Electronic Supplementary Material (ESI) for Materials Horizons.

Mineral Plastic Foams

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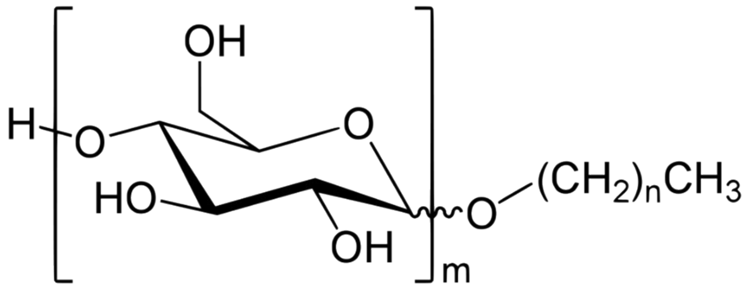

Scheme S1: Molecular structure of alkyl polyglucosides (C_nG_m). In our case m = 1.5, n = 8-16.

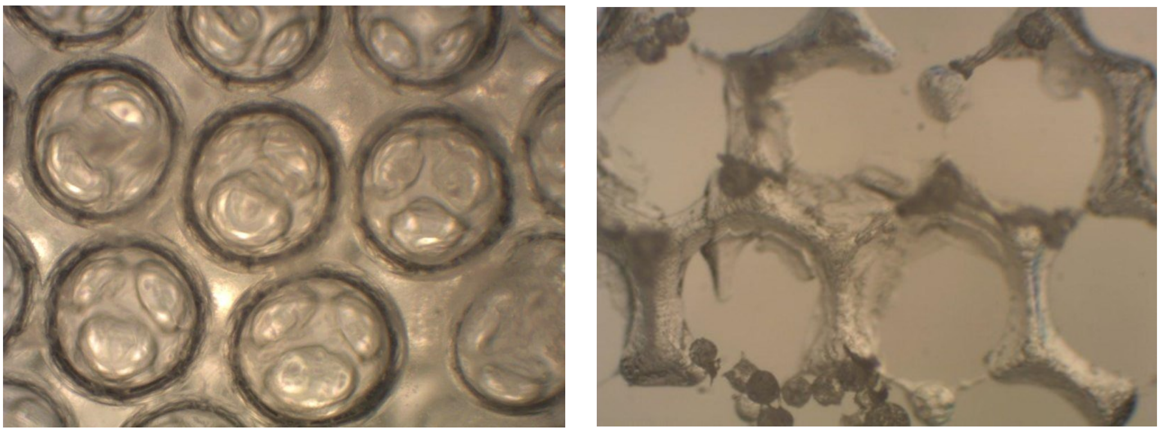

Figure S1: (left) Optical microscope image of the foamed liquid precursor, which was foamed via microfluidics and consisted of 0.1 M PAA, 0.1 M CaCl2, and 0.5 wt% Plantacare® 2000 UP. The separation of the bubbles (round shape) can be clearly seen. (right) Optical microscope image of the dried solid foam, so-called mineral plastic foam. For solidification a 0.1 M sodium carbonate solution was added to the liquid foam and subsequently dried in air. A homogeneous solid foam cannot be formed due to the low amount of PAA.

Powder X-Ray Diffraction: Powder X-Ray Diffraction (PXRD) measurements were carried out on a Bruker D8 Discover device equipped with a Vantec detector.

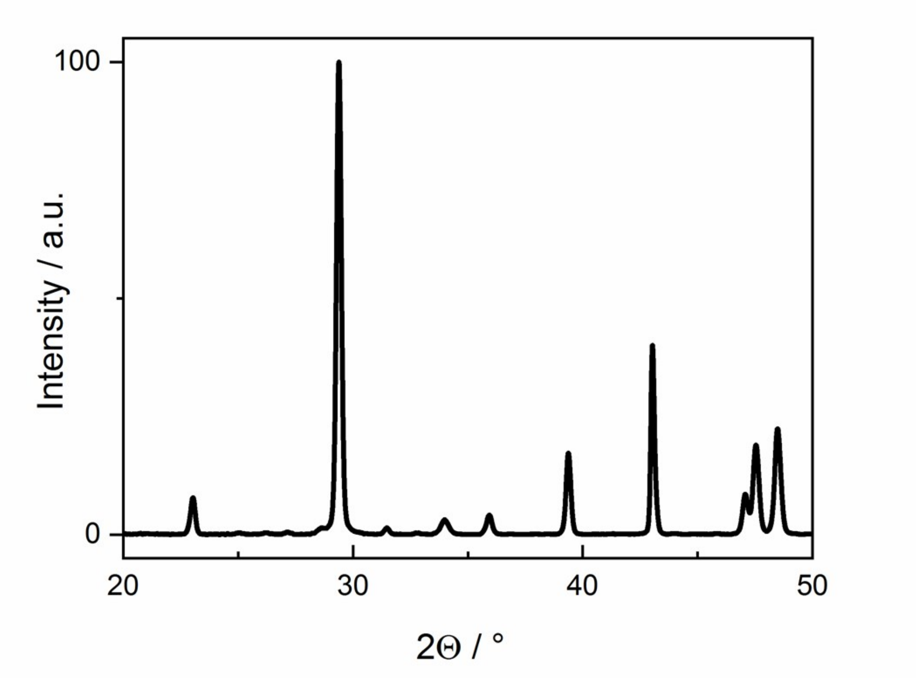

Figure S2: X-ray diffractogram of the white precipitate formed instead of mineral plastic. The precipitate was obtained by using a 1:10 mass ratio between sample and 4.0 M lithium hydroxide solution for the deprotonation of the PAA. The XRD pattern with peaks at 2Θ of 23.1°, 29.3°, 35.9°, 39.4°, 43.2°, 47.4°, and 48.4°, indicates that the sample is calcite. [1]

