

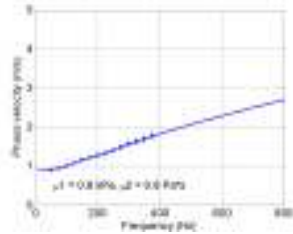
CIRS	Phantoms for Medical Imaging and Radiation Therapy
<div style="text-align: center;">  <p><i>Tissue Simulation & Phantom Technology</i></p> </div>	

CIRS	Phantom Materials for Shear Wave Elastography																																														
	<table border="1"> <thead> <tr> <th>Feature</th> <th>Agar/Gelatin</th> <th>Zerdine®</th> </tr> </thead> <tbody> <tr> <td>Sound speed</td> <td>~1450-1700 m/s</td> <td>~1450-1900 m/s</td> </tr> <tr> <td>Attenuation Magnitude</td> <td>~0.1-1.5 dB/cm/MHz</td> <td>~0.05-1.5 dB/cm/MHz</td> </tr> <tr> <td>Attenuation Frequency Dependence</td> <td>1-1.5</td> <td>1-1.5</td> </tr> <tr> <td>B/A</td> <td>Mimic range of soft tissues</td> <td>?</td> </tr> <tr> <td>Wide range of scattering properties</td> <td>Yes</td> <td>Yes</td> </tr> <tr> <td>Multi-modality (X-ray, microwave, MRI)</td> <td>Yes</td> <td>Yes</td> </tr> <tr> <td>Elasticity proportional to gel concentration</td> <td>Yes</td> <td>Yes</td> </tr> <tr> <td>Stress/strain</td> <td>Linear gelatin, nonlinear agar</td> <td>Linear</td> </tr> <tr> <td>Melting point</td> <td>50°C (higher with additives)</td> <td>> 80 °C</td> </tr> <tr> <td>Dispersions of oil droplets</td> <td>Lower elastic modulus, lower sound speed, mimic fatty tissues</td> <td>Same</td> </tr> <tr> <td>Uniform acoustic properties</td> <td>Yes</td> <td>Yes</td> </tr> <tr> <td>Repeatable elastic properties</td> <td>Yes</td> <td>Yes</td> </tr> <tr> <td>Lossless</td> <td>Yes</td> <td>Yes</td> </tr> <tr> <td>Lossy additives</td> <td>High molecular weight polysaccharides</td> <td>?</td> </tr> </tbody> </table>	Feature	Agar/Gelatin	Zerdine®	Sound speed	~1450-1700 m/s	~1450-1900 m/s	Attenuation Magnitude	~0.1-1.5 dB/cm/MHz	~0.05-1.5 dB/cm/MHz	Attenuation Frequency Dependence	1-1.5	1-1.5	B/A	Mimic range of soft tissues	?	Wide range of scattering properties	Yes	Yes	Multi-modality (X-ray, microwave, MRI)	Yes	Yes	Elasticity proportional to gel concentration	Yes	Yes	Stress/strain	Linear gelatin, nonlinear agar	Linear	Melting point	50°C (higher with additives)	> 80 °C	Dispersions of oil droplets	Lower elastic modulus, lower sound speed, mimic fatty tissues	Same	Uniform acoustic properties	Yes	Yes	Repeatable elastic properties	Yes	Yes	Lossless	Yes	Yes	Lossy additives	High molecular weight polysaccharides	?	
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Viscous Loss in Zerdine®: SDUV Measurements

In Vitro Liver Test

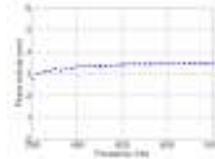


Standard Zerdine Formulation:

- Lossless
- CIRS elasticity measurements show good agreement to shear wave speed

40 kPa Phantom Sample

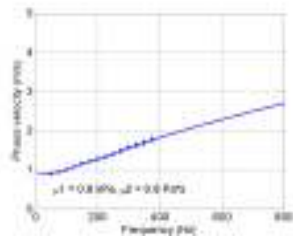
- Group velocity: 3.45 m/s



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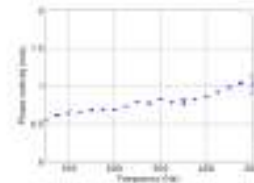
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In Vitro Liver Test



First Modification:
Viscosity at low modulus only

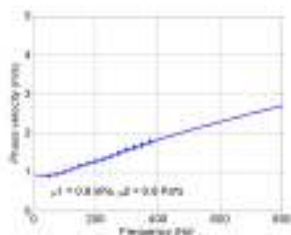
- Group velocity: 0.66 m/s



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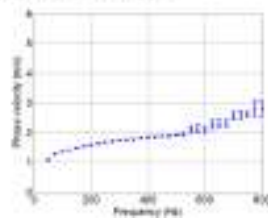
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Second modification: somewhat viscous at higher modulus

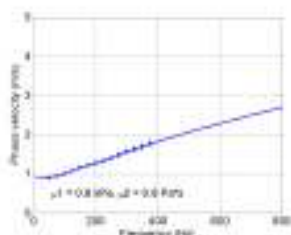
- Group velocity: 1.72 m/s



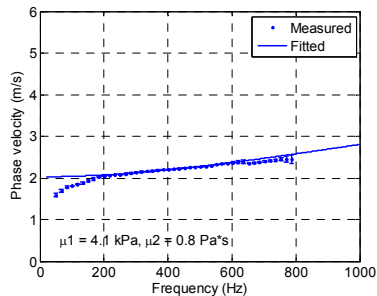
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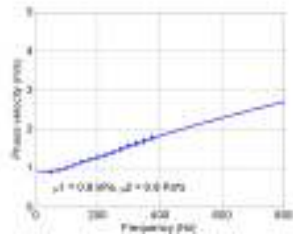
Third Modification:
Lossless & difficult to work with



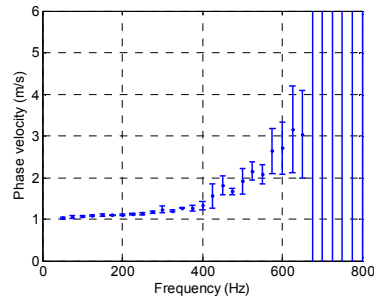
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Fourth modification: Shear wave energy too low at high frequencies to determine viscosity



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Conclusion

- Zerdine® hydrogel exhibits many of the same properties as agar/gelatin phantoms—including linear elastic properties
- Underlying strength of the polymer matrix complicates the addition of lossy components