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Electroreduction of aluminium and scandium from the fluoride and oxide-fluoride melts

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Abstract

A growing demand for alloys and composite materials based on aluminum and other light metals is widely observed. Thus the new energy-efficient ways of their production are relevant. In this work we studied the main kinetic features of the aluminium and scandium electro reduction during electrolysis of fluoride and oxide-fluoride melts by means of electrochemical methods. Particularly, features under study would be helpful at the choosing parameters of stable electrolysis of low-melting KF-AlF_3-based melts, which are selected as the main perspective melts due to their high capture with oxides. To clarify the potentials of aluminium and scandium electro reduction, measurements were also performed in KF-AlF_3-ScF_3, LiF-NaF-AlF_3-ScF_3, and LiF-CaF_2-ScF_3 melts.

It was shown that aluminium is electrically reduced into tungsten electrode in the potential range from -0.1 to -1.3 V in KF-AlF_3-Al_2O_3 melt. At the same time, the discharge precedes from different electroactive species. This accompanied with the diffusion peak formation at a potential around -0.4 to -0.5 V and further maintenance of the cathode current when the potential is shifted to the negative region. Despite the maintaining general kinetic features and parameters of the process under study replacing Al_2O_3 by Sc_2O_3 in KF-AlF_3 melts leads to a co-elecroreduction of aluminium and scandium. Depending on the potential sweep rate, a noticeable difference in the cathode process in KF-AlF_3-Sc_2O_3 melts is the potassium electroreduction with depolarization caused by the probable formation of K-Sc compounds. Under stationary conditions, the appearance and increase in the Sc_2O_3 content in KF-AlF_3 melt up to 5.7 wt. % leads to an increase in the limiting cathode current of co-electroreduction of aluminium and scandium from 0.45 to 0.81 A/cm^2 at a temperature of 800 ºC. The character of voltammograms obtained in KF-AlF_3-ScF_3 melts is complicated with using ScF_3 fluoride as a source of scandium. This is due to electroreduction of Al-Sc intermetallic compounds of different composition. Individual scandium electroreduction without visible aluminium and alkali metal reducing was observed in the LiF-CaF_2 fluoride melt at a potential of -0.40 to -0.45 V relative to the potential of the aluminum reference electrode. Obtained value is close to the thermodynamic one.

The obtained data are necessary at the development of the scientific foundations of new energy-efficient technology of producing Al-Sc master alloys production from their oxides during the electrolysis of oxide-fluoride melts.

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