(12) STANDARD PATENT (11) Application No. **AU 2017306576 B2**
(19) AUSTRALIAN PATENT OFFICE

(54) Title
Caustic digestion process

(51) International Patent Classification(s)
C22B 26/12 (2006.01) ***C22B 3/12*** (2006.01)

(21) Application No: **2017306576** (22) Date of Filing: **2017.08.02**

(87) WIPO No: **WO18/023159**

(30) Priority Data

(31) Number	(32) Date	(33) Country
2016903041	**2016.08.02**	**AU**

(43) Publication Date: **2018.02.08**
(44) Accepted Journal Date: **2019.12.12**

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(56) Related Art
CN 104003428 A
US 3112170 A
CN 103990217 A

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
08 February 2018 (08.02.2018)

WIPO | PCT

(10) International Publication Number
WO 2018/023159 A1

(51) International Patent Classification:
C22B 26/12 (2006.01) *C22B 3/12* (2006.01)

(21) International Application Number:
PCT/AU2017/050808

(22) International Filing Date:
02 August 2017 (02.08.2017)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
2016903041 02 August 2016 (02.08.2016) AU

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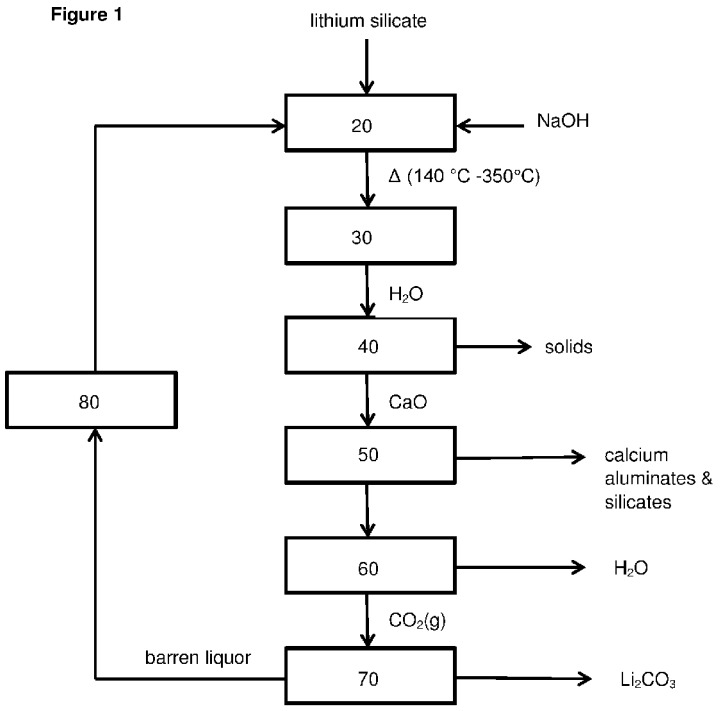
(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH,

WO 2018/023159 A1

(54) Title: CAUSTIC DIGESTION PROCESS

Figure 1



(57) Abstract: The present disclosure provides a process for extracting and recovering lithium values from a lithium-bearing material, in particular from lithium-bearing silicates such as spodumene and lepidolite. The process for extracting lithium values from the lithium-bearing material includes heating a mixture of the lithium-bearing material and a caustic solution up to 350 °C. The mixture may be heated in a range of 200 °C to 300 °C in an autoclave. Alternatively, the mixture may be baked at a temperature in a range of 250 °C to 350 °C at atmospheric pressure. The heated mixture is then diluted and aluminates and silicates from the diluted heated mixture are removed to produce a pregnant lithium solution. The pregnant lithium solution may be evaporated to increase the lithium concentration thereof and lithium carbonate and/or lithium hydroxide are recovered from the evaporated pregnant lithium solution.

[Continued on next page]

GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

"Caustic digestion process "

Technical Field

[0001] The present disclosure relates to a caustic digestion process for recovering lithium values from lithium-bearing materials. In particular, the present disclosure relates to a caustic digestion process for recovering lithium carbonate and/or lithium hydroxide from lithium-bearing silicates.

Background

[0002] Global supply of lithium is currently sourced from brines or hard rock deposits.

[0003] In the former, lithium is concentrated as soluble salts by solar evaporation. Lithium produced from brines is generally of a low grade and, while the capital input for brine production is high, operating costs are low.

[0004] In the case of hard rock deposits conventional mining and beneficiation techniques are used to produce high grade spodumene concentrate. It is possible to obtain lithium chemicals of technical, battery grade (99.5%) or high-purity (>99.9%) lithium carbonate from various acid-roasting and lime-roasting processes.

