Supplementary Information

Tuning the sound speed in macroporous polymers with hard or soft matrix

A. Kovalenko[1*], M. Fauquignon[1], T. Brunet[2], O. Mondain-Monval[1*]

1 – University of Bordeaux - CNRS, Centre de Recherche Paul Pascal, Pessac, France

2 – University of Bordeaux – CNRS – Bordeaux INP, Institut de Mécanique et d'Ingénierie, Talence, France

* - corresponding authors

1. Determination of mechanical moduli using longitudinal and transversal sound speed

The values of C_L and C_T of poly(styrene-DVB) were used to calculate the mechanical moduli using the following equations[1]:

$$G = \rho C_T^2 \qquad (SI.1)$$

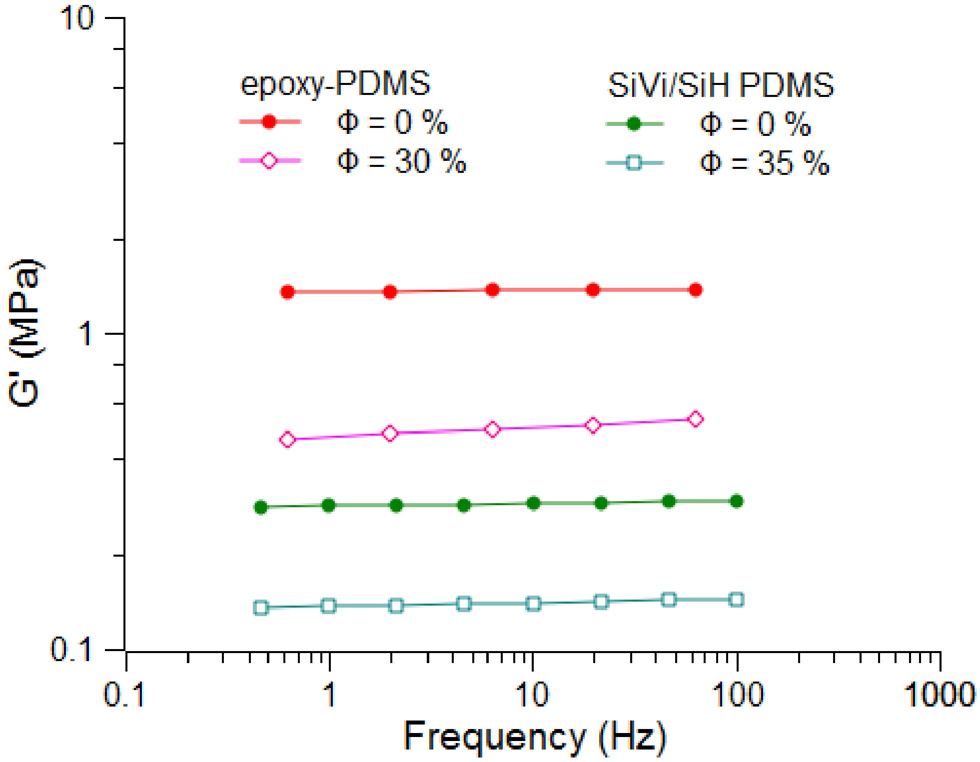
$$K = \frac{1}{3}\rho(3C_L^2 - 4C_T^2) \qquad (SI.2)$$

