Claims

1. A method of recovering titanium dioxide, aluminium sulphate and magnesium sulphate from a particulate material, said method comprising:
    a. contacting the particulate material with sulphuric acid and heating to form a sulphated mixture;
    b. filtering the sulphated mixture to produce a filter cake and a first permeate comprising sulphuric acid;
    c. contacting the filter cake with water to form a sulphated suspension comprising titanyl sulphate;
    d. filtering the sulphated suspension to produce a permeate comprising at least titanyl sulphate, and a retentate comprising insoluble residue;
    e. contacting the permeate comprising at least titanyl sulphate with water to produce a hydrolysis liquor; and
    f. hydrolysing the titanyl sulphate;
    g. separating titanium dioxide hydrate from the hydrolysis liquor to produce a permeate comprising aluminium sulphate and magnesium sulphate, and a retentate comprising titanium dioxide hydrate; and
    h. precipitating aluminium sulphate from the permeate;
    i. precipitating magnesium sulphate from the permeate;

    wherein step h. may be carried out after step d or after step g.
2. The method of claim 1 wherein the retentate comprising insoluble residue comprises at least one product selected from calcium sulphate and silica.
3. The method of claim 1 or 2 wherein the step of precipitating aluminium sulphate comprises:
    a. cooling the permeate from step d. or step g. to produce a cooled liquor comprising precipitated aluminium sulphate; and
    b. filtering the cooled liquor to produce a retentate comprising precipitated aluminium sulphate, and a permeate.
4. The method of claim 3 wherein the step of precipitating aluminium sulphate comprises cooling the permeate to between 10ºC and 4°C.
5. The method of any one of the preceding claims wherein the precipitation of magnesium sulphate comprises the steps of:
    a. increasing the acid concentration of the permeate comprising magnesium sulphate to form an acidified liquor; and

b. filtering the acidified liquor to produce a retentate comprising precipitated magnesium sulphate.

6. A method as claimed in claim 5 wherein the acid concentration of the permeate comprising magnesium sulphate is increased by the addition of sulphuric acid.
7. A method as claimed in claim 5 or 6 wherein the pH of the permeate comprising magnesium sulphate is reduced to less than approximately pH1 by the addition of sulphuric acid.
8. A method as claimed in any one of claims 5 to 7 wherein the acid concentration of the permeate comprising magnesium sulphate is increased by heating the permeate to remove water.
9. The method of any one of the preceding claims wherein the particulate material comprises greater than 8m% titanium dioxide, greater than 10m% aluminium oxide and greater than 10m% magnesium oxide.
10. The method of any one of the preceding claims wherein the particulate material comprises greater than 15m% titanium dioxide, greater than 10m% aluminium oxide and greater than 13m% magnesium oxide.
11. The method of any one of the preceding claims wherein the particulate material comprises a ratio of titanium dioxide to aluminium oxide (TiO_2:Al_2O_3) of approximately 0.2 to 2.6.
12. The method of any one of the preceding claims wherein the particulate material comprises a ratio of titanium dioxide to magnesium oxide (TiO_2:MgO) of approximately 0.5 to 3.0.
13. The method of any one of the preceding claims wherein the step of precipitating magnesium sulphate comprises:
    a. cooling the permeate comprising magnesium sulphate or the acidified liquor of claim 5 to produce a cooled liquor comprising magnesium sulphate; and
    b. filtering the cooled liquor comprising magnesium sulphate to produce a retentate comprising precipitated magnesium sulphate, and a permeate.
14. The method of claim 13 wherein the permeate or liquor is cooled to between 0°C and 4°C.
15. The method of any one of the preceding claims wherein the particulate material is selected from the group consisting of iron slag, melter slag, obtained from iron slag, obtained from melter slag, obtained from an iron manufacturing process, and obtained from a steel manufacturing process.
16. The method of any one of the preceding claims wherein the method further comprises the step of grinding raw material to form the particulate material of step a.
17. The method of claim 16 wherein the particulate material has a particle size between 10 to 180μm.
18. The method of any one of the preceding claims wherein the particulate material is contacted with 4-10 times its stoichiometric quantity of sulphuric acid.

19. The method of any one of the preceding claims wherein the step of filtering the sulphated mixture further comprises contacting the mixture with compressed air.
20. The method of claim 19 wherein the temperature of the compressed air is from 10ºC to 85ºC.
21. The method of any one of the preceding claims wherein the permeate comprising at least titanyl sulphate is heated to remove water and increase the free acidity.
22. The method of any one of the preceding claims wherein the hydrolysis liquor is contacted with water containing titanium dioxide particles.
23. A system for the recovery of products from a particulate material, the system comprising:
    a. a reactor adapted to receive and heat sulphuric acid and particulate material comprising at least titanium dioxide and produce a sulphated mixture;
    b. a first filtration unit adapted to receive the sulphated mixture and produce a first permeate comprising at least sulphuric acid, and a filter cake comprising at least titanyl sulphate;
    c. a reactor adapted to receive a solution comprising titanyl sulphate and heat said solution to produce a hydrolysis liquor;
    d. a separation unit adapted to receive the hydrolysis liquor and separate titanium dioxide hydrate.
    e. at least one precipitation tank to facilitate precipitation of aluminium sulphate; and
    f. at least one further filtration unit to facilitate separation of precipitated aluminium sulphate.
    g. at least one precipitation tank to facilitate precipitation of magnesium sulphate; and
    h. at least one further filtration unit to facilitate separation of precipitated magnesium sulphate.