[0005] The acid-roasting method involves firstly decrepitation (at 1070–1090 °C) to convert α-spodumene to the more reactive β-structure, followed by sulphation using sulphuric acid at 250 °C and water leaching of the calcine at 90 °C to extract lithium into solution. The lime-roasting process, on the other hand, relies on the roasting of spodumene and lime at 1030–1040 °C before water-leaching the clinker produced to recover lithium. Other routes used to extract lithium from spodumene via pressure leaching with soda ash or chlorination roasting have also been proposed.

[0006] All of these processes involve a roasting step with significant reagent consumption prior to leaching. The high energy cost associated with roasting low-grade lithium concentrates has proven uneconomic.

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[0007] There is therefore a need for alternative or improved processes to recover lithium from silicate materials.

[0008] It is to be understood that, if any prior art publication is referred to herein, such reference does not constitute an admission that the publication forms a part of the common general knowledge in the art, in Australia or any other country.

Summary

[0009] The present disclosure provides a process for extracting lithium values from a lithium-bearing material, in particular from lithium-bearing silicates such as spodumene and lepidolite. The present disclosure also provides a process for recovering lithium values as lithium carbonate and/or lithium hydroxide from a lithium-bearing material, in particular a lithium-bearing silicate.

[0010] According to a first aspect of the disclosure, there is provided a process for extracting lithium values from a lithium silicate comprising the steps of:

a) heating a mixture of the lithium silicate and a concentrated sodium hydroxide solution with a concentration in a range of 40-80 wt% up to 350 °C;

b) diluting the heated mixture from step a); and

c) removing aluminates and silicates from the diluted heated mixture from step b) to produce a pregnant lithium solution.

[0011] In an alternative embodiment, heating said mixture comprises baking said mixture at a temperature in a range of 250 °C to 350 °C at atmospheric pressure.

[0012] In an alternative embodiment, heating said mixture comprises heating in a range of 200 °C to 300 °C in an autoclave.

[0013] In one embodiment, the heated mixture from step a) is diluted to 5-20% w/w caustic strength.

[0014] In one embodiment, removing aluminates and silicates from the diluted heated mixture from step c) comprises adding lime to the diluted heated mixture in an

amount sufficient to produce calcium aluminate and calcium silicate solids and separating said solids therefrom.

[0015] According to another aspect of the disclosure, there is provided a process for recovering lithium values from a lithium-bearing silicate comprising the steps of:
a) extracting lithium values from a lithium-bearing material to produce a pregnant lithium solution according to the steps defined in the first aspect of the disclosure;
b) evaporating the pregnant lithium solution to increase a lithium concentration thereof; and,
c) recovering lithium carbonate and/or lithium hydroxide from the evaporated pregnant lithium solution.

[0016] In one embodiment, recovering lithium carbonate comprises contacting the evaporated pregnant lithium solution with carbon dioxide to produce lithium carbonate solids and a barren lithium solution.

[0017] In an alternative embodiment, recovering lithium hydroxide comprises lowering the temperature of the evaporated pregnant lithium solution to produce lithium hydroxide solids and a barren lithium solution. The barren lithium solution may be further treated with carbon dioxide to recover lithium carbonate therefrom.

[0018] Said solids may be separated from the barren lithium solution. In one embodiment the barren lithium solution may be recycled by mixing with the mixture of lithium-bearing material and caustic in step a). Further by-products, such as potassium hydroxide, may be produced from the barren lithium solution prior to recycling said solution to step a)

[0019] In one embodiment, evaporating the pregnant lithium solution increases the lithium concentration thereof to 8-10 g/L.

Brief Description of Drawings

[0020] Notwithstanding any other forms which may fall within the scope of the process as set forth in the Summary, specific embodiments will now be described, by way of example only, with reference to the accompanying figures in which:

[0021] Figure 1 is a process flow sheet depicting a process for recovery of lithium carbonate from lithium-bearing silicates.

Description of Embodiments

[0022] The present invention is described in the following various non-limiting embodiments, which relate to a process for recovering lithium values, in particular lithium carbonate or lithium hydroxide, from lithium-bearing materials such as lithium-bearing silicates.

GENERAL TERMS

[0023] Throughout this specification, unless specifically stated otherwise or the context requires otherwise, reference to a single step, composition of matter, group of steps or group of compositions of matter shall be taken to encompass one and a plurality (i.e. one or more) of those steps, compositions of matter, groups of steps or groups of compositions of matter. Thus, as used herein, the singular forms "a", "an" and "the" include plural aspects unless the context clearly dictates otherwise. For example, reference to "a" includes a single as well as two or more; reference to "an" includes a single as well as two or more; reference to "the" includes a single as well as two or more and so forth.

