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EFFECTIVENESS OF THE SEPARATION OF MAGNESIUM AND LITHIUM FROM SEAWATER WITH SODIUM SILICATE PRECIPITATION PROCESS

Eko Sulistiyono[a,*], **Sri Harjanto**[a], **Latifa Hanum Lalasari**[b], **Florentinus Firdiyono**[b], **Nadia Chrisayu Natasha**[b], **Yosephin Dewayani**[b]
[a]Departments of Metallurgical and Materials Engineering, Universitas Indonesia,
Kampus UI Depok, Jawa Barat, Indonesia, 16425
[b] Research Center for Metallurgy, National Research and Inovation Agency (BRIN)
Gedung 470, Kawasan Puspiptek Serpong, Banten, Indonesia, 15314
*E-mail: eko221068@gmail.com

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Abstract

The purpose of this experiment was to separate magnesium ions and lithium ions from seawater in order to obtain a lithium concentrate solution product free of magnesium using a sodium silicate precipitation process. The sample used in this experiment was seawater from the Ancol Lagoon Area in North Jakarta. The seawater used has a high Mg/Li ratio of 10521 and contains 0.1674 ppm lithium ions and 1761 ppm magnesium ions. Before initial processing, seawater with high magnesium levels is not suitable as a raw material for the manufacture of lithium carbonate (active battery ingredient). The variables in the study were the addition of sodium silicate solution in amounts corresponding to 13, 27, 40, 53, 67, 80, 93, and 107% stoichiometry of magnesium ion. One step and multiple stages were used to add sodium silicate solution. The experimental results show that the addition of sodium silicate with 80% stoichiometry is the most effective, as indicated by a decrease in the Mg/Li ratio from 10521 to 64. The limitation of this study is that many lithium ions are still precipitated with magnesium silicate during the precipitation process, so the lithium ions lost in the filtrate reached 82.26% in the single-stage process. As a result, a multi-stage process with six processing steps was used. At single-stage optimum conditions, the sodium silicate addition was 1/6 of the volume of sodium silicate solution. The multi-stage process results could reduce lithium-ion loss in the filtrate from 82.26% to 76.54%. According to the findings of this study, the sodium silicate precipitation process was ineffective in separating lithium and magnesium ions from seawater in both single and multi-stage processes.

Keywords: *Magnesium ion separation, lithium ion separation, sodium silicate residue, seawater*

1. INTRODUCTION

Seawater in unlimited quantities is one of the future natural resource potentials. The volume of seawater in the hemisphere is estimated to be 1.3 x 10^{18} tons, with a mineral content of 3.3%. Thus, the amount of minerals found in seawater around the world is estimated to be 3 x 10^{16} tons [1]. According to data from the 2015 USGS Mineral Commodity Summaries, the following cations are eligible for development from seawater mineral resources: Na, Ca, Mg, K, Li, Sr, Br, B, and U [1]. Based on the analysis of samples from various seawater regions around the world, the lithium potential is estimated to be 230 billion tons. While the world's known lithium reserves on land total only 14 million tons [2], When lithium reserves are compared, the ocean has 16,429 more lithium reserves than the land.

To ensure the availability of lithium raw materials, lithium extraction process technology must be developed while considering the potential of lithium from seawater resources. The adsorption method is commonly used in the research and development of lithium raw materials from marine natural resources. In contrast, lithium research and development on land typically employs the precipitation method for brine water and an alkaline digester for rocks [3]. One of the seawater lithium extraction studies using the adsorption method is manganese dioxide-based adsorbs. Research with

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manganese adsorption materials includes: adsorbing with sieve $MnO_2.0,5\ H_2O$ [4], with a mixture of lithium manganese dioxide and chitosan granules [5] and using λ -MnO_2 material in the form of hexagonal crystals [6]. The results of the three experiments showed that the adsorption capacity for the combination of MnO_2 with chitosan was 54.65 mg/g Li+ ions [5], the λ -MnO_2 hexagonal crystalline material was 24.7 mg/g Li+ ions [6]. The sieve MnO_2 ion material, 5 H_2O is 10.05 mg/g Li+ ion [4]. In addition to the adsorption process, a continuous electrical pumping membrane process was developed with the results of increasing the lithium concentration from 0.1-0.2 ppm to 9013.43 ppm [7]. The electrolysis process using the Pulsed Electrochemical Intercalation method obtained lithium ion selectivity results of 1.8 x 104 [8], the process two-stage precipitation using NaOH, Na_2CO_3, and HCl with the product yield of Li_2CO_3 content above 99% [9] and the separation process using metal aluminum foil [10].