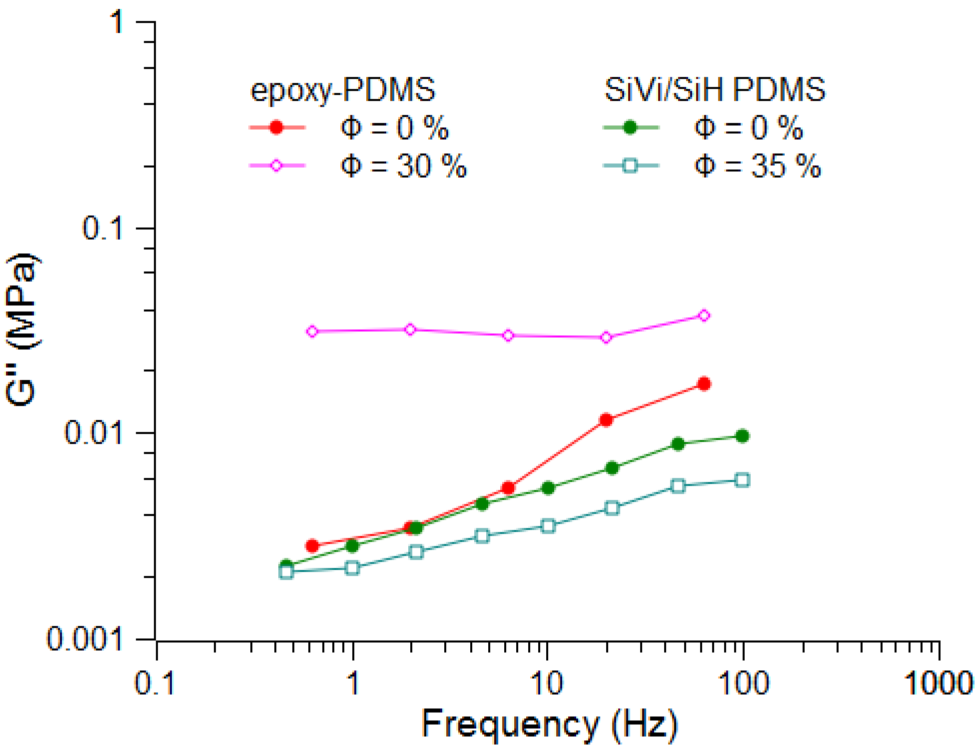
$$E = \rho\frac{C_T^2 \cdot (3C_L^2 - 4C_T^2)}{(C_L^2 - C_T^2)} \qquad (SI.3)$$

$$\nu = \frac{(C_L^2 - 2C_T^2)}{2 \cdot (C_L^2 - C_T^2)} \qquad (SI.4)$$

where G, K and E are shear, bulk and Young's moduli, and ν is the Poisson's ratio.

2. Shear moduli of PDMS samples as a function of frequency





3. Kuster and Toksoz equations[2].

$$\frac{K_0 - K}{4G_0 + 3K} = \Phi \frac{K_0 - K_{air}}{4G_0 + 3K_{air}} \qquad (SI.5)$$

$$\frac{G_0 - G}{G_0(9K_0 + 8G_0) + 6G(K_0 + 2G_0)} = \Phi \frac{1}{(9K_0 + 8G_0)} \qquad (SI.6)$$

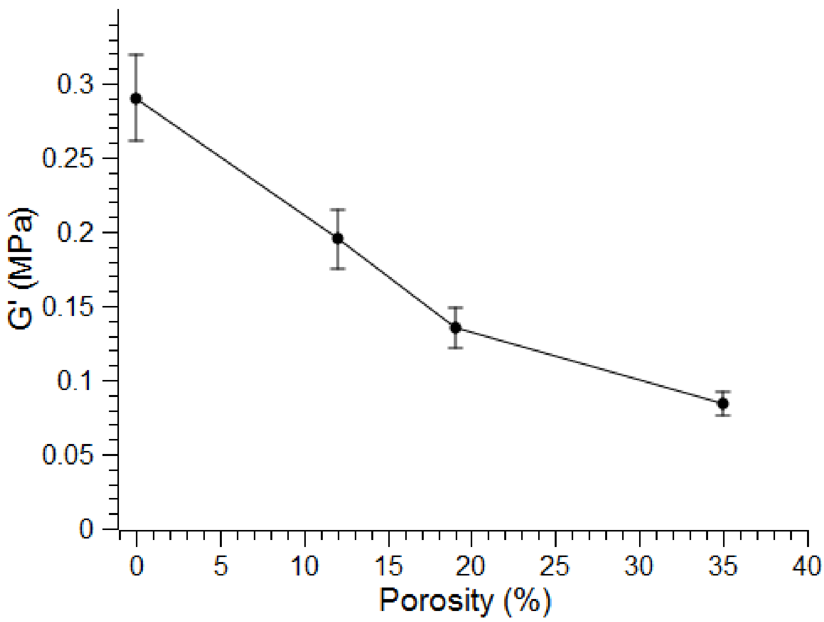
in which Φ is the porosity, K and G are the bulk and shear moduli, respectively; moduli without index correspond to the effective values of the porous solid; indexes *0* and *air* correspond to the matrix and air, respectively.

