

# Polymer and Colloid Highlights

## Division of Polymers, Colloids and Interfaces

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### Artificial Skin for Sensing and Energy Harvesting of Human Motion

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The search for synthetic skin that mimics the sense of touch characteristic to human skin has intensified over the years.<sup>[1]</sup> While common elastomers mimic the mechanical properties of skin, they fail to generate an electrical signal when strained. Imagine a piezoelectric elastomer that can sense body movements and harvest electrical energy from them to power either portable or implanted electronics. Such material could revolutionize personalized medicine and would likely advance soft robotics applications.

A promising recent synthetic strategy to piezoelectric elastomers uses a composite approach.<sup>[2,3]</sup> Polar polymers with a glass transition temperature ( $T_g$ ) significantly above room temperature are blended into a polysiloxane matrix. This composite is then processed into thin films, which are chemically cross-linked before a poling process introduces the permanent polarization needed to create a piezoelectric material (Fig. 1).<sup>[4]</sup> These poled films generate electricity when pressed and stretched.

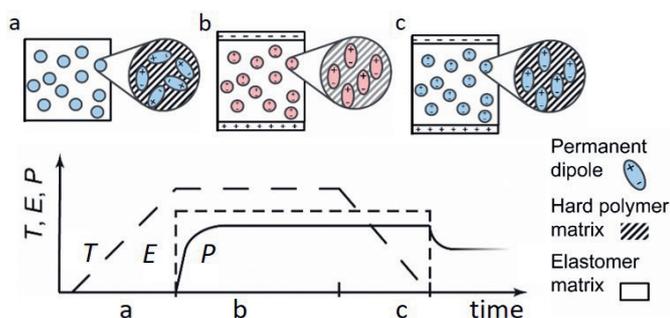


Fig. 1 Nanoparticles with randomly oriented dipoles in a chemically cross-linked elastomer matrix (a) are heated above the  $T_g$  of the particle, the dipoles are oriented in an electric field (b), and the oriented dipoles are frozen in by cooling the films below the  $T_g$  under the electric field (c).  $T$  = Temperature,  $E$  = Electric field,  $P$  = Polarization. Adapted from ref. [2]

In our initial work we used a poly(methyl methacrylate-co-disperse red 1 methacrylate) (PMMA-co-DR1MA) as polarizable filler. It was obtained by free radical polymerization and had a  $T_g = 124$  °C and an attractive relaxation strength of

$\Delta\epsilon' = 16.3$ . This copolymer was processed into nanoparticles by nanoprecipitation carried out by slowly adding the initial polymer solution to a non-solvent. Composites of the nanoparticles into a polysiloxane matrix were achieved by tip sonication. This processing allowed formation of homogenous composites, while doctor blading allowed formation of thin films ( $\sim 50$   $\mu\text{m}$ ). Poling was conducted at  $30$  V/ $\mu\text{m}$  and  $120$  °C. Films were achieved that had a piezoelectric response comparable to the gold standard poly(vinylidene fluoride) but were highly stretchable (Fig. 2).

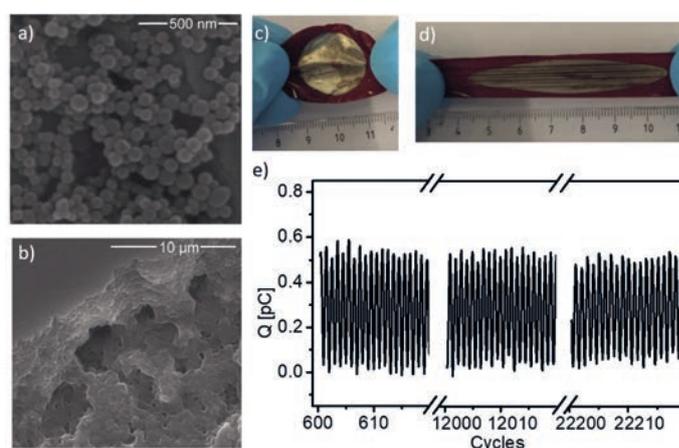


Fig. 2 SEM images of filler (a) and of the microstructure of the composite (b). Photographs of free-standing composite film in relaxed (c) and strained condition (d). The painted silver electrode was applied to illustrate the deformation more clearly ( $d = 2$  cm). Charge response over more than 20000 load cycles at 10 Hz and 80 mN amplitude (e). Adapted from ref. [2].

These new materials combine the level of piezoelectricity found in piezoelectric polymers with high elasticity, which is a promising combination of properties. The variety of fillers and elastomer matrices that can be combined in these materials is a further big plus and may allow creating biocompatible piezoelectric elastomers urgently needed for applications in implantable devices and personalized medicine.

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