Public summary of PhD-thesis of Frank Aangenendt
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Methods to determine properties of sponge-like materials

Porous, sponge-like structures are everywhere around us and even within us. The ground we stand on, is a porous medium that absorbs and expels fluids, just like a sponge. The food we eat, like meat and and fruit, are built from porous structures that swell or shrink when water is added or removed. The products we use, especially hygienic products, contain fluid absorbing materials. Even the cells in our own body exhibit this omnipresent (de)swelling behavior that typifies soft, porous materials. The volume is not the only property that changes during the (de)swelling of these soft materials, also the overall mechanical properties, such as the stiffness and permeability, vary significantly. Understanding these mechanical changes is crucial for further improving our understanding of sponge-like materials.

Such understanding has direct practical implications, for instance, sick and healthy cells show different swelling behaviors, and the viscoelastic properties of foods such as cheese greatly influences the taste. The main goal of our research is to gain a better understanding of the (de)swelling behavior and the mechanics of soft porous particles. We use hydrogels, polymeric networks swollen in water, with precise controllable properties, as model materials for studying this behavior. We developed measurement techniques and carried out experiments to investigate their response to changes in temperature and pressure, extracting compressive moduli, permeability, diffusion rates, swelling times and in general a better understanding of what is happening during swelling and deswelling. For example, we designed a unique approach that makes it possible to extract the compressive modulus of a thermo-sensitive hydrogel via calorimetry, without directly measuring any forces or stresses. We have also developed methods for obtaining the permeability of porous particles with sizes ranging from microns up to the macroscopic scale. The knowledge gained and measurement techniques developed in this thesis can be used to predict and probe the behavior of other sponge-like materials, like soil, foods, and biological cells, and many other soft objects and materials.

Title of PhD-thesis: Mechanics and dynamics of soft, sponge-like particles. Promotors: prof.dr.ir. Jaap den Toonder, TU/e, prof.dr.ir. Patrick Anderson, TU/e.