The physics of reassociation dynamics, “self-healing”, probed via nonlinear flows

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Polymers with intrinsic self-healing ability are a broadening class of materials with useful applications from medical devices to industrial adhesives. Rehological quantification of these materials is seriously lacking in the literature leading to very little quantification and funda-mental understanding of the recovery phenomena and resulting rheology. In this work we use model supramolecular networks consisting of poly-(n-buytl acrylate) (PnBA), poly-(acrylic acid) (PAA), poly-(methoxyethyl acrylate) (PMEA) and 2-ureido-4[1H]-pyrimidinone bear-ing methacrylate (UPyMA) to explore the complex dynamics of self-healing. We show the importance of the kinematic flow field on the measured degree of stress recovery. The degree of recovery is strongly dependent on the rate of extension, the applied stress, and the relax-ation time of the polymer network. We also show that there are two governing timescales for the degree of stress recovery: the time between fracture and adhesion and the relaxation time after adhesion. This work shows that recovery is a sequential processes wherein reptation is followed by re-association.