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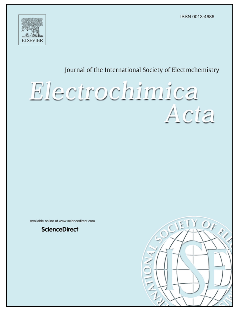

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Wenzhuo Deng, Ying Li

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Electrochemical Sensor for Determining the Manganese Content in Molten Iron

Wenzhuo Deng [a], Ying Li [a]*.

[a] Liaoning Key Laboratory for Metallurgical Sensor and Technology, Northeastern University, Shenyang, 110819, China.

Abstract: The measurement of manganese concentration in liquid iron without sampling is a challenge for better production control and improving the efficiency of the steelmaking process. An electrochemical sensor was developed to address this issue. As a crucial component of the sensor, the MnO, which functions as the auxiliary electrode material, was mixed with PVA water solution and deposited on the raw magnesia-doped zirconia tube, and thereafter annealed under an argon atmosphere at 1600°C. The X-ray diffraction indicates the MnO coating remains intact after sintering, and scanning electron microscopy shows the MnO layer tightly adheres to the solid electrolyte. The performance of the galvanic cell is appreciably affected by the particle size of the MnO powder, in the case of fine powder, steady cell potentials can be obtained quickly after immersion into the molten iron. The electromotive force of the cell is inversely proportional to the Mn content, and a linear equation between the two was derived. Furthermore, the relationship between the calculated Mn activities and the Mn concentrations determined by chemical analysis implies a positive deviation from Henry's law, which may chiefly arise from the fact that the MnO activity is less than unity. Additionally, the ionic conductivity of 8mol%Mg-PSZ and the activation energy were also investigated.

Keywords: Electrochemical Sensor, Solid Electrolyte, Auxiliary Electrode, Electromotive Force, Mg-PSZ

1. Introduction

Manganese is an essential element for most steel products, and steels generally contain less than 1wt.% manganese, which gives rise to enhanced intensity and hardenability. Furthermore, the alteration of morphology and distribution of sulfide in steel benefited from the formation of MnS, can further prevent hot shortness and improve the hot-working character. For some wear-resistant steels such as Hadfield steels, even more than 10wt.% of Mn is added. In the steelmaking process, the liquid iron is sampled using a sublance incorporated with a thermocouple and an oxygen sensor, the Mn concentration is subsequently determined by the means of chemical analysis performed on the solidified specimen and the end-point Mn content is adjusted accordingly by introducing either manganese ore or ferromanganese alloy. For the sake of cost and efficiency, accurate evaluation of the quantity of Mn in the hot melt is of considerable importance for the following refining process and for the precise quality control of the final product[1]. However, the conventional sampling method is time-consuming and cannot provide real-time information on the composition of liquid iron, as a result, the online monitoring of molten alloy is of great interest.

A lot of efforts have been implemented to detect the Mn content in hot metal. The conventional optical atomic spectroscopy techniques such as atomic emission spectrometry primarily involving the dissolving of the analyte-containing sample in a suitable solution, vaporization and nebulization of the liquid sample, excitation of the gaseous atoms, and analyzing the emitted radiation, are widely used for the quantitative analysis of solidified alloys[2-4]. However, when laser rather than traditional flame, spark, arc, or plasma was employed as the emission source due to the advantage of intense radiation and remote operation, the spectral lines emitted from the metal cloud either spontaneously vaporized or

*Corresponding author. E-mail address: liying@smm.neu.edu.cn