CHAPTER 1

INTRODUCTION AND OBJECTIVES

1.1 Introduction

Piezoelectric ceramics, such as lead zirconate titanate ($Pb(Zr_xTi_{1-x})O_3$) have been employed as sensors, actuators and transducers. They show large piezoelectric coefficient d_{33} and large dielectric constant ε_r [1-2]. Nevertheless, their transverse charge coefficient d_h, the hydrostatic voltage coefficient g_h and the hydrophone figure of merit (d_hg_h) are low. Furthermore, the PZT ceramics are hard and brittle materials in nature. These possess high acoustic impedance causing great acoustical mismatching between ceramics and the transmitting media like water or human tissue [3-4]. In order to overcome this disadvantage, piezocomposites which employed an active piezoelectric material in conjunction with an active or passive polymer phase have been suggested with different connectivity patterns [5]. The properties of ceramics/polymer composites can be tailored by changing the connectivity of the phases and volume fraction of active ceramic in composite samples. Since 1-3 ceramic/polymer composites possess the excellent overall piezoelectric properties when used in hydrophone and medical-imaging applications [6]. The 1-3 composites which comprise an active piezo-ceramic rods embedded within a passive polymer, has been extensively investigated by many researchers. 1-3 PZT/polymer composites which prepared by Schwarzer and Roosen [1] exhibited good piezoelectric and dielectric properties (d_{33} = 466 pC/N and ε_r = 1146) comparing with that of Janas *et* *al*. [3] who produced 1-3 piezocomposites by tape casting, honeycomb dicing and ceramic fiber weaving, having d_{33} = 370 pC/N and ε_r = 300, respectively. Taunaumang *et al*. [7] also fabricated 1-3 piezocomposite by dice and fill method. They varied the volume fraction of active piezoelectric ceramic by controlling the ceramic width and found that the value of d_{33} and k_p are 746 pC/N and 0.64, respectively. Moreover, there are many techniques used in producing 1-3 piezocomposites such as novel processing by weaving PZT fiber bundles through a honeycomb support [6], lost mold [8] and laser cutting [9].

Generally, the traditional method of synthesizing PZT powder is through solid-state reaction or mixed oxide method which involves mixing the constituent oxides (PbO, TiO_2 and ZrO_2) in stoichiometric ratio, followed by calcining for phase formation at an elevated temperature (> 700 °C). However, this often leads to an incomplete reaction and in particular, particle coarsening and agglomeration in the resulting PZT powder as a result of the multiple interfacial diffusions and reactions involved at the calcining temperature. Furthermore, nonstoichiometry in composition of the resultant PZT often occurs as a result of the undesirable loss in lead content through volatilization of PbO at elevated temperatures. Many chemistry-based processing routes such as the oxalate route, co-precipitatation, alkoxide hydrolysis and hydrothermal reaction, have thus been devised and employed to prepare ultrafine and sintering-reactive PZT powder. Since all these techniques offer many advantages, including low processing temperatures, excellent compositional control and uniform homogeneity. However, the PZT ceramics produced via the chemical processes usually require very high purity (> 99.9 %) and high cost chemicals which are not appropriate for large scale production [10-11].

This work reports our attempts to produce PZT particles via a modified chemical procedure and the spray drying technique employing low-purity-grade (< 99 wt%) chemicals. Characterization of the spray-dried PZT powders was then carried out and compared with mixed oxide powder. Thereafter, the PZT powders were used as the dispersed phase for fabricating the piezocomposite materials.

To obtain the piezocomposite with low acoustic impedance value, close to that of water or human tissue with reasonable properties of composite samples, in this work, the combination of 0-3 and 1-3 connectivities of piezocomposite materials was fabricated based on suction and dice and fill techniques. The PZT powder made by conventional mixed oxide method and spray drying technique were employed as the dispersed phase. The physical and electrical properties of samples were investigated. The microstructure of piezocomposites was also studied by scanning electron microscopy (SEM) technique.

1.2 Objectives

The objectives of this work can be divided into 2 major parts. Part I, is the preparation of PZT powder by using different techniques : conventional mixed oxide method and spray drying technique. Part II, is the fabrication of piezoelectric/ polymer composites. The dispersed phase which used in composite materials are PZT powders prepared from part I. The electrical, physical and piezoelectric properties of composite samples are studied. Furthermore, the SEM is employed for determining the microstructure of piezocomposites.