

## CHAPTER I

### INTRODUCTION

Electroactive materials are smart materials that provide large amounts of deformation in the presence of applied electric field (Snyder *et al.*, 2003). There are myriad of applications from sensing applications (Phumman *et al.*, 2009), shape memory materials (Koo, 2012), and robotic applications (Kim *et al.*, 2007). Electroactive polymers (EAPs) are attracting the attention of scientists and engineers for development and fabrication for a decade because of their lightweight, relatively low cost, good corrosion resistance, more flexibility, fast response and large strain under electrical stimulation (Bar-cohen, 2002; Vinogradov *et al.*, 2005).

Polycaprolactone (PCL), a rubber-like, hydrophobic and semi-crystalline synthetic polyester was discovered by Carothers group in 1930s. At present, PCL is a potential material for biomedical applications such as medical suture, wound dressing, medical splint, because of its low melting temperature (58-64 °C), biodegradability, high rigidity, and high modulus of elasticity (Woodruff *et al.*, 2010; Colwell, 2006). Normally, the mechanical strength will drop dramatically at above melting temperature so crosslinking is required to enhance thermal and mechanical properties (Han *et al.*, 2007). Radical crosslinking is a useful method because of low cost, easily available and a short preparation time (Pandini *et al.*, 2012; Xiao *et al.*, 2010).

For electroactive applications, electroactive fillers such as carbon nanotubes (CNTs), carbon particles, and electromagnetic fillers are utilized to enhance this unique effect (Liu *et al.*, 2009). For instance, a carbonous filler was embedded into polyurethane and coated with polypyrrole for fabricating a shape memory composite (Sahoo *et al.*, 2007). Electrical conductivity of the composite was increased up to 8 orders of magnitude, and the electroactive recovery effect occurred when a constant voltage of 25 V was applied.

Poly(p-phenylene) (PPP) is one of the most attractive conductive polymers for several decades because of high thermal stability, high conductivity from both

n-type and p-type doping processes, and various electronic structures achieved from different preparation methods, and a wider range of conductivity (Li *et al.*, 2008; Golovstov, 2005). There are several studies related to using conductive polymers as electroactive fillers. For example, poly(p-phenylene) (PPP) was blended with an acrylic elastomer to alter electroactive properties (Kunanuraksapong *et al.*, 2007). They discovered that electrical conductivity and electromechanical properties such as storage modulus response and sensitivity increase linearly with increasing PPP concentration.

Usually, the electrical conductivity of undoped conductive polymers is quite low (Sohn *et al.*, 2001), so a doping process with a variety of dopants such as arsenic pentafluoride ( $\text{AsF}_5$ ), alkali ions ( $\text{K}^+$  and  $\text{Na}^+$ ) antimony pentachloride ( $\text{SbCl}_5$ ), halogens ( $\text{Br}_2$  and  $\text{I}_2$ ) and iron (III) chloride ( $\text{FeCl}_3$ ) is required for enhancing the electrical conductivity. Doping with  $\text{FeCl}_3$  is one of the most popular way because of the least harmful dopant and relatively greater stability compared with other dopants (Bonagamba *et al.*, 1995).

In present work, an electroactive shape memory composite from PPP and PCL was fabricated. PPP was synthesized via the oxidative polymerization then mixed with PCL to generate more dipole moments. Mechanical stirring is required for good dispersion of PPP. Influences of the degree of crosslinking via the radical crosslinking, the doping level by varying concentration of the dopant, iron (III) chloride ( $\text{FeCl}_3$ ), and the concentration of embedded PPP on thermal, electrical conductivity and electromechanical properties with and without electric field were investigated.