Journal of Thermal Analysis, Vol. 43 (1995) 169-173

THE SYSTEM Y_2O_3–MgO–P_2O_5

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Abstract

The previously unknown ternary system Y_2O_3–MgO–P_2O_5 has been examined by thermal, X-ray and microscopic methods. Its phase diagram has been determined over the composition range: YPO_4–$Mg_3(PO_4)_2$–$Mg(PO_3)_2$–$Y(PO_3)_3$. In the system, the existence of two mixed phosphates: $MgYP_3O_{10}$ and $MgY(PO_3)_5$ has been found, and they occur, according to their composition, at the sections YPO_4–$Mg(PO_3)_2$ and $Y(PO_3)_3$–$Mg(PO_3)_2$, respectively.

Keywords: double magnesium–yttrium phosphates, phase diagrams, system Y_2O_3–MgO–P_2O_5

Introduction

Literature review proves that phase examinations in the ternary system Y_2O_3–MgO–P_2O_5 have not been carried out before and mixed magnesium–yttrium phosphates are not known, either. There are few literature data on mixed alkaline earth metals–lanthanides phosphates. It results from references [1–3] that compounds with formulas $M_3Ln(PO_4)_3$ (where M=Sr, Ba, Ca, Ln=La-Gd, Y) are known.

Experimental

The following original materials of analytical grade were used: Y_2O_3 99.99%, $NH_4H_2PO_4$, H_3PO_4 85%, MgO and $MgHPO_4 \cdot 3H_2O$. The syntheses of yttrium and magnesium phosphates are reported in references [4, 5, 9–12].

Preparations for the examinations were obtained from the initial materials mixed in assumed quantity ratios. The samples were ground in an agate mortar. 0.5–3 g samples were prepared for thermal analysis. Preparations for the synthesis in the solid phase or for the melting at higher temperatures (above 1400°C) were pelletized (for better contact of substances).

The investigations were carried out by thermal analysis (DTA heating), powder X-ray diffraction and microscopy in reflected light. Thermal analysis was performed on a derivatograph type 3427 (MOM, Hungary). Thermal examina-

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tions at high temperature were carried by means of a vertical resistance furnace with molybdenum winding, which had been constructed in this laboratory, under argon.

The temperature was measured by means of an optical pyrometer which was calibrated against the melting points of Na_3PO_4 and $Ca_3(PO_4)_2$. The phase purity of reagents and the phase structure of the products were studied by microscopy and powder X-ray diffraction, which was performed on an HZG-4 diffractometer with CuK_α radiation.

Results and discussion

The ternary system Y_2O_3–MgO–P_2O_5 is surrounded by three side systems: Y_2O_3–MgO [6], MgO–P_2O_5 [7], Y_2O_3–P_2O_5 [8]. Their phase diagrams had been determined by other authors. The results of examinations performed in this laboratory are in accordance with literature reports.

The ternary system was investigated within the composition range: YPO_4–$Mg_3(PO_4)_2$–$Mg(PO_3)_2$–$Y(PO_3)_3$. The other part of the system was not examined because the microscopic and X-ray analyses of completely or partially

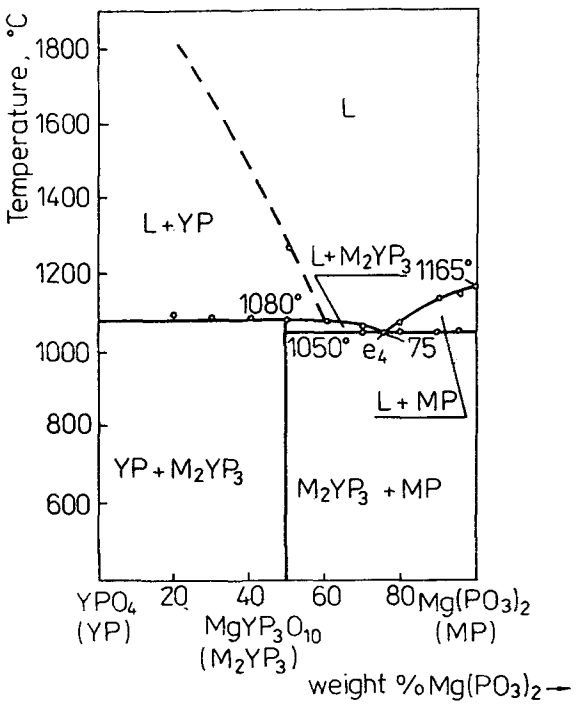

Fig. 1 Phase diagram of the system YPO_4–$Mg(PO_3)_2$; o - thermal analysis

molten samples from this composition range did not show the existence of any new chemical compounds, and because of great experimental difficulties (high temperature, high liability to form glasses, decomposition of preparations rich in P_2O_5 at considerably low temperature). Within the composition range under investigation, the occurrence of four main binary sections was discovered: YPO_4–$Mg_3(PO_4)_2$, YPO_4–$Mg_2P_2O_7$, YPO_4–$Mg(PO_3)_2$ and $Y(PO_3)_3$–$Mg(PO_3)_2$. The two former ones are simple eutectic systems. Their phase diagrams were reported in Ref. [9].

The systems YPO_4–$Mg(PO_3)_2$ and $Y(PO_3)_3$–$Mg(PO_3)_2$ are more complex. Their phase diagrams are presented in Figs 1, 2 and were published in Refs [10, 11].

