Claims

1. A method for the production of sodium bicarbonate, the method comprising the steps of:
    a. treating a carbonaceous feedstock to form a product stream comprising up to 10 v/v% carbon dioxide;
    b. capturing at least a portion of the carbon dioxide from the product stream to form a carbon dioxide stream, wherein capturing the carbon dioxide from the product stream to form the carbon dioxide stream comprises the steps of:
        i. contacting the product stream with a solvent;
        ii. absorbing carbon dioxide from the product stream into the solvent to form a carbon dioxide enriched solvent; and
        iii. desorbing carbon dioxide from the carbon dioxide enriched solvent to form the carbon dioxide stream;
    c. feeding the carbon dioxide stream to a reaction vessel;
    d. feeding an aqueous sodium carbonate solution to the reaction vessel;
    e. contacting at least a portion of the carbon dioxide stream with at least a portion of the aqueous sodium carbonate solution to form a slurry comprising solid sodium bicarbonate; and
    f. separating the solid component of the slurry from the liquid component of the slurry to provide solid sodium bicarbonate and an aqueous liquor.

2. The method according to claim 1, wherein the concentration of carbon dioxide in the product stream according to step a is in the range of from 1-10 v/v%; such as in the range of from 2-9 v/v%, from 3-8 v/v%, from 4-7 v/v%, or from 5-6 v/v%.

3. The method according to claim 1 or 2, wherein treating the carbonaceous feedstock comprises combusting the carbonaceous feedstock, optionally wherein the combusting occurs in a combined heating and power plant ("CHP").

4. The method according to any preceding claim wherein the carbonaceous feedstock is a hydrocarbon feedstock, optionally wherein the hydrocarbon feedstock is natural gas.

5. The method according to any preceding claim wherein the step of treating the carbonaceous feedstock produces heat and wherein at least a portion of the heat is used to vaporise a first water stream to form a steam stream.

6. The method according to claim 5 wherein at least a portion of the steam stream is condensed to provide a first condensate stream, optionally wherein the process comprises supplying water from the first condensate stream to at least one of:
    a. the first water stream; and
    b. the aqueous sodium carbonate solution.

7. The method according to claim 5 or 6, wherein at least a portion of the steam stream is used to generate electricity, optionally wherein the electricity is used to power the apparatus for one or more of the subsequent process steps.

~~8. The method according to any preceding claim wherein capturing the carbon dioxide from the product stream to form the carbon dioxide stream comprises the steps of:~~

~~a. contacting the product stream with a solvent;~~

~~b. absorbing carbon dioxide from the product stream into the solvent to form a carbon dioxide enriched solvent; and~~

~~c. desorbing carbon dioxide from the carbon dioxide enriched solvent to form the carbon dioxide stream.~~

~~9.~~8. The method according to any preceding claim, ~~8~~ wherein the solvent comprises an alkanolamine, optionally wherein the alkanolamine is selected from: N-methyldiethanolamine (MDEA), 2-amino-2-methyl-1-proponal (AMP), 2-(diethylamino)-ethanol (DEAE), diisopropanolamine (DIPA), methylaminopropylamine (MAPA), 3-aminopropanol (AP), 2,2-dimethyl-1,3-propanediamine (DMPDA), 3-amino-1-cyclohexylaminopropane (ACHP), diglycolamine (DGA), 1-amino-2-propanol (MIPA), 2-methyl-methanolamine (MMEA), monoethanolamine, diglycolamine, and mixtures thereof.

~~10.~~9. The method according to any preceding claim ~~8 or 9~~, wherein desorbing carbon dioxide from the carbon dioxide enriched solvent comprises at least one of heating the solvent and subjecting the carbon dioxide enriched solvent to a reduced pressure.

~~11.~~10. The method according to claim ~~10~~9, wherein the step of treating the carbonaceous feedstock produces heat and at least a portion of the heat is used to vaporise a first water stream to form a steam stream, and wherein a portion of the steam stream is used to heat the solvent, optionally wherein the provision of heat to the solvent by the steam stream condenses at least a portion of the steam stream to form a second condensate stream.

