Conference Paper

Study of Effectiveness of Sodium Hydroxide (NaOH) and Sodium Carbonate (Na₂CO₃) on the Impurities Removal of Saturated Salt Solution

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Abstract

Increasing the quality of salt can be done through various methods such as washing of salt by saturated salt solution, re-crystallization or twice crystallization, ion exchange methods and others. In the process of salt quality improvement by re-crystallization method where salt product diluted with water to form saturated solution and re-crystallized through heating process. The re-crystallization method can be done by chemicals or without chemical added. In this research is proposed a concept that before the saturated salt solution is re-crystallized needed chemicals added for removal of the impurities such as magnesium ion (Mg), calcium (Ca), potassium (K) and sulfate (SO₄). The chemical reagents that used are sodium hydroxide (NaOH) 2 N and sodium carbonate (Na₂CO₃) 2 N. This research aims to study effectiveness of sodium hydroxide and sodium carbonate on the impurities removal of magnesium (Mg), calcium (Ca), potassium (K) and sulfate (SO₄). Based on research results found that the addition of sodium hydroxide solution can decreased the impurity ions of magnesium (Mg) 95.2%, calcium ion (Ca) 45%, while the addition of sodium carbonate solution can decreased magnesium ion (Mg) 66.67% and calcium ion (Ca) 77.5%, but both types of materials are not degradable sulfate ions (SO₄). The sodium hydroxide solution more effective to decrease magnesium ion than sodium carbonate solution, and the sodium carbonate solution more effective to decrease calcium ion than sodium hydroxide solution.

Keywords: chemical, impurities, re-crystallization, removal, Salt

INTRODUCTION

Salt is a product that is needed in various processes such as fish preservatives, community consumption, health, supporting industrial activities and the pharmaceutical industry. Each designation needs different salt quality, such as salt for consumption salt require requirement of 94,7% NaCl content, for salt industrial supporting like soda industry needed NaCl content of 98,4% . While for industry salt NaCl content is close to 98,50% (Burgos et al., 2008).

The crude salt or traditional salt is produced by first stage evaporation to sediment of calcium ion, second stage evaporation to concentrate sea water, and the last stage is crystallization (Sedivy, 2009). The quality of salt product are influenced significantly with seawater quality and production facilities (Diyono et al., 2002; Myers and Bonython, 2007). The salt product has low quality with NaCl content 85-95% and the others are its impurities such as magnesium chloride (MgCl2), magnesium sulfate (MgSO4), calcium sulfate (CaSO4), and potassium chloride (KCl).

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The increasing of the salt quality can be done through a variety of ways like hydro-extraction (washing with saturated salt solution), and re-crystallization (Rathnayaka et al., 2014). The re-crystallization methods is salt product dissolved with water until form saturated salt solution and then crystallization again. The saturated salt solution before crystallization still contain impurities such as magnesium chloride (MgCl$_2$), magnesium sulfate (MgSO$_4$), calcium sulfate (CaSO$_4$), and potassium Chloride (KCl). The impurities content will decrease quality of salt product, the impurities has to remove for improvement of salt product quality. The improvement of salt product quality can be done by chemical or added of some kind of chemicals, the chemicals generally used such as Sodium hydroxide (NaOH) (Irving, 1926; Jijun et al., 2012), sodium carbonate (Na$_2$CO$_3$), calcium chloride (CaCl$_2$) and others. The addition of such chemicals aims to bind and precipitate impurities contained in the salt such as magnesium (Mg), calcium (Ca), sulfate (SO$_4$) and potassium (K) ions.

The reactions that occur in addition of sodium hydroxide (NaOH), sodium carbonate (Na$_2$CO$_3$), calcium chloride (CaCl$_2$) as below (Pujiastuti et al., 2016; Rathnayaka, 2014):

1. $\text{MgCl}_2 + 2 \text{NaOH} \rightarrow \text{Mg(OH)}_2 \downarrow + 2 \text{NaCl}$ (1)
2. $\text{MgCl}_2 + \text{Na}_2\text{CO}_3 \rightarrow \text{MgCO}_3 \downarrow + 2 \text{NaCl}$ (2)
3. $\text{CaSO}_4 + \text{Na}_2\text{CO}_3 \rightarrow \text{CaCO}_3 \downarrow + \text{Na}_2\text{SO}_4$ (3)
4. $\text{CaSO}_4 + 2 \text{NaOH} \rightarrow \text{Ca(OH)}_2 \downarrow + \text{Na}_2\text{SO}_4$ (4)

Base on reaction 1 and 2 above, added of sodium hydroxide (NaOH) and sodium carbonate will increase NaCl content on salt product (Diyono et al., 2002). Based on the above reactions, several factors that affect impurities removal in saturated salt solution are:

a. **Type of impurities**, The type of impurities contained in the salt solution will determine the type of chemicals that need to be added, because each type of impurities will be separated with certain chemicals.

b. **Concentration of impurities**, The impurities concentration in the saturated salt solution will affect the concentration of chemicals that need to be added, this can be determined by chemical reactions.

c. **Reaction time**, The reaction that occurs based on the above reaction is liquid-liquid reaction that will produce precipitate (precipitation process) so the reaction time will affect to the product quality.

