

CLAIMS

1. An integrated process for carbon dioxide capture, sequestration and utilisation, which comprises:
 - a) providing an aqueous slurry comprising an aqueous solution and a particulate solid comprising an activated magnesium silicate mineral;
 - b) in a dissolution stage, contacting a CO₂-containing gas stream with the aqueous slurry to dissolve magnesium from the activated magnesium silicate mineral to provide a magnesium ion enriched aqueous solution and a magnesium depleted solid residue;
 - c) recovering at least a portion of the magnesium depleted solid residue;
 - d) in a separate acid treatment stage, reacting the recovered portion of the magnesium depleted solid residue with a solution comprising a mineral acid or acid salt to further dissolve magnesium and other metals and to provide an acid-treated solid residue;
 - e) recovering the acid-treated solid residue; and
 - f) in a separate precipitation stage, precipitating magnesium carbonate from the magnesium ion enriched aqueous solution.
2. An integrated process for carbon dioxide capture, sequestration and utilisation, which comprises:
 - a) providing an aqueous slurry comprising an aqueous solution and a particulate solid comprising an activated magnesium silicate mineral;

- b) in a first dissolution stage, contacting a CO₂-containing gas stream with the aqueous slurry to partially dissolve magnesium from the activated magnesium silicate mineral to provide a magnesium ion enriched aqueous solution and a magnesium depleted solid residue;
 - c) recovering the magnesium depleted solid residue and forming an aqueous slurry comprising an aqueous solution and the magnesium depleted solid residue;
 - d) in a subsequent dissolution stage contacting a CO₂-containing gas stream with the aqueous slurry comprising magnesium depleted solid residue to further dissolve magnesium from the magnesium depleted solid residue to provide a magnesium ion enriched aqueous solution and a further magnesium depleted solid residue;
 - e) recovering at least a portion of the further magnesium depleted solid residue;
 - f) in a separate acid treatment stage, reacting the recovered portion of the further magnesium depleted solid residue with a solution comprising a mineral acid or acid salt to further dissolve magnesium and other metals and to provide an acid-treated solid residue;
 - g) recovering the acid-treated solid residue; and
 - h) in a separate precipitation stage, precipitating magnesium carbonate from the magnesium ion enriched aqueous solution from the first and/or subsequent dissolution stage.
3. The integrated process according to claim 1 or 2, wherein the magnesium ion enriched aqueous liquid is produced by dissolving the activated magnesium silicate mineral in one or more reactors fed by an input CO₂-containing gas stream near, at

or above atmospheric pressure and thereafter, in a separate precipitation stage, inducing a pH shift in the liquid by the removal of dissolved CO₂ through the application of a partial vacuum or sub-atmospheric pressure to the liquid thereby precipitating the magnesium carbonate.

4. The integrated process according to claim 1 or 2, wherein the magnesium ion enriched aqueous liquid is produced by dissolving the activated magnesium silicate mineral in one or more reactors fed by an input CO₂-containing gas stream near, at or above atmospheric pressure and thereafter, in two or more separate precipitation stages, inducing a pH shift in the solution by the removal of dissolved CO₂ through the application of a partial vacuum or sub-atmospheric pressure in at least one of the precipitation stages thereby precipitating the magnesium carbonate.
5. The integrated process according to claim 3 or 4, wherein the removed carbon dioxide is recycled back to the dissolution stage.
6. The integrated process according to any one of claim 1 to 5, wherein the CO₂-containing gas stream comprises a flue gas from a hydrocarbon combustion process.
7. The integrated process according to any one of claim 1 to 6, wherein the magnesium depleted solid residue from a dissolution stage is subjected to a wet magnetic separation process to extract an iron-rich portion.
8. The integrated process according to any one of claims 1 to 7, wherein the pressure in each dissolution stage is in the range 100-20000 kPa and the temperature is in the range 20 °C-185 °C.
9. The integrated process according to any one of claims 1 to 8, wherein the mineral acid or acid salt used in the acid treatment stage is selected from HNO₃, H₂SO₄, HCl, NaHSO₄, HBr, HF, HI, HClO₄, H₃BO₃ and H₃PO₄.

10. The integrated process according to any one of claims 1 to 9, wherein the pressure in the acid treatment stage is in the range 100-200 kPa and the temperature is in the range 20 °C-120 °C.
11. The integrated process according to any one of claims 1 to 10, wherein the pH in the acid treatment stage is in the range 0 to 3.
12. The integrated process according to any one of claims 1 to 11, wherein the pH of an acid solution from the acid treatment stage is raised to a pH in the range 4 to 8.5 by the addition of base and precipitated silica is separated from the solution.
13. The integrated process according to claim 12, wherein the pH of the acid solution is raised by addition of a base while stirring at a temperature in the range 20 to 100 °C.
14. The integrated process according to claim 13, wherein dissolved metal species are precipitated out of the solution by selectively adjusting the solution pH by addition of base to recover the metal species as metal hydroxides.
15. The integrated process according to claim 14, wherein the metal hydroxides are converted to corresponding metal oxides through thermal hydrolysis or thermal decomposition or a combination thereof.
16. The integrated process according to any one of claims 1 to 11, wherein the pH of an acid solution from the acid treatment stage is lowered below pH 0 by the addition of mineral acid and precipitated silica is separated from the solution.
17. The integrated process according to claim 16, wherein the remaining acid solution after precipitation of the silica is recycled to the initial acid treatment step.
18. The integrated process according to claim 16 or 17, wherein the temperature of the acid solution having a pH below pH 0 is in the range 20 to 80 °C.
19. The integrated process according to any one of claims 1 to 18, wherein the silicate mineral is activated by grinding or heating or both.

20. A reactor system adapted to perform the processes of any one of claims 1 to 19, the reactor system comprising a dissolution vessel, a precipitation vessel and an acid treatment vessel.