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Ecological recovery of Cobalt, other valuable Metals from spent Lithium Ion Batteries (LIBs)

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Abstract

Nowadays, the quantity of these discarded equipments is increasing with disquieting rate all over the world due to rudimentary disposal, improper collection system as well as lack of cost-effective technology for processing them. Among these e-wastes, mobile phones constitute a major fraction of e-waste. Lithium ion batteries (LIBs) dominantly used as electrochemical power sources in mobile phones consist of metals, organic chemicals and plastics materials. Thus, they cannot be disposed off. But in India, LIBs are collected from various sources and chopped randomly to get metals. In this course of processing, the black powder containing LiCoO2 along with many hazardous organic liquids is thrown. These unorganised acts contaminate the soil and underground water. Therefore, development of a recycling technology to recuperate metals from spent LIBs has gathered great attention as this step will not only protect the environment but also improve the utilization of secondary resources.

Key Words:

Ministry of Science & Technology has set up mechanism in Council of Scientific & Industrial Research (CSIR) to interact with Small-Scale Industry for transfer of Technology from CSIR Laboratories. Small-Scale Industry sector is largest employment provider in country and contributes 40 percent of gross industrial value added in Indian economy. In this regard, CSIR-National Metallurgical Laboratory, Jamshedpur is very much aware and engaged in the development of application oriented e-waste recycling processes, fulfilling zero waste concepts.

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consist of metals, organic chemicals and plastics materials. Thus, they cannot be disposed off. But in India, LIBs are collected from various sources and chopped randomly to get metals. In this course of processing, the black powder containing LiCoO2 along with many hazardous organic liquids is thrown. These unorganised acts contaminate the soil and underground water. Therefore, development of a recycling technology to recuperate metals from spent LIBs has gathered great attention as this step will not only protect the environment but also improve the utilization of secondary resources.

Huge amount of spent LIBs are generated after their end use. LIBs contain metals, organics and plastics which require proper treatment before disposal. Keeping in view of stringent environmental regulations, limited natural resources and energy crisis, adopting recycling will not only protect the environment and pacify the gap between demand and supply but also conserve the natural resources.

Lithium-ion batteries (LIBs) are essential component of modern technology and are widely used as electrochemical source of power in mobile phones, laptops, video-cameras, etc. due to their characteristic light weight, high energy density, getting constant and continuous power supply and good performance. They contain a cathode, an anode, organic electrolyte and a separator. Lithium cobalt oxide (LiCoO2), lithium manganese oxide (LiMn2O4), lithium nickel oxide (LiNiO2) or related oxides are most commonly used cathodic material for almost all types of commercial LIBs .

Among the above mentioned cathodic material, LiCoO2 is most widely used in LIBs because of its high energy density, operating voltage and good electrochemical performance. Presence of Li and Co in waste: Metals such as Co and Li present in the LIBs, are commercially important. In the upcoming decade, the global demand of Co and Li are expected to rise three times more compared to their current demand. They have diverse range of metallurgical and chemical applications varying from aircraft engines to rechargeable batteries. Co finds its applications in aircraft engine, magnets, super alloy making, carbides, rechargeable batteries, etc. whereas Li is used in the production of medicines related to psychological disorders like manic-depressive psychoses, mood swings, etc. The presence of Co and Li in the active cathodic material of LIBs is quite high compared to their natural resource which makes it a potential secondary resource. Hazardous effect of spent LIBs: Spent LIBs collected as municipal waste are environmentally unacceptable due to presence of various hazardous materials.

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LIBs consist of metals (~5–25%), organic chemicals (~15%) and plastics (~7%) which cannot be disposed-of unless these contents are properly treated. Land filling of LIBs may lead to leaching of metals (Co, Li, Fe and Cu) into the soil and pollute the ground water whereas incineration is illegal practice done by unorganized sector to make metals from e-waste including LIBs which leads to the generation of dioxins and furan gases that has adverse affect on the environment.

Presence of plastics and organic material in LIBs will contaminate water bodies and affect aquatic life as well as human beings. Therefore, proper treatment of LIBs is necessary prior to its disposal to the environment. Recycling of LIBs: In India and few other countries, recycling of LIBs is a big challenge due to improper collection system, illegal recycling by unorganized sector as well as lack of cost-effective technology for processing such scraps. As these LIBs contain metals, organic chemicals and plastics, it requires proper treatment to remove the hazardous content before disposal. For India, if the pre-deployment scenario is compared to the post deployment benefits, it could be observed that LIBs are collected from various sources and randomly chopped to get metals. During the course of processing, the cathodic material containing LiCoO2 gets discarded and contaminates the soil. Moreover, the heterogeneous nature of batteries (branded, local and cheaper) received from the municipal waste containing impurities puts forward a great challenge for selective recovery of metals from LIBs and their purification.

CSIR-NML has developed a complete and novel process flow-sheet, which consists of physical beneficiation, leaching, solvent extraction, precipitation and electro-winning processes for recycling of spent LIBs to get value added products (metal or salts) and protect the environment, based on zero waste concept.

The novelty of the process is the development of complete recycling flow-sheet for the recovery of plastics and all metals such as Co, Cu, Mn and Fe. The process has potential for industrial exploitation after some scale-up/pilot studies in the close-loop as generated raffinate and regenerated extractant can be recycled in the system. The systematic laboratory scale leaching studies were carried out and scientifically validated by well proven equation and characterization studies. The reported process is environmental and feasible compared to previously reported studies. Implementation of this process on larger scale will help to maintain clean and green environment. It will also bring awareness among

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common people regarding the loss of valuables and toxicity created due to dumping scrap batteries to the environment.

In this regard, CSIR-National Metallurgical Laboratory, Jamshedpur has made sincere efforts towards the ecological recovery of cobalt and other valuable metals from the black powder and other constituents of LIBs. But heterogeneous nature of variety of batteries (branded, local and cheaper) received from the municipal waste put forward a great challenge during the technology development. The active cathode material of LIBs contains variable concentration of cobalt, lithium, copper, manganese, etc. which make the chemical processes for metal recovery more complex. The major hindrance was provided due to manganese presence, which gets co-extracted with cobalt and prevent its extraction. But the hydrometallurgical route adopted by the CSIR-NML team is very selective and exigent.

Lastly, CSIR-NML team was successful to extract different saleable products like cobalt salt, cobalt metal, lithium salt, copper sheet, manganese salts, ingot of mix metals, plastics, etc. after their extensive R&D efforts. The whole process developed was feasible and environment friendly.

Being attracted by this output, a technology has been transferred on Thursday to M/s SBCON Recycling Private Limited, Ahmedabad for the extraction of cobalt and manganese from black cathodic material of lithium cobalt batteries. The party is satisfied with our developed technology and soon willing to start the process on ton scale in association with CSIR-NML. This collaborative work initiated by CSIR-NML will help to demonstrate this work for cobalt and other metal recovery on larger scale. This initiative step will not only prove to be fruitful to the unorganized sectors but also meet the need of the market.

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