CHAPTER V
CONCLUSIONS

In this study, the electromechanical properties, dielectric properties, and the cantilever bending of pristine silk fibroin and silk fibroin/polycarbazole hydrogels were investigated at electric field strength varying from 0-600 V/mm. Polycarbazole was synthesized via the oxidative polymerization.

For the pure silk fibroin hydrogels, the storage modulus response ($\Delta G'$) and the storage modulus sensitivity ($\Delta G'/G'_0$) increase dramatically with increasing electric field strength and show the highest storage modulus sensitivity value of 5.87. Increasing the amount of glutaraldehyde as the crosslinking agent causes the reduction of the storage modulus sensitivity value due to the decrease of reactive dipole moments from the crosslinking process.

For the silk fibroin/polycarbazole hydrogel system, particles of polycarbazole were embedded into silk fibroin hydrogels with the particle concentrations of 0.001, 0.005, 0.01, 0.05, 0.1, and 0.5 vol.%. The storage modulus response ($\Delta G'$) and the storage modulus sensitivity ($\Delta G'/G'_0$) decrease with increasing particle concentration because water residues create the softening effect, neutralizing the electric-induced-dipole moments of the conductive polycarbazole particles, and generating movable induced dipole moments. The storage modulus sensitivity values of pure silk fibroin and silk fibroin/polycarbazole hydrogels are proportional to the relative dielectric permittivity values corresponding to the ionic polarization.

For the temporal response, there are some irreversible interactions from the remaining dipole interaction along silk fibroin and polycarbazole polymeric chains when the electric field is off.

For the deflection measurement, the deflection distances and the dielectrophoretic forces of the pure silk fibroin and silk fibroin/polycarbazole hydrogels increase with increasing electric field strength. The pure silk fibroin hydrogel shows greater deflection distance and the dielectrophoretic force, 8.00 mm and 9.19 mN, than those of fibroin/polycarbazole hydrogels.