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Rheology of Active Gels

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Active networks drive a diverse range of critical processes ranging from motility to division in living cells, yet a full picture of their rheological capabilities in non-cellular contexts is still emerging, e.g., How does the rheological response of a network capable of remodeling under internally-generated stresses differ from that of a passive biopolymer network? In order to address this and other basic questions, we have engineered an active gel composed of microtubules, bidirectional kinesin motors, and molecular depletant that self-organizes into a highly dynamic network of active bundles. The network continually remodels itself under ATP-tunable cycles of extension, buckling, fracturing, and self-healing. Using confocal rheometry we have simultaneously characterized the network's linear and non-linear rheological responses to shear deformation along with its dynamic morphology. We find several surprising and unique material properties for these active gels; most notably, rheological cloaking, the ability of the active gel to drive large-scale fluid mixing over several orders of flow magnitude while maintaining an invariant, solid-like rheological profile and spontaneous flow under confinement, the ability to exert micro-Newton forces to drive persistent directed motion of the rheometer tool. Taken together, these results and others to be discussed highlight the rich stress-structure-dynamics relationships in this class of biologically-derived active gels.