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Harnessing Biomimetic Catch Bonds to Create Mechanically Robust Nanoparticle Networks

ANNA BALAZS, University of Pittsburgh

Using computer simulations, we investigate the mechanical properties of a network of polymer-grafted nanoparticles (PGNs) that are interlinked by labile "catch" bonds. In contrast to conventional "slip" bonds, the life time of catch bonds can potentially increase with the application of force (i.e., the rate of rupture can decrease). In effect, the bond becomes stronger under an applied force (if the strain rate is sufficiently high). Subjecting the PGN networks to a tensile deformation, we find that the networks encompassing catch bonds exhibit greater ductility and toughness than the networks interconnected by slip bonds. Moreover, when the applied tensile force is released, the catch bond networks exhibit lower hysteresis and faster relaxation of residual strain than the slip bond networks. The effects of the catch bonds on the mechanical behavior are attributed to transitions between two conformational states, which differ in their sensitivity to force. The findings provide guidelines for creating nanocomposite networks that are highly resistant to mechanical deformation and show rapid strain recovery.