

Investigation of a soft tissue-mimicking phantom dedicated to multi-modality elasticity imaging

S Chatelin¹, A Nahas¹, E Breton¹, M Schmidt¹, S Gioux¹, B Wach¹, A Guiguemdé², A Normand², L Meylheuc^{1,2}, J Vappou¹

¹ ICube, UMR7357 CNRS, University of Strasbourg, France

² INSA Strasbourg, France

Introduction

Over the past three decades, different methods have been proposed to investigate the mechanical properties of soft tissue using medical imaging. The development and the calibration of tissue elasticity imaging require calibration phantoms, which combines both mechanical and imaging adequate properties. Proposing a multimodality phantom is a major challenge. In the current study, we investigate the mechanical and imaging properties of polyvinyl chloride (PVC) gels (plastisol) depending their preparation protocol and compare them to typical range of values for biological soft tissues.

Material and Methods

Various PVC and additive concentrations in plastisol samples are investigated. The dynamic, static, linear and non-linear mechanical properties of plastisol are investigated using rheometry. Their sensitivity to preparation process, temperature of use and stability over time are also tested. Then, the acoustic (acoustic attenuation), magnetic resonance imaging (MRI) (T_1 and T_2 relaxation properties) and optical properties (refractive index, absorption and reduced scattering coefficients) of plastisol samples are measured to investigate their potential for multimodality tissue elasticity imaging. All these properties are systematically compared to typical range of values found in the literature for biological soft tissues.

Results and discussions

As illustrated in Fig. 1, the adjustment of PVC concentration results in mechanical (storage and loss moduli for elastic and viscous shear behavior), acoustic attenuation, optical refraction and MRI properties of the same range than typical values in biological soft tissues (such as brain or liver). While T_1 relaxation properties remains shorter than those of living organs, T_2 relaxation properties reproduce typical NMR properties. The results also show that adequate addition of scatterers (Nigrosin and TiO_2) or echography speckle (cellulose) makes plastisol mimicking typical optical (absorption and scattering, respectively) and ultrasonic (attenuation) properties of biological soft tissues. We observe that these properties are independent of the PVC concentration but can be easily related to the additive particle concentration following linear relationships.

Conclusions

By combining mechanical and imaging properties similar to soft tissues with other advantages (simple preparation process, inexpensiveness and simple long-time conservation), plastisol is an ideal candidate for use as multi-modality elasticity imaging phantom. In this way, the current study provides the main guidelines to prepare relevant soft tissue surrogates.

Acknowledgement

This work was supported by the French national program "Investissements d'Avenir" of the ANR (Agence Nationale de la Recherche): (1) by the IDEX-Unistra (ANR-10-IDEX-0002-02) with the support of the IRIS technology platform and (2) by the LABEX-CAMI (ANR-11-LABX-004).

References

- [1] Vappou J, 2012. Magnetic resonance- and ultrasound imaging-based elasticity imaging methods: a review. *Crit Rev Biomed Eng* 40(2), 121–34.
- [2] Oudry J, Chen J, Glaser KJ, Miette V, Sandrin L, Ehman RL, 2009. Cross-validation of magnetic resonance elastography and ultrasound-based transient elastography: A preliminary phantom study. *J Magn Reson Imaging* 30(5), 1145–1150.

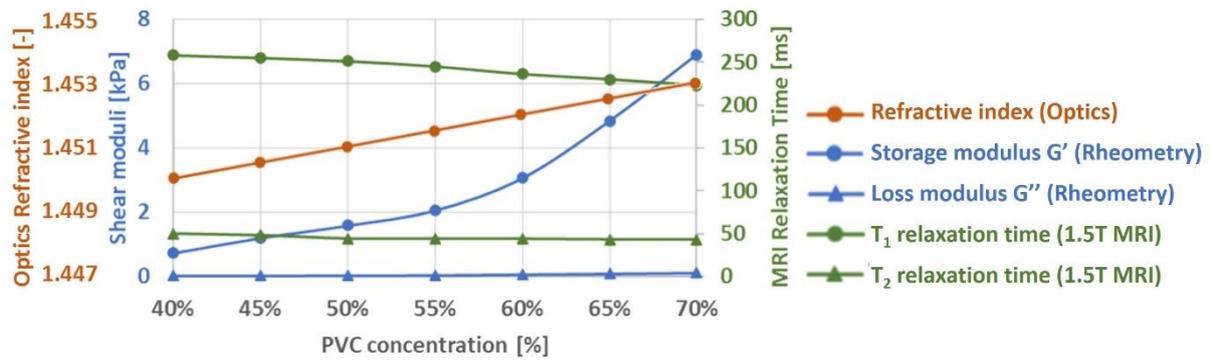


Fig. 1 Main mechanical and imaging properties of plastisol phantoms depending on PVC concentration.