



Biological Tissue Simulants For Higher Fidelity Test and Evaluation

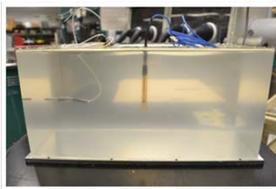


S&T Campaign: Materials Research Biological and Bio-inspired Materials

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Research Objective

- Produce synthetic analogs of soft and rigid biological tissues that provide a biofidelic response for the improved development and evaluation of protective equipment
- SOA: Current testing media like ballistic clay and ballistic gelatin does not capture the strain and strain-rate dependent response of individual tissues.



Behind Armor Blunt Trauma (BABT)



Blast Testing



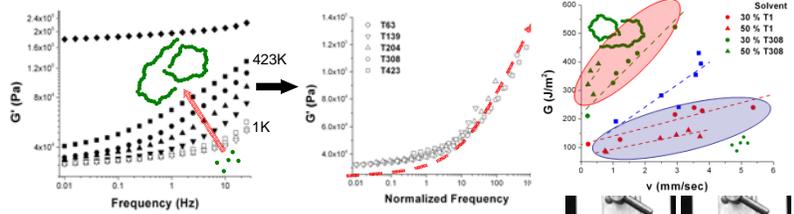
Specific Protection System Evaluation

Challenges

- Limited availability of high strain rate tissue data
- Most commercial materials do not exhibit the required strain rate dependent or toughness
- Accurately measuring the response of soft materials at high strain rates ($> 1 \text{ sec}^{-1}$)

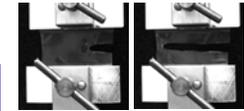
ARL Facilities and Capabilities Available to Support Collaborative Research

Expertise in Soft Material Design



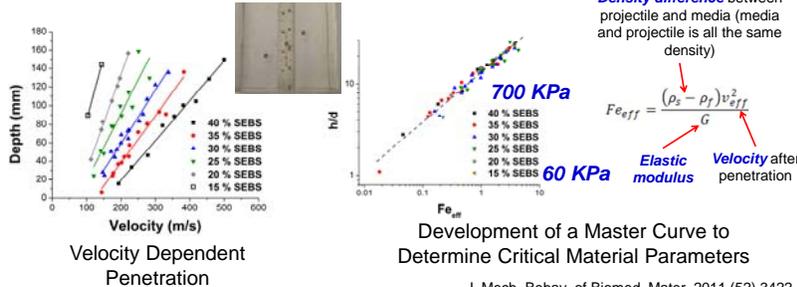
Normalized by using $\tau_r \sim M_w^{3.4}$

Manipulate solvent molecular weight to alter the rate-dependent mechanical response and toughness



Polymer 2011 (52) 3422

Model Projectile Studies



Density difference between projectile and media and projectile is all the same density

$$F_{eff} = \frac{(\rho_s - \rho_T) v_{eff}^2}{G}$$

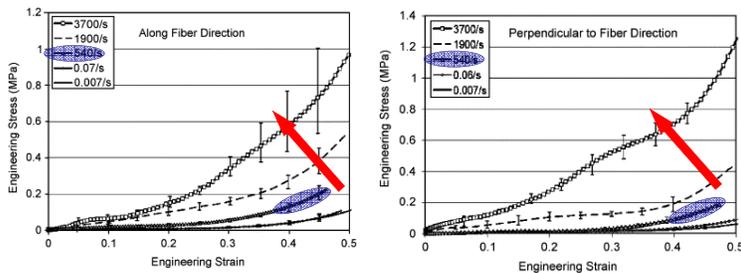
Elastic modulus Velocity after penetration

Development of a Master Curve to Determine Critical Material Parameters

J. Mech. Behav. of Biomed. Mater. 2011 (52) 3422

Initial Success Matching the Response of Biological Tissue

Porcine Muscle Tissue Data

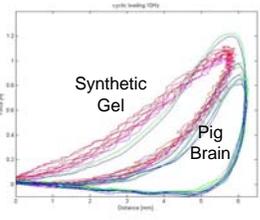


J. Biomech. 2007 (40) 2999

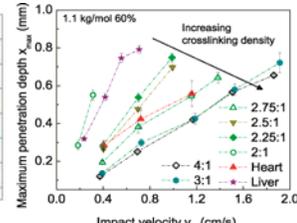
Pig Brain in collaboration with Simona Socrate (MIT/ISN)



Pig Brain Synthetic Gel



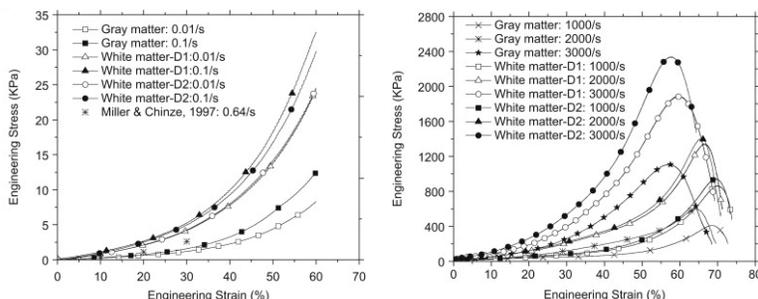
Rat Heart and Rate Liver in collaboration with Krystyn Van Vliet (MIT/ISN)



J. Biomech. 2013 (46) 1583

"Matched" mechanical response of pig brain, rat heart, and rat liver up to 20 sec⁻¹

Bovine Brain Tissue Data



J. Biomech. 2009 (42) 731

Complementary Expertise/ Facilities/ Capabilities Sought in Collaboration

- Methods for accurately measuring the response of soft materials at high strain rates
- Facilities for measuring synthetic and human tissue under the same loading conditions