~~12.~~11. The method according to claim ~~11~~10 wherein the second condensate stream provides water for at least one of:

a. the first water stream; and
b. the aqueous sodium carbonate solution.

~~13.~~12. The method according to any previous claim wherein following capture the carbon dioxide is liquefied.

~~14.~~13. The method according to any preceding claim wherein the carbon dioxide obtained following capture meets the following criteria:

a. a carbon dioxide content of at least 99.9 v/v%;
b. a moisture content of at most 20 ppm;
c. an ammonia content of at most 2.5 ppm;
d. an oxygen content of at most 30 ppm;
e. a nitric oxide content of at most 2.5 ppm;
f. an nitrogen dioxide content of at most 2.5 ppm;
g. a non-volatile residue (particulate) content of at most 10 ppm;
h. a non-volatile organic residue (oil and grease) content of at most 5 ppm;
i. a volatile hydrocarbon content (calculated as methane) of at most 50 ppm (of which at most 20 ppm may be non-methane hydrocarbons);
j. an acetaldehyde content of at most 0.2 ppm;
k. an aromatic hydrocarbon content of at most 0.02 ppm;

l. a carbon monoxide content of at most 10 ppm;
m. a methanol content of at most 10 ppm;
n. a carbonyl sulphide content of at most 0.1 ppm;
o. a hydrogen sulphide content of at most 0.1 ppm; and
p. a sulphur dioxide content of at most 1 ppm.

~~15.~~14. The method according to any preceding claim wherein the carbon dioxide stream fed to the reaction vessel has a carbon dioxide concentration in the range of from 20-90 v/v%; optionally in the range of from 25-80 v/v%, 30-70 v/v%, from 35-60 v/v%, from 35-55 v/v%, or from 40-45 v/v%; optionally wherein the remainder of the carbon dioxide stream comprises nitrogen or air.

~~16.~~15. The method according to claim ~~15~~14 wherein the carbon dioxide stream is formed prior to being fed into the reaction vessel by diluting the captured carbon dioxide with a diluent gas, optionally the diluent gas comprising nitrogen or air.

~~17.~~16. The method according to any preceding claim wherein the liquor comprises aqueous sodium bicarbonate and aqueous sodium carbonate.

~~18.~~17. The method according to claim ~~17~~16 wherein the liquor is heated to convert at least a portion of the aqueous sodium bicarbonate to aqueous sodium carbonate, carbon dioxide and water~~, or wherein the liquor is cooled to cause sodium bicarbonate to precipitate out of solution~~.

~~19.~~18. The method according to claim ~~18~~17 wherein the heat is provided by a portion of the steam stream, optionally wherein the provision of heat by the steam stream to the liquor condenses a portion of the steam stream to form a third condensate stream.

~~20.~~19. The method according to claim ~~19~~18 wherein the process comprises supplying water from the third condensate stream to at least one of:

a. the first water stream; and
b. the aqueous sodium carbonate solution.

~~21.~~20. The method according to any of claims ~~18~~17 to ~~20~~19 wherein at least a portion of the carbon dioxide produced by heating the liquor is collected to form a CO_2 off-gas.

~~22.~~21. The method according to claim ~~21~~20 wherein the CO_2 off-gas is cooled using a second water stream to produce a cooled carbon dioxide stream and a heated water stream, optionally wherein the process further comprises using at least a portion of the heated water stream to form the first water stream.

~~23.~~22. The method according to any preceding claim wherein at least a portion of any residual carbon dioxide which does not react with the aqueous sodium bicarbonate solution in the reaction vessel is formed into a carbon dioxide waste stream.

~~24.~~23. The method for the production of sodium bicarbonate according to any preceding claim, wherein carbon dioxide from at least one of:

a. the cooled carbon dioxide stream according to claim ~~22~~21; and
b. the carbon dioxide waste stream according to claim ~~23~~22

is recycled by feeding it into the reaction vessel.