International Journal of Advanced Research in Engineering Technology & Science

ISSN: 2349-2819

Email: editor@ijarets.org Volume-5, Issue-12 December- 2018 www.ijarets.org

A STUDY ON THE APPLICATIONS OF ALKALINE BATTERIES

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ABSTRACT

This article discusses the characterization of spent alkaline batteries and the results of leaching stage experiments using sulfuric acid as the leachant. These experiments are part of a more complex system that involves purification and electrolytic stages, and their ultimate goal is the recovery of zinc. In order to determine the components that make up the black powder, X-ray diffraction and atomic absorption spectrophotometry were used on a sample of the substance that was created after batteries were broken down using mineral processing procedures. Experiments in the laboratory using batch methods were carried out for the acid leaching technique in order to identify the conditions that should be used for leaching in order to get the most zinc out of the ore. In these experiments, a certain quantity of dry powder was mixed with sulfuric acid under a variety of circumstances, and then, after leaching and filtering, the aqueous solutions were put through an examination using atomic absorption spectrophotometry to determine the amount of zinc they contained.

Keywords *Alkaline batteries; Recycling; Acid leaching; Zinc; Recovery; Characterization*

INTRODUCTION

Use of energetic component materials and special designs to achieve high energy and power densities

Because of the wide variety of power needs that must be met by batteries, as well as the varying environmental and electrical conditions in which they must function, it is necessary to make use of a wide variety of battery types and designs. These batteries each have the ability to provide the best possible performance when applied to a particular set of working conditions. Although there have been many advancements made in battery technology in recent years, both through the continued improvement of a particular electrochemical system and the development and introduction of new battery chemistries, there is still no one "ideal" battery that performs optimally under all operating conditions. This is despite the fact that many advancements have been made in recent years. Because of this, over the course of history, a wide variety of electrochemical systems and battery types have been, and continue to be, the subject of research and development efforts. However, only a tiny percentage of them have managed to amass widespread fame in addition to large production and sales quantities. The less traditional systems are often put to use in military and industrial applications that require the unique capabilities afforded by these specialised batteries. These applications are the ones most likely to make use of these systems. In order to obtain high energy and power densities, using energetic component materials and unusual designs may require extra precautions to be taken during usage. These measures aim to prevent electrical and physical abuse as well as issues relating to safety. In addition to this, the circumstances of discharge, charge, and use of the battery are all factors that need to be taken into consideration. It is important to understand that even while the requirements of battery-using equipment are always seeking smaller, more powerful, and more energetic batteries, these criteria may not necessarily be reached due to the theoretical and practical constraints of battery technology. In order to obtain optimal performance in an application, it is essential to pick the battery that is capable of producing the greatest amount of power and to make appropriate use of this battery..

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Household batteries..

Some of the battery components are organic, such as paperboard and carbon/graphite and do not cause a serious environmental impact. Otherwise, other components, including steel, plastic, zinc and toxic metals are going to increase the volume of a landfill, since they decompose slowly, remaining into the environment. Coarse parts such as steel casings, paper, carbon, brass, and others could be reclaimed by means of mechanical treatment, while the remaining powder, could be treated in a process involving metallurgical procedures, aimed at the recovery of Zn used as the anode in alkaline cells. Batteries have a great number of components, which can be technically extracted and reused. The recovered component materials proportion offer some advantages in an economical concern meaning that it could be returned to the production of process of the batteries as raw material or be used for other purposes.

Plated steel scrap can be marketed in high-density bundles and sold to steel mills; manganese can be sold to the steel industry and recovered zinc to metallurgical industries. While recycling is not still used frequently as a method of solving the problem of spent batteries, the best solution is to dispose them properly in a landfill. Household batteries are disposed along with other household waste, although used batteries can be considered as secondary raw materials source. Treatment methods had been developed in many countries mainly due to environmental law restrictions regarding to toxic metal content in soil and water stream. Some proposed process for battery treatment has been described by Hurd et al. [5], which have pyrometallurgical and/or hydrometallurgical routes such as INMETCO, Metallurgy 101, MERECO, SNAM/SAVAM, SABNIFE AB, and RECYTEC.

Recycling process for spent household batteries.

Recycling and recovering can be an alternative way for solving disposal and treatment problems while decreasing the amount of wastes to be disposed in a landfill and in some cases providing economic savings. Separation of different types of batteries needs some developments and this segregation could select the appropriate treatment and disposal and the proposal of an efficient recycling process. Some techniques are being proposed for recycling this type of waste not only to protect the environment but also to bring economic advantages of recovering metals. 2.1. Hydrometallurgical process The processing of metals using hydrometallurgical techniques is becoming a well-established and efficient method for recovering metals from raw materials. It is chosen as an extraction process and environmental control as well, since the metal extracted will avoid the waste production. Hydrometallurgy has some benefits compared with pyrometallurgical techniques such as low cost requirements, possible recovery of leachants and decrease of air pollution as there are no particles produced. While producers had not made efforts to reduce some mercury content, pyrometallurgical operation were the techniques chosen for removing metals from used batteries despite its high costs. Hydrometallurgical processes have contribute to research in metals recovery, and their use have increased, compared to that of pyrometallurgical methods. Many patented processes have already been developed mainly for treatment of dry cell batteries as BATENUS for a mixture of batteries , PLACID, for mercury recovery , RECYTEC for simultaneous recovering of zinc and manganese dioxide and HYDROMETAL SPA for lead–acid batteries.

