A STUDY ON THE RECYCLING OF LITHIUM-ION BATTERIES FROM NEWLY GENERATED RECHARGEABLE SMALL ELECTRONIC DEVICES

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ABSTRACT

In 2021, the global home appliance market size increased by 8% compared to 2020, reaching an all-time high of about $360 billion. In particular, rechargeable and non-rechargeable small appliances grew by about 21% compared to the same period last year, and are expected to grow by 2.5% annually until 2030. Nevertheless, an effective treatment process and method for future waste resources have not been established. In general, the pretreatment process of large waste batteries such as electric vehicle batteries goes through the steps of physical disassembly - residual value evaluation - classification - waste battery discharge (deactivation), and then is introduced into the crushing process. In the case of small electronic devices, because they are so small, physical treatment (dismantling and discharging) reduces the efficiency of the entire process. In addition, undischarged waste batteries have a risk of fire or explosion when small rechargeable electronic devices are directly shredded. Among electric vehicles and medium/large home appliances, products that include batteries are processed through a discharge system to prevent fires and explosions during pre-recycling, but remarkably small-sized wireless and rechargeable electronic products (wireless earphones, robot vacuum cleaners, Bluetooth audio devices, smart watch, etc.) requires the development of a preprocessing system for small home appliances that does not require physical disassembly and discharge systems.

In this study, a safe crushing technology was researched through a pretreatment system customized for small equipment, and hydrometallurgical research was conducted to recover cobalt, lithium, nickel, etc. from black powder containing valuable metals generated through pretreatment.

A fire-resistant shredder for small electronic devices was manufactured to be shredded in an inert gas atmosphere, and the effect of the type and partial pressure of gas on fire during crushing was investigated. In the air, sparks and fire occurred due to contact between the cathode active material and oxygen, but no fire occurred in the shredded material. However, since a fire due to an explosion can be expected when crushing more than a pilot scale, crushing was carried out in a nitrogen and carbon dioxide atmosphere. The crushing was performed while changing the nitrogen partial pressure to 85%, 90%, and 95%, and at 85%, no spark occurred during crushing, but a fire occurred in the crushed material after completion of crushing. Even at a nitrogen partial pressure of 90%, sparks did not occur during crushing and a fire occurred in the crushed material. At a nitrogen partial pressure of 95%, no sparks or fire occurred. In the case of carbon dioxide, the experiment was conducted while changing the partial pressure by 10%, 20%, and 30%. Sparks and fires did not occur during crushing under 10-30% conditions, and the crushed materials were also in a stable state.

The chemical components of the crushing product obtained through the pretreatment are shown in the table below.

Table. Chemical compositions of crushed material

Sample	Chemical composition (wt%)						
waste battery sample	Ni	Co	Mn	Li	Cu	Al	Carbon
	16.55	4.62	5.22	3.05	3.25	3.73	30.1

Nickel, cobalt, manganese, lithium, copper, aluminum, and graphite are the main components in anode and cathode materials, and fine black powder obtained through classification of 0.2 mm or less contains a large amount of nickel, cobalt, lithium, and manganese. Valuable metals in black powder were effectively separated through flotation, and as a result, high-quality black powder concentrate was obtained, and efficient recovery and low energy generation (relative CO_2 emission reduction) can be expected in the hydrometallurgical process.

Keywords: Recycling, Lithium-ion battery, Small electronic device, Safe crushing technology