SUMMARY

There is provided a method of recycling black mass obtained from lithium iron phosphate batteries, comprising an alkaline leaching step, comprising adding an alkaline solution with a pH of 13-14 to the black mass to obtain a first leachate and a first solid residue, an acid leaching step, comprising adding a 4M-6M acid solution to the first solid residue for a first duration to obtain a second leachate, passing the second leachate through a first ion-exchange column wherein fluoride ions from the second leachate are retained in the first resin column to obtain a first eluate, passing the first eluate through a second ion-exchange column wherein copper ions from the first eluate are retained in the second resin column to obtain a second eluate, an iron precipitation step, comprising raising the pH of the second eluate to 2.5-5 and adding a quantity of phosphoric acid to the second eluate, to obtain a first solution and an iron (III) phosphate precipitate, combining the first leachate and the first solution to obtain a second solution and adjusting the pH of the second solution to about 6.5 to obtain a residual precipitate and a lithium solution, wherein the quantity of phosphoric acid is sufficient to achieve an equivalent stoichiometric ratio of ferric iron and phosphate anions in the second eluate.

In one aspect of the disclosure, there is provided a method of recycling black mass obtained from lithium iron phosphate batteries, comprising an alkaline leaching step, comprising adding an alkaline solution with a pH of 13-14 to the black mass to obtain a first leachate and a first solid residue, an acid leaching step, comprising adding a 4M-6M acid solution to the first solid residue for a first duration to obtain a second leachate, passing the second leachate through a first ion-exchange column wherein fluoride ions from the second leachate are retained in the first ion-exchange column to obtain a first eluate, passing the first eluate through a second ion-exchange column wherein copper ions from the first eluate are retained in the second ion-exchange column to obtain a second eluate, an iron precipitation step, comprising raising the pH of the second eluate to 2.5-5 and adding a quantity of phosphoric acid to the second eluate, to obtain a first solution and an iron (III) phosphate precipitate, combining the first leachate and the first solution to obtain a second solution and adjusting the pH of the second solution to 6.5 to obtain a residual precipitate and a lithium solution, wherein the quantity of phosphoric acid is sufficient to achieve an equivalent stoichiometric ratio of ferric iron and phosphate anions in the second eluate.

Optionally, the acid solution is selected from a group consisting of sulphuric acid and hydrochloric acid. Optionally, the acid leaching step further comprises diluting the acid solution by about ½ and adding a first oxidising agent to the acid solution for a second duration to obtain the second leachate. Optionally, the first and second duration are each about 30-60 minutes and run consecutively. Optionally, the iron precipitation step further comprises adding a second oxidising agent to the second eluate.

Optionally the first and/or second oxidising agent are selected from a group consisting of hydrogen peroxide, ozone, oxygen, chlorine and potassium permanganate. Optionally, the first and/or second oxidising agent added is hydrogen peroxide and about 500ml per kg of the black mass. Optionally, the iron (III) phosphate precipitate has a purity of >99.5%.Optionally, the residual precipitate comprises mainly aluminium hydroxide, copper (II) hydroxide, calcium fluoride and iron (III) hydroxide.

BRIEF DESCRIPTION OF DRAWINGS

Fig. 1 is a block diagram depicting a lithium iron phosphate recycling process according to a primary embodiment of the present invention.

Fig. 2 depicts an XRD analysis graph of the precipitate obtained from a first solution.

CLAIMS

1. A method of recycling black mass obtained from lithium iron phosphate batteries, comprising:

an alkaline leaching step, comprising adding an alkaline solution with a pH of 13-14 to the black mass to obtain a first leachate and a first solid residue;

an acid leaching step, comprising adding a 4M-6M acid solution to the first solid residue for a first duration to obtain a second leachate;

passing the second leachate through a first ion-exchange column wherein fluoride ions from the second leachate are retained in the first ion-exchange column to obtain a first eluate;

passing the first eluate through a second ion-exchange column wherein copper ions from the first eluate are retained in the second ion-exchange column to obtain a second eluate;

an iron precipitation step, comprising raising the pH of the second eluate to 2.5-5 and adding a quantity of phosphoric acid to the second eluate, to obtain a first solution and an iron (III) phosphate precipitate;

combining the first leachate and the first solution to obtain a second solution; and

adjusting the pH of the second solution to 6.5 to obtain a residual precipitate and a lithium solution;

wherein, the quantity of phosphoric acid is sufficient to achieve an equivalent stoichiometric ratio of ferric iron and phosphate anions in the second eluate.

2. The method according to claim 1, wherein the acid solution is selected from a group consisting of sulphuric acid and hydrochloric acid.

3. The method according to claim 1, wherein the acid leaching step further comprises diluting the acid solution by ½ and adding a first oxidising agent to the acid solution for a second duration to obtain the second leachate.

4. The method according to claim 1, wherein the iron precipitation step further comprises adding a second oxidising agent to the second eluate.

5. The method according to claim 3, wherein the first and second duration are each 30-60 minutes and run consecutively.

6. The method according to claims 3 or 4, wherein the first and/or second oxidising agent are selected from a group consisting of hydrogen peroxide, ozone, oxygen, chlorine and potassium permanganate.

7. The method according to claim 6, wherein the first and/or second oxidising agent added is hydrogen peroxide and 500ml per kg of the black mass.

8. The method according to claim 1, wherein the iron (III) phosphate precipitate has a purity of >99.5%.

9. The method according to claim 1, wherein the residual precipitate comprises mainly aluminium hydroxide, copper (II) hydroxide, calcium fluoride and iron (III) hydroxide.