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Review Article

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Nickel-Iron and Zinc Oxide Batteries-An Overview

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ABSTRACT

The use of batteries in all industrial process is inevitable and found as key component in energy storage devices and alternate to electricity. The research works on solar cells is playing vital role now a days. The batteries such as leclanche cells (First applicable battery) Alkaline Zinc battery, Ni-Cd, Ni-MH, Pb-Acid, Na-S and Lithium batteries were found to play significant role in industrial applications. This review paper focuses on literature to understand the research and development on Ni-Fe batteries and Zinc Oxide used as such / composite materials in batteries in particular to electrochemistry of batteries and further to facilitate the investigators to update knowledge in application of batteries.

Keywords: Nickel; Zinc oxide; Storage devices; Lithium

INTRODUCTION

Batteries are an essential electric component used in engineering industries to get electrical energy from chemical energy. The important components of battery are anode material, cathode material, separator, binder and an accelerator. Even though batteries have been proven has an imperative component in engineering sector, during its operation the batteries undergo detoriaration due to the existence of electrolytes and other additives. The prolonged usage of battery leads to loss of its life and the new formation batteries is highly expensive. Researchers found that the batteries which are offering higher output voltage are showing negative impact on their life. Also recently lithium based batteries have been developed by Sony et al[1-3]. R.C.Weast[4] studied the electrochemical reaction of nickel oxide batteries. M.Dixit [5] and co-investigator a found that a turbostatic layered structure with an interlayer spacing of ca 8Å for α-$Ni(OH)_2$ which was being synthesized by them. The thermodynamic stability was achieved by contraction in the surface diameter of β-$Ni(OH)_2$ through a soluble – insoluble process wherein larger sized crystal grow faster than smaller crystal[6]. According to Borthomieu[7] the discharge of Ni(OH) battery was found as lower due to Ostwald ripening. Similar observation was made by Thaller and Zimmerman[8]. The initial stages on Ni based batteries used where of pocket –plate technology and tubular-plate technology. These technologies on Ni electrodes have been exhausted due to difficulties in manufacturing process and enormous operation cost. Hence sintered-Ni Plaques was developed. The sintered plates where produced by a loose-powder process/wet-slurry process. The operating temperatures whereas 800° and 1000° C in a controlled atmosphere [9]. Nickel oxide electrodes comprise the positive plates of several storage batteries namely Ni-Cd, Ni-Ion, Ni-MH.

Zinc oxide batteries

The commercial production of zinc oxide electrodes using Nanospherss of carbon are playing prominent role in performance improvement for Li-Ion battery [10]. The coastal structure designed of zinc Oxide carbon nano spheres where synthesized by a extended stober method[11]. Qingshui Xie et al[12] have studied the calcinations process for amorphous $ZnSno_3$-C hollow micro cubes which were improving the performance of reversible capacities, electronic conductivity and offered higher cycling rate. The doping of PVA/PDDA with zinc electrode improved the corrosion resistance of zinc electrode and preventing pulverization of anodethe network structure comprised of PVA as polymer matrix and PDDA as anion charge carriers. Further the surface morphology changes where analyzed by FT-IT, SEM and TEM [13]. Huang et al[14] found that the influence of porous ZnO nanosheets on copper plate which were used as anode in Li-Ion Batteries. It was explained that others that Zno Nano sheets could significantly improve the electrochemical performance. Recently carbon coating on ZnO was developed by Weilong et al [15] to improve the corrosion resistance as well as prevents the formation of Zinc dendrite during discharging of battery. The efficacy of Lithium zinc titanate anode material was studied by Haoqing tang et al [16]. It was noted that the coatings could reduce surface resistance by intercalation/de-intercalation of lithium ions. This was further confirmed by electrochemical studies. The self-polymerization of dopamine on the surfaces of zinc ferrite nanorods was investigated by Xiayin Yao et al[17] It was observed that the carbon layer on the $ZnFe_2O_4$ nanorods was homogeneous with the thickness of 3 to 5nm. Also coating had enhanced the electrochemical performance in particular to rate capability and cycling stability. Further galvanostatic discharging/charging at 0.5 and 2 A/g, coated anode could release reversible capacities of 805 and 504 mAh/g. SEM, XRD, Thermogravimetric analyses, TEM, brunauer Emmett-Teller(BET) nitrogen adsorbtion apparatus(Pore) were portrayed for surface characteristics of $ZnFe_2O_4$ nano rods. Muhammad et al [18] absorbed that incorporation of Zinc Manganate nano particles with carbon electrodes exhibited a higher reversible charge capacities of 666.1 $mAhg^{-1}$ at 0.03 C and inspite of that it also fixed a reversible capacity of 539 $mAhg^{-1}$ over 50 cycles under the same current rate and 121.9 $mAhg^{-1}$ under the high current rate 3.0 C. Cuiping Han et al[19] investigated that the efficiency of ZnO coatings on LTO spinel particles employing diminished the surface reactivity of LTO particles. LTO particles were prepared by hydrothermal reaction in subsequent to heat treatment. XRD, FE-SEM, HR-TEM, EDS, galvanostatic were used for analysis of surface topography of LTO particles. The electrochemical properties of ZnO mixed with Zn-Al-Hydrotalcitites as anode electrode used in Zn/Ni alkaline secondary battery by Xiaoe xie et al[20] It was demonstrated that Zn-Al layer double hydroxides (LDHS) were prepared through a simple hydrothermal methods and proposed as an anode additive for Zn/Ni alkaline secondary batteries. XRD, SEM, Galvanostatic, cyclic voltammogram were performed for crystalities studies. The addition of 24% LDHS improved the electrochemical stability of ZnO electrode in comparison to pure ZnO anode. The moderate amount of Zn-Al-LDHS in ZnO electrode could not only improved the cycling stability of Zn/Ni secondary but also keep the higher capacity of ZnO electrode Results showed Zn-Al-LDHS is a novel and efficient additive for the ZnO electrodes.