Indonesia, a maritime country in the form of an archipelago, has the second longest beach in the world [11]. Therefore, mastery of seawater treatment technology into useful products must be done. Currently, the use of mineral resources from seawater in Indonesia is only in salt production. The total salt production in Indonesia from 44 regions in Indonesia was 2,915,461.17 tons in 2016 [11]. Until now, there has been no use of seawater in Indonesia to produce lithium carbonate products. Constraints faced in the process of extracting lithium from seawater resources are the very high ratio of lithium to magnesium (ratio Mg/li) and low levels of lithium from seawater. For example, the lithium content of seawater on the Lamongan beach is 0.17 ppm [12]. Based on the theory, with a low lithium content of about 0.18 ppm and an Mg/li ratio above 7000, it is challenging to be economically processed into lithium carbonate products [13].

In this research, the process of separating lithium ions and magnesium ions from seawater will be carried out using the sodium silicate precipitation process. In previous experiments with bittern as raw material from salt pond waste, the results obtained were only able to take up about 20% lithium ions, and the Mg/Li ratio was 1033 [12]. The precipitation process is one of the most straightforward and most practical lithium and magnesium ion separation processes [14]. In several methods, separating lithium ions and magnesium ions in brine water with the precipitation process showed promising results. The separation process for lithium and magnesium ions includes the precipitation process with the following materials: aluminum metal powder and sodium sulfate [15], oxalic acid and sodium carbonate with brine water Bledug Kuwu as raw material [16], ammonium phosphate for lithium anolyte concentrate as raw material [17], and the precipitation process with sodium metasilicate as precipitating agent [18].

The separation of magnesium ions and lithium ions will do to obtain a filtrate containing only lithium ions and no magnesium ions. This filtrate will be use as a raw material in the production of lithium carbonate. Lithium carbonate is a key ingredient in the production of lithium batteries.

2. MATERIALS AND METHODS

In this experiment, the precipitation process carried out the separation of lithium ions and magnesium ions in seawater. In this study, the principle of separating lithium ions and magnesium ions in seawater is the process of precipitation of magnesium ions with sodium silicate to produce magnesium silicate deposits. The reaction of sodium silicate with magnesium ion occurs in various possibilities, based on a literature study on the reaction of sodium silicate with magnesium ion as in the manufacture of synthetic talc, by reaction [19].

$$4\ (Na_2SiO_3) + 3\ (MgCl_2) + 2\ HCl + m\ H_2O == Si_4Mg_3O_{11}.n\ H_2O + 8\ NaCl + (m-n+1)H_2O \quad (1)$$

From reaction (1), a solid magnesium silicate and a filtrate free of magnesium ions were obtained. The effectiveness of the precipitation process can be seen from the decrease in the ratio of Mg/li ions in the filtrate due to a decrease in magnesium ions in the filtrate. In addition to reducing the ratio of magnesium to lithium ions, the percentage of lithium ions removed in the filtrate was also considered. The rate of lithium ions lost is formulated as follows:

$$X\ (\%) = \{(A – B)/A \} * 100\ \% \ \ldots\ldots\ldots (1)$$

Descriptions:
X = Percentage ion remove
A = Mass ion in Raw Material
B =Mass ion in Filtrate after precipitation of sodium silicate

2.1 Materials

In this experiment, the seawater was taken from the Ancol Beach Lagoon, Jakarta, Indonesia. The ICP-OES (inductively coupled plasma-optical emission spectroscopy) analysis was carried out to identify seawater's chemical composition of seawater as shown in Table 1.

The precipitant was a sodium silicate solution derived from this study's water glass dilution process. The water glass used was sold in the market as a very thick solution containing a high concentration of sodium silicate.

Tabel 1. Chemical composition of seawater and sodium silicate (ppm)

Element	Seawater	Sodium Silicate
Magnesium (Mg)	1761	37.73
Sodium (Na)	4932	27126
Lithium (Li)	0.1674	-
Potassium (K)	243	201
Calcium (Ca)	421	54
Boron (B)	5,16	131
Ratio Mg/li	10521	-

2.2 Methods

In this experiment, the seawater performed a filtration process to remove solid impurities. The seawater of Jakarta Bay has high levels of nitrate, phosphate, and excessive algae growth [20]. In the filtration process, sufficient activated carbon was added to seawater to obtain clear seawater. After getting a clear solution, the precipitation process was prepared.

