MAR13-2012-000390

Abstract for an Invited Paper
for the MAR13 Meeting of
the American Physical Society

Tuning the Photoinduced Motion of Glassy Azobenzene Polymers and Networks[1]

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Continual innovation at the forefront of soft-matter, in areas such as liquid crystal networks, nano-composites and biomolecules, is providing exciting opportunities to create smart materials systems that exhibit a controlled, reproducible and reversible modulation of physical properties. These material systems evoke the adaptivity of natural organisms, and inspire radical aerospace notions. A key example is photo-responsive polymers, which convert a light stimulus input into a mechanical output (work). Photoinduced conformational changes, such as within azobenzene, dictate molecular-level distortions that summate into a macroscopic strain, which often manifests as a shape change or motion. The transduction of the molecular-level response to a macroscale effect is regulated by mesoscopic features, such as chain packing, free volume, and local molecular order - factors which depend on chemical composition as well as the process history of the material. For example, physical aging increases the density of the glass, reduces local free volume, and thus decreases the minima in local conformation space which strongly influences the azobenzene photochemistry (trans-cis-trans isomerization). The subsequent change in the energy landscape of the system reduces the fraction of azobenzene able to undergo reconfiguration as well as increases the probability that those photoinduced conformations will relax back to the initial local environment. The result is a tuning of the magnitude of macroscopic strain and the ability to shift from shape fixing to shape recovery, respectively.

[1] Work done in collaboration with H. Koerner, K.M. Lee, M. Smith, D. Wang, L-S. Tan. and T. White, Air Force Research Laboratory.