Claims

1. Process for the recovery of Ni and Co from Li-ion batteries or their waste, comprising the steps:

-providing a furnace lined with magnesia-bearing refractory bricks;

-providing a charge comprising slag formers and Li-ion batteries or their waste, wherein the content of Al in the charge is less than 8%; and,

-smelting the charge in reducing conditions, thereby obtaining an alloy containing the major part of the Ni and Co, and a Li-containing slag, wherein the slag has a percent composition by weight according to:

$25\% < MnO < 70\%$;

$Al_2O_3 + 0.5\ MnO < 45\%$

$SiO_2 > 5\%$;

$Li_2O > 1\%$;

$0.5\% < P_2O_5 < 10\%$;

$MnO + Li_2O + Al_2O_3 + CaO + SiO_2 + FeO + MgO + P_2O_5 > 90\%$; and,

wherein $(CaO + 2\ Li_2O + 0.4\ MnO) / SiO_2 \geqslant 2.0$.

2. Process according to claim 1, wherein the content of MnO in the slag is 30% or more.

3. Process according to claim 1 or 2, wherein the content of Al_2O_3 in the slag is less than 30%.

4. Process according to any one of claims 1 to 3, wherein the Li-ion batteries or their waste is Black Mass.

5. Process according to any one of claims 1 to 4, wherein the content of CaO in the slag is 40% or less, preferably 30% or less.

6. Process according to any one of claims 1 to 5, wherein the content of Li_2O in the slag is more than 3%.

7. Process according to any one of claims 1 to 6, wherein the content of cobalt oxide

in the slag is 0.05% < CoO < 1%.

8. Process according to any one of claims 1 to 7, wherein the content of Fe in the slag is 25% or less, preferably 10% or less.

9. Process according to any one of claims 1 to 8, wherein the content of Fe in the charge is 5% or less.

10. Process according to any one of claims 1 to 9, wherein the step of smelting the charge is performed at a temperature of at least 1400 ° C and at most 300 ° C above the liquidus point of the slag, preferably at most 100 ° C above the liquidus point of the slag, thereby avoiding overheating.

11. Process according to any one of claims 1 to 10, the smelting step comprising the further steps:
- sampling the slag;
- cooling down the slag sample and assessing its color; and,
- in case the slag sample is green, terminating the smelting step; or,
- in case the slag sample is not green, proceeding with the smelting step after adjusting the pO_2-level to achieve more reducing conditions.

12. Process according to any one of claims 1 to 11, wherein the pO_2-level is adjusted to $10^{-7} > pO_2 > 10^{-12}$, preferably to $pO_2 < 10^{-8}$, more preferred to $pO_2 < 10^{-8.5}$, and most preferred to $pO_2 < 10^{-9}$.

13. Process according to claims 11 or 12, wherein the color of the slag is green according to standard ASTM D1535-14.

14. Process according to any one of claims 1 to 13, wherein the furnace is an electric furnace.

15. Li-containing metallurgical slag having a percent composition by weight according to:
25% < MnO < 70%;

Al_2O_3 + 0.5 MnO < 45%

SiO_2 > 5%;

Li_2O > 3%;

0.5% < P_2O_5 < 10%;

MnO + Li_2O + Al_2O_3 + CaO + SiO_2+ FeO + MgO + P_2O_5 > 90%; and,

wherein (CaO + 2 Li_2O + 0.4 MnO) / SiO_2 $\geqslant$ 2.0.

16. Li-containing metallurgical slag according to claim 15, wherein the color of the slag is green according to standard ASTM D1535-14.

17. Li-containing metallurgical slag according to claim 15 or 16, wherein the content of MnO in the slag is 30% or more, preferably 40% or more.

18. Li-containing metallurgical slag according to any one of claims 15 to 17, wherein the content of Al_2O_3 in the slag is less than 30%.

19. Li-containing metallurgical slag according to any one of claims 15 to 18, wherein the content of CaO in the slag is 40% or less, preferably 30% or less.

20. Li-containing metallurgical slag according to any one of claims 15 to 19, wherein the content of Fe in the slag is 25% or less, preferably 10% or less.

21. Use of the Li-containing metallurgical slag according to any one of claims 15 to 20 as slag former in a pyrometallurgical recycling process.

22. Use of the Li-containing metallurgical slag according to any one of claims 15 to 20 as slag former in the process according to any one of claims 1 to 14, thereby partially or fully replacing slag formers in the step of providing a charge comprising slag formers.

23. Use of the Li-containing metallurgical slag according to any one of claims 15 to 20 in a process for the recovery of lithium.

24. Li-containing metallurgical slag according to any one of claims 15 to 20, wherein

the slag further contains cobalt.

25. Use of the metallurgical slag according to claim 24 in a process for the recovery of cobalt.