**METHODS**

This research was conducted on a batch laboratory scale, the traditional salt that use as the study material in this study was obtained from Gresik city in East Java. The quality of salt is determined by gravimetric method for sulfate (SO$_4$), stoichiometry for sodium chloride (NaCl), and Titrimetry for calcium (Ca) and magnesium (Mg). In this study we studied the effect of the addition of 2 N sodium hydroxide (NaOH) solution and sodium carbonate (Na$_2$CO$_3$) 2N solution to impurities removal (magnesium, calcium, and sulfate ions). The Block diagram of the study as shown in Figure 1.

![Figure 1. Schematic diagram of research](image-url)
RESULT AND DISCUSSION

Chemical Composition of the Traditional Salt
The chemical composition of traditional salt that use as raw material in this research is presented in the following table 1.

Table 1. Chemical composition of traditional salt

| No | Parameters              | Concentration (%) |
|----|-------------------------|-------------------|
| 1  | Sodium chloride (NaCl)  | 90.36             |
| 2  | Magnesium (Mg)          | 0.056             |
| 3  | Sulfate (SO₄)           | 0.475             |
| 4  | Calcium (Ca)            | 0.234             |

Chemical Composition of the Saturated Salt Solution
The saturated salt solution is a solution obtained from 360 g of salt dissolved with 1 liter of water. The chemical composition of the saturated salt solution is presented in the following table 2.

Table 2. Chemical composition of traditional salt

| No | Parameters              | Concentration (%) |
|----|-------------------------|-------------------|
| 1  | Sodium chloride (NaCl)  | 32.5296           |
| 2  | Magnesium (Mg)          | 0.0129            |
| 3  | Sulfate (SO₄)           | 0.1674            |
| 4  | Calcium (Ca)            | 0.0792            |

The chemical composition of the saturated salt solution that use as raw material in this research. The saturated salt solution contains magnesium (Mg), sulfate (SO₄) and calcium (Ca) ions that will be precipitated using sodium hydroxide (NaOH) or sodium carbonate (Na₂CO₃).

The Influence of Increasing Volume Sodium Carbonate (Na₂CO₃) Solution Added on Impurities Removal

![Correlation increasing ratio of Na₂CO₃ 2 N to saturated salt solution to impurities removal (%)](image-url)

Figure 2. Correlation increasing ratio of Na₂CO₃ 2 N to saturated salt solution to impurities removal (%)
Figure 2 shows that the increasing ratio of Na₂CO₃ 2 N to saturated salt solution will increase percentage of impurities removal. The highest ion removal percentage is calcium (Ca) ion reached 77.5 %, magnesium (Mg) ion 66.67 % and sulfate (SO₄) ion 0.00 %, it is will on added 60 ml Na₂CO₃ per one liter of saturated salt solution.

**The Influence of Increasing Volume Sodium Carbonate (Na₂CO₃) Solution Added on Solid Composition**

![Graph showing solid composition](image)

Figure 3. Correlation increasing ratio of Na₂CO₃ 2 N /Saturated salt solution to impurities solid composition (%)

Figure 3 shows that the increasing ratio of Na₂CO₃ 2 N/Saturated salt solution will increase percentage of solid composition. The highest ion solid composition is calcium oxide (CaO) ion reached 79.3 %, magnesium oxide (MgO) 0.9 %, chloride (Cl) 19.1 % and sulfate (SO₄) 0.00 %, it is will on added 60 ml Na₂CO₃ per one liter of saturated salt solution.

**The Influence of Increasing Volume Sodium Hydroxide (NaOH) Solution Added on Impurities Removal**

![Graph showing impurities removal](image)

Figure 4. Correlation increasing ratio of NaOH 2 N /saturated salt solution to impurities removal (%)
Figure 4 shows that the increasing ratio of NaOH 2 N to saturated salt solution will increase percentage of impurities removal. The highest ion removal percentage is magnesium (Mg) ion reached 95.2 %, calcium (Ca) ion 45.00 % and sulfate (SO₄) ion 0.00 %, it is will on added 60 ml NaOH per one liter of saturated salt solution.

The Influence of Increasing Volume Sodium Hydroxide (NaOH) Solution Added on Solid Composition

![Graph showing solid composition vs ratio of NaOH 2 N/Saturated salt solution](image)

Figure 5. Correlation increasing ratio of NaOH 2 N/Saturated salt solution to impurities solid composition (%)

Figure 5 shows that the increasing ratio of NaOH 2 N/Saturated salt solution will increase percentage of solid composition. The highest ion solid composition is chloride (Cl) ion reached 54.5 %, magnesium oxide (MgO) 40.7 %, calcium oxide (CaO) 2.3 % and sulfate (SO₄) 0.00 %, it is will on added 60 ml NaOH per one liter of saturated salt solution.

CONCLUSION

Based on the results of research can be concluded that the addition of sodium hydroxide (NaOH) 2 N solution is more effective in removal of magnesium ions (Mg) than calcium ions (Ca), the percentage of magnesium removal is 95.2 % and calcium (Ca) 45.00 %. The addition of sodium carbonate (Na₂CO₃) 2 N solution is more effective in removal of calcium ions (Ca) than magnesium ions (Mg). the percentage of calcium removal is 77.5 %, and magnesium (Mg) ion 66.67 %. The Addition of sodium hydroxide (NaOH) 2 N solution and sodium carbonate (Na₂CO₃) 2 N solution cannot separate sulfate ions (SO₄)

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