[0024] Each example of the present disclosure described herein is to be applied mutatis mutandis to each and every other example unless specifically stated otherwise. The present disclosure is not to be limited in scope by the specific examples described herein, which are intended for the purpose of exemplification only. Functionally-equivalent products, compositions and methods are clearly within the scope of the disclosure as described herein.

[0025] The term "and/or", e.g., "X and/or Y" shall be understood to mean either "X and Y" or "X or Y" and shall be taken to provide explicit support for both meanings or for either meaning.

[0026] Throughout this specification the word "comprise", or variations such as "comprises" or "comprising", will be understood to imply the inclusion of a stated

element, integer or step, or group of elements, integers or steps, but not the exclusion of any other element, integer or step, or group of elements, integers or steps.

[0027] It will be clearly understood that, although a number of prior art publications are referred to herein, this reference does not constitute an admission that any of these documents forms part of the common general knowledge in the art, in Australia or in any other country.

[0028] Unless otherwise defined, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. Although methods and materials similar or equivalent to those described herein can be used in the practice or testing of the present invention, suitable methods and materials are described below. In case of conflict, the present specification, including definitions, will control. In addition, the materials, methods, and examples are illustrative only and not intended to be limiting.

SPECIFIC TERMS

[0029] The term "lithium-bearing material" as used herein refers to any lithium containing substance. The term may be used predominantly to refer to naturally occurring minerals that contain lithium values, including but not limited to silicates, fluorophosphates, boro-silicates, aluminium silicates, phosphates such as amblygonite, lithium-containing micas, and lithium-containing clays.

[0030] It will be appreciated by those skilled in the art that the lithium-bearing material may comprise one or more naturally occurring lithium minerals because they frequently occur together, for example in pegmatite bodies. Several metals, such as Mn, Rb and Cs, and other minerals such as quartz, albite, feldspar, topaz and beryl may also be associated with these lithium minerals. Accordingly, the term "lithium-bearing material" encompasses high grade ores and concentrates as well as medium to low grade ores, concentrates and blends thereof.

[0031] The term "lithium bearing silicate" as used herein refers to a concentrate, ore, or tailings derived from one or more silicate minerals containing lithium values. Exemplary lithium bearing silicates include, but are not limited to, jadarite, spodumene

and other pyroxenes, trilithionite, petalite and other lithium-bearing silicates from the nepheline group of minerals, holmquistite and other lithium-bearing silicates from the amphibole group of minerals, lepidolite, zinwaldite, elbaite and other tourmalines, chlorites, smectites, lithium-containing micas, and lithium-containing clays.

[0032] A reference to 'g/kg' or 'kg/t' throughout the specification refers to the mass of a substance per kilogram or tonne, respectively, of the lithium-bearing material.

PROCESS FOR EXTRACTING LITHIUM VALUES

[0033] The process for extracting lithium values from lithium-bearing materials, as described herein, is particularly suited to lithium bearing silicates. Lithium extraction achieved by the process may be > 85%, > 90%, > 95%, or even > 98%.

[0034] Prior to undergoing the processes described herein, the lithium-bearing material may be ground and milled to P_{100} <160 µm. In certain embodiments the lithium-bearing material may have a particle size with P_{80} in a range of 20-160 µm, 40-100 µm, or in the range of 40-50 µm. The lithium-bearing material may be ground and milled to the desired particle size by conventional techniques well known in the art in a dry milling process or a wet milling process.

[0035] The process for extracting lithium values from a lithium-bearing material comprising the steps of:

a) heating a mixture of the lithium-bearing material and a caustic solution up to 350 °C;

b) diluting the heated mixture from step a); and

c) removing aluminates and silicates from the diluted heated mixture from step b) to produce a pregnant lithium solution.

[0036] The term 'caustic solution' as used herein generally refers to aqueous sodium hydroxide solutions but may also comprise aqueous hydroxide solutions having one or more types of counter-cations including, but not limited to, potassium or magnesium. In a preferred embodiment, the caustic solution is a concentrated sodium hydroxide (NaOH) solution with a concentration in a range of 40-80 wt%, 40-60 wt% or 40-50 wt%.

[0037] The resulting mxiture may be stirred or mechanically agitated during the heating step.

[0038] The mixture may be heated for a period of time sufficient to achieve a particular level of extraction of lithium values. The time required for the extraction depends upon the mineralogy and particle size of the lithium-bearing material, the concentration of the caustic solution, the solids density of the mixture, and the temperature conditions.

[0039] It will be appreciated by those skilled in the art that, other things being equal, the higher the temperature, the shorter the reaction time to achieve the desired level of extraction.

