Preparation and Dissolution Properties of the Eco-glass Fertilizer containing Trace Elements

Hoi Kwan Lee, Sheng Jean Hwang, and Won Ho Kang

Department of New Materials Science and Engineering, Dankook University, Cheonan 330-714, Korea
E-mail : hoikwanlee@korea.com

Abstract

At the previous papers, we showed that K2O-CaO-P2O5 glasses had a solubility in air so that they could be used for glass fertilizer. In this work, we fabricated the Eco-glass fertilizer containing trace elements such as B, Mg, Zn, Fe, Cu, Co, and Mo by a melt-quenching process and the dissolution properties of these glasses were investigated with pH meter and ICP analyzer. In case of the glasses containing the trace elements, effect of trace elements on the dissolutions is not obvious and ignorant the stability of mother glass. Also, the dissolution amounts of each trace elements depend on the mother glass composition and the quantity of each trace element, and mother glasses determined the dissolving velocity of chemical elements

Keywords: Environment conscious, Glass fertilizer, Dissolution, Phosphate glasses, Slowly-effective fertilizer

1. Introduction

Since conventional phosphate glass has hygroscopic property and poor chemical durability caused by the glass structure, its application was limited. Thus many efforts have been focused on to increase the chemical durability1), 2). However, the new applications for phosphate glasses are lately emerging for environmental materials such as glass fertilizer, anti-bacterial, far-infrared radiation, dental, and bio-medical materials3),4). The usage for glass fertilizer is being focused nowadays for environment conscious inorganic fertilizer5). Presently, the dissolution properties of chemical fertilizer used widely in agriculture have immediate effect so that it offers excess nutrition than those plants needed or releases to the soil. Resulting in not only the great waste of fertilizer but environmental problems due to the soil acidulation. Therefore, the controllable release glass fertilizer that offers the nutrients as much as the plants needed for months or years is studied by many researchers. We also reported the papers concerned with glass fertilizer based on K2O-CaO-P2O5 glasses6).

In this study, we prepared the trace elements needed for crops doped K2O-CaO-P2O5 glasses by melt-quenching process and observed the dissolution behavior of the trace elements and mother glass with pH meter and ICP analyzer.

2. Experiment

Table 1 shows the chemical composition of this experiment. As inorganic fertilizer components,

K2O-CaO-P2O5 system3)was selected and melting procedure was performed in 40 and 60mole% P2O5 region for stable glass. The raw materials were mixed with distilled water for one hour and kept for 12 hours in dry oven. Then the batch was melt in porcelain crucible at 1200℃ for one hour and poured into water bath. And then glasses were dried in the dry oven at 120℃. For the observation of dissolution properties, we used the powder between 500-250μm and placed them in plastic container full with distilled water with 25ml and kept at the room temperature. The pH and ICP-MS (Shimadzu Co., ICP 7500) were used to observe dissolution behavior by time sequence.

Table 1. Chemical Compositions of Glasses

samples	KCP Glass (93.92 wt%)	Trace Elements (6.08 wt%)	
KCP2M	30mol%K2O-30mol%CaO -40mol%P2O5	MgO	5.00%
		B2O3	0.322%
		Fe2O3	0.179%
KCP7M	10mol%K2O-30mol%CaO -60mol%P2O5	MnO	0.516%
		ZnO	0.0280%
		CuO	0.0188%
		MoO3	0.0113%

3. Results and Discussion

The change of pH value in the KCP2M (KCP2 glass containing trace elements) and KCP7M (KCP7 glass containing trace elements) is shown in Figs. 1, 2. In the case of KCP7M containing lots amount of P2O5, the pH value decrease to the acid range because the network of phosphate glass was broken by attracted water, and released phosphorus reacts with water and changes to HPO3 resulting in decrease in pH value. Such change in pH value is similar with KCP7 without trace element, suggesting strongly that doped trace element (6.08wt%) not have effects on stability and pH value of the KCP7. In case of KCP2M, however, since this glass contains lots amount of alkali oxide and less amount of P2O5 than KCP7M, the glass is stable and shows quietly different result in pH value. This case could be considered by that the pH value depends on the dissolute alkali ion from glass as silicate glass7), 8) in the water bath.

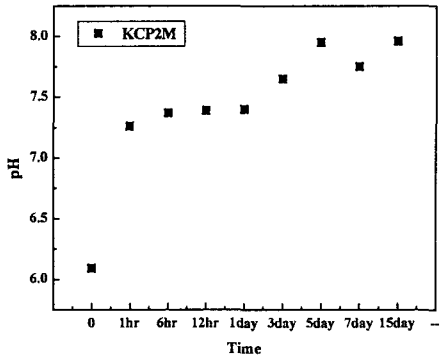

Fig. 1. pH changes of aqueous solution of the KCP2M glass according to time sequence.

