Journal of Power Sources 390 (2018) 38–44

Contents lists available at ScienceDirect

Journal of Power Sources

journal homepage: www.elsevier.com/locate/jpowsour

Effective regeneration of anode material recycled from scrapped Li-ion batteries

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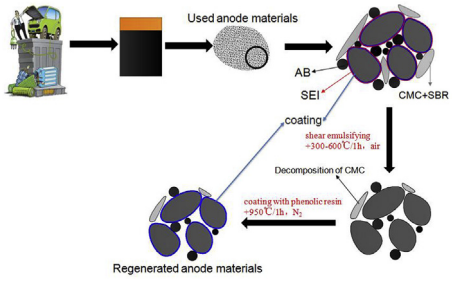
HIGHLIGHTS

- A novel regeneration process is proposed to regenerate recycled anode material.
- Most AB and all the SBR, CMC are removed in regenerated anode material.
- Performances of regenerated anode material meet the reuse requirement.

GRAPHICAL ABSTRACT



ARTICLE INFO

Keywords:
Scrapped lithium ion batteries
Recycling
Anode material
Heat-treating
Coating
Regeneration

ABSTRACT

Recycling high-valuable metal elements (such as Li, Ni, Co, Al and Cu elements) from scrapped lithium ion batteries can bring significant economic benefits. However, recycling and reusing anode material has not yet attracted wide attention up to now, due to the lower added-value than the above valuable metal materials and the difficulties in regenerating process. In this paper, a novel regeneration process with significant green advance is proposed to regenerate anode material recycled from scrapped Li-ion batteries for the first time. After regenerated, most acetylene black (AB) and all the styrene butadiene rubber (SBR), carboxymethylcellulose sodium (CMC) in recycled anode material are removed, and the surface of anode material is coated with pyrolytic carbon from phenolic resin again. Finally, the regenerated anode material (graphite with coating layer, residual AB and a little CMC pyrolysis product) is obtained. As expected, all the technical indexs of regenerated anode material exceed that of a midrange graphite with the same type, and partial technical indexs are even closed to that of the unused graphite. The results indicate the effective regeneration of anode material recycled from scrapped Li-ion batteries is really achieved.

1. Introduction

The consumption of Li-ion power batteries is sharply increasing with the increasing use of electric vehicles (EV) all over the world, so there are a large number of Li-ion power batteries retired from EV each year. Echelon use as storage batteries will be the preferred option for these retired batteries [1–3]. However, for those scrapped batteries that can not be echelon used, recycling valuable materials after dismantling

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https://doi.org/10.1016/j.jpowsour.2018.04.039
Received 24 January 2018; Received in revised form 31 March 2018; Accepted 10 April 2018
0378-7753/

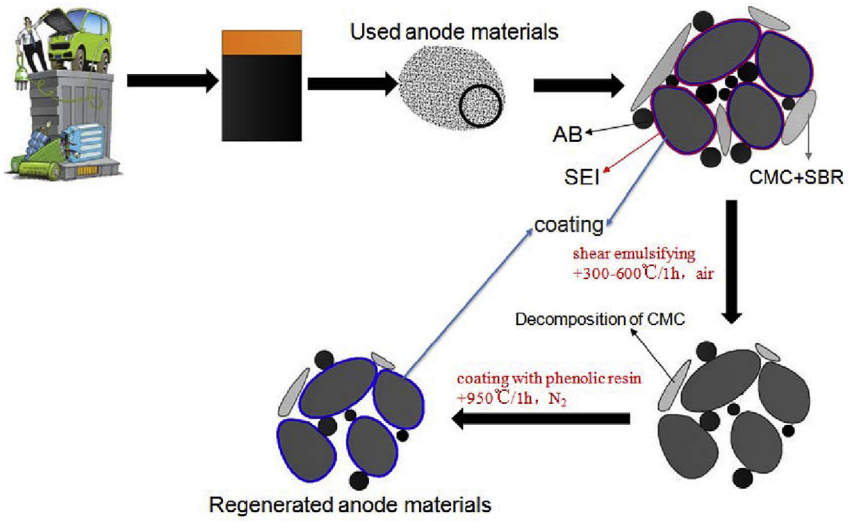

Fig. 1. Schematic illustration for the regenerating process of anode material from scrapped batteries.