This study proposes the use of hydrometallurgical process for the treatment of batteries. The soluble portion (dry powder), resulting from mechanical treatment and isolated from others coarse components, was chosen to be treated as it contains the metals. The metals recovery proposition includes as first stage an acid leaching procedure followed by purification step to remove impurities, such as iron, and in sequence the metals recovery from aqueous solution through electrolytic deposition step. 3. Household batteries — alkaline type Household batteries are those used to power small and portable devices as flashlights, radios and toys and approximately 90% of the battery-operated devices require AA, C or C.C.B. Martha de Souza et al. / Journal of Power Sources 103 (2001) 120–126 121 D battery sizes. The zinc–carbon and alkaline batteries are included in this group as non-rechargeable batteries (primary cells), which are designed to be fully discharged only once, and then discarded. The alkaline cell uses the same electrochemical system of zinc–carbon/Leclanche´ cells, with zinc and manganese dioxide as anode and cathode, respectively. The alkaline cell only differs from the latter one as that includes a strong electrolyte of KOH (potassium hydroxide) solution. The anode contains powdered zinc with corrosion inhibitor and the compacted cathode of manganese dioxide is mixed with carbon/graphite and acetylene black. The electrolytically produced manganese dioxide used in alkaline batteries provide capacity and higher reactivity than the natural ores used for the cathode in zinc–carbon battery. The cell is totally enclosed in a high-density steel can with both edges covered with plated steel. A separator made from non-woven fabric is used inside to separate the anode and cathode from electrolyte solution. An asphalt insulator is added to prevent any leakage from batteries and an adhesive plastic coated is added for finishing operations. An average initial composition of alkaline batteries is given in Table

OBJECTIVES OF THE STUDY

***To study on* Recycling process for spent household batteries.**

***To study on*Household batteries..**

Experimental studies

The experimental study made use of a mixture of different sizes of spent cylindrical alkaline batteries (AAA, AA, C, and D) from different manufacturers, supposing a similar feature of the waste batteries in found the wastestream.

Pre-treatment

The used batteries were treated by applying mineral processing methods to provide the fine powder for experimental procedure. First, the batteries were fed to a hammer mill for dismantling. Magnetic separator removed the magnetic fractions; the non-magnetic fraction was screened in sieve with openings of 10 mesh (2.0 mm). The coarse fraction was separated while the undersize portion was picked up and dried to be submitted through next treatment stages. A second magnetic separation was carried out to remove the ferrous materials, which remains in the sample. In sequence, this last non-magnetic fraction was added to a ball mill for increasing the size reduction and afterwards screened in sieve with openings of 65 mesh (0.208 mm). The undersize portion was carefully sampled. The sampling methodology was made by using of a Jones riffle, consisting of an assembly comprising an even number of equally sized chutes, adjacent chutes discharging at opposite sides, and the divided portion was used for characterization and leaching tests.

The sample was submitted to X-ray diffraction method and atomic absorption spectrophotometry to qualitative and quantitative analysis, respectively.

Batch laboratory leaching tests

A series of batch laboratory leaching tests was conducted to define the efficiency of Zn extraction. Different conditions of solid/liquid ratio (weight sample/leaching solution volume), temperature, sulfuric acid concentration and leach times were chosen for this purpose. These experiments were conducted as one stage of a more complex hydrometallurgical process aimed at the recovery of zinc and manganese present in this kind of battery. In the bench scale leaching process, dry powder was fed into a glass vessel, containing dilute sulfuric acid. A magnetic variable mixer with heating system was available to provide a good contact area between sample and leaching solution and temperature control as well. pH and temperature were monitored with a bench pH meter and a simple mercury thermometer. After leaching test, the leached suspension was filtered with paper filter in Bu¨chner funnel. The solid residue, which is composed of manganese dioxide, graphite and other metals, remained in the paper filter. This was recovered and subsequently dried. The filtrate was a clean liquid with Zn soluble in a zinc sulfate (ZnSO4) form.

