Elastoelectricity of Elastomers: Mechanical-To-Electrical Energy Conversion

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***Abstract*—Tribo- and piezoelectricity are effects of mechanical action on materials, whose structural features determine the amount of electrical energy obtained. The two effects account for the electrostatic potentials detected in most anthropic and natural environments, often reaching many-thousand volts. Elastomers acquire charge when they are handled and this is loosely assigned to tribo- and/or piezoelectricity, but this has not yet been studied in sufficient detail to understand charge build-up and dissipation. Well-controlled experiments show that when rubber tubing is subjected to cyclic stretching and relaxation, a Kelvin probe measures a periodic potential variation. Surprisingly, an extensive literature survey revealed that this phenomenon has not yet been examined through extensive experimentation and it has not yet received satisfactory explanation, although closely related experiments were published. The initial potential for silicone tubing equilibrated in the laboratory environment is ca. -5V, decreasing to zero when the rubber is stretched and then to negative values, when it relaxes. Repeatedly stretching silicone rubber produces values as low as -3300 V that is the lower limit for the voltmeter used. Natural rubber shows analogous features. This cannot be assigned to piezo- or triboelectricity, given the structure of the two rubbers and the absence of surface contact with another solid or liquid surface, during rubber stretching. This is thus a new electrostatic effect, named elastoelectricity and our current working hypothesis to explain it is the following: charging is due to i) water sorption/desorption in the rubber, due to the change in free volume associated to rubber chain stretching together with ii) water ion partition during sorption/desorption, as in other interfacial phenomena. Since vibrations and elastomer deformation are taking place all over around us, we propose the application of elastoelectricity in energy harvesting systems, where rubber parts subjected to vibration under normal atmosphere will convert mechanical energy to electricity.**