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Abdelkader Abdessattar, David Boa, Dalila Hellali, Hmida Zamali

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Experimental study and thermodynamic analysis of ($CsNO_3$+$TlNO_3$) binary system

Abdelkader ABDESSATTAR [a], David BOA [b], Dalila HELLALI [a, *] and Hmida ZAMALI [a]

[a] Université de Tunis El Manar, Faculté des Sciences de Tunis, LR15ES01 Laboratoire de Matériaux, Cristallochimie et Thermodynamique Appliquée, 2092, Tunis, Tunisie.
[b] Laboratoire de Thermodynamique et de Physico-Chimie du Milieu, Université Nangui Abrogoua, UFR SFA, 02 BP 801, Abidjan 02, Côte d'Ivoire.

* Corresponding author.
E-mail address: dalilahlali@hotmail.fr and dalila.hellali@fst.utm.tn

Abstract

Phase diagram of the ($CsNO_3$+$TlNO_3$) binary system is investigated between 293 K and 700 K, under atmospheric pressure, by means of simultaneous direct and differential thermal analysis, DSC and X-ray diffraction techniques. This phase diagram is characterized by two continuous solid solutions, a minimum "like-azeotrope" at 403 K and a very limited solid solution rich in $TlNO_3$. An optimization of the thermodynamic parameters of this binary system is also performed using all the available experimental data.

Keywords: caesium nitrate, thallium nitrate, solid solution, phase diagram, azeotrope, optimization.

1. Introduction

Mixtures of alkali nitrate salts are characterized by a high thermal stability in the liquid state, relatively low melting temperatures and relatively high enthalpies of fusion. They have the advantage of being non-volatile and not very corrosive [1]. These properties are readily adaptable to be used commonly for thermal storage and heat transfer in Concentrated Solar Power plants (CSP) [2-4]. Among these nitrates we mention the mixtures of: ($NaNO_3$+$NaNO_2$+KNO_3) (Hitec), ($NaNO_3$+KNO_3) (Solar salt), ($LiNO_3$+$NaNO_3$+KNO_3), ($Ca(NO_3)_2$+$NaNO_3$+KNO_3) and ($Ca(NO_3)_2$+$LiNO_3$+KNO_3).

They are also used in electrochemistry and metallurgical electrolysis [5] and in the processing and development of functional glass such as ($TlNO_3$ + $NaNO_3$) and ($TlNO_3$ + KNO_3) mixtures [6-7].

Thus, knowledge of the thermodynamic properties of these pure nitrates and their mixtures and the composition of mixtures having low melting temperatures motivates the industrial investigators to improve their products in many fields. The phase diagrams of binary and higher order systems are an initial "roadmap" which provides these information. However, some of their published phase diagrams are incomplete, inconsistent, or not available.

There is a dispersion of the experimental results published in the literature, concerning the thermodynamic properties of caesium nitrate, thallium nitrate and their mixtures. It is also noted that their published phase diagram ($CsNO_3$+$TlNO_3$) is incomplete [8-10].

Therefore, in order to choose the most probable values for the updating of the thermodynamic data, the coupling of theoretical modelling and experimental investigations (compilation + optimization + coherence) is necessary. Currently, this method constitutes a research axis in its own right and involves several competences on the experimental, theoretical and computer levels.