In the system YPO_4–$Mg(PO_3)_2$, the intermediate compound occurs at the 1:1 molar ratio of the initial phosphates and its formula is $MgYP_3O_{10}$. Tripolyphosphate $MgYP_3O_{10}$ is formed peritectically and the peritectic reaction is irreversible.

Figure 2 presents the phase diagram of the system $Y(PO_3)_3$–$Mg(PO_3)_2$. In the system, the intermediate compounds occurs at the 1:1 molar ratio of the initial metaphosphates and its formula is $MgY(PO_3)_5$. This double metaphosphate

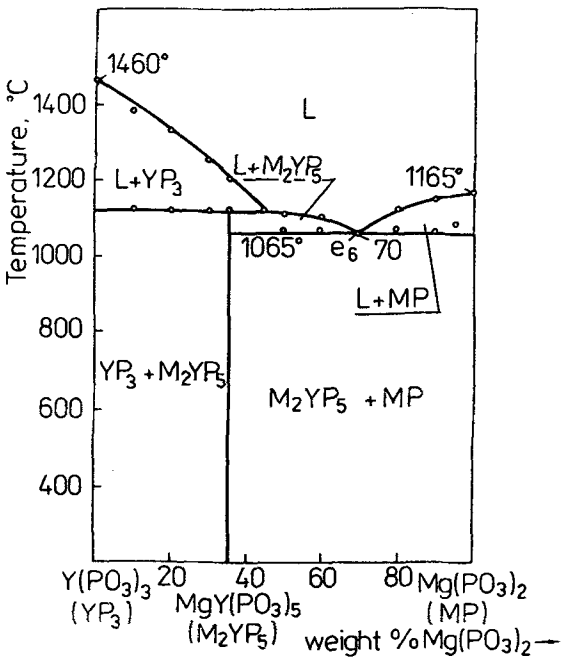

Fig. 2 Phase diagram of the system $Y(PO_3)_3$–$Mg(PO_3)_2$; o - thermal analysis

melts incongruently forming $Y(PO_3)_3$ and a liquid, at 1120°C. The peritectic reaction is irreversible.

Both phosphates $MgYP_3O_{10}$ and $MgY(PO_3)_5$ are formed with difficulty and could not be obtained in a phase pure form.

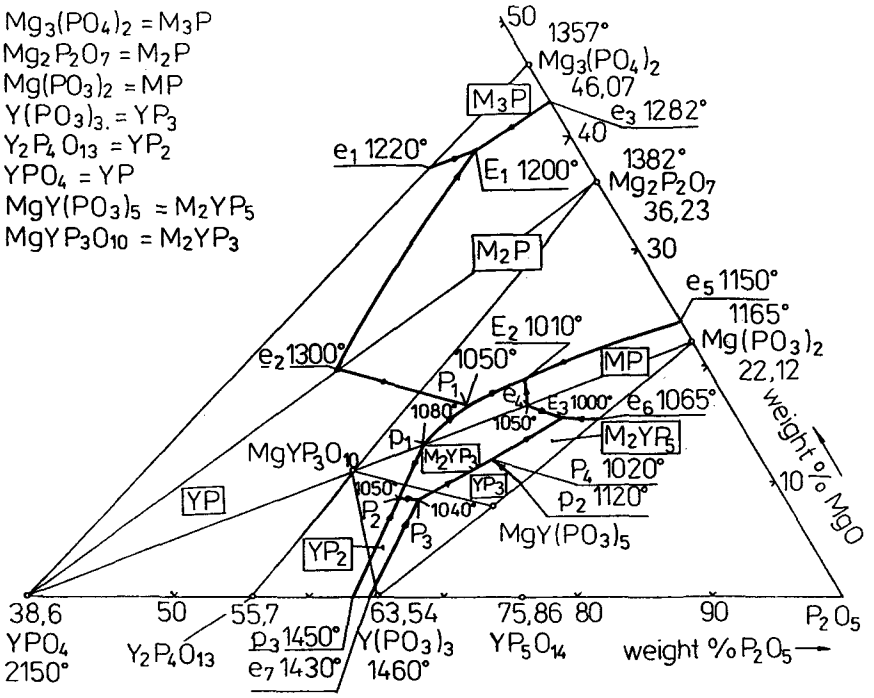

Fig. 3 Phase diagram of the system Y_2O_3–MgO–P_2O_5

Figure 3 presents the phase diagram of the system Y_2O_3–MgO–P_2O_5 within the composition range YPO_4–$Mg_3(PO_4)_2$–$Mg(PO_3)_2$–$Y(PO_3)_3$. Six binary compounds and two ternary compounds occur within this area. All these compounds crystallize from the liquid phase. The primary crystallization field of the individual compounds are separated with eutectic and peritectic curves. Three ternary eutectics and four ternary peritectics occur within the composition range under investigation. The samples start crystallizing within the temperature range from approx. 1000 to 2000°C.

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Zusammenfassung — Mittels thermischen, Röntgendiffraktions- und mikroskopischen Methoden wurde das zuvor unbekannte System Y_2O_3–MgO–P_2O_5 untersucht. Das Phasendiagramm für das Zusammensetzungsintervall YPO_4–$Mg_3(PO_4)_2$–$Mg(PO_3)_2$–$Y(PO_3)_3$ erstellt. In diesem System wurde die Existenz von zwei Mischphosphaten: $MgYP_3O_{10}$ und $MgY(PO_3)_5$ gefunden, die entsprechend ihrer Zusammensetzung in den Regionen YPO_4-$Mg(PO_3)_2$ und $Y(PO_3)_3$–$Mg(PO_3)_2$ vorkommen.