The precipitation process was carried out by adding sodium silicate solution calculated based on the stoichiometry of the magnesium ion. The stoichiometric variables are 13, 27, 40, 53, 67, 80, 93, and 107%. Precipitation experiments with sodium silicate solution were carried out at room temperature (without heating), a processing time of 5 minutes, and a stirring speed of 300 rpm. After the precipitation process was carried out, the residual solid and filtrate were obtained, and then the separation process was carried out. The filtrate obtained was then measured in volume and analyzed for ion concentration using ICP-OES. The solids obtained are then measured by weight, and the drying process is carried out. The obtained solids were then analyzed by XRD (x-ray diffraction). After analyzing the filtrate and solids, the data was investigated to get the best condition of the experiment.

In the sodium silicate precipitation experiment, two processes were carried out, namely single-stage and multi-stage processes (Figure 1). In the first stage, a single-stage process is carried out, namely the sodium silicate precipitation process which is given in one stage of the process. After knowing the optimum conditions for the single-stage process with the addition of 80% stoichiometric sodium silicate, a multistage process was carried out under these conditions. In this experiment, the multistage process was carried out six times. The addition of sodium silicate at each stage of the multistage process is 1/6 of 80% stoichiometric sodium silicate. So that each stage was added 13.33 % stoichiometric sodium silicate.

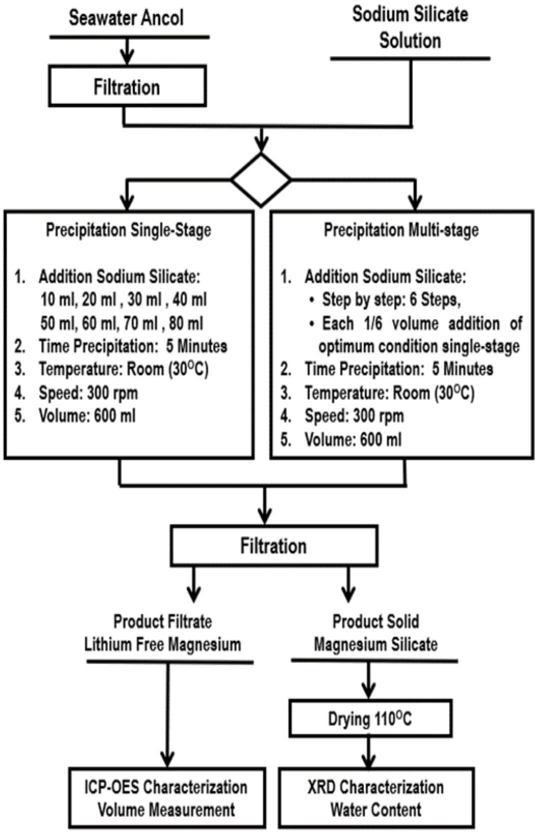

Figure 1. The progression of stage in this study

Based on the data from the ICP-OES analysis before the precipitation process (Table 1) and the ICP-OES analysis after the precipitation process (Table 3), a comparison ratio of elemental concentrations can be made. The formula for the ratio of the concentration of elements is as follows:

$$R \ = (CA \ / \ CB \ ) \ \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Descriptions:
R = Ratio Concentration
CA = Concentration Filtrate Product
CB = Concentration seawater

3. RESULT AND DISCUSSION

3.1 Single-Stage Process

Magnesium ions in seawater react with sodium silicate to form a white precipitate during the separation of magnesium ions and lithium ions from seawater. The white precipitate is formed by the reaction of magnesium ions and silicate ions, which results in the formation of a new compound of magnesium silicate that is insoluble in water.

3.1.1 Ratio Mg/Li in Filtrate after Precipitation

The sodium silicate precipitation process was carried out in this study with variable sodium silicate addition. Figure 2 depicts the effect of sodium silicate on the Mg/Li ratio. In addition to up to 40% sodium silicate, the stoichiometric separation of lithium-ion and magnesium ions did not produce an effective separation. This is due to the lack of a significant decrease in the Mg/Li ratio. With the addition of 40% stoichiometric sodium silicate, the Mg/Li ratio increased to 11417.

With more than 40% stoichiometric sodium silicate, the Mg/Li ratio decreased to 3426; with 53% stoichiometric sodium silicate, the Mg/Li ratio decreased to 306; and with 67% stoichiometric sodium silicate, the Mg/Li ratio decreased to 306 (Fig 2).

