PRODUCTION OF SCANDIUM AND Al-Sc ALLOY BY USING $CaCl_2$ MOLTEN SALT

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Abstract

Scandium (Sc) is considered to be one of the most effective hardening elements in aluminum (Al) alloys. Currently, Sc is produced in the form of an oxide (Sc_2O_3) as a byproduct during the smelting of uranium (U), tungsten (W), or tantalum (Ta). The production volume of Sc obtained as a byproduct is very small, and Sc and its compounds are extremely expensive. In recent years, the nickel (Ni) smelting process has undergone a partial transition from a pyrometallurgical process to a hydrometallurgical process that can recover Ni even from low-grade laterite ore. Further, it is reported that Sc can also be efficiently recovered from a leaching solution in the hydrometallurgical Ni smelting process[1]. When a hydrometallurgical process for extracting Ni from low-grade ores containing Sc will be developed, Ni ore will become a new Sc resource, and Sc_2O_3 can be produced at low cost. Presently, metallic Sc is produced by the calciothermic reduction of scandium fluoride (ScF_3) because Sc_2O_3 is thermodynamically stable and it is difficult to reduce it to metallic Sc even by using metallic calcium (Ca)[2]. However, the production cost of this process is high because an expensive reaction apparatus is required for treating the fluorides. Furthermore, contamination of the produced metal with the reactor material and reductant is a serious technical problem because the process involves a reduction reaction at high temperature. With this background, we investigate a new process for producing Sc by the calciothermic reduction of Sc_2O_3 with Al as a collector metal. It is demonstrated that Al-Sc alloy is successfully produced by this process[3, 4].

Figure 1 shows the flowchart of the new production process of Al-Sc alloy. A mixture of Sc_2O_3, Al, and $CaCl_2$ in a tantalum crucible was placed inside a stainless steel reaction container, and the feed mixture was reacted with Ca vapor at 1273 K for 6 h. After the reduction experiment, the reaction product (CaO), $CaCl_2$ flux, and excess Ca reductant were removed from the obtained alloy sample by leaching with an aqueous solution.

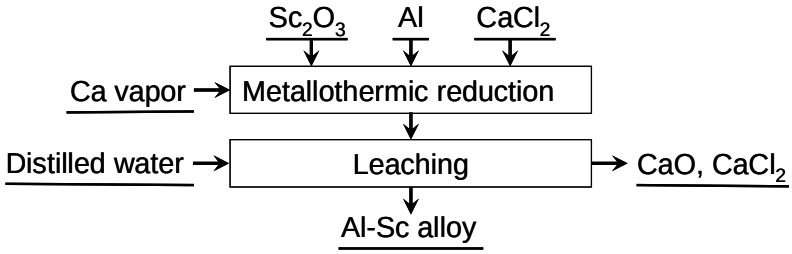

Fig. 1 Flowchart of the process for producing Al-Sc alloy by the calciothermic reduction of Sc_2O_3 with Al as a collector metal.

Figure 2 shows the elemental mapping of the sectioned sample obtained after the reduction experiment in which Sc_2O_3, Al, and $CaCl_2$ were used as the feed material, collector metal, and flux, respectively. Sc- and Ca-enriched phases were observed in the Al matrix. X-ray diffraction analysis revealed that they were Al_3Sc and Al_4Ca phases, respectively. This result indicates that Sc_2O_3 was successfully reduced to metallic Sc and alloyed in situ to form liquid Al-Sc alloy during the reduction; however, excess Ca reductant remained in the Al_4Ca phase. When Al was not used for the reduction, a complex oxide ($CaSc_2O_4$) was formed, and the reduction was incomplete.

Currently, we are developing a new process for producing Al-Sc alloy by molten salt electrolysis using $CaCl_2$ as an electrolyte. Figure 3 shows a schematic diagram of this process. A carbon electrode is used as the anode, and Al is used as the cathode, which serves as the collector metal of Sc. It is expected that by employing the electrochemical method, Al-Sc alloy with low Ca contamination can be produced directly from the oxide feed dissolved or dispersed in the molten salt. Some results of the molten electrolysis experiment will be displayed on the poster to be presented.

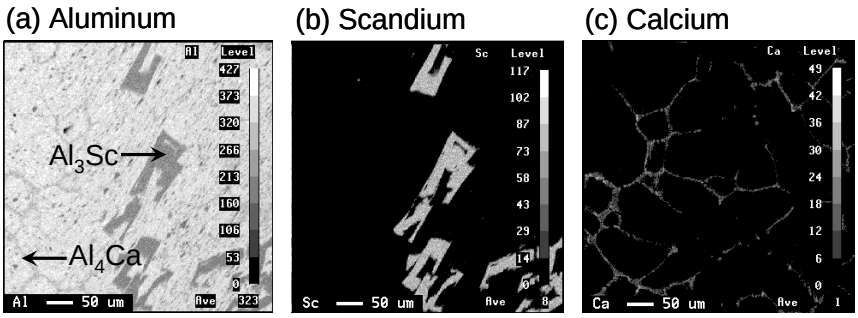

Fig. 2 Elemental mapping of the sectioned Al alloy sample obtained after the reduction experiment.
(Feed: Sc_2O_3, collector metal: Al, flux: $CaCl_2$, $T_{red.}$ = 1273 K, $t'_{red.}$ = 6 h)

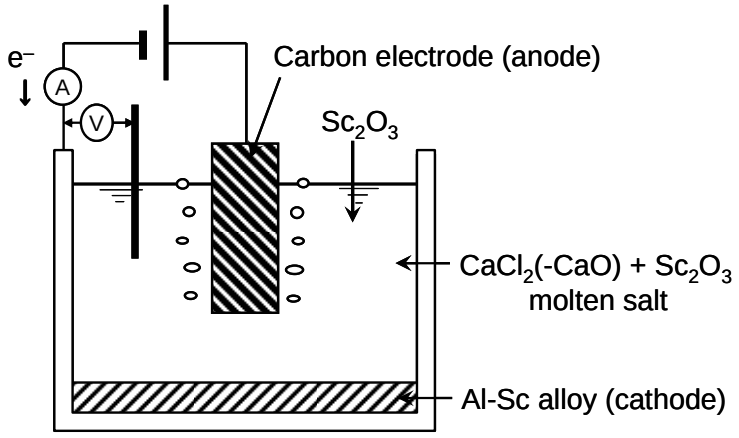

Fig. 3 Schematic diagram of the process for producing Al-Sc alloy by molten salt electrolysis.

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