# CHAPTER I
# INTRODUCTION

Artificial muscle development has received interest with a view to create biologically inspired actuators or devices which possess electromechanical responses. Potential applications of artificial muscles are for animal- and human-like robots; it is also logical to consider artificial muscles for human medical purposes. Conductive-electroactive polymers in which biopolymers are used as the matrix phase can be utilized to serve such functions.

Polycarbazole is a conductive polymer that contains two six-membered benzene ring fused on either side of a five-membered nitrogen containing ring. Mostly, it has been used in fabrication of light-emitting diodes, electrochromic displays, organic transistors, and rechargeable batteries (Morin *et al.*, 2005). Also, it is water-insoluble and stable in the environment (Macit *et al.*, 2005).

Silk fibroin is a natural protein fiber, which can be woven into a traditional textile, and can be used in medical applications such as sutures and soft tissues (Grath *et al.*, 1997). In general, silk fibroin can be processed into different kinds of morphology: particles, fibers, films, sponges, hydrogels, and scaffolds (Vepari *et al.* 1997 and Bini *et al.*, 2004). The most popular morphology is to fabricate silk fibroin into films, because it is a relatively easy preparation technique and the processing conditions can be controlled. Nevertheless, silk fibroin films have shown weak mechanical properties because of brittleness in the dry state, which limits their practical applications (Freddi *et al.* 1995). Consequently, there are many studies to improve the mechanical and physical properties of silk fibroin films by blending it with other polymers, such as poly(vinyl alcohol), chitosan, and cellulose (Li *et al.* 2002; Freddi *et al.*, 2003; and Laungbudnark *et al.* 2012 ).

Silk fibroin hydrogels have been developed to provide an important set of material options in the fields of controlled release, biomaterials, and scaffolds for tissue engineering, with a combination of biocompatibility, biodegradability, and cell interaction. Recognizing these advantages, an attempt will be made to use silk fibroin hydrogels as actuator muscle-like materials. Moreover, water molecules contained in the hydrogels will aid the electrical conductivity because water itself can conduct electricity.

It is interesting to note that silk from silkworm can show actuation performances. Jin and coworkers (2006) showed that a silk film prepared from high concentrations of regenerated fibroin in aqueous solution can be used as the base material for a biomimetic actuator. The silk actuator was made by constructing thin gold electrodes on both sides of the film. When electrical voltage was applied across the electrodes, the silk film actuator produced bending displacement. However, the bending deformation of silk film actuator was smaller than that of electroactive paper actuator.

In this work, we are interested in fabricating an electroactive material from polycarbazole embedded in silk fibroin hydrogel. A small amount of polycarbazole is added as the dispersed phase in an effort to improve the electrical properties of the silk hydrogel. Also, it is of interest to study and test silk fibroin hydrogels and silk fibroin/polycarbazole composites for actuator applications. The mechanical properties, viscoelastic properties, electrical properties, and actuator performances will be investigated and examined along with the effects of silk fibroin concentration, polycarbazole concentration, and electric field strength.