Wastes from Recycling of Spent Batteries

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With the proliferation of electronics, the extensive use of batteries has increased tremendously. It is estimated that the global battery market will be close to $139.36 billion by 2026 (Zhao, 2020). In parallel, the total quantity of spent batteries generated in Turkey has approached to 10,000 tons per year (TAP, 2018). To reduce the adverse environmental effects of spent batteries containing hazardous substances, and recover semi-precious metals with high values, it is vital to encourage spent battery recycling. The metals recovered from spent battery recycling are Zn, Mn, Li, Ni, Co, Cd, Ag and a small number of rare earth elements (TAP, 2020). Like all other processes, spent battery recycling processes generate wastes. To our knowledge, no studies have been published to interpret the wastes generated in battery recycling. This article aims to provide comprehensive information on the different types of processes applied for battery recycling and a process-based assessment of the process wastes and non-process wastes generated by these processes.

The methodology used in the study involved five main steps, namely, i) investigating alternative processes used for spent battery recycling, ii) studying every process step involved in recycling processes, iii) identification of all potential process wastes and non-process wastes from each process, iv) classification of each waste with the correct European Waste Catalogue codes (EWC codes) so that the waste can be handled properly, and v) identification of management strategies for each of the waste types generated in each industrial activity.

There are many types of batteries, and according to the types, there are changes in the materials used and obtained in the recovery. Nevertheless, spent battery recovery includes three main steps (Fig.1). These are mechanical pretreatment, metallurgical processes, and refining. The first step of pretreatment involves crushing spent batteries and subsequent separation of materials. The second step that provides the separation of valuable metals can be pyrometallurgical or hydrometallurgical. Pyrometallurgical processes are heat treatment (thermal), and their recovery efficiency is high. Hydrometallurgical processes are chemical processes with aqueous solutions, and the degree of purity of the recovered substances is high. In the refining step, the substance to be recovered is purified. The refining process may not be needed after hydrometallurgical applications (Zhang et al., 2018). Figure 1 illustrates the spent battery recovery processes and the wastes generated from these processes. As shown, the metal-extraction process which can be pyrometallurgical or hydrometallurgical, generates several waste streams that require attention.

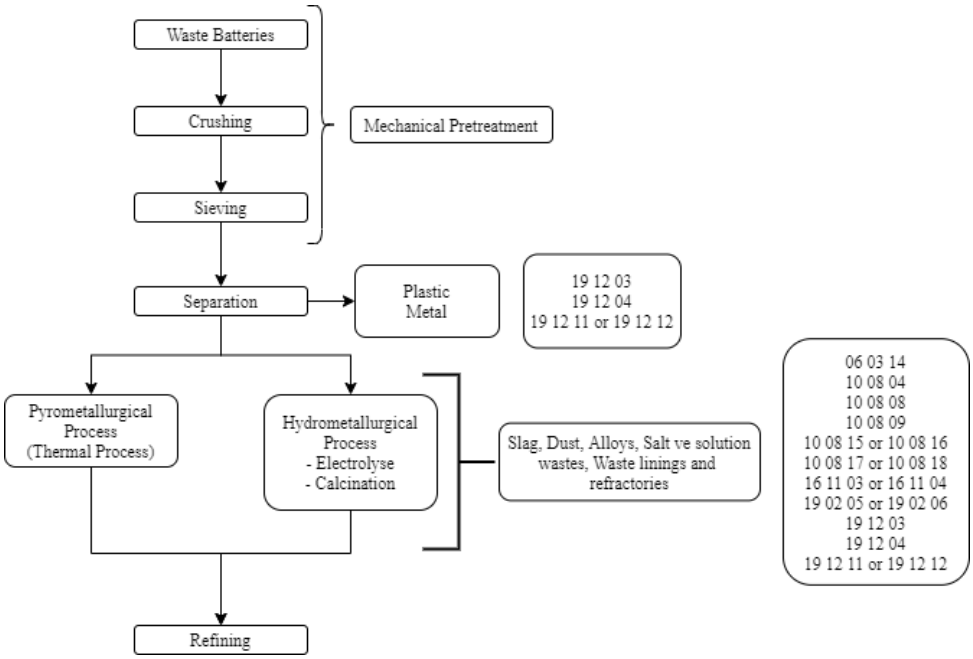

Figure 1. Process scheme and waste generation of waste battery recovery

Table 1 lists the wastes generated from the waste battery recovery process, their definition and recovery/disposal codes, according to the European Waste Catalogue. As shown, the only hazardous waste is the salt slag from metallurgical processes.

Table 1. Process wastes list of waste battery recovery plants

EWC Codes[1]	Definition	A/M[2]	R/D Codes[3]
06 03 14	Solid salts and solution other than those mentioned in 06 03 11 and 06 03 13	I	R4, R13, D5/D15
10 08 04	Particulates and dust	I	-
10 08 08	Salt slag from primary and secondary production	A	-
10 08 09	Other slags	I	-
10 08 15*	Flue-gas dust containing dangerous substances	M	R5, R13, D1/D4/D5
10 08 16*	Flue-gas dust other than those mentioned in 10 08 15		R13, D1/D5
10 08 17* 10 08 18*	Sludges and filter cakes from flue-gas treatment containing dangerous substances	M	R3/R4/R5, R13, D1/D4/D5
	Sludges and filter cakes from flue-gas treatment other than those mentioned in 10 08 17	I	R13, D1/D5
16 11 03*	Other linings and refractories from metallurgical processes containing dangerous substances	M	R5, R12, D5
16 11 04*	Other linings and refractories from metallurgical processes other than those mentioned in 16 11 03	I	R5, R12, D5
19 02 05* 19 02 06*	Sludges from physico/chemical treatment containing dangerous substances	M	R4, R13, D5
	Sludges from physico/chemical treatment other than those mentioned in 19 02 05	I	R4, R13, D5
19 12 03	Non-ferrous metal	I	R4, D1
19 12 04	Plastic and rubber	I	R1/R3, D10, D5
19 12 11*	Other wastes (including mixtures of materials) from mechanical treatment of waste containing dangerous substances	M	R1, D9/R12/R13, D10, D5
19 12 12*	Other wastes (including mixtures of materials) from mechanical treatment of wastes other than those mentioned in 19 12 11	I	R1/R3, D9/R12/R13, D10, D5

[1]European Waste Catalogue Codes - http://www.nwcpo.ie/forms/EWC_code_book.pdf
[2]A: Hazardous wastes / M: Mirror wastes, I: inert wastes
[3]R: Recovery / D: Disposal - given in the EU Waste Framework Directive
*Wastes which can be replaced with each other

The identification of sector-specific process and non-process wastes is vital not only for the national authorities to implement correct management strategies but also for the waste producers to declare their wastes to the national authorities correctly.

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