

Review

Phase Equilibrium Study of Rare Earth Oxide–Fluoride Salt System: A Review

Quan Zhou ¹, Jinfa Liao ^{1,2,*} , Chunfa Liao ^{1,2} and Baojun Zhao ^{1,2,3}

¹ School of Metallurgical Engineering, Jiangxi University of Science and Technology, Ganzhou 341000, China; qz2021085748@mail.jxust.edu.cn (Q.Z.); cfliao@jxust.edu.cn (C.L.); bzhao@jxust.edu.cn (B.Z.)

² National Rare Earth Functional Materials Innovation Center, Ganzhou 341000, China

³ Sustainable Minerals Institute, The University of Queensland, Brisbane, QLD 4072, Australia

* Correspondence: liaojinfat678@outlook.com

Abstract: The applications of rare earth metals and alloys are becoming increasingly widespread and there is a strong market demand. Currently, most of the production enterprises adopt the fluoride–oxide system for electrolytic preparation of rare earth metals and alloys. The solubility of rare earth oxides in molten salt directly affects the selection of operational parameters in the electrolysis process. When the added amount of RE_2O_3 is less than its solubility, it leads to a decreased electrolytic efficiency. Conversely, an excessive amount of oxide is prone to settle at the bottom of the electrolytic cell, impeding smooth production. The RE_2O_3 solubility in the fluoride salt can be represented by the phase equilibrium of the RE_2O_3 – REF_3 – LiF system. The isothermal lines in the primary phase field of rare earth oxide represent the solubility of the oxide in the fluoride salt at the corresponding temperature. This paper outlines the research methods and experimental results on the phase equilibria of the RE_2O_3 – REF_3 – LiF system. The characteristics and existing problems in the current phase equilibrium study are analyzed. The solubility data of RE_2O_3 are expressed in the forms of ternary and pseudo-binary phase diagrams of the RE_2O_3 – REF_3 – LiF system, providing theoretical guidance for the establishment of an accurate and reliable rare earth electrolysis system database and the optimization of electrolytic processes.

Keywords: rare earth; molten salt electrolysis; phase equilibrium; solubility



Citation: Zhou, Q.; Liao, J.; Liao, C.; Zhao, B. Phase Equilibrium Study of Rare Earth Oxide–Fluoride Salt System: A Review. *Metals* **2024**, *14*, 314. <https://doi.org/10.3390/met14030314>

Academic Editor: Duc Nguyen-Manh

Received: 27 January 2024

Revised: 26 February 2024

Accepted: 4 March 2024

Published: 7 March 2024



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1. Introduction

Rare earth metals and alloys are increasingly used in the field of new materials, and there is a strong market demand. Rare earth elements have unique physical and chemical properties due to their special electronic structures, such as excellent optical and electrical properties, magnetic properties, and active chemical properties. With the development of modern science and technology, REEs have become indispensable key materials for high-tech and novel functional materials [1,2].

In recent years, with the momentum of technological innovation and the ongoing revolution in global manufacturing, there have been significant changes in the consumption structure of REEs, with an increasing production of rare earth metals such as La, Ce, Nd, Pr, and Y [3–5]. The production of rare earth metals and alloys is an important component of the rare earth industry. Rare earth metals, being highly reactive, are usually produced from chloride or oxide raw materials using two major methods: metallothermic reduction and molten salt electrolysis. Compared with thermal reduction, molten salt electrolysis is a relatively economical method as it allows continuous production and easy control of product quality. It is currently widely used in the production of single rare earth metals, such as La, Ce, Pr, and Nd, and mixed rare earth metal alloys [6–9].

The production of rare earth metals and alloys by molten salt electrolysis can be divided into two categories: a chloride melt system and an oxide–fluoride melt system. The

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group tickets hershey bears hockey cub scout pack 203 hershey - Feb 18 2022

web group tickets join bear nation by bringing your team to giant center groups of 15 with more receive deeply discounted tickets exciting group specialty november plus delicious food and beverage options let s build bear

amusement park tickets hersheypark 2023 discounted hersheypark - Sep 08 2023

web hersheypark haunting ticket valid all day all darkness experience thrilling coasters including lights out on wildcat s revenge trick button treating dim nights haunted housing real scare zones

amusement park tickets hersheypark boy scout discount hershey park - Aug 07 2023

web receive a free summer tickets whereas thee buy 2 full price tickets hurry available for ampere limited time only 169 90 thirds 1 day tickets ages 3 254 85

hillsborough gs hershey park tickets - Sep 27 2022

web hershey park tickets each year in march our service unit takes pre orders for discounted hershey park admission tickets funds raised are used to provide scholarships to graduating seniors and camporee scholarships for our scouts and adult volunteers check back in march 2024 for our sale flyer

pennsylvania dutch council boy scouts of america facebook - Mar 02 2023

web save 19 85 on every ticket purchased before july 31st you must purchase your tickets throught the pa dutch council website to get this special discount you do not have to be a scout to experience the savings pass this on all your friends padutchbsa org discounted hersheypark tickets

boy scout discount hershey park tickets november 2023 - May 24 2022

web with the boy scout discount hershey park tickets program scouts can save up to 20 per ticket making it an ideal way to save money while still enjoying the park s attractions the program is available to all registered boy scouts venturers explorers and

amusement park tickets hersheypark 2023 discounted hersheypark - Apr 03 2023

web each amusement park ticket packet in thrills on rollers coasters sommer cruises bottom waterslides spins and twirls on our family rides and so big more

pennsylvania dutch council boy scouts of america facebook - May 04 2023

web discount hersheypark tickets are now available share this post with all your friends and help support scouting while enjoying a great day at hersheypark you will save over 19 00 per ticket if you purchase before july 5th padutchbsa org discounted hersheypark tickets

amusement park tickets hersheypark - Feb 01 2023

web admission tickets tickets groups season passes tickets tickets as low as 29 99 dated ticket wrap up hersheypark happy for the whole family early with our 12 days of christmas pre sale buy more save more and get tickets as low as 29 99 hurry sale ends nov 12 starting at 36 99 84 95 1 to 3 tickets purchased

cheapest hershey park tickets here now the dis disney - Nov 29 2022

web apr 29 2016 we are going to heroes park saturday though can retrieve in tomorrow night for an preview i must not purchases tickets yet we stopped at behemoth supermarket than per the hershey homepage or they said they haven t receive in the discount get yet i see that padutch man scouts are selling tickets online

discount hersheypark tickets for aaa members - Jul 26 2022

web junior one day ticket ages 3 8 49 00 regular price 51 75 children two and younger free your aaa membership also gives you access to special hersheypark aaa member special days with tickets starting at 52 60 hersheypark aaa member special days are subject to change but are valid may 1 through jun 30 2022

boy scout discount hershey park tickets july 2023 10 off - Jun 24 2022

web 11 active promo codes with 10 off save 28 33 per order the best boy scout rate hershey park tickets youth scout discount hershey search tickets verified super discount

2023 discounted hersheypark tickets now available - Oct 09 2023

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