LATEST ADVANCEMENTS IN THE CONDUCTIVITY ENHANCEMENT GRAPHITE FOR ALKALINE BATTERIES

Igor Barsukov[1], Paul Jurek, Maritza Gallego, Thomas Huerta and Peter Zaleski

Superior Graphite Co.
Peter R. Carney Technology Center
4201 West, 36th Street, Chicago, IL 60632, USA

Introduction.

Alkaline batteries of the electrochemical system Zn|KOH|MnO_2 represent the second largest market in the worldwide battery industry in terms of production volume[1]. Growing competition with advanced rechargeable battery systems with non-aqueous electrolytes for both new and traditional alkaline battery markets has recently resulted in a very significant evolution in the development of the battery chemistry. What used to be for decades a conservative industry is currently undergoing breakthrough changes, often resulting in the commercialization of significantly improved products.

Graphite powder is used for the purpose of conductivity enhancement in the MnO_2 (EMD) cathodes. The powders have played important roles in the development of new alkaline battery systems, which entered the market in 1998-2001. We will describe some of the changes that took place in the graphite technology in order to make the above advancements possible.

Results and Discussion.

The paper provides a comparison between five major candidates for the role of conductivity enhancement in the cathodes of alkaline batteries. These types are as follows:

1. Synthetic graphite;
2. Thermally purified natural flake graphite;
3. Chemically upgraded natural flake graphite;
4. Purified expanded graphite;
5. Acetylene black.

The paper will provide an in-depth comparison between the properties of chemically and thermally purified flake graphite. Residual sulfur, halogen and ash in the chemically upgraded graphite may be potential poisons for batteries with KOH electrolyte. The neutralization reactions between the electrolyte and residual acid on the basal plane edge of graphite may catalyze self-discharge reactions in batteries. They are believed to shorten the calendar life and cause gassing.

Also, we will show that thermally purified natural graphite is now available in high purity, and unique morphology, which allow it to successfully outperform conventional high quality synthetic graphite. The example of Superior's newly developed natural graphite grade FormulaBT 2939APH has been observed to offer competitive electrochemical performance to the high quality synthetic graphite of similar size distribution (see Fig. 1). Extensive studies indicate that 2939APH may be used alone for application in all standard alkaline battery sizes of the base performance, including "AA", "AAA", "9V", "C" and "D". This is currently not the case with synthetic graphite where only certain synthetic graphite size distributions are applicable to certain sizes of batteries.

[1] Corresponding author; E-mail: IBarsukov@GraphiteSGC.com

The new thermally purified grade of natural flake was shown to offer superior mechanical properties when combined with EMD (see, for instance, Fig 2, which is the dependence of the coefficient of cohesiveness for the EMD/graphite cathodes on the type and concentration of graphite used). The low resiliency of 2939APH may allow its application without additions of PTFE binders.

FormulaBT 2939APH was observed to have higher lubricious properties, which leads to up to 40% lower tool wear as compared with electrodes having synthetic graphite. This has been determined by the new method of expedited tool wear estimation, which we have developed and will discuss during the presentation.

Purified expanded graphite[2], another new type of material, just recently adopted by the alkaline battery industry, represents an attractive conductivity enhancement candidate for the premium performance alkaline batteries. Switching to SGC's significantly higher conductive expanded graphite instead of synthetic flake material recently enabled up to 32% improvement in the performance of the commercial alkaline batteries.

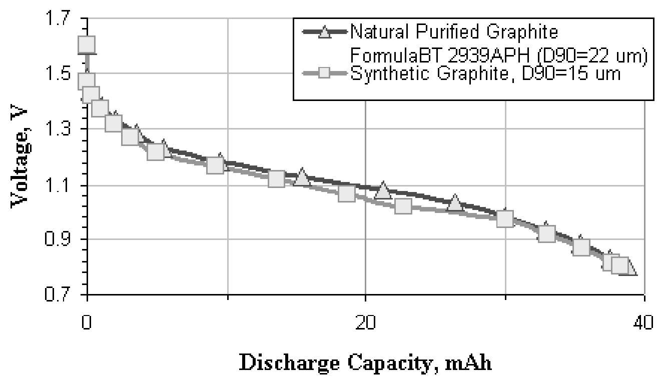

Fig. 1 – Galvanostatic discharge curves of LR2016 primary cells (Zn|KOH|MnO_2) with synthetic & thermally purified natural graphite in the cathodes; continuous discharge current density: 100mA/g EMD.

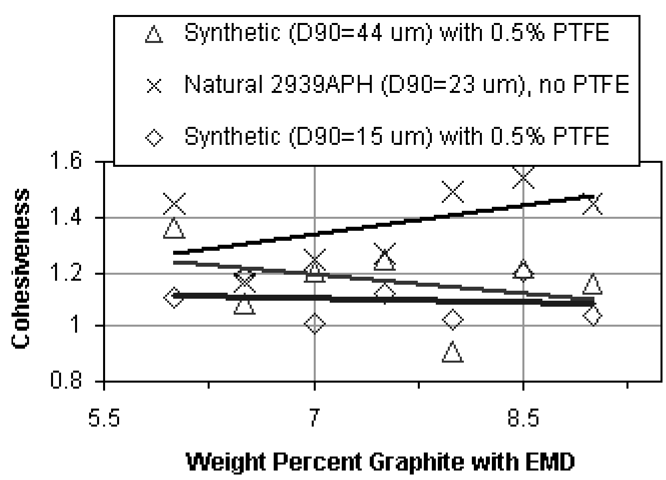

Fig. 2 - Coefficient of Cohesiveness vs Type of Graphite and Presence of PTFE Binder in the EMD. Test elelctrodes had a consistent density of ~ 3.1 g/cm^3.

Conclusions.

The primary battery electrode conductivity enhancement materials market is currently undergoing fast evolution, which is being backed up by significant changes in graphite technology. Natural thermally purified and expanded graphite seem to be the most promising types.

References.

1. R. Powers and D. MacArthur. *The 1999 Review and Analysis of Battery Industry Developments*. 2000.
2. I. Barsukov *et al.*/ *ITE Battery Letters*, 2, **1**, 2000.