Advances in Rechargeable Batteries using Recycled Mattress Materials

Executive Summary

A research team led by Dr. Ram Gupta at the National Institute for Materials Advancement (NIMA) at Pittsburg State University in Kansas completed a 3-year study sponsored by the Mattress Recycling Council (MRC) which successfully developed high-performance carbon using recycled mattress materials for rechargeable energy storage devices such as supercapacitors and batteries.

The findings are significant for several reasons. The rapid increase in rechargeable battery demand has created a global shortage in carbon feedstocks used to make electrodes. Recycled mattress materials, particularly non-woven textiles, may be an inexpensive, clean, and abundant feedstock that can fill current and emerging needs. Presently, a large percentage of mattress textiles are landfilled due to a lack of economically viable markets. Creation of a new market channel using recycled textiles to generate domestically produced carbon electrodes would have significant environmental benefits.

In its report National Blueprint for Lithium Batteries, the U.S. Department of Energy (DOE) reviews the strategic importance of establishing a domestic supply chain for rechargeable batteries. Battery technology and manufacturing capacity are considered essential components of building a clean energy economy. Key drivers include the electrification of the transportation sector and the development of a more robust stationery grid storage market. The document serves as a guide for investment and research. It cites that the worldwide lithium battery market is expected to grow by a factor of 5 to 10 over the next decade.

The DOE reports one key impediment is a global battery grade graphite supply shortage. Graphite is an essential raw material for making thermally stable, chemically resistant electrodes necessary for durable batteries with high energy density. At this point, there are no U.S. based sources capable of producing graphite to meet industry specifications and capacity needs. All domestic consumption is imported. The recycled materials are expected to be a cleaner, more consistent feedstock with the advantage of being a large and reliable supply channel. At present, nearly 90% of all discarded in the U.S. are landfilled. Repurposing certain mattress materials for use as carbon feedstocks would have significant environmental benefits. Furthermore, these findings also suggest that other textiles may be suitable feedstocks as well.

The first year of the NIMA research program was focused on developing a process that generates high-performance carbon using various mattress components. Mote cotton, shoddy, coconut fiber, and polyurethane foam were evaluated as potential feedstocks to make carbon electrodes suitable for use in high-performance rechargeable batteries (Figure 1). Process conditions were optimized for each material and physical properties were measured. A review of industry

performance requirements indicated that the lab scale electrodes met or exceeded the performance of incumbent electrode materials.

In the following years, the NIMA team conducted studies evaluating the electrical performance and durability of the experimental electrodes in test devices and batteries. Results were very encouraging. For dual carbon batteries, both the anode and cathode were made using recycled materials. Cathodes suitable for use in lithium-sulfur batteries were also developed. These devices were electrochemically stable up to 10,000 charge-discharge cycles. The Coulombic efficiency was almost 100% suggesting no loss of energy during the charge and discharge process.

Further details are in Dr. Gupta's full report. At this point, the NIMA team is interested in developing industry relationships to explore commercialization potential.

The full report is also on this website.