[0040] Generally, the mixture may be heated for a period from 1 h to 6 h, in particular 1 h to 2 h.

[0041] The process may be carried out in either a batch mode or a continuous mode. The particular choice of operation will depend upon a residence time necessary to extract the desired amount of lithium values.

[0042] In various embodiments, the lithium-bearing material may be mixed with the caustic solution to produce a mixture having a solids content in a range of from 10-50 wt%, preferably from 10-25 wt% or from 40-50 wt%.

[0043] Mixtures having a solids content at the low end of the range (10-25 wt%) may undergo 'caustic digestion' in an autoclave, whereas mixtures having a solids content at the higher end of the range (40-50 wt%) may undergo a 'caustic bake' at atmospheric pressure.

[0044] In some embodiments, the mixture having a solids content of 10-40 wt% may be heated in an autoclave at a temperature in a range of 200 °C to 300 °C for a period of 1 to 6 hours. For example about 99% extraction of lithium could be achieved by heating the mixture in an autoclave at ~240 °C for 2-4 h with at least 2800 kg/t caustic.

[0045] Alternatively, in other embodiments, the mixture having a solids content of 40-50 wt% may be baked at a temperature in a range of 250 °C to 350 °C at atmospheric pressure for a period of 1 to 6 hours. In this particular embodiment, extraction of > 90% of lithium from lithium silicates such as spodumene and lepidolite (P_{90} ~45 µm) may be achieved after 1-2 h at 300 °C using excess of caustic from between 2600 kg/t to 4800 kg/t.

[0046] The resulting heated mixture may then be diluted to 5- 20% w/w with respect to caustic solution concentration.

[0047] The resulting slurry may then undergo a conventional separation technique to separate solids from liquids. Suitable conventional separation techniques include, but are not limited to, filtration, gravity separation, centrifugation and so forth. It will be appreciated by those skilled in the art that additives such as clarifying agents and/or thickeners may be mixed into the resulting slurry prior to separating solids from liquids to facilitate efficient separation thereof.

[0048] It will be appreciated by the person skilled in the field, that one or more impurities may be co-dissolved with lithium in the separated liquid. The term "impurities" as used herein refers to a metal value, other than lithium, contained in the lithium-bearing material which is capable of dissolving under the same process conditions. Examples of typical metal values, other than lithium, include but are not limited to K, Na, Cs, Rb, Si, Al and Fe.

[0049] Soluble aluminates and silicates present in the separated liquid are then removed therefrom by treating the separated liquid with an excess of lime to precipitate calcium aluminates, calcium silicates and calcium aluminosilicates out of solution and produce a pregnant lithium solution. The precipitates are removed by a conventional separation technique, as described above.

PROCESS FOR RECOVERING LITHIUM VALUES FROM LITHIUM-BEARING MATERIALS

[0050] After extracting the lithium values from the lithium-bearing material as described in the foregoing paragraphs, lithium values may be subsequently recovered from the lithium-bearing solution as lithium carbonate or lithium hydroxide.

[0051] In addition to removing calcium aluminates, calcium silicates and calcium aluminosilicates, in some embodiments the pregnant lithium solution may be passed through an ion exchange resin to remove soluble calcium therefrom.

[0052] The pregnant lithium solution is then evaporated to increase a lithium concentration thereof. The lithium concentration may be increased from 1.5 -2 g/L to 8-10 g/L or above. Evaporation of the pregnant lithium solution may be performed by boiling the pregnant lithium solution or by passing the pregnant lithium solution through an evaporator operating at reduced pressure.

[0053] Lithium carbonate may be recovered from the pregnant lithium solution having increased lithium concentration by contacting said pregnant lithium solution with carbon dioxide to produce lithium carbonate solids and a barren lithium solution. In some embodiments, said pregnant lithium solution is sparged with carbon dioxide at a steady rate of about 0.8 L/min. The temperature of said pregnant lithium solution may be in the range of 90 °C -100 °C.

[0054] The resulting lithium carbonate solids may be separated from the resulting barren lithium solution by conventional separation techniques described in the preceding paragraphs.

[0055] In an alternative embodiment, lithium hydroxide may be recovered from the pregnant lithium solution having increased lithium concentration by lowering the temperature of said pregnant lithium solution to produce lithium hydroxide solids and a barren lithium solution. Typically, said pregnant lithium solution may be cooled to about 10 °C to encourage precipitation of lithium hydroxide solids. The barren lithium solution may be further treated with carbon dioxide as described above to recover lithium carbonate therefrom.

[0056] Alternatively, the barren lithium solution may be recycled by mixing with the caustic solution and lithium-bearing material.

