Rational Design and Fabrication of Smart Elastomer Materials

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By virtue of the large actuated strain, fast response, lightweight, and reliability, Dielectric elastomers actuators (DEAs) find many applications in industry such as artificial muscles, sensors and micro-robotics. Thus, DEAs have been receiving much attention since 1990s. The design and preparation of dielectric elastomer (DE) which are capable of achieving large actuated strain at a low electric field is one priority for the development of next generation DEAs. The keys to achieve the large maximum actuated strain or large actuated strain at a low electric field is to prepare DE materials with high dielectric constant (*k*), low dielectric loss and low elastic modulus. In recent years, we have focused on the design and preparation of various advanced dielectric elastomers and developed three methodologies:(1) introducing dielectric/conductive fillers into elastomer matrix. By controlling the dispersion of fillers and interface modification, DE composites with both high *k* and low elastic modulus were successfully achieved. We have revealed the influence of filler dispersion, filler-matrix interface, matrix polarity on the electromechanical properties; (2) blending of elastomer with micro molecules or macromolecules, simultaneously high dielectric constant and low modulus were achieved by tailoring the molecular interaction; (3) synthesizing new DEs or chemically modify existing ones. In the meantime, aiming at the problems faced by DE during practical application (low mechanical strength and liable to damage), we tailored the molecular structure and crosslinking network to realize the self-enhancing and self-healing of silicone-based DE.

Recycling energy from various motion into electricity is also meaningful and environmental-friendly. As one of the most significant inventions in modern history, automobile drastically changed the life of all people for a century, simultaneously, eaten large proportion of oil and emitted lots of carbon dioxide and other pollutions. Thus, many countries had launched or tightened their Corporate Average Fuel Economy (CAFE) standards to force carmakers to improve efficiency and reduce carbon dioxide emissions. Although, engine and transmission play key roles in improving the efficiency of the whole car, improving tire's fuel consumption can also contribute a lot to the overall thermal efficiency of vehicles. In the modern tire industry, the consensus is that silica tire is the best choice for the next generation green tire until now. Based on this, we introduced the concept of the triboelectric nanogenerator into the silica filled green tires to utilize those static charges for generating electricity. Meanwhile, the static electricity problem, which at present hinders the large-scale application of silica-filled green tires, was solved by reducing electric field intensity and electric potential around tire. More interestingly, we can also monitor the tire pressure and the road condition from the changes of the generated electrical signals, which thus leads to the development of the smart application of green energy tire.

Keywords dielectric elastomers (DEs); dielectric constant; actuated strain; green tire; triboelectric nanogenerator.

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