

## Method For Recycling Cathode Current Collectors

### Technical Field

5           The present application relates to battery recycling technology. In particular, the present application relates to a method for recycling cathode material from cathode current collectors of batteries.

### Background

10           Batteries such as lithium batteries have becoming one of the most widely used mobile energy sources in many industrial and daily life applications. With the usage of batteries greatly increasing, aged and discarded batteries have become a major issue of environmental concern and sustainability of social developments. Industrial players have  
15           been endeavoured with continuous efforts in developing effective and practical solutions for battery recycling for the purposed of possible environmental pollutions reduction and better reusage of the precise metals and other materials from the recycled battery parts.

          Present battery recycling technologies mainly focus on active ingredients recycling  
20           and less solution is available for recycling of inactive materials such as copper material from the cathode current collectors of batteries. Limited known cathode current collectors recycling involves complicated and high cost processes of pulverization of both the anode and cathode current collectors, for the purposes of obtaining the aluminium and copper materials and by refinery processes. The aluminium material of the anode is itself  
25           consumed as the reducing agent during the refinery and further, the copper material is mixed with other elements such as nickel and cobalt etc, which require further metallurgical processes of purification before the copper material can be obtained.

          It is therefore desirable to provide an improved cathode material recycling method  
30           to solve at least one of the problems identified above.

## Summary

According to one aspect, the present invention provides a method for recycling cathode current collectors from batteries. In one embodiment, the method comprises  
5 extracting cells from batteries, separating a cathode current collector from an anode current collector of the cell, soaking the cathode current collector in a first solution for a predetermined time period to separate a graphite coating from a copper foil, drying the copper foil, and cleaning the copper foil to remove attachments from the copper foil.

10 Preferably, the first solution comprises a 3% to 8%wt hydrochloric acid.

Preferably, the predetermined time period is 2 minutes to 5 minutes.

Preferably, the method further comprises subjecting the first solution to a first  
15 ultrasonic oscillation, during soaking the cathode current collector in the first solution, to separate the graphite coating from the copper foil.

Preferably, the first ultrasonic oscillation has a power of 600 watts to 1500 watts and a frequency of 30 KHz to 50KHz.

20 Preferably, the method further comprises, after soaking the cathode current collector in the first solution and prior to drying the copper foil, cleaning the copper foil in a second solution to remove residues of the first solution.

25 Preferably, the method further comprises subjecting the second solution to a second ultrasonic oscillation during cleaning the copper foil to remove residues of the first solution.

Preferably, the second solution is water and the second ultrasonic oscillation has a  
30 power of 300 watts to 1500 watts and a frequency 20 KHz to 35KHz.

Preferably, the step of drying the copper foil is implemented under a temperature not exceeding 60 degrees Celsius.

Preferably, the step of cleaning the copper foil to remove attachments from the copper foil comprises cleaning the copper foil to remove oxides, adhesive particles and carbon powders from the copper foil.

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Preferably, cleaning the copper foil comprises laser ablating the copper foil to remove the oxides, adhesive particles and carbon powers.

Preferably, the laser ablating is implemented under a cleaning speed of 0.3 – 0.5 second per square centimeter on a surface of the copper foil.

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Preferably, the laser ablating forms a surface texture on the copper foil, wherein the surface texture comprises grooves and ridges with a pitch of 10 micrometers.

Preferably, the laser ablating is implemented by a MOPA (Master Oscillator Power Amplifier) laser.

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With the solutions provided by the present application, the present invention enables cathode current collectors recycling by effectively obtaining the copper material from the cathode current collector of batteries. A method according to the present invention enables copper material and cathode current collectors recycling without cutting or shredding the batteries into fragments and achieves copper material recycling with high efficiency.

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## Brief Description of Drawings

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The technical solutions and corresponding technical features of the embodiments will be more comprehensively understood in conjunction with the accompanying drawings, in which:

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Fig. 1 is a flow chart showing a method for recycling cathode current collectors from batteries according to one embodiment of the present invention;

Fig. 2 is a flow chart showing an exemplary detailed step of the method shown in Fig. 1;

Fig. 3 is a flow chart showing an exemplary additional step of the method shown in Fig. 1;

5 Fig. 4 is a flow chart showing an exemplary detailed step of the method shown in Fig. 1;

Fig. 5 is a flow chart showing an exemplary further step of the method shown in Fig. 1;

10 Fig. 6 is a flow chart showing an exemplary further step of the method shown in Fig. 5.

### Detailed Description

15 As shown in Fig. 1, according to one embodiment of the present invention, a method 100 for recycling cathode current collectors from batteries comprises, a step 120 of retracting a cell from a housing of a battery, a step 130 of separating a cathode current collector from an anode current collector of the cell, a step 140 of soaking the cathode current collector in a first solution for a predetermined time period to separate a graphite coating from a copper foil, a step 160 of drying the copper foil and a step 170 of cleaning  
20 the copper foil to remove attachments from the copper foil.

Preferably, the first solution comprises a 3% to 8 %wt hydrochloric acid, and the predetermined time period is 2 minutes to 5 minutes. As shown in Fig. 2, during the step 140 of soaking the cathode current collector in a first solution for a predetermined time  
25 period to separate a graphite coating from a copper foil, the method 100 may include a step 142 of subject the first solution to a first ultrasonic oscillation e.g. an ultrasonic oscillation having a power of 600 watts to 1500 watts and a frequency of 30 KHz to 50KHz.