[0057] It will be appreciated that the lithium carbonate solids may be sold as is or further refined to produce a higher purity lithium carbonate or lithium hydroxide.

[0058] In the claims which follow and in the preceding description of the invention, except where the context requires otherwise due to express language or necessary implication, the word “comprise” or variations such as “comprises” or “comprising” is used in an inclusive sense, i.e. to specify the presence of the stated features but not to preclude the presence or addition of further features in various embodiments of the invention.

[0059] It will be appreciated by persons skilled in the art that numerous variations and/or modifications may be made to the above-described embodiments, without departing from the broad general scope of the present disclosure. The present embodiments are, therefore, to be considered in all respects as illustrative and not restrictive.

Examples

[0060] The invention is further illustrated by the following examples with reference to the figure. The examples are provided for illustrative purposes only. They are not to be construed as limiting the scope or content of the invention in any way.

Example 1a. Caustic Digestion - Lepidolite

[0061] Four samples (CL-1, CL-2, CL-3 and CL-4) of lepidolite (P_{80} 157 µm) were mixed (20) with a sodium hydroxide solution of different concentrations to provide a mixture having a solids content of 10 wt%.

[0062] Samples CL-1 and CL-2 were heated (30) to 148-154 °C for 6 hours at atmospheric pressure in conventional baffle reactors and samples CL-3 and CL-4 were heated to 220 °C and 240 °C, respectively for 4 hours in an autoclave at vapour

pressure ('caustic digestion'). The operating conditions of the caustic digestion tests together with the resulting metal extraction results are provided in Table 1.

[0063] Atmospheric caustic digestion of samples CL-1 and CL-2 showed extraction up to ~50% Li.

[0064] With respect to samples CL-3 and CL-4 which underwent caustic digestion under autoclave conditions, high extraction of lithium (99%) was achieved in CL-4, along with all other alkali metals such as K, Rb and Cs. The concentration profile for Li throughout the test for CL-3 showed that during the initial stages, the concentration of Li reached ~2200 mg/L, however the concentration of Li in solution progressively decreased to ~1400 mg/L, together with a decrease in both Al and Si concentrations. This suggests that Li was re-precipitated with silicon in this test.

Example 1b. Caustic Digestion - Spodumene

[0065] The extraction of Li from spodumene was by caustic digestion under autoclave conditions of elevated temperature and pressure (vapour pressure only) with a 4 h residence time was examined, under similar conditions to that undertaken for lepidolite.

[0066] The extraction of Li from spodumene with P_{80} 76 µm was 77% which was significantly greater than for spodumene with P_{80} 100 µm (40-57%).

Example 2. Caustic baking

[0067] The extraction of Li from lepidolite ore (P_{80} 157 µm) was examined in two (2) sighter tests CB-1 and CB-2 using an excess of caustic at below and above the melting pint (m.p.~330 °C) of caustic. A summary of the results from these two tests is presented in Table 2.

[0068] Extraction of Li was observed to increase with an increase in baking temperature over 1 h from 68% at 250 °C to 86% at 350 °C. The more aggressive conditions, where the caustic melts and a typical 'fusion' occurs, increased the overall extraction of the major elements.

[0069] The resulting heated mixtures were then diluted (40) to 20 wt% with respect to caustic strength with subsequent separation of solids and liquids.

Example 3. Impurity Removal

[0070] Aluminium and Si solubilised during caustic digestion (or caustic baking) can be removed by the addition of lime ('liming out') to precipitate calcium aluminate and calcium silicate. A series of sighter Al and Si removal tests were undertaken using liquors from Tests CL-1 (atmospheric digestion). A summary of the tests undertaken and the results are presented in Table 3.

[0071] An excess of lime ranging from about 30 g/L feed to 150 g/L feed was added (50) into the separated liquid to remove Al and Si as calcium aluminate and calcium silicate precipitates. About 50% of the Al and Si impurities were removed as separated solids, leaving a pregnant lithium solution.

[0072] The lithium concentration of the pregnant lithium solution was increased to 8-10 g/L by evaporation (60).

Example 4. Lithium Carbonate Precipitation

[0073] Lithium carbonate was precipitated (70) from the evaporated pregnant lithium solution at 90 °C to 100 °C by introducing a steady stream of carbon dioxide to said at a rate of about 0.8 L/min.. The introduced carbon dioxide was almost completely absorbed by the pregnant lithium solution (which is highly caustic) so that almost no bubbling was observed.

[0074] Approximately 70% of lithium was precipitated as lithium carbonate under these conditions (see Table 4). The final concentration of lithium in the pregnant lithium solution is dependent on the caustic strength. This demonstrates the importance of operating at the highest lithium concentration in the feed to lithium carbonate precipitation.

