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Metals Resources from Spent Lithium Ion Battery

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Abstract—*Increasing industrialization and technological advancement causes the rapid increase in the use of rechargeable lithium ion battery (LIB). Rechargeable LIB are very promising due to their light weight, high efficiency and long cycle life, thus used in various portable and consumer's electronic equipments, electric vehicles, space applications and many other. The management of spent lithium ion batteries has been an issue of environmental concern in absence of proper management due to the presence of various metals including heavy metal. LIB consists of various valuable metals including Li, Al, Cu, Au, Ag etc. and waste can be a source of these metals. In this study quantification of metals from various spent lithium ion batteries is proposed to show them as material resource. The sources of LIB used for this study are button cells, mobile batteries and laptop batteries. Samples from batteries were digested and analyzed using ICP-MS technique to quantify the metals present in batteries. It is found that button cells consist of Li (42.674), Mn (642.762), Co (0.02), Ni (0.461) ppm respectively. Mobile battery consists of Li (29.645), Al (1407.13), Cu (683.872), Mn (185.778), Co (87.421), Ni (25.061), ppm respectively and the laptop battery consists of Li (41.835), Mn (0.449), Cu (679.665), Al (54.177), Co (0.101), Ni (0.1), ppm respectively. It is also found that mobile and laptop battery circuit contains 0.02 to .04% gold justifies the economic aspect of recycling.*

Keyword: *Spent Lithium ion batteries, Metal resources, Metal recovery, Quantification, Leaching.*

1. INTRODUCTION

The production and consumption of lithium-ion batteries is going to be increased with the increase in the use of portable electronic devices such as mobile phones, laptop and cameras etc. Increasing demand of LIBs also increased generation of battery scarp. In 2000, the worldwide production of LIBs reached about 500 millions cells. From this consumption, LIB waste is annually estimated at 200–500 MT, with a metal content of 5–15 wt. % Co and 2–7 wt. % Li [1]. The management of lithium ion batteries scarp has been an issue of environmental concern in absence of proper management due to the presence of various metals including heavy metal. Li-ion batteries contain high amounts of valuable metals, such as aluminium, iron, copper, lithium, cobalt, nickel and manganese [2, 3]. LIBs consist of heavy metals, organic chemicals and plastics in proportions of 5–20% cobalt, 5–10% nickel, 5–7% lithium, 15% organic chemicals and 7% plastics [4]. The lithium ion batteries are mainly composed of lithium metal oxide as cathode, lithiated carbon as anode, PVdF binder and organic electrolyte. The cathode LiCoO2 is usually linked together with aluminum foil and anode with copper foil through adhesive agent such as polyvinylidene fluoride (PVDF) binder[5]It is predicted that there will be a shortage of lithium between 2021 and 2023 if lithium is not recycled [6]. This study proposed the quantification of different metals in various types of LIB to project its recycling aspects.

2. QUANTIFICATION OF METALS FROM SPENT BATTERIES

The different types of spent lithium ion batteries such as button cells, mobile batteries and laptop batteries were collected for this study. The batteries were sorted according to type, sizes and manufacturers. The batteries were dismantled manually and all parts were collected separately. To quantify the metal resources of the lithium ion battery, the anode and cathode are uncurled and submitted to ICP-MS. Before doing ICP- MS samples was digested in of different concentration HCl is used as a leaching solution.

2.1 Quantification of Button or Coin cells batteries

Initial segregation involves of button cells: (i) collection and separation of different sizes of button cells,(ii) cells are dismantled and collected separately according to their parts as shown in Fig.2 and (iii) material separated were weighed and the results are shown in Table. 2.

2.2 Quantification of mobile phone battery

Different brands of mobile phone batteries are collected in terms of brands i.e. Nokia, Samsung, Micromax, Spice and LG. These batteries are then dismantled and segregated according to wrapper, plastic and metallic parts as presented in Fig 3. All parts were weighed separately and the results are shown in Table. 3

2.3 Quantification of laptop battery

Laptop battery of two brands HP and Dell were collected and dismantled in terms of plastic and metallic parts is presented in Fig 4. And weighing results are shown in Table. 4

