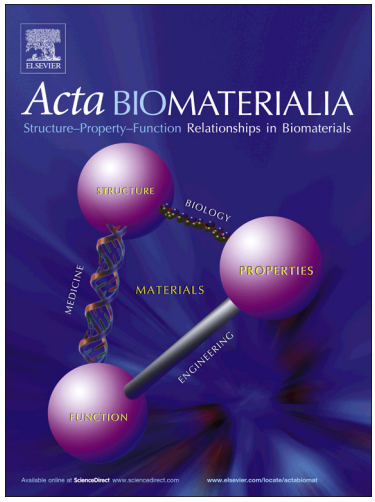

Full length article

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PII: S1742-7061(18)30087-4
DOI: https://doi.org/10.1016/j.actbio.2018.02.017
Reference: ACTBIO 5322

To appear in: *Acta Biomaterialia*

Received Date: 30 September 2017
Revised Date: 19 January 2018
Accepted Date: 15 February 2018

Please cite this article as: Mijailovic, A.S., Qing, B., Fortunato, D., Van Vliet, K.J., Characterizing viscoelastic mechanical properties of highly compliant polymers and biological tissues using impact indentation, *Acta Biomaterialia* (2018), doi: https://doi.org/10.1016/j.actbio.2018.02.017

Characterizing viscoelastic mechanical properties of highly compliant polymers and biological tissues using impact indentation

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Precise and accurate measurement of viscoelastic mechanical properties becomes increasingly challenging as sample stiffness decreases to elastic moduli less than 1 kPa, largely due to difficulties detecting initial contact with the compliant sample surface. This limitation is particularly relevant to characterization of biological soft tissues and compliant gels. Here, we employ impact indentation which, in contrast to shear rheology and conventional indentation, does not require contact detection *a priori*, and present a novel method to extract viscoelastic moduli and relaxation time constants directly from the impact response. We first validate our approach by using both impact indentation and shear rheology to characterize polydimethylsiloxane (PDMS) elastomers of stiffness ranging from 100s of Pa to nearly 10 kPa. Assuming a linear viscoelastic constitutive model for the material, we find that the moduli and relaxation times obtained from fitting the impact response agree well with those obtained from fitting the rheological response. Next, we demonstrate our validated method on hydrated, biological soft tissues obtained from porcine brain, murine liver, and murine heart, and report the equilibrium shear moduli, instantaneous shear moduli, and relaxation time constants for each tissue. Together, our findings provide a new and straightforward approach capable of probing local mechanical properties of highly compliant viscoelastic materials with millimeter scale spatial resolution, mitigating complications involving contact detection or sample geometric constraints.

Statement of significance

Characterization and optimization of mechanical properties can be essential for their proper function of biomaterials in diverse applications. However, precise and accurate measurement of viscoelastic mechanical properties becomes increasingly difficult with increased compliance (particularly for elastic moduli < 1 kPa), largely due to challenges detecting initial contact with the compliant sample surface and measuring response