The solution for $K_{air} << K_0$:

$$K = K_0 \frac{\left(1 + \frac{3K_{air}}{4G_0}\right)(1 - \Phi)}{\left(1 + \frac{3K_{air}}{4G_0} + \frac{3K_0}{4G_0}\Phi\right)} \qquad (SI.7)$$

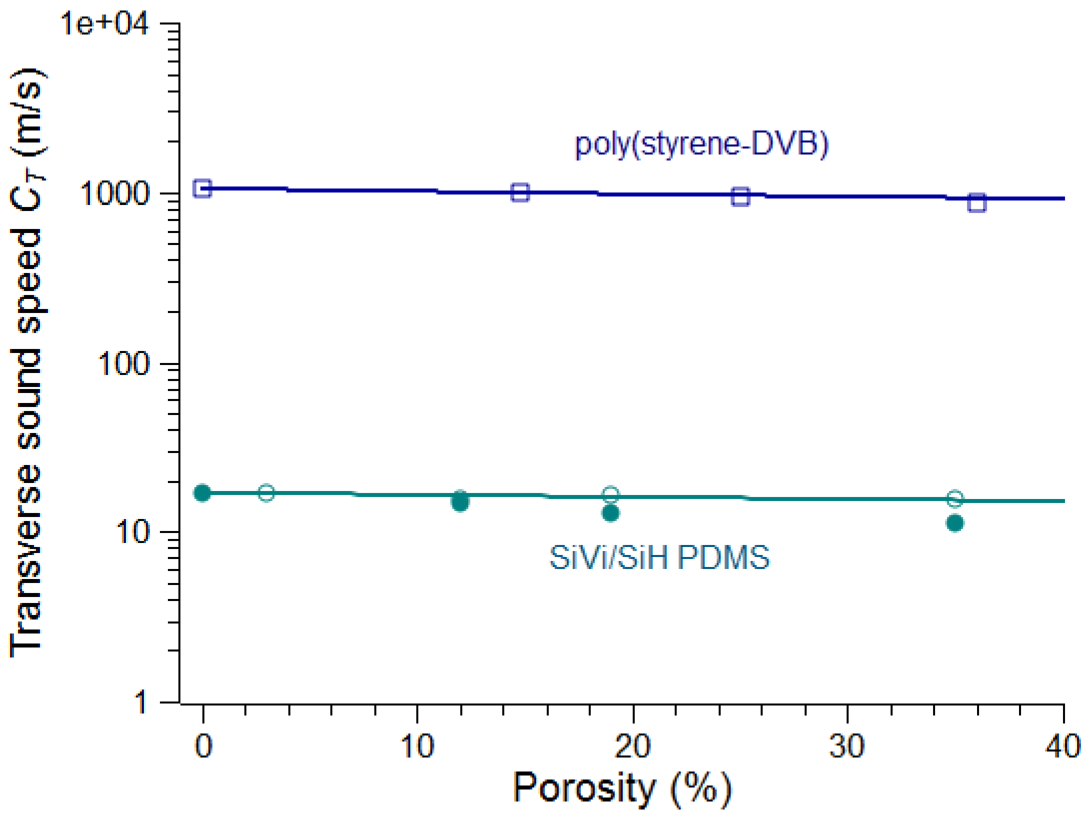
$$G = G_0 \frac{\left(1 + \frac{8G_0}{9K_0}\right)(1 - \Phi)}{\left(1 + \frac{8G_0}{9K_0} + \frac{2}{3}\left(1 + \frac{2G_0}{K_0}\right)\Phi\right)} \qquad (SI.8)$$