Results and discussion

The resulting X-ray diffraction spectrum is shown in Fig. 1 and the quantitative composition determined by atomic absorption spectrophotometry is shown in Table 2. As the discharge overall reaction suggest, the electrolyte KOH is non-variant and zinc oxide is being formed as the solid reaction product. The quantitative analysis results revealed a potassium oxide form (KO2 — named potassium superoxide or peroxide). The existence of superoxides of alkali metals was reported by Volv'nov . The author observed the formation of potassium superoxide via the reaction of KOH and atomic oxygen: 2KOH þ 1:5O2 ! 2KO2 þ H2O The oxidation of KOH might occur during the mechanical treatment procedure and dehydration steps, when dismantled batteries are being handling and in contact with atmosphere. In the commercial batteries, the mercury content was kept between 4 and 8% in the past , but nowadays the trend is to lower the concentration. The major producers inform that they are manufacturing batteries with a ‘‘mercury-free’’ formula.

The small amount of Hg and Cd found in the sample's analysis go toward the producer's information about their compromise in eliminating these toxic metals from alkaline batteries, while maintaining the features that the consumers demand. Otherwise, there is no information available from the manufacturers regarding the Pb content in alkaline batteries, but is also known that often 0.04–0.06% is added in zinc powder anode formulation in order to prevent zinc corrosion . The battery producers do not mention about Pb either in a toxicity perspective, or as a trend to eliminate it from the composition of alkaline batteries. The Pb content found in the sample analyzed could also be originated as one of the impurities in the electrolytic manganese dioxide used as cathode. The iron oxide content observed in the results might have its origins either from the friction of the whole batteries with mill hammers in the crushing stage, producing small particles of ferrous material, which caused the contamination of the sample or from corroded or oxidized batteries, due to its storage conditions.

Furthermore, cell component parts of batteries such as steel, which probablyhad shredded in the mechanical treatment process, remained as fine particle. The mechanism of the cathode reaction in the alkaline MnO2–zinc system was studied and the results are presented in a series of papers, as described by Heise and Cahoon . Some authors examined the cathode reaction and found different stages in the cell discharge with electrolytic MnO2, developing different manganese oxide phases. Others report that the electrochemical oxidation of the electrode could be affected by electrolyte concentration, consequently reducing MnO2 to a different species. The forms of manganese oxides detected in the sample by X-ray diffraction analysis are in agreement with these observations, and these results stress that complex reaction mechanism during the discharge process still needs further information and elucidation.

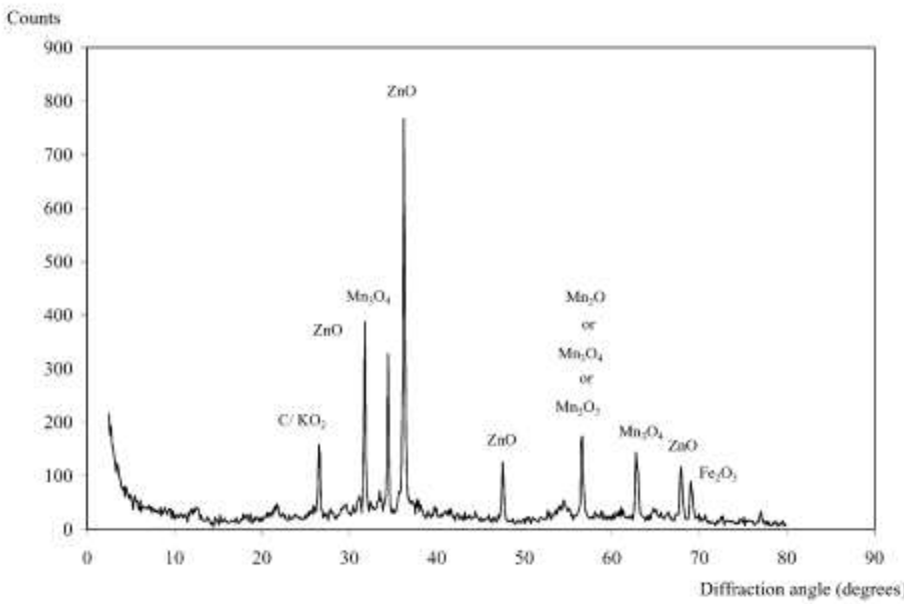

Fig. 1. X-ray diffraction spectra of dry powder from spent alkaline battery

CONCLUSION

The measurement system has been designed for multiple setup combinations to combat any changing ideas and hypothesis from the research. This includes different combinations of Loads connected to the batteries, different forms of signal conditioning before the ADC, and most importantly full control over how and when the batteries are under specific loads. The constant current modules described in this chapter are the chosen method for applying loads to the batteries as they best resemble connection to a wireless communication device. It was decided that measuring the discharge current would not be required as the constant current sources/sinks were calibrated to within ±2 % accuracy. The data collected by the measurement system can be easily transferred to a PC using the SD card and then can be converted by the windows application for further data analysis. In conclusion the measurement system and temperature controlled encasement; provide an experimental framework capable of performing controlled discharges of the standard AA Alkaline-Manganese batteries

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