WORK BEHAVIORS OF CONDUCTING POLYMER SOFT ACTUATORS

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Conducting polymers are electrochemically oxidizaed and the electrical conductivity increases to a level of metals, keeping the flexibility of polymeric materials. During the oxidation a deformation named electrochemical deformation (ECMD) [1] takes place. The ECMD is induced mainly by the insertion of bulky ions. The maximum strain, stress and strain rate of polypyrrole (PPy) films so far are 39 %, 22-34 MPa and 14 %/s[1], respectively. These figures can be compared with those of skeletal muscles of approximately 30 %, 0.4 MPa and 300 %/s, respectively.

Two types of PPy films with the thickness of ca. 20 μ m were prepared in electrolyte solutions of TBACF₃SO₃/Methylbenzoate and dodecylbenzensulfonic acid (DBS)/Water. The former (PPy /CF₃SO₃) was operated in aqueous NH₄/PF₆, showing anion driven feature [2]. On the other hand, the later film (PPy/DBS) operated in aqueous LiCl with Young's modulus s of 0.26 and 0.15 GPa for oxidized and reduced states, respectively, showed cation driven characteristics [3].

The PPy /CF₃SO₃ tube was contracted upon reduction, while PPy/DBS tube was contracted upon oxidation. It is interesting to note that the PPy/DBS contracted and stiffened, being similar to natural muscles. Since, the tube did work to lift weights by contraction, Various wights was suspended to the tubes and the relationships between contraction ratio (strain) and load tension (stress), to elucidate the work behaviors. Curves in Fig.1 show typical time response of contraction (strain) under load stresses in PPy/DBS tube, indicating smaller the strain at larger loads. Figure 2 shows the strain-stress curve of the tube. Figure 3 shows the mechanical out put and the conversion efficiency in ECMD of PPy/DBS tube. The mechanical out put energy was 100 μ J at 3-4 MPa. The maximum energy conversion efficiency was 0.12 %. This figure is unecpectively small due to the charging during oxidation. The overall results including aqueous electrolytes of NaCl and KCl will be discussed as well as anion driven tube and films, which showed the conversion efficiency of 0.25%.



Fig.1 Strain-time curves. Fig.2 Strain-load stress curve. Fig.3 Mechanical output and Efficiency.

References

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