On the use of lyophobic heterogeneous systems (LHS) in payload comfort

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Intrusion of liquid in non-wetting nanoporous particles requires an important mechanical energy in the form of pressure. Depending on the lyophobicity and on the pore sizes, this mechanical energy can be recovered, partially dissipated or totally dissipated. Here, we are particularly interested in the second type of comportment: a partial dissipation where, at the end of the experiment, we are back to the initial condition and we can restart a reproducible experiment (see figure 1). The dissipated energy can be from 5 to 50 J/g depending on the material and the liquid which permits to envisage to use those systems in vibration control. [1] [2]

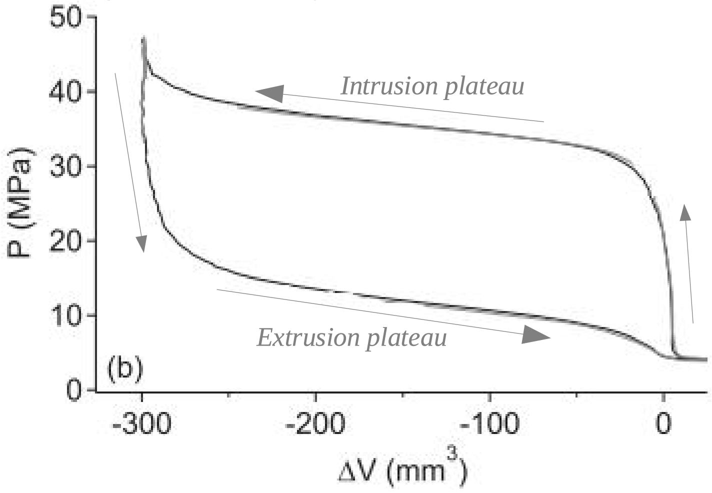

Fig.1. Pressure-volume curve of MTS/water system. [3]

In the aim of using such systems for launchers payload comfort, we focused on the influence of two parameters: temperature and solicitation speed [3]. The first systems which have been studied are Micelle Templated Silica (MTS)/water systems [3]. MTS are silica particles with very ordered porosity (cylindrical, parallel and not connected pores) controlled between 2 nm and 10 nm [4].

On these systems it has been showed that intrusion is controlled by a classical capillary law: the Laplace-Washburn law [2]. On the contrary, extrusion is controlled by a thermically assisted nucleation phenomenon where a microscopic parameter, line tension, play a great role. As a consequence, we can observe that dissipated energy depends on temperature (see figure 3) but does not depend so much on frequency (see figure 4) contrary to classical damping systems such as thermoplastic systems. The extrusion dynamic is totally understood thanks to the nucleation model. However, intrusion dynamic is still unknown as far as a classical Poiseuille law can not explain the observed behavior.

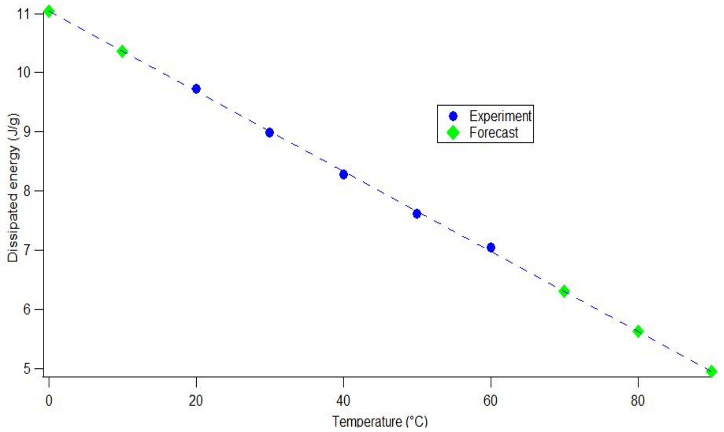

Fig.3. Dissipated energy vs temperature for a MTS/water system at 0,01 Hz.

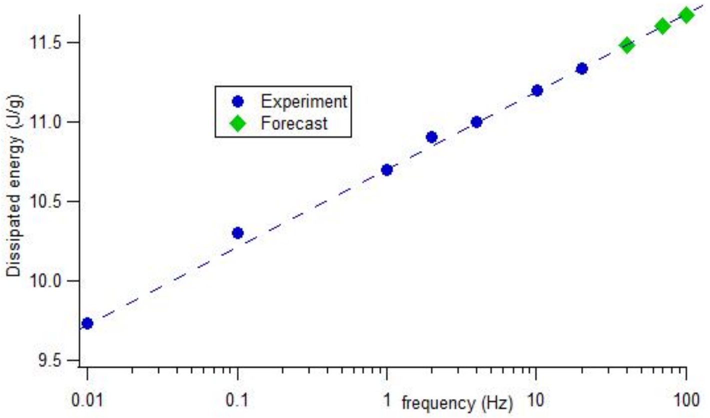

Fig.4. Dissipated energy versus frequency for a MTS/water system at 30°C.

Payload comfort application requires specific external conditions and particularly temperatures below 0°C and higher than 100°C. Therefore, it's impossible to use water for this specific application. To overcome this problem, we focused on two other systems: MTS/salt water and Controlled Pore Glasses (CPG)/Galinstan systems. Salt water stays liquid until -20°C (if salt is sodium chloride) or -50°C (if salt is calcium chloride). Galinstan is an eutectic alloy ($Ga_{0,685}In_{0,215}Sn_{0,1}$) which is non-toxic, non-polluting and can stay liquid till -19°C. Surprisingly, temperature behavior of CPG/Galinstan system is very different from the one of MTS/water system, and particularly dissipated energy increases with temperature. We attributed this phenomenon to surface tension temperature dependance of the liquid which is different for water and Galinstan.

The understanding of nanoscale phenomena occurring in LHS has permitted to explain the macroscopic comportment of such systems alloying to tailor anti-vibration devices which represents a breakthrough in energy dissipation field. However in the aim of using such systems for space applications, the extension of the study to new LHS (such as CPG/Galinstan or MTS/salt water systems) have to be pursued.

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