Mechanical Properties: Mechanical compression tests were carried out with the zwickiLine 5 kN universal testing machine from Zwick / Roell, which was equipped with a 5 kN force transducer and was regulated by the testXpert III software. The stress-strain curves were obtained with normal forces and a test speed of 1 mm min^{-1}. A pre-force of 5.0 N was chosen to obtain a flat sample surface that was uneven from cutting with a scalpel. The slope of the linear part at the beginning of the stress-strain curve (cf. dashed regression line in Fig. S3) was used to determine the Young`s modulus E. It holds

$$E = \frac{\sigma}{\varepsilon} = \frac{F \cdot I_0}{A \cdot \Delta I} \quad (1)$$

with σ being the stress (force F acting on a cross-sectional area A) and ε being the strain (difference Δl between the sample height before compression l_0 and after compression l). [2] We obtained E = 48.26 ± 0.19 MPa for a cube-shaped mineral plastic foam sample with a density of 327 ± 31 kg m^{-3}.

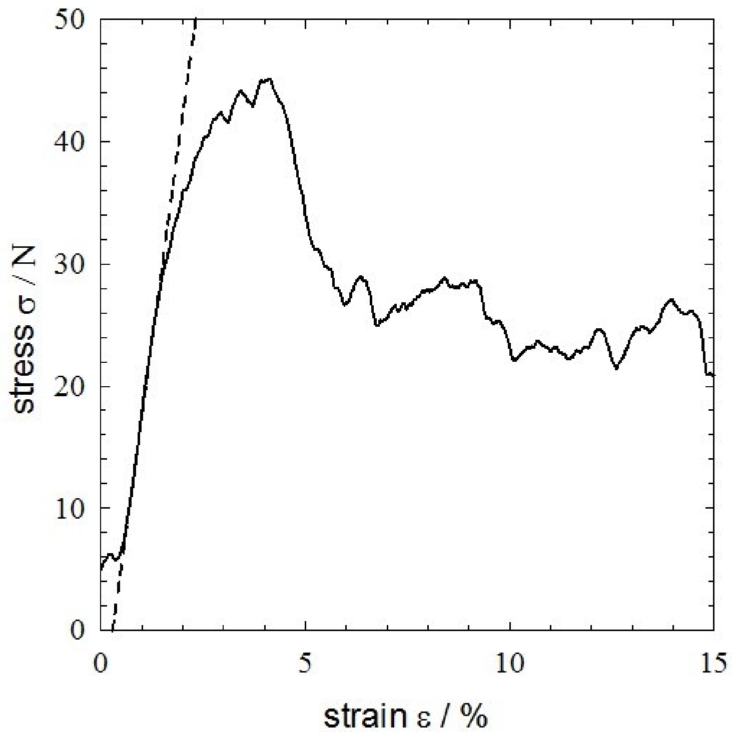

Figure S3: Stress (σ) - strain (ε) curve with a pre-set force of 5.0 N for a cube-shaped mineral plastic foam sample with a density of (327 ± 31) kg m^{-3}. The Young's modulus of (48.3 ± 0.2) MPa was determined from the slope of the linear part (dashed curve) at the beginning of the stress-strain curve.

Solid foams have been studied extensively and there is general agreement that the relative Young‘s modulus ($E_{\mathrm{foam}}/E_{\mathrm{polymer}}$) is proportional to the squared relative density ($\rho_{\mathrm{foam}}/\rho_{\mathrm{polymer}})^2$. It holds for open-pore systems

$$\frac{E_{foam}}{E_{polymer}} = C_c \cdot \left(\frac{\rho_{foam}}{\rho_{polymer}}\right)^2 \qquad (2)$$

with $C_c \sim 1$ according to Gibson and Ashby.[2-4] Using $E_{\mathrm{polymer}} = (380 \pm 2)$ MPa (experimental stress-strain curve not shown) and $\rho_{\mathrm{polymer}} = (1117 \pm 4)$ kg m^{-3}, one obtains a relative elastic modulus ($E_{\mathrm{foam}}/E_{\mathrm{polymer}}$) of 0.127 and a relative squared density $(\rho_{\mathrm{foam}}/\rho_{\mathrm{polymer}})^2$ of 0.086. The resulting proportionality factor $C_c \sim 1.5$ is in the usual range.

References

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2. L. J. Gibson, M. F. Ashby, Cellular Solids, Structures and Properties, Cambridge University Press, Cambridge 1999.
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