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Sacrificial bonds and hidden length in biomaterials – a kinetic description of strength and toughness in bone CHARLES K. C. LIEOU, AHMED E. ELBANNA, JEAN M. CARLSON, University of California, Santa Barbara — Sacrificial bonds and hidden length in structural molecules account for the greatly increased fracture toughness of biological materials compared to synthetic materials without such structural features, by providing a molecular-scale mechanism of energy dissipation. One example of occurrence of sacrificial bonds and hidden length is in the polymeric glue connection between collagen fibrils in animal bone. In this talk, we propose a simple kinetic model that describes the breakage of sacrificial bonds and the revelation of hidden length, based on Bell's theory. We postulate a master equation governing the rates of bond breakage and formation, at the mean-field level, allowing for the number of bonds and hidden lengths to take up non-integer values between successive, discrete bond-breakage events. This enables us to predict the mechanical behavior of a quasi-one-dimensional ensemble of polymers at different stretching rates. We find that both the rupture peak heights and maximum stretching distance increase with the stretching rate. In addition, our theory naturally permits the possibility of self-healing in such biological structures.

Charles K. C. Lieou
University of California, Santa Barbara

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