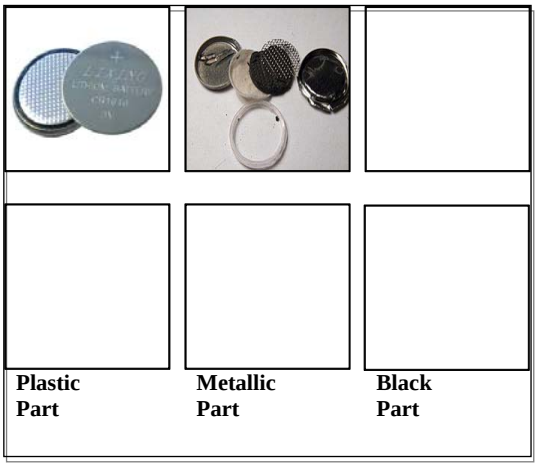

Fig. 1: Dismantling of Button Cell Battery

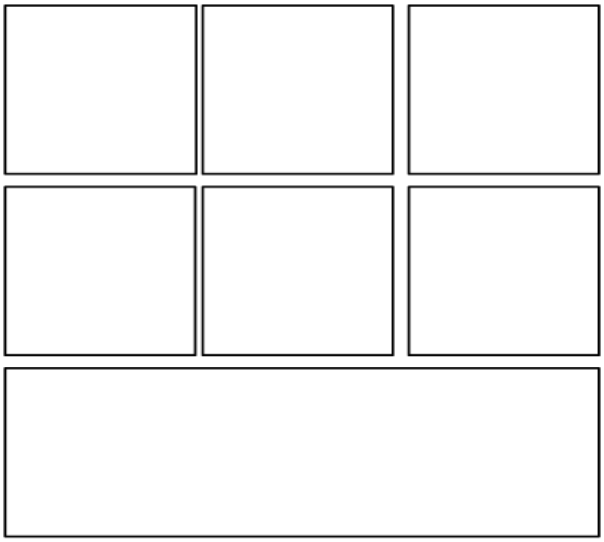

Fig. 2: Dismantling of Mobile Battery

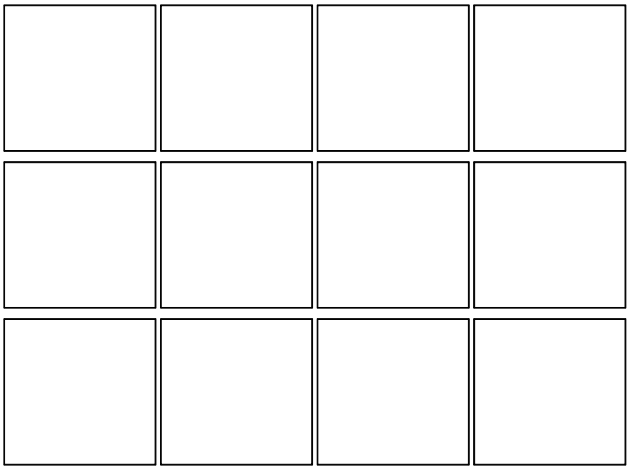

Fig 3: Dismantling of Laptop Batteries

Table 1: Quantification of button cell battery (average weight of 10 batteries)

Diameter (mm)	Average weight (g)	Black Part (g)	Metallic part (g)	Plastic part (g)
12	3.7035	1.2577	0.2552	0.1399
6	3.488	0.930	2.338	0.220
4	1.810	0.238	0.552	0.368
3	1.113	0.742	1.855	0.089
2	0.597	0.104	1.256	0.060

Table 2: Quantification of mobile battery (average weight of 10 batteries; in grams)

Brand	wt. of batteries	Wrapper Part	Plastic Part	Metallic Part		
				Cu	Al	Other
Nokia	21	0.5	3	6	8	4
Samsung	22	0.3	10	5	7	4
Micromax	28	0.7	5	8	13	5
Spice	20	0.5	5	2.5	7.5	7.5
Lg	18	0.4	8	12.5	15	2.5

Table 3: Quantification of Laptop Battery (average weight of 05 batteries; in grams)

Brand	Total wt of battery	Plastic Part		Metallic Part		
		Cover	Sheet	Cu	Al	Other
HP	290	45	80	40	70	55
Dell	315	45	95	45	75	55

3. METAL QUANTIFICATION BY ICP-MS

After weighing the metallic parts are separated for further experiments. A metallic part contains the cathode and anode electrodes. Cathode and anode were digested separately in the different concentrations of HCl. Mobiles and laptops sample are prepared by digesting cathode and anode material in 10 M HCL concentration while the button cells carbon and gauze were digested in 5M HCl concentration. Anode and cathode samples are prepared by digesting in 5 M HCl concentration. After digestion samples were submitted to ICP-MS.

Table 4: Showing the Results of ICP-MS (ppm concentration).

Sample	Sample Name	Cu	Al	Mn	Co	Ni	Li
M1C	Mobile Carbon			185.778	87.421	25.061	29.645
M1Cu	Mobile Copper	683.872		0.059	0.034	0.049	0.195
M1Al	Mobile Aluminium		>1407.13	8.863	0.105	0.039	0.815
L1C	Laptop Carbon			35.534	48.09	38.313	41.835
L1Cu	Laptop Copper	679.665		0.038	0.037	0.012	0.116
L1Al	Laptop Aluminium		54.177	0.449	0.101	0.1	0.298
P1C	Pin Carbon			642.762	0.02	0.019	42.674
P1G	Pin Gauze			40.474	0.035	0.461	3.464

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