CHAPTER 1

INTRODUCTION

1.1 Overview

Perovskite-type ceramics are extensively known in several industries due to their many outstanding properties. Its structure is found in a number of materials with the chemical composition ABO_3. The structure may be described as a simple cubic unit cell with a large cation at the corners (A site), a smaller cation in the body center (B site), and oxygen at the centers of the faces [1-4]. $PbTiO_3$, $PbZr_{1-x}Ti_xO_3$ and $PbZrO_3$ are well known perovskite compounds and widely used in electronic devices, i.e. sensors, actuators, capacitors, thermistors and energy storage devices, etc. However, volatilization of toxic PbO during high-temperature sintering not only causes environmental pollution but also generates instability of composition and electrical properties. Also, products containing Pb-based gadgets are not recyclable. According to the mentioned disadvantages of lead-based materials, lead-free ceramics have received a great deal of attention from the scientific community in searching for environmentally friendly compounds. Thus, many researches are pointing out to look for novel lead-free materials and extend knowledge of those materials in order to fine a promising substituted candidate for lead-based compounds in many electronic devices.

In a few years ago, $Bi_{0.5}Na_{0.5}ZrO_3$ (BNZ) compound was first introduced by Lily et al. [5]. The ceramic was revealed to possess a negative temperature coefficient of resistance (NTCR) characteristics. Accordingly, it was possibly believed to be a promising candidate for the above-mentioned electronic devices, in particular NTC-type thermistors. Nonetheless, other significant information of this material, i.e. powder preparation, ceramic fabrication, phase characteristic, microstructure, mechanical properties, thermal expansion properties and electrical properties was missing due to the novelty of this material system.

Zr^{4+}/Ti^{4+} substitution at B-site in perovskite lattice is well known to affect significantly the properties of perovskite ceramics. For example, $Pb(Zr_{1-x}Ti_x)O_3$ system showed a good piezoelectric and ferroelectric properties at morphotropic phase boundary [6, 7] and $Ba(Zr_{1-x}Ti_x)O_3$ compound exhibited a polar cluster and relaxor behaviors at Ti-rich compositional side [8, 9]. Hence, it was attractive to study the Zr^{4+}/Ti^{4+} occupancy dominance on physical characteristics and properties of Ti-doped BNZ system.

In present study, BNZ and BNZT ceramic systems were therefore examined. $Bi_{0.5}Na_{0.5}ZrO_3$ and $Bi_{0.5}Na_{0.5}Zr_{1-x}Ti_xO_3$ powder and ceramics where x = 0.1, 0.2, 0.3, 0.4, 0.5 and 0.6 were prepared and subsequently characterized, particularly in terms of the processing parameters, phase evolution, morphologies, microstructural change, dielectric properties at room and higher temperatures, ferroelectric properties, mechanical properties and thermal expansion behavior. The results were reported and discussed in details. It is expected that this work would bring more understanding and give useful novel information on the area of lead-free perovskite materials.

Objectives of this work

The main objectives of this study are to investigate powder and ceramic processing of BNZ based materials prepared by mixed oxide method and conventional sintering technique, respectively. The relationships between phase evolution, microstructure, dielectric properties, ferroelectric properties and thermal expansion behavior of the ceramics will be investigated and discussed. The objectives of this study are as follows;

1. To prepare pure powders of $Bi_{0.5}Na_{0.5}ZrO_3$ based compounds employing a mixed oxide method.

2. To prepare high-quality ceramics of $Bi_{0.5}Na_{0.5}ZrO_3$ based compounds employing a conventional sintering technique.

3. To investigate phase, microstructure, mechanical and electrical properties of the $Bi_{0.5}Na_{0.5}ZrO_3$ based systems.