Zinc air batteries

Pucheng Pei et al[21] reviewed the performance of Zinc-Air battery's and its cycle life. In their study zinc air used for longtime due to its high energy density, great availability, and low level pollution, and Zinc –Air primary battery has already commercialized in hearing aids, navigation lights, and railway signals. Research progress of a rechargeable zinc-Air battery respectively based on bifunctional air electrode and triple electrodes discussed in this work have been analysed in comparison with other findings of secondary batteries through its high specific energy, low cost, non-pollution and good safety. Yang and Lin[22] studied that an alkaline composite PEO-PVA-Glass-fiber-mat polymer electrolyte which could be applied to solid state primary zinc air batteries because of its ionic conductivity of 10^{-2} Scm^{-1}.

Performance of nickel based batteries [23-32]

The nickel ion battery was based on the use of nickel oxyhydroxide (NiOOH) at the positive electrode and iron at the negative electrode. The charge-discharge reactions of the battery formed the process like $2Ni(OH)_2 + Fe(OH)_2$. Under deep discharge a Ni-Fe cell with a negative limited configuration will undergo a favor discharge reaction at a potential that is lower than the first step represented by a reaction. The cell reactions are highly reversible in the alkaline solution, particularly, if the discharge is followed to the first step. The reversibility at the two electrodes provides a long charge-discharge cycle-life of the battery. The two sets of electrodes are arranged alternate fashion and interlaced with porous separators generally of polyvinyl chloride, polyethylene, polyamide or polypropylene. The whole electrode stack is kept immersed in a solution of 30 wt.% aqueous KOH. Cell terminals and links are usually made from nickel coated mild steel. The cells are provided with vents, which may be of different designs, to prevent spillage and carbonation while allowing the escape of gases produced in the cell. Positive-limited Ni-Fe cells offer better cycle life. The charge-discharge reactions at the negative electrode of the Ni-Fe cell followed in two steps. The mechanism of electrode reaction includes both solid and liquid phases (heterogeneous mechanism) with $HFeO_2$ as the dissolved ion intermediate which on further discharge, changes to $Fe(OH)_2$. The open-circuit potential of the charged alkaline iron electrode was found to be more cathodic than the hydrogen electrode reaction in the same solution. Iron is thermodynamically unstable and suffers corrosion through local cells with hydrogen release reaction as the conjugate reaction. Besides the dissolved oxygen in an alkaline solution can also favoured an as a conjugate reaction during the corrosion of the iron electrode [33-41].

CONCLUSION

Among the various batteries reviewed, ZnO incorporated batteries seem to have easy to manufacture and show designs flexibility. ZnO inclusion in batteries appeared to be the technologies of choice for emerging electric vehicles, Hybrid and fuel cells electric vehicles. These review also explained the development of Ni-Fe batteries with nickel Oxy hydroxide at the positive electrode and comparison was made with research findings of ZnO batteries. Further improvement in ZnO incorporated batteries are already being progressive with significant improvement are subject of targetive to new ZnO batteries.

