CHAPTER VIII
CONCLUSIONS AND RECOMENDATIONS

8.1 Conclusions

In the absence of electric field, the storage modulus of the PDMS systems increases linearly with crosslinking density due to the larger number of strands. For electric field strength between 0.5 to 2.0 kV/mm, storage modulus increases nonlinearly with electric field. For the G' temporal characteristic of the crosslinked PDMS (N_c/N_m = 0.01) under electric field strengths of 1 and 2 kV/mm, data indicate that it is nearly a reversible system consistent with the deflection experiment. The degree of bending of the PDMS films and the dielectrophoretic forces F_D, increase linearly with electric field strength.

The electromechanical properties of the PPV/PDMS blends, with PPV particle volume fractions of 3, 5, 7, 10, 15, and 20 vol%, the storage modulus of each polymer blend is higher than the crosslinked PDMS due to the PPV particles within the matrix acting as fillers. They can absorb the stresses within the matrix. The dependence of $\Delta G'$ on electric field follows a scaling behavior: $\Delta G' = aE^{\alpha}$, $\alpha \approx 1.00 -$ 1.95, within the electric field range of 0.2 to 1 kV/mm. This is the result of the polarized PPV particles leading to interparticle interaction. The storage modulus sensitivity, $\dfrac{\Delta G'}{G'_0}$, attains a maximum G' % sensitivity values of 41, 42, 45, 46, 50, 36, and 7% at particle concentrations of 0, 3, 7, 10,15, and 20 vol% at an electric field strength of 2 kV/mm, respectively. For the G' temporal characteristic of the PPV/PDMS-10 under electric field strengths of 1 kV/mm, data indicate that it is nearly a reversible system, consistent with the deflection experiment. The degree of deflection of the PPV/PDMS films and the dielectrophoretic forces, F_D, increase linearly with electric field strength. Thus, we clearly demonstrate that our blend systems (PPV/PDMS) may be used as a new type of low-power consumption linear electromechanical actuators.

The SA-loaded polyacrylamide hydrogels were prepared by varying the crosslinking ratio to study the release mechanism and the apparent diffusion

coefficient, D_{app}, of the model drug from drug-loaded PAAM hydrogels with and without an electric field. Regarding the effect of crosslinking ratio, the D_{app} decreases with increasing crosslink ratio due to the larger pore size with the lower crosslink ratio. Regarding the effect of electric field strength, the D_{app} increases with increasing electric field strength and reaches the maximum value at an electric field strength of 0.1 V; it then decreases with further electric field strength increase and becomes saturated at an electric field strength of 5.0 V. The increase in D_{app} at low electric field strength is due to the electrophoresis effect driving the SA, the expansion of pore size, and the creation of transient pathways in the pigskin. D_{app} decreases at high voltage, due mainly to the contraction of pore size resulting from the electrolysis of buffer solution. The negative buffer ions are generated at the cathode electrode, resulting in the deprotonation and the neutralization of positive charged groups of PAAM.

The SA-loaded PAAM and SA-doped PPV/PAAM hydrogels were prepared by varying the crosslinking ratio to study the release mechanism and the apparent diffusion coefficient, D_{app}, of the model drug from drug-loaded PAAM and drug-doped conductive polymer/PAAM with and without an electric field. In the absence of electric field, SA is not released from SA-doped PPV/PAAM hydrogel in the first 3 hr period, and then it is released until reaching an equilibrium value. The zero amount of drug released in the first period originates from the ionic interaction between the conductive polymer and its counter ion (PPV/drug ion). After this period, the drug anion can diffuse through the PAAM matrix. On the effect of crosslinking ratio, D_{app} of both SA-loaded PAAM and SA-doped PPV/PAAM hydrogels system decreases with increasing crosslink ratio due to the larger mesh size with the lower crosslinking ratio. On the effect of electric field strength, the D_{app} of both SA-loaded PAAM and SA-doped PPV/PAAM hydrogel systems increases with increasing electric field strength. The increase in D_{app} at low electric field strength is due to the electrophoresis effect driving the SA and the expansion of the mesh size. The D_{app} of the SA-doped PPV/PAAM hydrogel system is larger than the D_{app} of the SA-loaded PAAM by one order of magnitude, due mainly to the reduction reaction of SA-doped PPV, where the negative potential accelerates the SA diffusion out of the PAAM matrix. It is possible to conclude that by varying

crosslinking density, the electric field strength, the drug size, the hydrogel matrix mesh size, the drug-matrix interaction, and the presence of a conductive polymer, the drug release rate can be precisely controlled towards an optimal desired level.

8.2 Recommendations for Future Work

The new type of low power consumption actuator and controlled drug delivery devices are prepared. The electromechical properties of PPV/PDMS blends in oscillatory shear have been investigated. Some important parameters, for examples dielectric properties of polarized particles, presenting of surfactant or ion are interesting for further investigation to provide clarification and more understanding in the electromechanical fundamentals. The relative polarizability of the system, which governs the electromechanical response, is one parameter that needs to be studied. In the deflection experiment, varied type of electrodes and operating temperatures would provide useful data that is applicable to develop new type of low power consumption actuator.

In order to overcome charge build up, irritation and burning of the skin in the area of prolong continuous current electrode application, a pulsed current will be used and characterized the released profile at higher voltage and current condition.