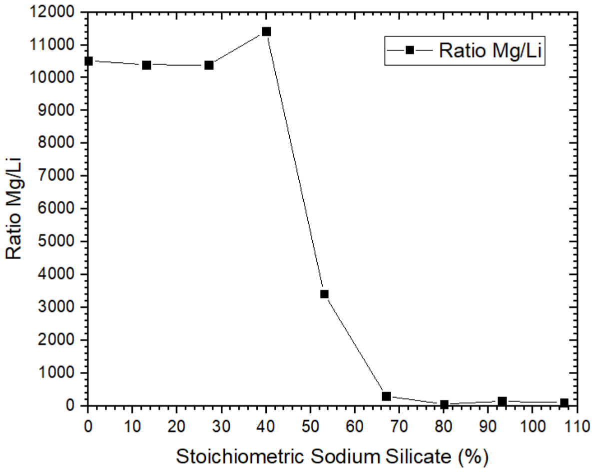

Figure 2. Effect of the addition of sodium silicate on the Mg/Li ratio in the single-stage precipitation process

The Mg/Li ratio dropped to 3426 with more than 40% stoichiometric sodium silicate. The Mg/Li ratio was reduced to 306 after the addition of 53% stoichiometric sodium silicate and then 67% stoichiometric sodium silicate (Fig 2). The addition of 60 mL sodium silicate, or 80% stoichiometry, produced the best results; the Mg/Li ratio was 64. The Mg/Li ratio did not fall below 64 in the sodium silicate range of 80% stoichiometric to 107% stoichiometric. Instead, it was increased to 152 by adding 93% stoichiometric sodium silicate (Fig 2). According to the experimental results, the Mg/Li ratio decreases not only as a result of reduced magnesium ions in the filtrate, but also as a result of reduced lithium ions in the filtrate.

3.1.2 The Percentage of Ion Removal in Filtrate after Precipitation (Single-Stage)

The sodium silicate precipitation process, which can reduce the Mg/Li ratio from 10521 to 64, opens the door to the possibility of extracting lithium from seawater. Previous research concluded that lithium resources with Mg/Li ratios greater than 7000 are impossible to extract [13].

In addition to the Mg/Li ratio factor, the mass percentage of lithium ions removed from the filtrate after the precipitation process is shown. The sodium silicate precipitation experiment results show that the concentration of lithium ions and magnesium ions decreases as magnesium ions precipitate to form magnesium silicate solids. The experimental results with the variable addition of sodium silicate show that the addition of sodium silicate up to 40% increases the mass removal of lithium and magnesium ions. With the addition of 40% stoichiometric sodium silicate, the number of lithium ions removed increased to 74.93% and magnesium ions decreased to 72.79%. (Fig 3).

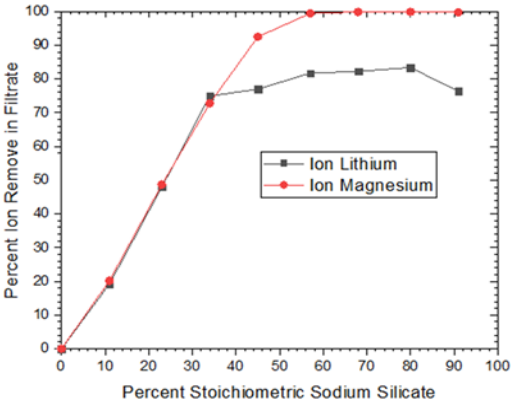

Figure 3. Effect of the addition of sodium silicate on the percent ion remove infiltrate in the single-stage precipitation process

The precipitated magnesium ion increased when the sodium silicate concentration was increased above 40%. Meanwhile, the lithium-ion concentration did not decrease significantly, so the process of separating lithium and magnesium ions became visible. The percentage of lithium-ion loss increased slightly to 77% after the addition of 53% stoichiometric sodium silicate. When sodium silicate was added to the optimum point of 80% stoichiometry, it became 82.26% (Fig 3). The percentage of magnesium ions in sodium silicate above 40% still increased, with the addition of 53% sodium silicate resulting in 92.49% precipitated magnesium ion, and the optimum addition of sodium silicate was 80% magnesium ion precipitated to 99.89% (Fig. 3).

The sodium silicate precipitation process successfully precipitated magnesium ions, according to the experimental results; the optimum results showed that 99.89% of magnesium ions were present in the solid-state, which precipitated into magnesium silicate according to the reaction (1). However, because many lithium ions are bound in solid magnesium silicate as a gel during this precipitation process, lithium ions are removed in the filtrate up to 82.26%. According to a literature review, magnesium silicate is formed by the precipitation of sodium silicate with magnesium ions in the form of a tetrahedral-octahedral gel. The tetrahedral-octahedral gel can bind lithium ions to form a formulation similar to hectorite [21]. This demonstrates that solid magnesium silicate has adsorbed lithium ions, as evidenced by the relatively high percentage of lithium in the filtrate. The lithium-ion concentration in the filtrate is found to be relatively low, at 0.1674 ppm.

