SHA Zuoliang, LI Jibin, WANG Yanfei and YUAN Jianjun, 2014. Separation Technologies of Potassium from Salt Lakes. *Acta Geologica Sinica* (English Edition), 88(supp. 1): 367-368.

Separation Technologies of Potassium from Salt Lakes

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1 Introduction

Salt Lake, as a kind of chemical resources, has been attracted to many researchers，especially the resources of lithium. As reported, many kinds of brines exist in the world depending on the compositions of the brine. Based on the chemical composition the brines can be classified as the types of chloride, carbonate, sulfate. For different types of brines the salt forming order will have great difference and require different type technologies for separating salts to be product. For many cases, especially the salt lakes in Tibet China, the lithium is the main target product. The technology development is how to extract the lithium from salt lake brine. However, the salt lake brines are mostly much diluted for the lithium. It needs to concentrate the brines into a lever where the lithium can be economically extracted. During the concentrating process, the other chemicals, such as sodium, potassium, boron will be salting out with different combination of the Cl^- or SO_4^{2-}. Also two or more than two salt could be crystallized together or forming a complex compounded salt. The mixed salt brings a difficult case to separate the pure product which is commercial useful.

The lithium was considered as a most valuable chemical to the extracted from salt lack brines. However, the potassium is also the valuable chemical in the brine because the amount of potassium in the lack is much higher than lithium. On the other hand, the potassium is mostly crystallized out during the process to produce lithium. In this work, we will more concentrate to discuss the technologies to separate the potassium from the mixed salt which were obtained during the brines to be concentrated.

2 The potassium salts formed during brine evaporation process

In order to concentrate the brine from salt lack, the solar energy was mostly economically used. During evaporation process, the salt forming order will be changed much. Even the brine have the same chemical elements, the salt forming order and the crystallized slats will changed much based on the ratio of the chemical elements composition. On the other hand, the evaporation temperature can also affect the form of the salt forming. Fig. 1 shows the possibilities of the salt form which containing the potassium in Na^+、K^+、Mg^{2+}//Cl^-、SO_4^{2-} - H_2O and Na^+, K^+//Cl^-, SO_4^{2-}, CO_3^{2-}–H_2O systems.

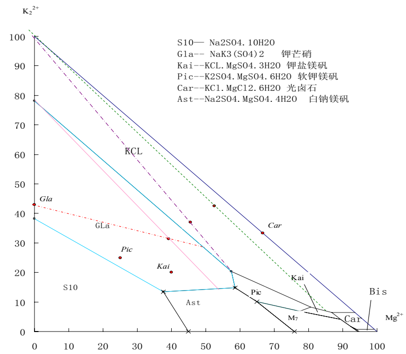

Fig. 1. the phase diagram at 15℃.
Na^+, K^+, Mg^{2+}//Cl^-, SO_4^{2-} - H_2O.

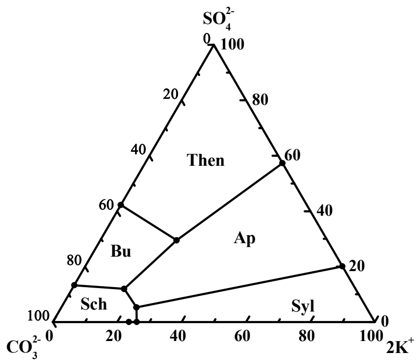

Fig. 2. Na^+, K^+//Cl^-, SO_4^{2-}, CO_3^{2-}–H_2O unsteady phase diagram at 25 ℃.
Syl, KCl ; Then, $NaSO_4$; Ap, $NaSO_4{\cdot}3K_2SO_4$; Bu, $2NaSO_4{\cdot}K_2SO_4$; Sch, $NaCO_3{\cdot}7H_2O$.

From Fig.1 and Fig.2 it can be seen that the first formed salt is normally the salts containing sodium (NaCl, or Na_2SO_4), depending the composition of the salt during the evaporation. The second salts to be formed are the salts in which contains the potassium. It could be the KCl, or

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$NaK_3(SO)_4$ (Gla), or $K_2SO_4.MgSO_4.3H_2O$, or $KCl.MgSO_4.3H_2O$ (Kai), or KCl. $-MgCl_2.6H_2O$ (Car), or $2NaSO_4{\cdot}K_2SO_4$, which will give different mixed salt containing the potassium. The different complex potassium compound and the mixed salt requires different technologies to separate potassium from mixed salt.