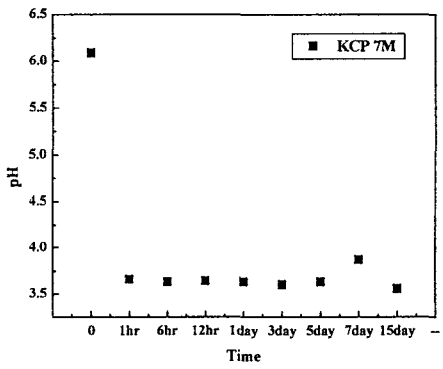

Fig. 2. pH changes of aqueous solution of the KCP7M glass according to time sequence.

ICP-MS was used to analyze the dissolution amount and elements as shown in Figs. 3, 4. It shows that the dissolution amount of KCP7M is larger than KCP2M by about 250times. Such phenomenon indirectly proves why pH value of KCP7M rapidly decreases to acid range within 30 seconds. In the case of KCP7M, the dissolution amount of doped trace elements was in proportional to amount of doped oxides quantities and measured by the order as follow Mg > Mn > B > Fe > Zn > Cu > Mo.

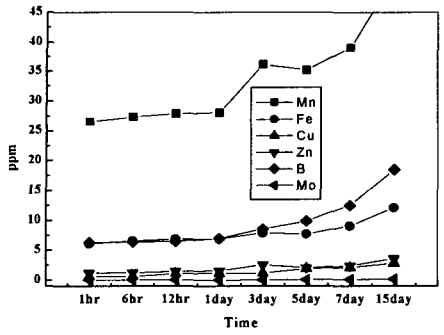

Fig. 3. Dissolved amount of chemical element contained in KCP7 glass in distilled water measured by ICP-MS.

Even though KCP2M shows the similar tendency in the dissolution property, the amount of dissolved elements is much smaller than KCP7M. As the composition of KCP2M contains lots of alkali oxides and less P2O5, it can be said that the glass is stable state and dissolution property is controlled by alkali ions as silicate glass in the water bath. The dissolution amount depends on the doped oxide quantities and checked by the order as Mg > Mn > B > Fe > Cu > Zn, Mo. Zn and Mo was not detected until 15 days.

Therefore, we expect that the needed nutrients will be supplied selectively and timely by changing the glass compositions.

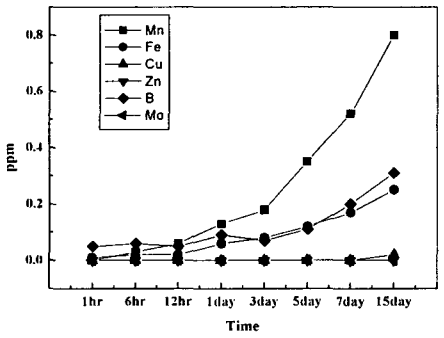

Fig. 4. Dissolved amount of chemical element contained in KCP2 glass in distilled water measured by ICP-MS.

4.Conclusion

We fabricated the K2O-CaO-P2O5 glasses containing trace elements and investigated the dissolution properties with pH meter and ICP analyzer. The doped trace elements do not have significant effect on the KCP2M, KCP7M, and the pH values of both samples were changed rapidly with 30 seconds and showed reciprocal results. The ICP analysis confirmed that the velocity of doped trace elements is proportional to the quantities of alkali oxides and could be controlled by mother glasses.

References

1) S. T. Reis, M. Karabulut, and D. E. Day, J. Non-cryst. Solids, Vol.292, pp.150-157 (2001).

2) H. S. Liu, T. S. Chin, and S. W. Yung, Mat. chemistry and physics,Vol.50, pp.1-10 (1997).

3) A. E. R. Westman and J. Crowther, J. Am. Ceram. Soc., Vol.37, pp.420-427 (1954).

4) J. H. Joe, Y. Lee, S. Y. Choi, C. S. Shin and K. N. Kim, J. Kor. Ceram. Soc., Vol.32, pp. 1093-1102 (1995).

5) P. Knott, Glasstech., Vol.62, pp. 29-34 (1989).

6) Yoon Young Jin, Yoon Tae Min, Lee Yong Su and Kang Won Ho, Kor. J. Materials Research, Vol.12, pp.545-549 (2002)

7) R. W. Douglas and T. M. M. Shamy, J. Am. Ceram. Soc., Vol.50, pp.1-8 (1967).

8) D. M. Sanders, L. L. Hench, J. Am. Ceram. Soc., Vol.56,pp. 373-378 (1973).