LITHIUM-ION BATTERY SHEDDING CHALLENGES

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ABSTRACT

Lithium-ion batteries (LIBs) are increasingly becoming a significant waste stream, presenting substantial challenges for recycling and disposal. Due to their complex design and the variety of materials used, several steps are necessary before they can be reused or recycled. Initially, LIBs are sorted and typically undergo pre-processing, which includes discharge or deactivation, disassembly, and separation. After these steps, they can either be directly recycled or processed using pyrometallurgy, hydrometallurgy, or a combination of these methods.

Each recycling process for lithium-ion batteries has its own advantages and disadvantages. While pyrometallurgy might seem like the simplest option due to its ability to handle a flexible feedstock, it has issues such as relatively low lithium recovery rates and the production of hazardous off-gases and fly ash residues. These challenges have led most recent recycling projects to shift towards hydrometallurgy processing routes.

For safe processing, both pyrometallurgy and hydrometallurgy require the discharge and disassembly of larger battery packs. These packs are commonly used in rapidly growing markets such as Electric Vehicles (EV) and Battery Energy Storage Systems (BESS). Due to competitive manufacturing costs, these sectors are increasingly using battery packs as structural components and employing foam encapsulation for thermal management. This, however, inhibits access to the Battery Management System (BMS) and greatly complicates the discharge and disassembly of the packs.

This manufacturing trend has meant that traditional wet shredding in air is increasingly not variable, due to the inherent inability to guarantee electric discharge, through the lack of access to the BMS, and the volatile organics used in the battery's electrolyte which present significant fire and environmental risks. Current, state-of-the-art employs dry shredding in an inert atmosphere using an airlock, to ensure safer operation. It also allows for the potential recovery of the electrolyte, either through non-aqueous organic washing, direct vacuum distillation, or a combination of both.

While this method theoretically reduces fire and environmental hazards, it is practically impossible to ensure full discharge of LIBs due to inaccessible terminals and inherent voltage rebound. Our tests with a custom designed industrial shredder show that even fully discharged, cells create thermal hotspots and release elevated temperature gases. Battery cells at low charge state will cause electrical arcing during the shredding process, and if oxygen levels cannot be kept below flammability limits, the cell's electrolyte solvents are likely to ignite. Maintaining a near-inert atmosphere in an industrial shredder processing encapsulated EV or BESS packs is impractical due to the battery packs' large geometry and corresponding volume of air trapped within the foam encapsulation, and inevitable process airlock leaks.

This presentation will discuss the magnitude of the challenge and key safety insights from our experimental pilot shredder, which operates in a low oxygen atmosphere when shredding LIB cells at various discharge levels. It will also outline future research directions and suggest potential solutions for upstream manufacturing.

Keywords: Lithium-ion battery, resource recycling, battery shredding, electrolyte recovery.