4. Variation of the shear modulus with porosity for samples with SiH/SiVi PDMS matrix



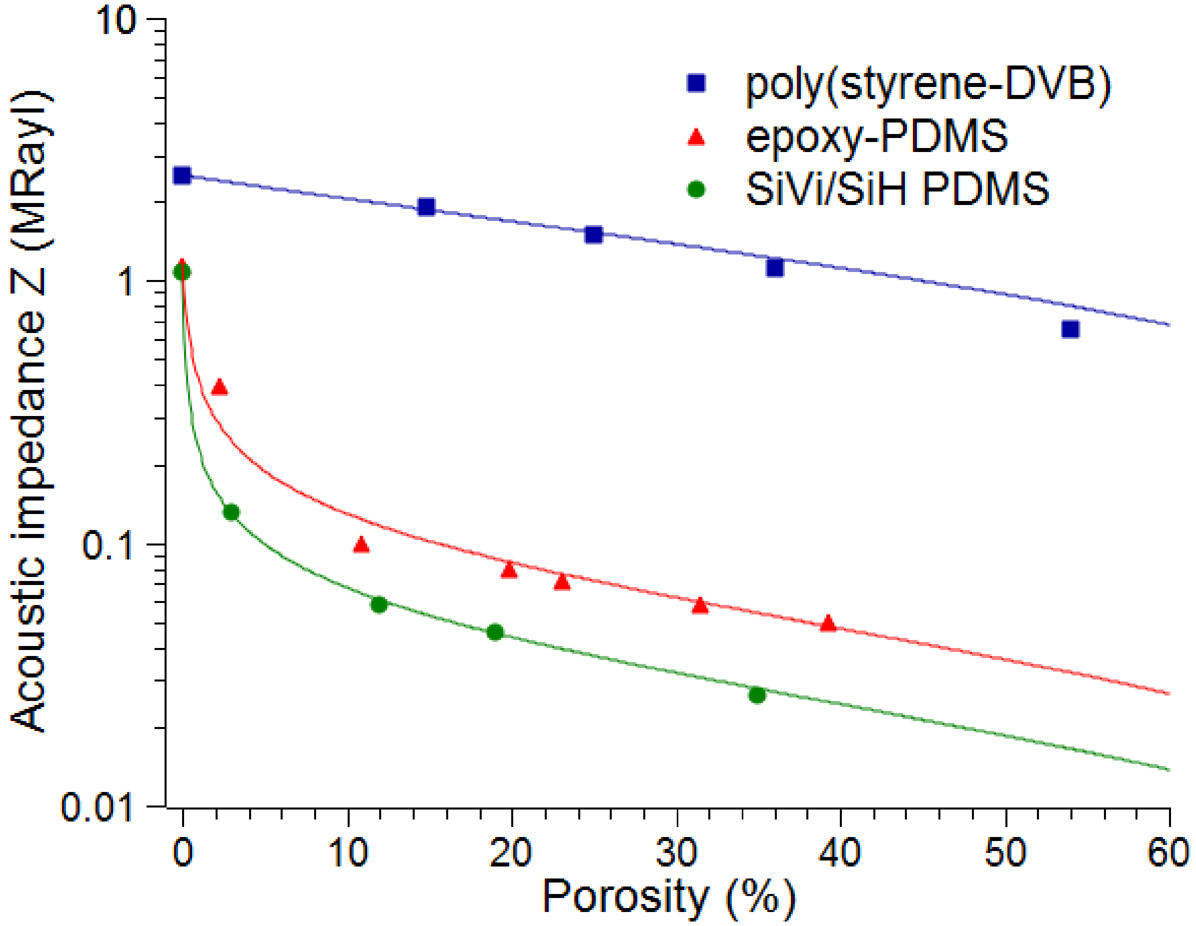
5. Variation of the transversal sound speed C_T with porosity for samples with poly(styrene-DVB) and SiH/SiVi PDMS matrix

The following figure shows experimental values (open symbols) of the transversal sound speed in porous poly(styrene-DVB) and SiVi/SiH samples as a function of porosity. The measurement of C_T was not possible in the soft PDMS matrix at zero porosity due to the strong attenuation of the acoustic wave in the material. The solid lines are predicted curves from the Kuster and Toksoz model using G_0 value of the matrix (equation 7). Filled symbols are calculated values from the mechanical data of the porous SiVi/SiH PDMS samples (see SI-4) using equation $C_T = \sqrt{G/\rho}$. Due to the higher shear modulus of poly(styrene-DVB) with respect to PDMS (see Table 1 in the main paper), the C_T in pure poly(styrene-DVB) is almost 100 times higher than in PDMS samples. The variation of C_T with porosity is low in both cases which may be explained by the low value of the coefficient $B \sim 1$ (see equations 7 and 10 in the main text).



6. Variation of the acoustic impedance with porosity

Acoustic impedance $Z = \rho C_L$ was calculated using density $\rho = \rho_0(1 - \Phi)$ and longitudinal sound speed C_L. The solid lines are the computed curves obtained from the Kuster and Toksoz model using the experimental K_0 and G_0 values of the matrix (Table 1).



References:

[1] Still, T.; Oudich, M.; Auerhammer, G. K.; Vlassopoulos, D.; Djafari-Rouhani, B.; Fytas, G.; Sheng, P. Soft silicone rubber in phononic structures: Correct elastic moduli. *Phys. Rev. B* **2013**, *88*, 094102.

[2] Kuster, G.; Toksöz, M. Velocity and attenuation of seismic waves in two-phase media: Part I. theoretical formulations. *Geophysics* **1974**, *39*, 587–606.