

Thermodynamic assessment of the Al₂O₃-TiO₂-SiO₂ system for modeling interactions at the ceramic filter-melt interface

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The Al₂O₃-TiO₂-SiO₂ system is important for a metal melt filtration process. In recent years, a concept of the installation of Al₂O₃-based filter systems, through which steel or Al melt passes, is being developed [1,2,3,4]. It should be noted that the main system to model Al melt filtration is the Al-Mg-Ti-Si-O system. For instance, TiO₂ coating deposited on corundum is supposed to filter actively MgAl₂O₄ spinel phase from Al-based molten alloy. Besides this, the Al-based melt can then react with TiO₂ reducing it to sub-oxides and metallic titanium. An excess of Ti, not dissolved in Al, can form intermetallic compounds TiAl₃, TiAl₂, or TiAl. In the Al melt containing Mg, the MgAl₂O₄ or MgTiO₃ phases can form. In Si-containing Al alloy, Ti₅(Si,Al)₃, Ti(Al,Si)₃ and ternary phases can form. Therefore, to model chemical reactions at the interface between ceramic filter and Al melt, a thermodynamic database of the Al-Mg-Ti-Si-O system is necessary. The Al₂O₃-TiO₂-SiO₂ system is a sub-system of the mentioned complex system. To ensure a reliable thermodynamic description of the ternary system, phase relations in the Al₂O₃-TiO₂-SiO₂ system were studied experimentally. The samples prepared by a co-hydrolysis method followed by annealing experiments were investigated using XRD, SEM/EDX, and DTA. The isothermal sections at 1213, 1449, 1474, and 1517°C were constructed based on obtained results which are mainly in an agreement with the literature data [5,6,7]. However, the solid-state invariant reaction of a transitional type, TiO₂ + Al₆Si₂O₁₃ ↔ SiO₂ + Al₂TiO₅, was indicated at 1470°C for the first time. On the liquidus surface, a eutectic invariant reaction between TiO₂ rutile, SiO₂ cristoballite, and Al₂TiO₅ tialite was detected at 1477°C. An invariant transitional-type reaction L+Al₆Si₂O₁₃↔SiO₂+Al₂TiO₅ was found at 1506°C in the SiO₂-rich area. Other invariant reaction L+Al₂O₃↔Al₆Si₂O₁₃+Al₂TiO₅ was observed at 1733°C in the alumina-rich area of the ternary system. The experimental data obtained as well as previously reported databases for the binary Al₂O₃-TiO₂, TiO₂-SiO₂, and Al₂O₃-SiO₂ systems were used to derive the thermodynamic description of the Al₂O₃-TiO₂-SiO₂ system.

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