
Why cutting elastomers is easier than tearing?

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Abstract

We all know that tearing tough soft solids such as rubbers, leather or meat can be quite difficult while cutting them with a sharp blade is much easier. Understanding why is crucial to optimize energy efficiency in material processing. By using samples labeled with mechanically sensitive fluorophores to investigate cutting and fracture behavior in PDMS elastomers we are able to quantify the extent of covalent bond scission resulting from cutting prestretched samples. Our findings reveal that stretch-induced cracks, as they occur in tearing, exhibit significant deformation, bond scission and blunting near the crack tip, requiring a higher fracture energy to propagate. In contrast, using sharp blades reduces the amount of stretching and blunting required for crack propagation, results in a lower fracture energy and producing sharp and clean fracture surfaces. The observed linear correlation between fracture energy and the number of broken chains per unit area, validated through mechanical testing and mechanochemical experiments, clarifies the relationship between pre-stretching, blunting, and the extent of molecular damage. These comprehensive insights demonstrate the key differences between fracture and cutting mechanics of soft materials, paving the way to optimize cutting processes for engineering applications.

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