3.2 Multi-Stage Process

The single-stage experiment yielded the best results for removing 99.98% magnesium ions and 82.26% lithium ions from the filtrate. The sodium silicate precipitation process, which can reduce the Mg/Li ratio from 10521 to 64, opens the door to the possibility of extracting lithium from seawater.

The six-stage experiment was carried out in reference to the previous single-stage process's optimal condition. The goal of the multi-stage experiment was to reduce lithium ion loss and increase magnesium ion removal in the filtrate, so that the separation of magnesium and lithium ions in the filtrate improved and the Mg/Li ratio decreased. The optimum condition for adding sodium silicate based on the results of the single-stage experiment was 80% stoichiometry or 60 ml of sodium silicate solution. As a result, in a multi-stage experiment, 10 ml of sodium silicate was added to the filtrate per step (6 stages) to ensure that the chemical precipitation process ran smoothly. Previous researchers had never conducted multi-stage experiments in seawater using sodium silicate chemical precipitation techniques. Assume the multi-stage process is effective in significantly reducing lithium ion loss in the filtrate. In that case, further research will be conducted to optimize the multi-stage process.

3.2.1 Ratio Mg/Li in Filtrate after Precipitation

According to the Mg/Li ratio, the multi-stage process yields a higher Mg/Li ratio than the single-stage process. The Mg/li ratio was 64 in the single-stage process and 110 in the multi-stage process. This indicates that the multi-stage process has lower selectivity for magnesium and lithium ions than the single-stage process.

Figure 4 shows that the Mg/li ratio decreases dramatically with each step of the multistage sodium silicate process, from stage 1 (13.33% stoichiometric sodium silicate) to stage 4 (53.33% stoichiometric sodium silicate). The decrease in the Mg/li ratio is very small in the multistage process at stages 5 (66.66% stoichiometric sodium silicate) and 6 (80% stoichiometric sodium silicate). Because the number of magnesium ions in the filtrate is already deficient at stages 4, 5, and 6, only a small amount of magnesium ions can be taken up again with the addition of sodium silicate in the next stage.

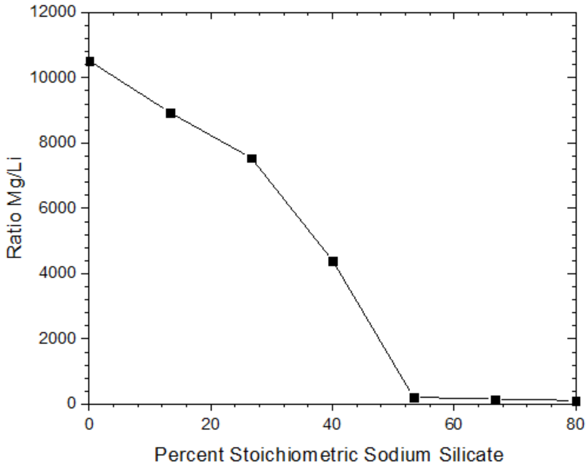

Figure 4. The effect of the addition of sodium silicate on the Mg/Li ratio in the multi-stage sodium silicate precipitation process

When the multi-stage experiment results were compared to the single-stage investigation, the multi-stage process produced a higher Mg/Li ratio than the single-stage process.

3.2.2 The Percentage of Ion Removal in Filtrate after Precipitation (Multi-Stage)

The multistage process in this experiment was carried out in six steps, with each step adding 10 ml of sodium silicate solution, bringing the total to 60 ml (80% stoichiometric). This is based on a single-stage experiment in which the addition of 60 ml of sodium silicate (80% stoichiometric) produced the best results, with the percent lithium-ion loss reaching 82.26% (Fig 2).

The results of the multi-stage experiment showed that the percentage of lithium ions lost increased significantly from the first to fourth stages. The number of lithium ions lost in the fourth stage was 75.41% (Fig 4).