[0075] The purity of the lithium carbonate produced was 98% with major impurities being KOH, NaOH and Si (presumably as silicate). The lithium carbonate may be

used as a feed to either a further refining step to produce high purity lithium carbonate or in a lithium hydroxide conversion process.

[0076] The barren liquor is recycled (80) back into the autoclave in order to minimise lithium losses.

Summary of Caustic Digestion Sighter Test Work – Lepidolite

Test	CL-1			CL-2			CL-3			CL-4		
Type	Atmospheric						Autoclave					
P_{80} M/C	157											
Temperature	148-154°C						220			240		
Residence Time	6			6			4			4		
Initial Solids	10			10			10			10		
Initial NaOH	60			50			60			40		
NaOH Addn. (kg/t	5400			4482			5396			3605		
NaOH Stoich. Consump. (kg/t	900											
NaOH Consump.* (kg/t	388			264			638			641		
Caustic Diln. (L/kg	5.0			5.8			-			-		
Mass Loss	30			30			65			63		
Element	Feed	Residue	PF	Extraction	Residue	PF	Extraction	Residue	PF	Extraction	Residue	PF	Extraction
	(wt%)	(wt%)	(mg/L)	(%)	(wt%)	(mg/L)	(%)	(wt%)	(mg/L)	(%)	(wt%)	(mg/L)	(%)
Al	14.9	16.15	2311	16	15.53	2177	22	11.90	9385	34	16.52	2355	15
Ca	**0.001**	**0.001**	15	0	**0.001**	13	0	**0.001**	10	0	**0.001**	**10**	0
Cs	0.281	0.138	0	64	0.240	0	36	0.002	0	98	0.003	0	99
Fe	0.031	0.182	315	0	0.032	21	23	0.036	13	0	0.021	13	-16
K	7.22	3.649	5395	63	6.569	2297	32	0.043	14071	100	0.043	12695	100
Li	1.790	0.899	998	63	0.635	461	74	0.888	778	63	0.020	2552	99
Mg	**0.010**	**0.010**	7	0	0.005	**10**	0	**0.010**	10	0	**0.010**	**10**	63
Mn	0.403	0.239	241	0	0.373	87	0	0.393	84	0	0.170	336	75
Na	0.400	9.809	270700	0	2.419	213400	0	22.59	405500	0	20.79	297700	0
Rb	1.74	1.281	0	46	1.758	0	25	0.016	0	100	0.009	0	100
S	**0.001**	0.006	**100**	0	0.004	**100**	0	**0.001**	10	0	**0.001**	**100**	0
Si	23.6	19.73	8879	38	22.36	5905	29	17.89	17894	45	17.08	16874	45
F	nd	-	36	-	-	43	-	-	0	-	-	1520	-

Table 1

Summary of Caustic Bake Sighter Test Work – Lepidolite

Test #		LA-CB01			LA-CB02		
Caustic Bake							
Bake Time (h)		1			1		
Bake Temperature (°C)		250			350		
NaOH Addn. (kg/t ore)		2611			2597		
NaOH Consump. (kg/t ore)		324			890		
Mass Gain Bake (%)		263			240		
Water Leach							
Leach Time (min./wash)		20			20		
Temperature (°C)		60			60		
Wash Type		Repulp					
Wash Number		4					
Wash Ratio (~L/kg/wash)		6					
Total Wash Ratio (L/kg)		24			24		
Mass Loss Leach (%)		77			75		
Mass Loss Overall (%)		15			16		
Element	**Feed**	**Leach Residu**	**PF**	**Extraction**	**Leach Residu**	**PF**	**Extraction**
	(wt%)	(wt%)	(mg/L)	(%)	(wt%)	(mg/L)	(%)
Al	14.9	15.59	1849	12	15.82	983	11
Cs	0.281	0.18	271	45	0.194	nd	42
K	7.22	2.30	11150	73	0.99	13460	88
Li	1.790	0.68	2180	68	0.292	2560	86
Mn	0.403	0.30	186	38	0.438	**10**	9
Rb	1.74	0.86	4133	58	0.384	nd	81
Si	23.6	20.09	10880	28	17.98	14420	36

