oxide to accomplish the reaction, which allows the process to be forced-to-remain in stoichiometric balance, and operate as an industrial process, will benefiting from the portion of low-energy-hydroxide/chloride production of the passive process, for all local/available minerals, oxides, and wastes (e.g. ash, slags, dusts) that can source that process.

[0007] In this regard, a method for capturing carbon dioxide from a gas stream and sequestering the carbon dioxide in the form of calcium carbonate is disclosed herein. The method comprises a first step of decomposing a magnesium chloride-containing material to form a first mixture comprising magnesium hydroxide and a second mixture comprising gaseous hydrogen chloride and water, a second step of combining calcium oxide with a magnesium chloride brine to produce a third mixture comprising magnesium hydroxide and calcium chloride, a third step of combining the first and third mixtures to provide a fourth mixture comprising magnesium hydroxide and calcium chloride, and a fourth step of contacting the fourth mixture with carbon dioxide to produce a product mixture comprising calcium carbonate and an aqueous solution of magnesium chloride. In one aspect, the present disclosure relates to a method for capturing CO_2 from a gas stream and sequestering the CO_2 in the form of $CaCO_3$, the method comprising: (a) decomposing a $MgCl_2$-containing material to form a first mixture comprising $Mg(OH)_2$ and a second mixture comprising HCl and H_2O; (b) combining CaO with a $MgCl_2$ brine to produce a third mixture comprising $Mg(OH)_2$ and $CaCl_2$; (c) combining the first and third mixtures to provide a fourth mixture comprising $Mg(OH)_2$ and $CaCl_2$; and (d) contacting the fourth mixture with CO_2 to produce a product mixture comprising $CaCO_3$ and an aqueous solution of $MgCl_2$. In some examples, substantially no heat is provided as an input for the second step. In some examples, the calcium carbonate is a solid precipitate and is separated from the aqueous solution of magnesium chloride. In some examples, the aqueous solution of magnesium chloride is de-watered to provide a magnesium chloride-containing material. The aqueous solution of magnesium chloride can be de-watered to provide a magnesium chloride hydrate, for example.

[0008] In some examples, the fourth mixture comprises approximately equal amounts of the magnesium hydroxide produced in the first step and the magnesium hydroxide produced in the second step. In some examples, the magnesium hydroxide in the fourth mixture comprises a weight to weight ratio of magnesium hydroxide produced in the first step to magnesium hydroxide produced in the second step of any one of, less than, greater than, between, or any range thereof of 1:99, 2:98, 3:97, 4:96, 5:95, 6:94, 7:93; 8:92, 9:91, 10:90, 11:89, 12:88, 13:87, 14:86, 15:85, 16:84, 17:83, 18:82, 19:81, 20:80, 21:79, 22:78, 23:77,

24:76, 25: 75, 26:74, 27:73, 28:72, 29:71, 30:70, 31:69, 32:68, 33:67, 34:66, 35:65, 36:64, 37:63, 38:62, 39:61 40:60, 41:59, 42:58, 43:57, 44:56, 45:55, 46:54, 47:53, 48:52, 49:51, 50:50, 51:49, 52:48, 53:47, 54:46, 55:45, 56:44, 57:43, 58:42, 59:41, 60:40, 61:39, 62:38, 63:37, 64:36, 65:35, 66:34, 67:33, 68:32, 69:31, 70:30, 71:29, 72:28, 73:27, 74:26, 75:25, 76:24, 77:23, 78:22, 79:21, 80:20, 81:19, 82:18, 83:17, 84:16, 85:15, 86:14, 87:13, 88:12, 89:11, 90:10, 91:9, 92:8, 93:7, 94:6, 95:5, 96:4, 97:3, 98:2, and 99:1.

[0009] In some examples, the magnesium chloride-containing material is a magnesium chloride hydrate. The magnesium chloride hydrate can comprise magnesium chloride dodecahydrate, octahydrate, hexahydrate, tetrahydrate, dihydrate, and combinations thereof. In some examples, the magnesium chloride hydrate comprises magnesium chloride tetrahydrate or magnesium chloride dihydrate. In some examples, the magnesium chloride hydrate comprises 2.0-2.1 molar equivalents of waters of hydration. All of these forms of magnesium chloride can be used for both forced decomposition and passive dissolution methods to produce magnesium hydroxide and a corresponding chloride-of-the-metal-oxide used. Passive dissolution can be accomplished in brines of magnesium chloride; forced-decomposition can be accomplished only with the crystal forms of magnesium chloride. This elimination of the energy required to crystallize and decomposes the magnesium-chloride salt (as the passive dissolution steps are spontaneous and do not require these energies) is a major contributor to the low-energy combination of the two processes in supplied precursor chemicals to the SkyCycle process.