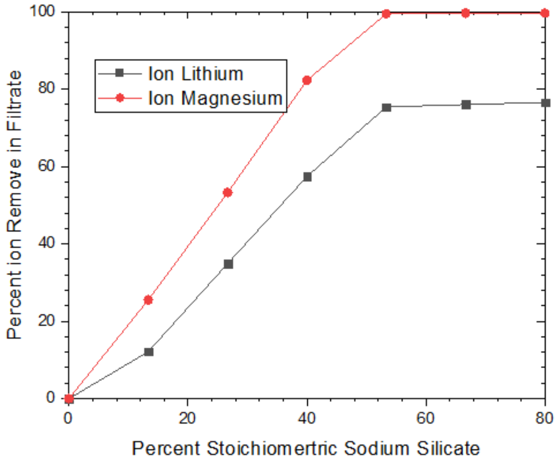

Figure 5. Effect of the addition of sodium silicate on the percentage of ion removal infiltrate in the multi-stage precipitation process

The lithium-ion removal process in the first to fourth stages is also consistent with the magnesium ion precipitation process, in which the precipitated magnesium ion reaches 99.50% purity in the fourth stage (Fig. 5). The experimental results at stages 5 (66.66 percent Stoichiometric Sodium Silicate) and 6 (80 percent Stoichiometric Sodium Silicate) revealed that the percentage of lithium ions reduced in the process fell to 76.54 percent at the end of the precipitation process (Fig 5). When compared to the single-stage process, the multi-stage process reduced lithium-ion removal from 82.26 percent (Fig. 2) to 76.54 percent (Fig. 5). The multi-stage process could only precipitate 99.67 percent magnesium ions (Fig. 5), which was less than the single-stage experiment, which could precipitate up to 99.89% magnesium ions.

Because the results of the multi-stage investigation were slightly better than the single-stage process, it is necessary to develop different process technology to reduce the lithium removal from the filtrate after precipitation.

3.3 The comparison of Associated Elements of Filtrate after Precipitation Process for Single-Stage and Multi-Stage Products

After obtaining the filtrate product from the single-stage and multistage processes, an ICP-OES (inductively coupled plasma-optical emission spectrometry) analysis of the elemental content in the filtrate was performed in the study. This paper compares the element concentrations determined by ICP-OES analysis of the precipitation filtrate to the results of ICP-OES analysis on seawater in Table 1. After learning the results of each element's ICP-OES analysis in seawater and filtrate products in Table 2.

Following the precipitation process, the magnesium content of seawater was determined to be 1761 (Table 1) ppm to 2.08 ppm for the single-stage precipitation process and 4.91 ppm for the multi-stage precipitation process based on the filtrate results.

Tabel 2. Chemical composition of seawater and sodium silicate (ppm)

Element	Single-Stage	Multi-Stage
Magnesium (Mg)	2.08	4.91
Sodium (Na)	4957	5773
Lithium (Li)	0.0324	0.0447
Potassium (K)	148	172
Calcium (Ca)	8	29
Boron (B)	1.98	1.53
Ratio Mg/li	64	110

Because the magnesium content requirement is 173 ppm, the resulting filtrate has the potential to be a lithium carbonate product based on the shallow magnesium content. However, due to the low lithium recovery, processing it into 17,350 ppm lithium concentrate is difficult. According to the literature, the concentrate solution for crystallization of lithium carbonate must contain 17.350 ppm lithium-ion and 173 ppm magnesium ion [22]. The ICP-OES analysis revealed that, with the exception of the element sodium, all ions in the filtrate decreased in concentration after the sodium silicate precipitation process.

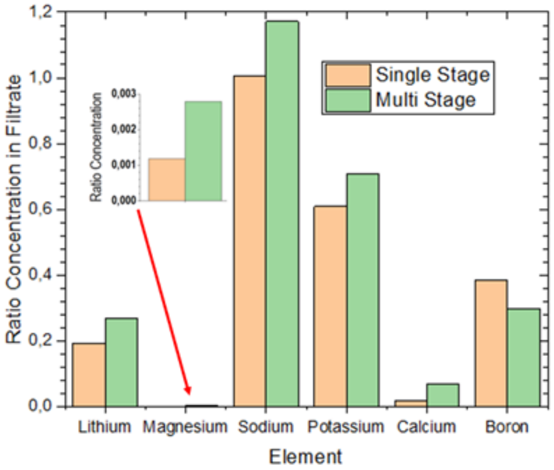

Figure 6. Comparison of the concentration of elements infiltrates after the precipitation process between a single-stage and multi-stages (80 % stoichiometric sodium silicate)

The sodium element in the filtrate product results from sodium silicate precipitation; the sodium content rises due to ion exchange during the precipitation process, particularly magnesium and calcium ions.

