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Water Expandable PolyStyrene (WEPS)

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Introduction
During the conventional production of EPS foams, the physical blowing agent (e.g. pentane) is emitted into the environment. As environmental concern grew, NOVA Chemicals in collaboration with TU/e started developing a new generation PS-foam, containing no hydrocarbon blowing agent. In the new approach, the conventional blowing agent pentane is replaced by water, resulting in WEPS1,2 [Figure 1,2]. Many existing foaming processes involve more art than science, while the replacement of the common blowing agents change the expansion behaviour drastically. To predict the most common features concerning the novel expansion process, an experimental expansion technique and a model are presented.

Figure 1 SEM micrographs of (a) compact and (b) expanded WEPS.

Figure 2 Schematic representation of the WEPS-synthesis.

Experimental

Figure 3 The relative volume as function of time for two WEPS-beads (wt. % water, 130°C), also showing cross-sections at different stages in the WEPS expansion process and one bead of a commercial EPS grade (NOVA) (wt. % pentane, 105°C), expanded in the experimental setup (right-top-corner).

Model
The overall growth process involves simultaneous transport of momentum, mass and energy. At the start of expansion, the bubbles inside the foam can be considered as single spherical bubbles in an infinite sea of linear viscoelastic (Maxwell) fluid [Figure 4].

Numerical approach

Figure 4 Schematic drawing of the single bubble model.

Figure 5 The radius $R$ as function of time $t$ (left) and the imaginary part of $FFT[R(t)]$ as function of the frequency $\omega$ for different $\alpha$.

Using the imaginary part of this equation yields the important asymptotical timescales, see Table 1.

Analytical approach
Performing an asymptotical analysis on the final momentum equation by substituting $R(t) = R_{eq} + u(t)$ yields after performing a Laplace Transformation:

$$0 = X + (X + Y)s + s^2 + s^3,$$

$$s0 = 1/\tau_0,$$

$$s1 = 1/\tau_1 \pm i\Omega_1,$$

$$X = f(\alpha, \rho_{ext}, \gamma),$$

$$Y = f(\lambda).$$

Calculating the timescales using the variables as used in the ‘Numerical approach’ gives the values as given in Table 1.

Conclusions & Future Work
The timescales for the asymptotical and numerical analysis are in good agreement. The numerical model will be improved by incorporating mass diffusion, better rheological descriptions for the fluid and heat transport. Different grades of WEPS and WE(PS/PPE) are prepared and will be expanded in the near future to verify the numerical outcome.

References:

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