3 Technologies to separate potassium from the mixed salts

Normally, the salt contain the potassium will be crystallized together with other salt. The simple mixed salt is NaCl and KCl. To separate KCl from the mixture of NaCl and KCl, the dissolving and recrystallization method were mostly employed. The key technology for this process is how to control the purity and energy saving. The multi-step vacuumed cooling system could be a nice choice. The flotation method can also be used to separate NaCl and KCl for same cases, but is need additives which may bring environment problems. Sometimes, the quality and recovery rate is a problem to be faced.

The second salt containing potassium is carnallite. Normally, carnallite crystallized together with NaCl. Two kinds of technologies were used for separating the mixed salt to produce KCl. One is the decomposition by adding water to carnallite, and washed. The second technology is flotation method to separate NaCl and carnallite, and then decomposition carnallite with right amount of water.

The complex compound $K_2SO_4.MgSO_4$-$3H_2O$, or $KCl.MgSO_4.3H_2O$ (Kai) is a good material to produce K_2SO_4. However, it also has the problems of quality controlling and increasing recovery ratio.

The most difficult compound to separate potassium is the $NaK_3(SO)_4$ and $2NaSO_4{\cdot}K_2SO_4$. Even the decomposition method can be theoretically used to produce K_2SO_4 from pure $NaK_3(SO)_4$, the mixed salt with $NaK_3(SO)_4$ are normally having NaCl or $NaSO_4$. The impurity of NaCl or NaSO4 will reduce the recovery rate very much, even potassium salt can not be produced by directly adding water.

In many cases the mixed salt which contains the potassium have huge amount of other chemicals. The method for separating potassium from introduced technology above can not be used because the potassium recovery could be quit low. Here, a new technology is introduced, with which all kinds of potassium complex compound or any kinds of mixed salt can be treated.

The principle of method is shown in Fig.3. The mixed salt which contains the potassium can be mixed with a certain a mount of $MgCl_2$ solution. When temperature is higher, the KCl and $MgCl_2$ are dissolved in the liquid phase. The NaCl and MgSO4 are mostly keeping in the solid phase. After separating liquid and solid at high temperature, most NaCl and MgSO4 are get rid from the mixed salt. After cooling the remained liquid phase, the carnanllite can be obtained and then the KCl can be produced. The schematic diagram to produce potassium chloride from mixed salt is shown in Fig.4.

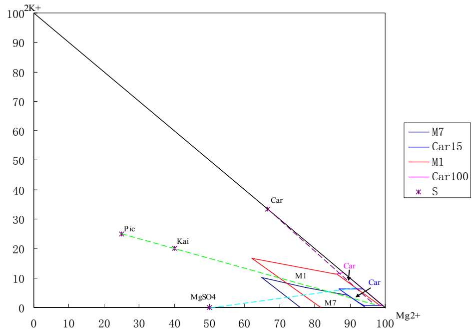

Fig. 3. the principle phase diagram for separating potassium from mixed salt.

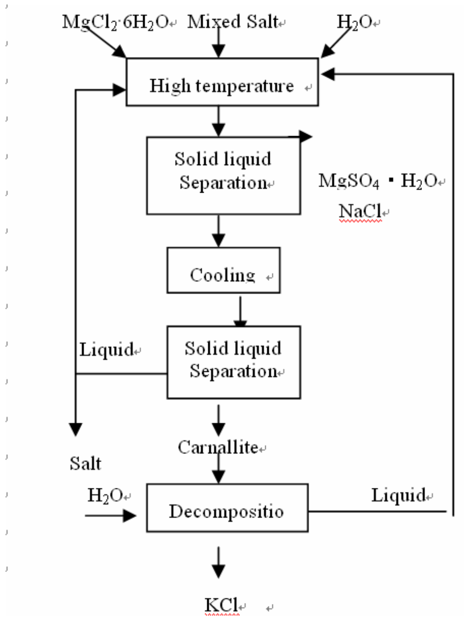

Fig. 4. The schematic diagram to extracting. potassium from mixed salt.

To simplify the potassium separation process, chemical treatment of the brine could be considered. For example, complex compound of $NaK3(SO)_4$ can be easily obtained for the brine in which Na_2SO_4 has relative high concentration. If the brine can process a low temperature period, the $NaSO_4.10H_2O$ can be crystallized, which will be much simplifying the potassium processing process.

4 Conclusion

Huge amount of potassium is in the salt lack brines. The technologies to separate potassium from salt lack brine is introduces in this work. Even there are many technologies can be used to produce the potassium from salt, but the reliable and economical technology has to be paid more attention to be developed, especially for the places where the industrial background is not good enough.