REFERENCES

[1] Y Nishi. *J Power Sour.* **2001**, 100, 101.
[2] K Mizushima; PC Jones; PJ Wiseman, JB Goodenough, *Solid State Ionics*, **1981**, 3e4 171.
[3] MGSR Thomas; PG Bruce; JB Goodenough. *Solid State Ionics*, **1985**, 13.
[4] RC Weast. CRC Handbook of Chemistry and Physics, 57th Edition, CRC Press, Boca Raton, FL, **1976/1977**, 142.
[5] M Dixit; RS Jayashree; PV Kamath; AK Shukla; V Ganesh Kumar; N Munichandraiah. *Electrochem. Solid-State Lett*. **1999**, 2, 170.
[6] W Ostwald; *J Phys Chem*, **1897**, 22, 289.
[7] Y Borthomieu; N Sac-Epee; T Jamin. In: Proceedings of the NASA Aerospace Battery Workshop, Huntsville, AL, 18–20 November **1997**, 587-626.
[8] LH Thaller; AH Zimmerman. In: Proceedings of the 35th IECEC, Las Vegas, Navada, 24-28 July **2000**, 1073-1085.
[9] AK Shukla; SVenugopalan; B Hari Prakash. *J Power Sour*. **2001**, 100, 125-148.
[10] Z Bai; Y Zhang; N Fanb; C Guo; BTang. *Mater let*, **2014**, 119, 16-19.
[11] Y Liu; Y Li; M Zhong; Y Hu; P Hu; M Zhu; W Li; Y Li; *Mat Lett*, **2016**, 171, 244-247.
[12] Q Xie; Y Ma; X Zhang; H Guo; A Lu; L Wang; G Yue; DL Peng. *Electrochimica Acta*, **2014**, 141, 374-383.
[13] W Gan; D Zhou; L Zhou; Z Zhang; J Zhao. *Electrochimica Acta*, **2015**, 182, 430-436.
[14] J Zhang; P Gu; J Xu; H Xue; H Pang. *Nanoscale*, **2016**, 8(44), 18578-1895.
[15] W Long; Z Yang; X Fan; B Yang; Z Zhao; J Jing. *Electrochimica Acta*, **2013**, 30, 105, 40-46.
[16] H Tang; J Zhu; C Ma; Z Tang. *Electrochimica Acta*. **2014**, 144, 76-84.
[17] X Yao; J Kong; C Zhao; D Zhou; R Zhou; X Lu. *Electrochimica Acta*. **2014**, 146, 464-471.
[18] MH Alfaruqi; AK Rai; V Mathew; J Jo; J Kim. *Electrochimica Acta*. **2015**, 151, 558-564.
[19] C Han; YB He; H Li; B Li; H Du; X Qin; F Kang. *Electrochimica Acta*. **2015**, 157, 266-273.
[20] X Xie; Z Yang; Z Feng; Z Zhang; J Huang. *Electrochimica Acta*. **2015** 154, 308-14.
[21] P Pei; K Wang; Z Ma. *Appl Energ*, **2014**, 128, 315-324.
[22] C Yang; S Lin. *J Power Sour*, **2002**, 112(2), 497-503.
[23] X Wu; HB Wu; W Xiong; Z Le; F Sun; F Liu; J Chen; Z Zhu; Y Lu. *Nano Energ*. **2016**, 30, 217-224.
[24] W Jiang; F Liang; J Wang; L Su; Y Wu; L Wang. *RSC Adv*. **2014**, 4(30), 15394-15399.
[25] J Liu; M Chen; L Zhang; J Jiang; J Yan; Y Huang; J Lin; HJ Fan; ZX Shen. *Nano lett*, **2014**, 14(12), 7180-7187.
[26] D Lei; DC Lee; A Magasinski; E Zhao; D Steingart; G Yushin. *App Mate Inter*, **2016**, 8(3), 2088-2096.
[27] S Enbo; L Fei; L Jing; C Zhaorong; L Quanmin; Y Xiao-Zi; W Haijiang. *J Power Sour*, **2015**, 291, 29-39.
[28] G Huo; X Lu; Y Huang; W Li; G Liang. *J Electrochem Soc*, **2014**, 161(6), A1144-A1148.
[29] C Guan; W Zhao; Y Hu; Q Ke; X Li; H Zhang; J Wang. *Adv Energ Mater*. **2016**, 6(20).
[30] DL Cai; DS Shen. *J Mater Sci Technol*, **2003**, 19(6).
[31] H Wang; Y Liang; M Gong; Y Li; W Chang; T Mefford; J Zhou; J Wang; T Regier; F Wei; H Dai. Nature Commun. **2012**, 3, 917.
[32] I Mabbett; CF Glover; JH Malone; DA Worsley. ECS Transactions, **2013,** 50(45), 25-35.
[33] S Ghasemi; S Reza Hosseini; P Asen. *Electrochimica Acta*, **2015**,160, 337-346.

[34] SH Jadhav; RS Kalubarme; AH Jadhav; JG Seo. J Alloys Compd, **2016**, 666, 476-448.
[35] RD McKerracher; HA Figueredo-Rodríguez; C Ponce de León; C Alegre; V Baglio; AS Aricò; FC Walsh. *Electrochimica Acta*, **2016,** 206, 127-133.
[36] PC Pandey; D Panday. *J Electroanal Chem*, **2016**, 763, 63-70.
[37] SH Shin; JH Lee; JK Lee; JH Kim. *J Power Sour,* **2015**, 297, 105-112.
[38] P Periasamy; B Ramesh Bahu; S Venkata Krishna Iyer. *J Power Sour*, **1996**, 62, 9-14.
[39] MK Ravi kumar; TS Balasubramanian; AK Shukla. *J Power Sour*, **1995**, 56, 209-212.
[40] BT Hang; DH Thang. *J Electroanal Chem*, **2016**, 762, 59-65.
[41] S Min; C Zhao; P Ju; T Zhou; H Gao; Y Zheng; H Wang; G Chen; X Qian; Z Guo. *J Power Sour*. **2016**, 304, 311-318.