Table 2

Summary of Caustic Impurity Removal Sighter Test Work

Test		**CR-1**			**CR-2**					
Feed Liquor		CL1 PF								
Temperature (°C)		85			90					
Cumulative Residence Time (h)		3			1		2		3	
Lime Addition. (g/L feed)		80			33		58		141	
Lime Addition. (kg/kg LC feed)		15			6.2		11		26	
Dilution (~%)		-			100					
[Na] (g/L feed)		271			125		129		130	
Element	**Feed**	**Residue**	**PF**	**Precip.**	**PF**	**Precip.**	**PF**	**Precip.**	**PF**	**Precip.**
	(mg/L)	(wt%)	(mg/L)	(%)	(mg/L)	(%)	(mg/L)	(%)	(mg/L)	(%)
Al	2311	0.128	2378	4	788	29	633	43	565	42
Ca	15	51.12	**10**	0.2	12	83	14	88	20	91
Cs	-	**0.001**	-		-		-		-	
Fe	315	0.142	53		26		18		**10**	
K	5395	0.016	5490		2385	7	2440	6	2392	2
Li	998	0.020	999	2	476	0	478	0	472	2
Mg	7	0.268	**10**		**10**		**10**		**10**	
Mn	241	0.019	107	6	26	78	31	74	**10**	36
Na	270700	0.480	267000	0.1	125500	3	128700	1	129800	2
Rb	-	**0.001**	-		-		-		-	
S	**100**	**0.001**	**100**	7	**100**	40	**100**	69	**100**	72
Si	8879	0.801	9076		2523		1334		847	
F	36	0.000	29							

Table 3

Summary of LC Precipitation

Test		**P-1**		
Feed Liquor		CR-3		
Temperature (°C)		100-90		
Cumulative Residence Time (h)		2		
Carbonate Source		CO2		
CO2(g) Addition. (kg/kg LC)		2.6		
Stoich. Addition. (n-times)		3.3		
Element	**Feed**	**Residue**	**PF**	**Precip.**
	(mg/L)	(wt%)	(mg/L)	(%)
Al	328	0.009	330	0.9
Ca	16	0.025	11	31
Cs	-	**0.001**	-	
Fe	**10**	**0.001**	**10**	0.3
K	45970	0.437	41650	
Li	9000	18.36	2672	69
Mg	**10**	0.005	**10**	
Mn	**10**	**0.001**	**10**	0.3
Na	110000	0.940	105000	
Rb	-	0.006	-	-
S	**100**	**0.010**	**100**	-
Si	2284	0.300	2150	1.3
F	-	0.058	-	-

Table 4

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CLAIMS:

1. A process for extracting lithium values from a lithium silicate comprising the steps of:

a) heating a mixture of the lithium silicate and a concentrated sodium hydroxide solution with a concentration in a range of 40-80 wt% up to 350 °C;

b) diluting the heated mixture from step a); and

c) removing aluminates and silicates from the diluted heated mixture from step b) to produce a pregnant lithium solution.

2. The process according to claim 1, wherein heating said mixture comprises baking said mixture at a temperature in a temperature range of 250 °C to 350 °C at atmospheric pressure.

3. The process according to claim 2, wherein the mixture has a solids content of 40-50 wt% and is baked at a temperature in a range of 250 °C to 350 °C at atmospheric pressure for a period of 1 to 6 hours.

4. The process according to claim 1, wherein heating said mixture comprises heating said mixture in a temperature range of 200 °C to 300 °C in an autoclave.

5. The process according to claim 4, wherein the mixture has a solids content of 10-40 wt% and is heated in an autoclave at a temperature in a range of 200 °C to 300 °C for a period of 1 to 6 hours.

6. The process according to any one of claims 1 to 5, wherein the silicate is mixed with the caustic solution to produce a mixture having a solids content in a range of from 10-50 wt%.

7. The process according to any one of claims 1 to 6, wherein the heated mixture from step a) is diluted to 5-20% w/w caustic strength.

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8. The process according to any one of claims 1 to 7, wherein removing aluminates and silicates from the diluted heated mixture from step c) comprises adding lime to the diluted heated mixture in an amount sufficient to produce calcium aluminate and calcium silicate solids and separating said solids therefrom.

9. A process for recovering lithium values from a lithium silicate comprising the steps of:

a) extracting lithium values from a lithium silicate to produce a pregnant lithium solution according to any one of claims 1 to 8;

b) evaporating the pregnant lithium solution to increase a lithium concentration thereof; and,

c) recovering lithium carbonate and/or lithium hydroxide from the evaporated pregnant lithium solution.

10. The process according to claim 9, wherein recovering lithium carbonate comprises contacting the evaporated pregnant lithium solution with carbon dioxide to produce lithium carbonate solids and a barren lithium solution.

11. The process according to claim 9, wherein recovering lithium hydroxide comprises lowering the temperature of the evaporated pregnant lithium solution to produce lithium hydroxide solids and a barren lithium solution.

12. The process according to claim 10 or claim 11, wherein the barren lithium solution is treated with carbon dioxide to recover lithium carbonate therefrom.