30 Preferably, as shown in Fig. 3 and with reference to Fig. 1, after the step 140 of soaking the cathode current collector in the first solution and prior to the step 160 of drying the copper foil, the method 100 may further include a step 150 of cleaning the copper foil in a second solution, to remove residues of the first solution.

Preferably, as shown in Fig. 4, the step 150 of cleaning the copper foil in a second solution to remove residues of the first solution may further comprise a step 152 of subjecting the water to a second ultrasonic oscillation during cleaning the copper foil, to remove residues of the first solution. Preferably, the second solution is water, and the second ultrasonic oscillation has a power of 300 watts to 1500 watts and a frequency of 20 KHz to 35KHz. Preferably the step 160 of drying the copper foil is implemented under a temperature not exceeding 60 degrees Celsius.

Preferably, as shown in Fig. 5, the step 170 of cleaning the copper foil to remove attachments from the copper foil comprises a step 172 of cleaning the copper foil to remove oxides, adhesive particles and carbon powders from the copper foil. More preferably, as shown in Fig. 6, the step 172 of cleaning oxides, adhesive particles and carbon powders from the copper foil comprises a step 174 of laser ablating the copper foil to remove the oxides, adhesive particles and carbon powders.

Preferably, the laser may be a MOPA laser, and implemented under a cleaning speed of 0.3 to 0.5 second per square centimeter on a surface of the copper foil.. The laser ablating forms a surface texture on the copper foil upon completion of the laser ablation, and the surface texture comprises grooves and ridges with a pitch of 10 micrometers.

This disclosure has been presented for purposes of illustration and description of the embodiments of the present invention, but is not intended to be exhaustive or limiting. For example, while the present invention is presented by making reference to one type of battery as illustrated in the drawings and the description, it should be appreciated that the present invention may be practiced for batteries of various other types, other structures other models and other architectures. Many modifications and variations will be apparent to those of ordinary skilled in the art. The example embodiments are chosen and described to explain principles and practical application of the present invention, and to enable those of ordinary skilled in the art to understand the disclosure for various embodiments with various modifications as are suited to the particular technical solution contemplated and described. Further, while some technical details may be omitted from the description and drawings, for the purpose of clarity and conciseness, such omissions

are not meant to be understood that the omitted features are necessarily absent or missing in the relevant structures, parts, processes and/or steps, as described herein, for understanding and practicing the invention.

5           Thus, although illustrative example embodiments have been described herein with reference to the accompanying drawings, it is to be understood that this description is not limiting and that various other changes and modifications may be effected therein by one skilled in the art without departing from the scope or spirit of the disclosure as sets out and defined the claims appended hereto.

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## Claims

1. A method for recycling cathode current collectors, the method comprising:  
retracting a cell from a housing of a battery;  
5 separating a cathode current collector from an anode current collector of the cell;  
soaking the cathode current collector in a first solution for a predetermined time  
period to separate a graphite coating from a copper foil;  
drying the copper foil;  
cleaning the copper foil to remove attachments from the copper foil.  
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2. The method as recited in claim 1, wherein the first solution comprises a 3% to 8 %wt  
hydrochloric acid.
3. The method as recited in claim 2, wherein the predetermined time period is 2  
15 minutes to 5 minutes.
4. The method as recited in claim 1, further comprising subjecting the first solution to a  
first ultrasonic oscillation during soaking the cathode current collector in the first  
solution to separate the graphite coating from the copper foil.  
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5. The method as recited in claim 4, wherein the first ultrasonic oscillation has a power  
of 600 watts to 1500 watts and a frequency of 30 KHz to 50KHz frequency.
6. The method as recited in claim 1 further comprising, after socking the cathode  
25 current collector in the first solution and prior to drying the copper foil, cleaning the  
copper foil in a second solution to remove residues of the first solution.
7. A method as recited in claim 6, further comprising subjecting the second solution to  
a second ultrasonic oscillation during cleaning the copper foil to remove residues of  
30 the first solution.

8. The method as recited in claim 7, wherein the second solution is water and the second ultrasonic oscillation has a power of 300 watts to 1500 watts and a frequency of 20 KHz to 35 KHz frequency.

5 9. The method as recited in claim 1, wherein drying the copper foil is implemented under a temperature not exceeding 60 degrees Celsius.

10 10. The method as recited in claim 1, wherein cleaning the copper foil to remove attachments from the copper foil comprises cleaning the copper foil to remove oxides, adhesive particles and carbon powders from the copper foil.

11. The method as recited in claim 10, wherein cleaning the copper foil comprises laser ablating the copper foil to remove the oxides, adhesive particles and carbon powders.

15 12. The method as recited in claim 11, wherein the laser ablating is implemented under a cleaning speed of 0.3 – 0.5 second per square centimeter on a surface of the copper foil.

20 13. The method as recited in claim 12, wherein the laser ablating forms a surface texture on the copper foil, wherein the surface texture comprises grooves and ridges with a pitch of 10 micrometers.

25 14. The method as recited in claim 11, wherein the laser ablating is implemented by a MOPA laser.