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Phase Equilibrium and Phase Diagram of the Ternary System ($\text{MgCl}_2 + \text{MgB}_2\text{O}_4 + \text{H}_2\text{O}$) at 288 and 298 K

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1 Introduction

The brines with high concentrations of magnesium and boron resources are widely distributed in the Qaidam Basin of the Qinghai-Tibet plateau, China (Zheng & Tang, 1988). Although some works on the ternary system ($\text{MgCl}_2 + \text{MgB}_4\text{O}_7 + \text{H}_2\text{O}$) at 298 and 328 K and the ternary systems ($\text{MgCl}_2 + \text{MgB}_6\text{O}_{10} + \text{H}_2\text{O}$) and ($\text{MgSO}_4 + \text{MgB}_6\text{O}_{10} + \text{H}_2\text{O}$) at 323.15 K (Meng et al., 2012; Bi et al., 1997; Luo et al., 2011), the ternary system ($\text{MgCl}_2 + \text{MgB}_2\text{O}_4 + \text{H}_2\text{O}$) at 288 and 298 K are not reported in the literature. It is well known that the thermodynamic phase equilibrium and phase diagrams play an important role in exploiting the brine resources and describing the geochemical behavior of brine and mineral system (Deng et al., 2011; Guo et al., 2013; Liu et al., 2011).

In this paper, the phase equilibrium and phase diagram of the ternary system ($\text{MgCl}_2 + \text{MgB}_2\text{O}_4 + \text{H}_2\text{O}$) at 288 and 298 K were studied with the method of isothermal dissolution equilibrium.

The solubilities and physicochemical properties including density, pH and refractive index value in the ternary system at 288 and 298 K were determined experimentally.

The composition of the invariant points and its binary co-saturated points of the ternary system ($\text{MgCl}_2 + \text{MgB}_2\text{O}_4 + \text{H}_2\text{O}$) at 288 and 298 K shows in Table 1.

Table 1 Comparison of the solubilities in the invariant points and its binary co-saturated points of the ternary system ($\text{MgCl}_2 + \text{MgB}_2\text{O}_4 + \text{H}_2\text{O}$) at 288 and 298 K

No.	T/K	Composition of the liquid phase in 100w ^a			Equilibrium solid phase ^b
		MgCl ₂	MgB ₂ O ₄	H ₂ O	
A	298	0.00	0.24	99.76	Mb
E	298	35.38	0.25	64.37	Bis+Mb
B	298	36.08	0.00	63.92	Bis
A'	288	0.00	0.19	99.81	Mb
E'	288	35.71	0.23	64.06	Bis+Mb
B'	288	35.18	0.00	64.82	Bis

^a w, mass fraction; Bis, $\text{MgCl}_2 \cdot 6\text{H}_2\text{O}$; Mb, $\text{MgB}_2\text{O}_4 \cdot 3\text{H}_2\text{O}$.

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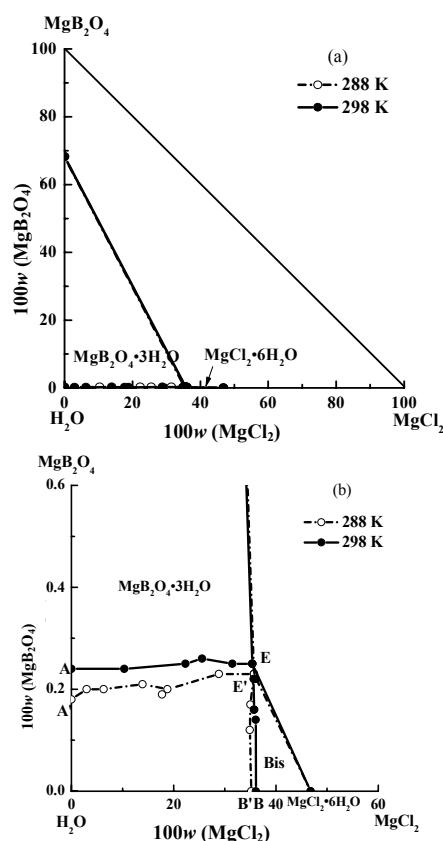
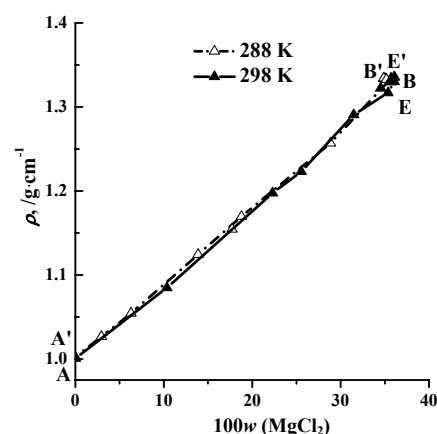