[0010] In some examples, the first mixture comprises substantially no magnesium hydroxychloride. In some examples, the first mixture comprises substantially no magnesium oxide. In some examples, the magnesium chloride-containing material that is decomposed in the first step comprises at least a portion of the magnesium chloride produced in the fourth step.

[0011] In some examples, a calcium-containing mineral or industrial material is contacted with an acid to produce calcium oxide. In some examples, the calcium-containing mineral is selected from the group consisting of alite, jaffeite, perlite, vermiculite, diopside, tremolite, combinations thereof, or any other calcium-containing silicate mineral. In some examples the calcium-containing industrial material comprises masonry, concrete, steel furnace slag, bio-mass fuel production slag, waste coal fly ash, combinations thereof, and other mineral-containing waste materials. In some examples, the acid is selected from the group consisting of hydrochloric acid, sulfuric acid, and nitric acid. In some examples, at least a portion of the acid used to dissolve the calcium-containing mineral or industrial material is obtained from the decomposition of the magnesium chloride-containing material. In some examples, the CaO produced from dissolution of a calcium-containing mineral or waste material is used as an input for the second step.

[0012] It is specifically contemplated that any limitation discussed with respect to one example of the disclosure may apply to any other example of the disclosure. Furthermore, any composition of the disclosure may be used in any method of the disclosure,

and any method of the disclosure may be used to produce or to utilize any composition of the disclosure.

[0013] Other objects, features and advantages of the present disclosure will become apparent from the following detailed description. It should be understood, however, that the detailed description and the specific examples, while indicating preferred examples of the disclosure, are given by way of illustration only, since various changes and modifications within the spirit and scope of the disclosure will become apparent to those skilled in the art from this detailed description.

DETAILED DESCRIPTION

A. Definitions

[0014] As used herein, the terms "carbonates" or "carbonate products" are generally defined as mineral components containing the carbonate group, $[CO_3]^{2-}$. Thus, the terms encompass both carbonate/bicarbonate mixtures and species containing solely the carbonate ion. The terms "bicarbonates" and "bicarbonate products" are generally defined as mineral components containing the bicarbonate group, $[HCO_3]^{1-}$. Thus, the terms encompass both carbonate/bicarbonate mixtures and species containing solely the bicarbonate ion.

[0015] As used herein "Ca/Mg" signifies either Ca alone, Mg alone or a mixture of both Ca and Mg. The ratio of Ca to Mg may range from 0:100 to 100:0, including, e.g., 1:99, 2:98, 3:97, 4:96, 5:95, 6:94, 7:93; 8:92, 9:91, 10:90, 11:89, 12:88, 13:87, 14:86, 15:85, 16:84, 17:83, 18:82, 19:81, 20:80, 21:79, 22:78, 23:77, 24:76, 25: 75, 26:74, 27:73, 28:72, 29:71, 30:70, 31:69, 32:68, 33:67, 34:66, 35:65, 36:64, 37:63, 38:62, 39:61 40:60, 41:59, 42:58, 43:57, 44:56, 45:55, 46:54, 47:53, 48:52, 49:51, 50:50, 51:49, 52:48, 53:47, 54:46, 55:45, 56:44, 57:43, 58:42, 59:41, 60:40, 61:39, 62:38, 63:37, 64:36, 65:35, 66:34, 67:33, 68:32, 69:31, 70:30, 71:29, 72:28, 73:27, 74:26, 75:25, 76:24, 77:23, 78:22, 79:21, 80:20, 81:19, 82:18, 83:17, 84:16, 85:15, 86:14, 87:13, 88:12, 89:11, 90:10, 91:9, 92:8, 93:7, 94:6, 95:5, 96:4, 97:3, 98:2, and 99:1. The symbols "Ca/Mg", "$Mg_xCa_{(1-x)}$" and "$Ca_xMg_{(1-x)}$" are synonymous. The phrases "Group II" and "Group 2" are used interchangeably. A hydrate of magnesium chloride refers to any hydrate, including but not limited to hydrates that have 2, 4, 6, 8, or 12 equivalents of water per equivalent of magnesium chloride. Based on the context, the abbreviation "MW" either means molecular weight or megawatts. The abbreviation "PFD" is process flow diagram. The abbreviation "Q" is heat (or heat duty), and heat is a type of energy. This does not include any other types of energy.