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Electroactive Polymers
The Future of Artificial Muscle

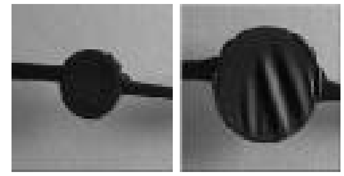
In the past few years electroactive polymer (EAP) materials have become increasingly available with large displacement response to a voltage. These characteristics are similar to the operation of biological muscle, and therefore could prove to be helpful to the advancement of artificial muscle technology.

Electroactive polymers (EAP) are human made actuators that most closely emulate natural muscles. When an electric current is applied to and EAP, it responds by bending, stretching, or contracting. These actions can then be used to perform some sort of work. For simplicity these materials have been separated into two different groups Ionic EAP and Electric EAP.

Ionic EAPs are materials that involve mobility or diffusion of ions. They consist of two electrodes and an electrolyte within the material itself. The biggest advantage of Ionic EAP materials is that they respond to voltages as low as 1 volt. Example of Ionic EAP materials are: Carbon Nanotubes, Conductive Polymers, and Ionic Polymer Gels.

Ionic EAP materials are formed from and ionic polymer metal composite (IPMC), which contains a positive counter ion like Na^+ and Li^+. Then conductive metals like platinum or gold are added to the surface. The resulting EAP polymer can absorb water and when voltages are applied it cause movement of water and positive ions in the polymer composite, thus causing the polymer to deform.

Electronic EAP materials are driven by Coulomb Forces (Coulomb's Law). Advantages of Electronic EAPs are that they can operate in open air without risk of dehydration; and they can produce larger actuation forces when compared with Ionic materials. However, the do require voltages form 30- 150 volt and can require up to several thousands of volts for thicker materials. Examples of Electronic EAP materials are: Dielectric EAP (above) and Electorstrictive Graft Elastomers. Electron EAP can also be made to hold the induced displacement while activated under a DC voltage causing strong consideration for use in robotics rather than as artificial muscles.



EAP materials are currently only used experimentally, like this NASA developed four fingered gripper (left) and several other robotic hand application. And like their use as "muscles" under the skin of an artificial face replica of Albert Einstein (below).

As actuators these materials are light weight, operate quietly, and are fracture tolerant. They can be shapes as desired with properties that can be engineered. However, this technology is still far from maturity, actuators still produce low actuation forces and result in low efficiency values when tested. And also these materials are still not available as a standard commercial product and their properties are still insufficiently documented for use by engineers. But hopefully with further investigation and experimentation in this field EAPs will become a form of artificial muscle.

Sources:
http://www.ars-journal.com/ars/Interview/Interview%20with%20Yoseph%20Bar-Cohen.htm
http://www.polysep.ucla.edu/Research%20Advances/EAP/electroactive_polymers_as_artifi.htm
http://ndeaa.jpl.nasa.gov/nasa-nde/lommas/eap/EAP-web.htm
http://www.dtic.mil/ndia/2003triservice/korn.ppt#273,6,Many%20Possible%20EAP%20Transducer%20Configurations