The ion analysis results show that the multi-stage process is more profitable, as evidenced by an increase in the content of lithium ions in the filtrates. With the six-stage method, a lithium concentration ratio after precipitation of about 0.267 was obtained in the multi-stage process. In the single-stage experiment, the lithium concentration ratio was 0.193. (Fig. 6). However, the magnesium element increased in the filtrate with the multi-stage methods, rising from a ratio concentration of 0.00118 (single-stage) to 0.00279 (multi-stages) (Fig. 6). The increase in magnesium ions in the filtrate increased the Mg/li ratio from 64 in the single-stage process to 110 in the multi-stages (Fig. 5). According to the experimental results, the technology for extracting lithium concentrate from seawater using the sodium silicate reagent is extremely difficult. Until now, the process of extracting lithium from seawater has been developed using various methods in combination. No industry has been able to economically extract lithium from the sea. Lithium is extracted commercially from brine water with a low Mg/Li ratio all over the world. Salar de Atacama in Chile, for example, has a Mg/Li ratio of 6.4, Salar Del Hombre Muerto in Argentina has a Mg/Li ratio of 1.4, and Silver Peak in the United States has a Mg/Li ratio of 1.4 [14].

3.4 The comparison of Solid Product

3.4.1 Percent Solid after Precipitation

The results of the process with variable sodium silicate addition show that the more sodium silicate added, the more white precipitate is formed. According to the experimental data, the addition of sodium silicate from 13% to 67% stoichiometric shows a significant increase. There was a decrease in the formation of white magnesium silicate precipitate with the addition of between 67% and 80% stoichiometric. Figure 7 shows that the accumulation of 67 percent stoichiometric solids yielded 27.46% and the accumulation of 80% stoichiometric solids yielded 24.25%.

Because 100% stoichiometric sodium silicate with a magnesium ion has not been achieved, there should be no decrease in solids recovery based on the stoichiometric sodium silicate with a magnesium ion addition of between 67% stoichiometric to 80% stoichiometric. Several possibilities exist, including the reaction of sodium silicate and calcium ions to form calcium silicate in the mineral wollastonite [23]. The second possibility is that some magnesium ions become trapped in the gel and do not react with the other sodium silicates.

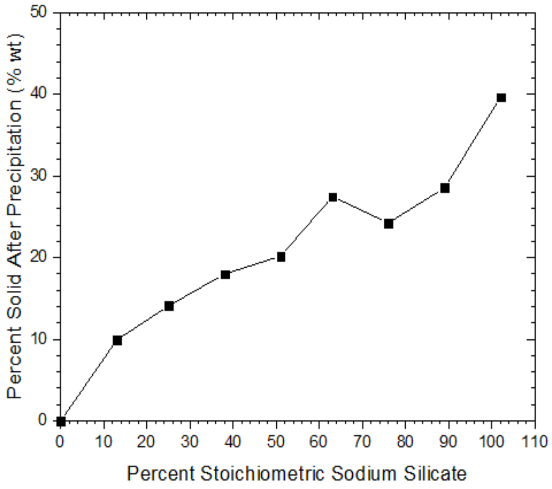

Figure 7. The effect of adding sodium silicate to the single-stage precipitation process on the increase in percent solid

The solids formed in a multi-stage process are similar to those formed in a single-stage process (Fig. 8).

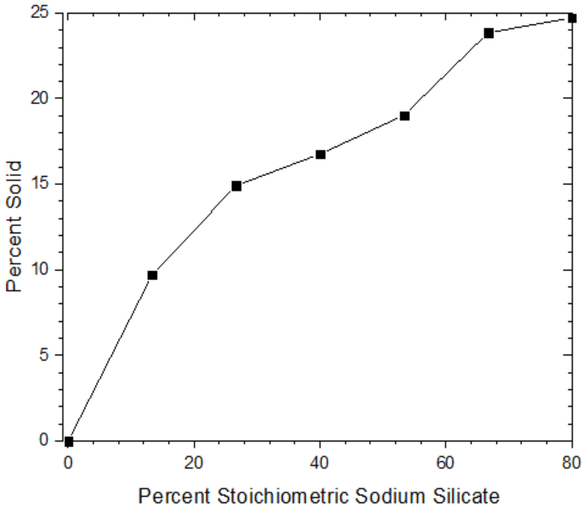

Figure 8. The effect of the addition of sodium silicate on the multi-stage precipitation process on the increase in percent solid

Figure 8 shows that the maximum solid percent formed in the multi-stage process is 24.72%, while in the single-stage process the percent solid obtained is 24.25% (Fig 6). The comparison of multi-stage and single-stage experimental results shows that the single-stage process stores relatively more lithium, magnesium, and other ions than the multi-stage process.

