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Rheo-PIV Investigation of Fracture and Self-Healing in a Triblock Copolymer Gel

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ABSTRACT

Physically associating polymer gels have shown the ability to heal after failure, making them promising candidates for various medical applications or consumer products. However, the processes by which these materials self-heal is not well-understood. This study seeks to explain the self-healing behavior of the triblock copolymer poly(methyl methacrylate)-poly(n-butyl acrylate)-poly(methyl methacrylate), or PMMA-PnBA-PMMA, by probing the material's post-fracture behavior with rheometry and particle image velocimetry (PIV). The self-healing behavior was studied by deforming each gel in shear until failure multiple times with "recovery" periods in-between. PIV was used to verify the occurrence of each fracture in both time and space. Stress relaxation experiments were also performed on the gels to give greater context to the results of the investigation into fracture recovery. Using these data, it was possible to determine the activation energy required for the network chain dissociation and re-association that transpires during the deformation and self-healing of the gel. Stress relaxation experiments yielded an activation energy of 359 kJ/mole for chain dissociation, while fracture-recovery experiments produced an activation energy of 439 kJ/mole for chain re-association. Building upon these insights could lead to a better understanding of the microscopic mechanisms that govern the behavior of intrinsic self-healing materials so that they can be used to their full potential.

KEYWORDS

Polymer, triblock, copolymer, heal, fracture, failure, gel