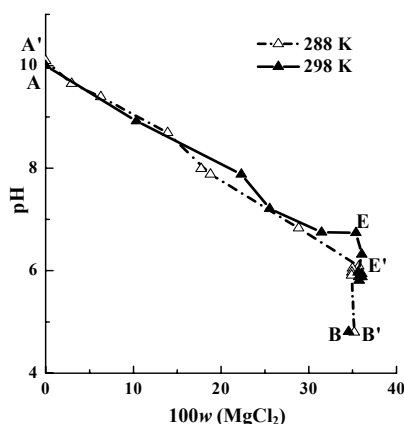
Fig. 1. Comparison of the phase diagram of the ternary system ($\text{MgCl}_2 + \text{MgB}_2\text{O}_4 + \text{H}_2\text{O}$) at 288 and 298 K.

On the basis of experimental data, the phase diagram of the ternary system at 288 and 298 K was plotted in Figure 1(a), and Figure 2(b) is the part enlargement.

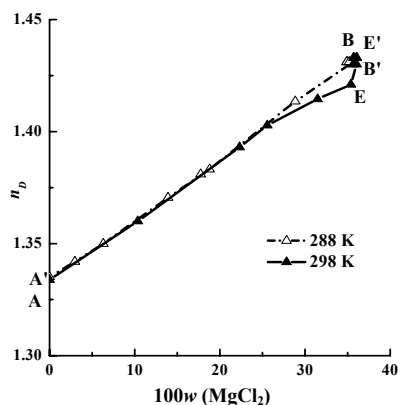
The phase equilibrium diagrams of the ternary system ($\text{MgCl}_2 + \text{MgB}_2\text{O}_4 + \text{H}_2\text{O}$) at 288 and 298 K, there are all in one invariant point, two isothermal solubility curves, and two crystallizing zones corresponding to trihydrate magnesium metaborate ($\text{MgB}_2\text{O}_4 \cdot 3\text{H}_2\text{O}$) and bischoofite ($\text{MgCl}_2 \cdot 6\text{H}_2\text{O}$). Neither double salts nor solid solutions at two temperatures are found in the ternary system, and they all belong to a simple hydrates type-I.



(a) Density vs. composition



(b) pH vs. composition



(c) Refractive index vs. composition

Fig. 2. Comparison of the physicochemical properties versus composition at 288 and 298 K.

A comparison of the equilibrium phase diagrams of this system at 288 and 298 K shows that the crystallized area of those minerals of trihydrate magnesium metaborate and bischofite were decreased with the increasing of temperature.

In addition, the physicochemical properties including were measured experimentally. The comparison diagrams of the physicochemical properties versus composition of

magnesium chloride in the solution were plotted, and shown in Figure 2.

Figure 2 shows that the physicochemical properties including density, pH and refractive index in the ternary system change regularly with the increasing concentration of magnesium chloride in the solution, and singular values occurring at the invariant point.

2 Conclusion

In this work, the phase equilibria and the physicochemical properties including density, pH and refractive index of the ternary system ($\text{MgCl}_2 + \text{MgB}_2\text{O}_4 + \text{H}_2\text{O}$) at 288 and 298 K were determined experimentally with the isothermal dissolution method. On the basis of the experimental data, the phase diagrams and the diagrams of the physicochemical properties versus composition for the ternary system at 288 and 298 K were plotted. The solubility data in the invariant points and their relative binary co-saturated points at 288 and 298 K were presented, which is not reported in the literature.

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