3.4.2 The Phase of Solid Product

XRD (x-ray diffraction) analysis was performed on solids resulting from single-stage and multi-stage precipitation processes.

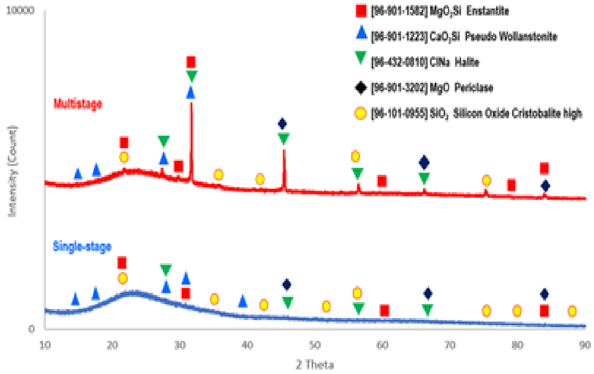

Figure 9. Comparison of XRD analysis results on solid products resulting from sodium silicate precipitation with single-stage and multi-stage processes

XRD analysis revealed that solid magnesium silicate formed peaks at 27.38°, 31.70°, 45.44°, 56.44°, 66.16°, 75.30°, and 83.93° (Fig 9). By looking at the peak point, the analysis carried out with the Match Three program shows five possible compounds with the cations Magnesium, Calcium, Sodium, and Silica. These compounds include Enstantite, Pseudo Wollanstonite, Halite, Periclase, and Cristobalite. Figure 9 shows that the solid form with the single-stage process is still an amorphous compound; in the multistage process it is a crystalline compound with visible peaks. From the results of the Match Three analysis, it can be seen that the composition of the solid compounds.

The results of XRD analysis show that the composition of compounds differs between the single-stage and multi-stage processes, with the single-stage process dominated by silica and the multi-stage process dominated by magnesium silica. In general, the component composition of the solid product is similar to that of talc, with SiO2 content of 59.6% and MgO 19.3% in single-stage production (Table 3).

Tabel 3. Compound arrangement based on Match Three analysis

Compound	Single-Stage	Multi-Stage
[96-901-1582] MgO3Si Enstantite	19.3	81.2
[96-1010955] O2Si Silicon Oxyde Cristobalite	59.6	0.5
[96-901-1223] CaO3Si Pseudo Wollanstonite – 4 A	20.0	6.8
[96-432-0810] Cl Na Halite	0.1	6.4
[96-101-3203] Mg O Periclase	1.1	5.2

From the results of the XRD analysis, it can be seen that the reactions that occur in the precipitation process of sodium silicate and seawater are as follows in the equations below.

$Na_2SiO_3 + Mg^{2+} === MgO_3Si$ (Enstantite) $+ 2\ Na^+$…(2)

$Na_2SiO_3 + Mg^{2+} === MgO$ (Periclase) $+ SiO_2$ (Chrystobalite) $+ 2\ Na^+$ …(3)

$Na_2SiO_3 + Ca^{2+} === CaO_3Si$ (Pseudo Wollanstonite) $+ 2\ Na^+$ …(4)

Talc compounds found in Turkey have a chemical structure of $Mg_3(Si_2O_5)_2(OH)_2$. Theoretically, it has a chemical composition of 63.5 wt.% of SiO_2, and 31.7 wt.% of MgO, and 4.8 wt.% of H_2O [24]. From the results of solids characterization, it can be seen that there is a possibility that the solids can be used as raw material for synthetic talc.

4. CONCLUSIONS

The goal of this experiment is to separate magnesium ions from seawater in order to liberate a lithium solution from magnesium ions. The precipitation experiment results revealed that the addition of 80 percent stoichiometric sodium silicate resulted in the most effective separation of lithium and magnesium ions. The Mg/Li ratio in the filtrate was reduced from 10521 before precipitation to 64 after precipitation, which was the most effective result. When lithium and magnesium ions are separated using the sodium silicate precipitation process, the removed lithium from the filtrate is 82,26%. The multi-stage process could only reduce the amount of lithium-ion lost in the filtrate from 82.26% to 76.54%. According to the findings of this study, the sodium silicate precipitation process was ineffective in separating lithium and magnesium ions from seawater in both single-stage and multi-stage processes. Because the obtained solids have a chemical structure similar to talc, solid products could be used as basic ingredients in the pharmaceutical industry.

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