Segregation of batteries from pyrolyzed entire smartphones by means of density separation

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Introduction

The recycling industry of electronics (including smartphones) is dominated worldwide by small and medium recyclers that employ techniques of low complexity and efficiency, with predominance of manual work and rudimentary tools, sometimes verging informality. Basically, complex electronics are manually dismantled and only the printed circuit boards (PCBs) are separated and sent to appropriate valorization in terms of recovery of precious and critical materials, representing a wasting of valuable materials that are possibly allocated in other components.

In this scenario, solutions that facilitate the work of small and medium recyclers and promote a better valorization of the residues urge. For smartphones, this study proposes the approach of directly process entire smartphones from the beginning of an automated the recycling route, avoiding the need of dismantling and separating components through manual work. This approach may promotes higher recovery rates of valuable materials, labor security, formality, and improves profitability for recyclers. Specifically, we apply pyrolysis as the first step to process entire smartphones, and, to promote an adequate valorization of the residues, the batteries require a separated treatment as they are composed of valuable materials that are not present in the other components (namely Li and Co).

The objective of this work is to introduce the idea of recycling entire smartphones (through pyrolysis) and explore techniques to promote the separation of batteries, particularly through the physical property of density (gravimetric separation using a liquid medium). It is expected that an ideal density can be defined for the separation of batteries from other components by floating or sinking, and finding liquid media that are technically and economically applicable to industry.

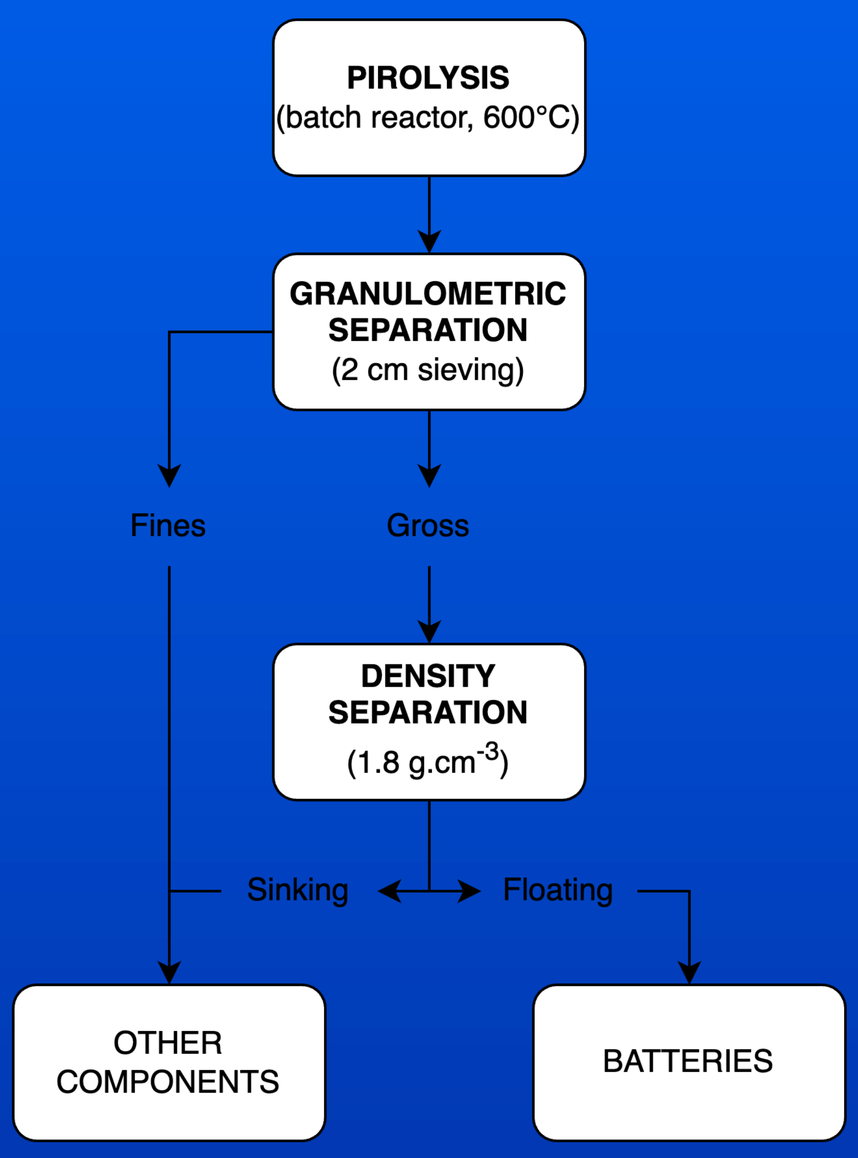

Figure1: Flowchart of the proposed recycling route

Figure 3: Batteries floating on a solution of zinc chloride

Results & Discussion

Entire smartphones were pyrolyzed in a batch furnace and the output material was sent to granulometric separation in a 2 cm-sieve. Sieving separates the batteries along with other gross components (Figure 2) and guarantee that fines do not enter the density separation.

- Experiments of density separation were initially performed with a solution of Sodium Polytungstate (SPT), starting from a density of 3.1 $g.cm^{-3}$ and decreasing the density in increments of 0.2 $g.cm^{-3}$ (adding water) to find a possible ideal density to separate the batteries.
- The components of 8 pyrolyzed smartphones were individually tested for floating or sinking through the immersion and holding into the solution.
- It was found that the density of 1.8 $g.cm^{-3}$ permits the separation of the batteries (floating) from other components (sinking) with an efficiency of 100 %.
- It was performed additional experiments with 50 batteries and 50 other components from different brands and models, in solutions of zinc chloride and clay, to confirm the viability of the method. 96% of efficacy was achieved with zinc chloride.

Figure 2: Gross fraction after pyrolysis and sieving

Conclusions

- The concept of density separation to segregate batteries from pyrolyzed entire smartphones was proved effective.
- The proposed route may facilitate and cheapen the work of recyclers. The concept can be adapted and tested for different electronic devices.
- In terms of products, pyrolysis generates gaseous and liquids sub-products, and a solid fraction rich in metals, and the step of density separation generates a flow of batteries which permits a dedicated downstream recycling route.

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