PROCESS FOR REMOVING IMPURITIES IN THE RECYCLING OF LITHIUM-ION BATTERIES

Field of Invention

The present invention generally relates to a method for recycling spent lithium-ion batteries. More particularly, it relates to a method for removal of impurities from a leaching solution of spent lithium-ion batteries.

Background

Lithium-ion batteries contain valuable precious metals which would go to waste when the batteries are spent and discarded. With the rising use of lithium-ion batteries, the recovery of precious metals from spent lithium-ion batteries have become an important industry.

Typically, spent lithium-ion batteries are dismantled, crushed, or shredded to form a black mass to prepare them for recycling. Current lithium-ion battery recycling efforts are often primarily focused on recovering the precious metals cobalt and lithium from lithium cobalt oxide cathodes. However, there are many other types of cathode materials used in lithium-ion batteries. A significant portion of these cathode materials include other precious metals such as nickel and manganese. Conventional recycling methods do not adequately handle the recycling of different types of lithium-ion battery cathode materials and fail to sufficiently address the extraction of these other precious metals.

Further, black mass, especially those derived collectively from different types of lithium-ion batteries contains many types of impurities. Failing to effectively remove them adversely affects the purity of precious metals recovered from recycling. Present efforts of impurity removal involve numerous steps requiring many reactors and filters. Not only does this lengthen the entire recycling process, but with each reactor or filter, valuable material is lost along the way resulting in a severe reduction in the amount of precious metals available for recovery.

Thus, there exists a need for a lithium-ion battery recycling process which can better handle the removal of impurities in black mass, especially that derived collective from different types of lithium-ion batteries. There also exists an associated need to remove impurities in a more efficient way that requires less equipment and results in less reduction in the amount of precious metals available for recovery.

The invention seeks to answer these needs. Further, other desirable features and characteristics will become apparent from the rest of the description read in conjunction with the accompanying drawings.

Summary

In a first aspect of the present disclosure, there is provided a method of treating a leaching solution derived from a black mass, comprising:

setting pH of the leaching solution to about pH 1.2 to 2.15;

adding iron powder to induce copper cementation;

after copper cementation, adding lime; and

after adding lime, transiting pH of the leaching solution to about pH 6 to extract calcium fluoride, titanium hydroxide, aluminium hydroxide, iron hydroxide, and iron phosphate.

In another aspect of the present disclosure, there is provided a black mass recycling system comprising an impurity removal reactor configured to receive a sodium hydroxide feed, an iron powder feed, and a lime feed.

In accordance with the present ~~invention~~disclosure, a method of treating a leaching solution derived from a black mass is provided. The method comprises setting pH of the leaching solution to about pH 1.2 to 2.15, adding iron powder to induce copper cementation, adding lime after copper cementation, and after adding lime, transiting pH of the leaching solution to about pH 6 to extract calcium fluoride, titanium hydroxide, aluminium hydroxide, iron hydroxide, and iron phosphate. Preferably, about 2.5g of iron powder is added for each litre of the leaching

solution. More preferably, the iron powder may be added over a period of about 15 minutes. Preferably, the lime is calcium oxide and about 20-40g of calcium oxide is added for each kg of black mass. Alternatively, the lime is calcium hydroxide and about 30-60g of calcium hydroxide is added for each kg of black mass. Preferably, the leaching solution is derived from the black mass by leaching the black mass with sulfuric acid and hydrogen peroxide. Preferably, the sulfuric acid is 4M sulfuric acid, and about 6 litres of sulfuric acid is added for each kg of the black mass. Preferably, about 50ml of hydrogen peroxide (30% concentration) per litre of solution is added. Preferably, the sulfuric acid and hydrogen peroxide are added in consecutive order. The method may further comprise agitating the black mass, sulfuric acid, and hydrogen peroxide for a period of 1 hour. The method may further comprise diluting the sulfuric acid to 2M by adding deionised water after the period of 1 hour.

In another ~~aspect~~example, a black mass recycling system is provided. The black mass recycling system comprises an impurity removal reactor configured to receive a sodium hydroxide feed, an iron powder feed, and a lime feed. Preferably, the black mass recycling system may further comprise a leaching reactor configured to receive a sulfuric acid feed, a hydrogen peroxide feed, and a deionised water feed, and a first valved outlet associated with the leaching reactor providing fluid communication between the leaching reactor and the impurity removal reactor. More preferably, the black mass recycling system may further comprise an impurity removal agitator provided within the impurity removal reactor, and a leaching reactor agitator provided within the leaching reactor.

Brief Description of Drawings

Fig. 1 is a process flow diagram of a process of leaching and removal of impurities.

Detailed Description

In the following detailed description, reference is made to the accompanying drawings which form a part hereof. The processes and systems described in the detailed description and drawings are for illustrative purposes and are not meant to be limiting. Other embodiments can be utilised, and other changes can be made, without departing from the scope of the disclosure presented herein. In the present disclosure, the depiction of a given element or consideration or use of a particular element number in a particular Fig. or a reference thereto in corresponding descriptive material can encompass the same, an equivalent, or an analogous element or element number identified in another Fig. or descriptive material associated therewith.

Black mass is poured from its holding container **100** into a first reactor, namely a leaching reactor, **102**. The black mass may collectively include lithium-ion batteries with cathodes made from lithium cobalt oxide (LCO), lithium manganese oxide (LMO), lithium nickel manganese cobalt oxide (NMC), lithium iron phosphate (LFP), lithium nickel cobalt aluminium oxide (NCA), and lithium titanate (LTO). As a result, the black mass comprises impurities of iron, copper, fluorine, phosphorous, titanium and aluminium.

In the first phase of leaching, an inorganic acid, preferably sulfuric acid (H_2SO_4), provided from an inorganic acid source **110** is added to the black mass in the first reactor **102**, forming a solution. Preferably, a proportion of about 1 kg of black mass to about 6 litres of 4M sulfuric acid is observed. The inorganic acid may optionally be