]. One of the largest problems in a development of Zn-air batteries is dendritic growth caused by the uneven deposition of zinc in the charging process [2]. The solving of this problem implies the good knowledge of all phenomena related with Zn deposition, and regarding it, this study aims to establish a correlation between morphology and structure of electrolytically produced Zn irregular forms, especially Zn dendrites. Zinc was electrodeposited potentiostatically from the concentrated electrolyte (0.35 M ZnO in 6.0 M KOH) at overpotentials belonging to the end of the plateau of the limiting diffusion current density (η = 160 mV), and to the zone of the fast growth of the current density after the end of the plateau of the limiting diffusion current density (η = 220 and 280 mV). Morphology and structure of Zn particles were characterized by scanning electron microscope (SEM) and X-ray diffraction (XRD), respectively.
Morphology of Zn electrodeposits changed with the increase of overpotential of the electrodeposition from regular hexagonal and other regular crystal forms (Figure 1a) to the mixture of 2D (two dimensional) and 3D (three dimensional) dendrites (Figure 1b and 1c). The increase of overpotential of the electrodeposition led to an appearing and then intensification of hydrogen evolution reaction as a parallel reaction during Zn electrodeposition at the high overpotentials.

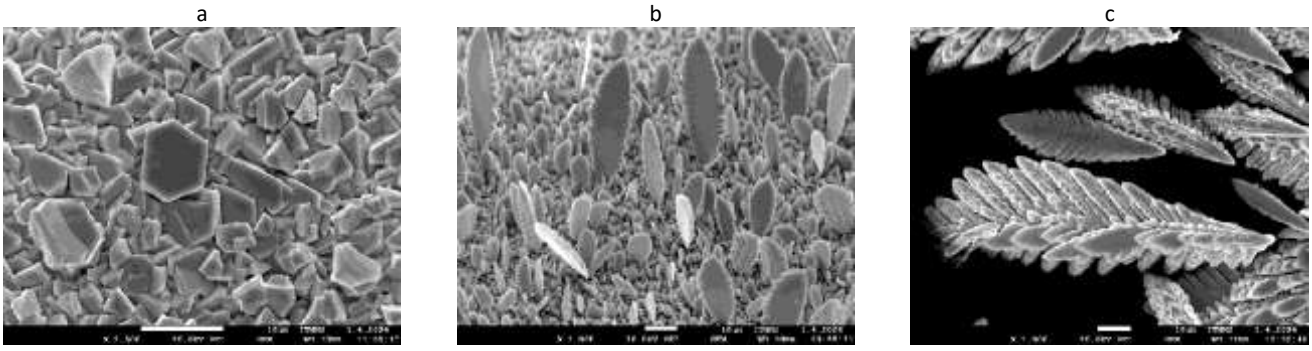

Figure 1. Morphology of Zn disperse forms electrodeposited at overpotentials of: a) 160 mV, b) 220 mV, and c) 280 mV. The amount of electricity: 3.0 mAh cm^{-2}.

In spite of various shapes, Zn particles electrodeposited at all three overpotentials exhibited the strong (002) preferred orientation. The explanation for this predominant preferred orientation can be found in an analogy with a electrolytic growth of lead dendrites from the concentrated electrolyte [3]. Although these two metals belong to different types of crystal lattice (Pb - face-cantered cubic type, and Zn - hexagonal close packed type), the common characteristic of dendritic growth is the preferred orientation in a crystal plane with the lowest surface energy. Namely, during growth of dendrites, this plane survives, while other crystal planes with the higher surface energy values disappear, causing the predominant orientation of Zn disperse forms in (002) crystal plane. In this way, interior of the Zn dendrites is constructed from (002) crystal plane, while tips and edges of Zn dendrites and other types of particles are from other crystal planes.

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References

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