13. The process according to any one of claims 10 to 12, wherein said solids are separated from the barren lithium solution.

14. The process according to any one of claims 10 to 13, wherein the barren lithium solution is recycled by mixing with said mixture of lithium silicate and caustic.

15. The process according to any one of claims 9 to 14, wherein evaporating the pregnant lithium solution increases the lithium concentration thereof to 8-10 g/L.

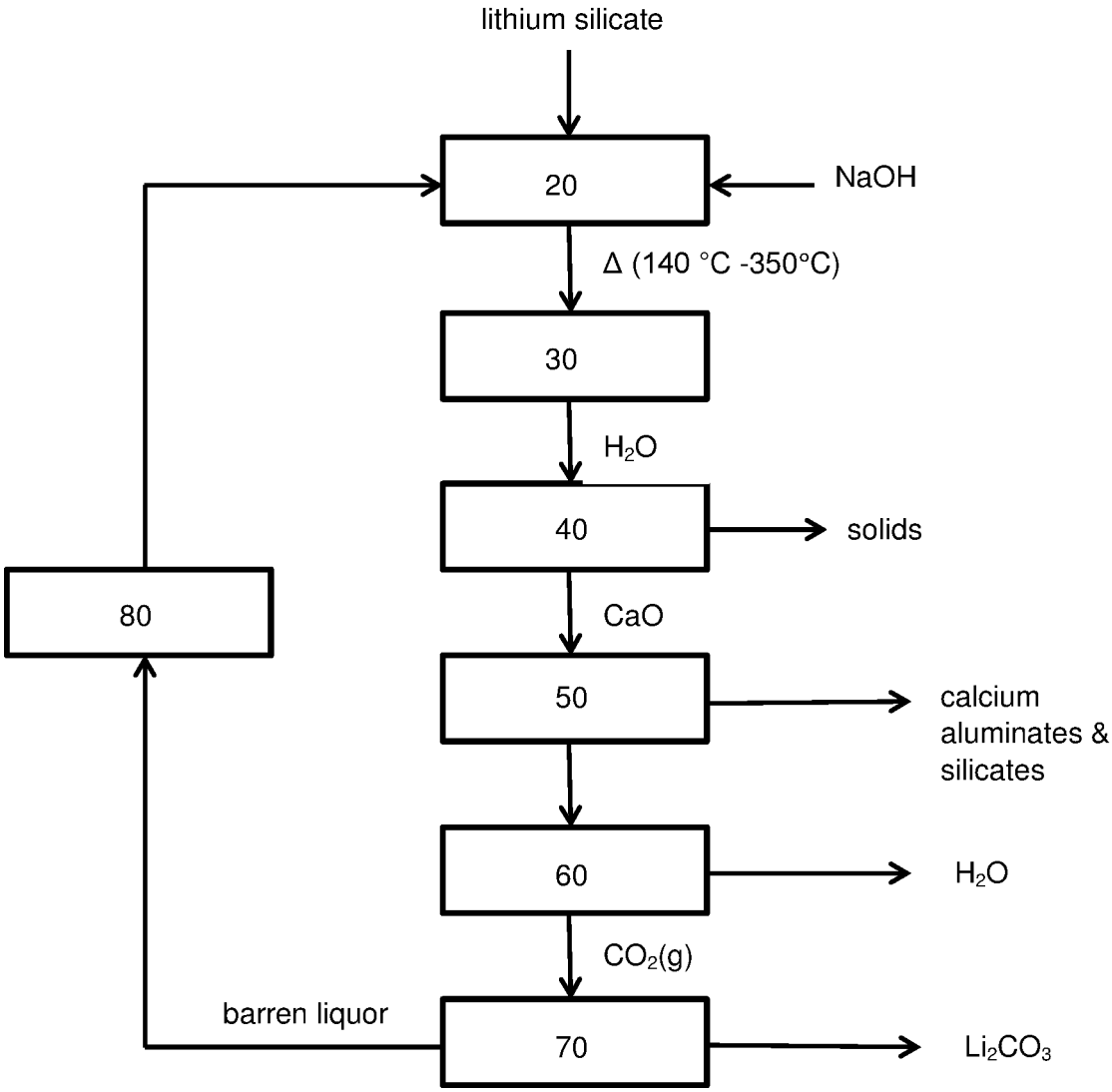
lithium silicate
20
NaOH
Δ (140 °C -350°C)
30
H_2O
40
solids
80
CaO
50
calcium
aluminates &
silicates
60
H_2O
$CO_2(g)$
barren liquor
70
Li_2CO_3

Figure 1