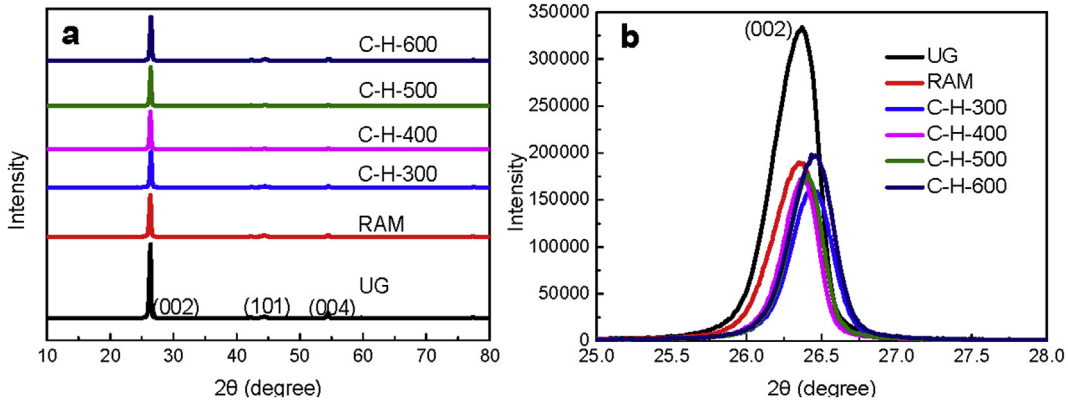

Fig. 2. XRD patterns of regenerated anode materials. (b) is a local enlargement of (a).

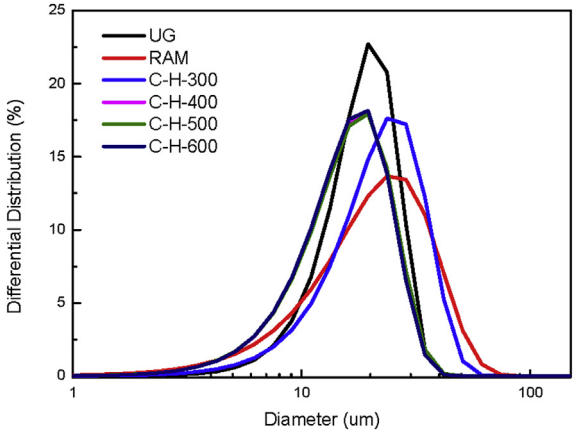

Fig. 3. Size distribution curves of regenerated anode materials.

is the only option. If threw away without recycling properly, these scrapped batteries will lead to not only a severe waste of valuable resources, but also a serious environmental pollution because of harmful substances such as electrolyte [4,5]. So these scrapped batteries must be recycled with green and feasible processes.

To be profitable, recycling high-valuable metal elements (such as Li, Ni, Co, Al and Cu elements) from scrapped Li-ion batteries is the main focus in the current recycling processes [6,7]. However, recycling and reusing anode material has not yet attracted wide attention up to now, due to the lower added-value than the above valuable metal materials and the difficulties in regenerating process. Considering the rapid increasing in the number of scrapped Li-ion batteries, it is believed that reusing recycled anode material after effectivly regenerated as a fully closed cycle can also bring considerable economic benefit and realize the sustainable development of Li-ion power battery industry [8–10]. So the concept of recycling anode material and reusing in Li-ion battery is in the focus.

Table 1
Size distribution data of regenerated anode materials.

Regenerated anode materials	D10 (μm)	D50 (μm)	D90 (μm)
UG	8.63	18.19	29.25
RAM	7.41	19.05	34.74
C-H-300	9.80	20.35	32.39
C-H-400	7.13	14.53	22.87
C-H-500	7.12	14.68	23.17
C-H-600	7.14	14.65	23.16

In this paper, anode material is recycled from scrapped Li-ion power batteries using a self-made small scale model line. Then, recycled anode material is regenerated through two steps. Firstly, recycled anode material is heat-treated in air to remove conductive agent, binder and thickener. Secondly, heat-treated anode material is further coated with pyrolytic carbon from pyrolytic carbon [11]. The test results show that all the technical indexs of regenerated anode material exceed that of a