Material Properties and Aesthetic Qualities of Gels

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#biopolymers #gels #experimental #biodegradable plastics
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We live in a time of many challenges. The 'Great Acceleration' (Steffen et al., 2015) is a trend that can be observed in numerous fields in our world: be it the development of CO2 emissions, the land use or the enormous amount of produced plastics accompanied by massive environmental pollution. This 'phenomenon' is obviously directly linked to the way we live and how our society works. To meet these developments, we need to move away from the big, prone concepts that got us here in the first place, and instead build on a variety of dynamic and changing solutions.

In the case of plastics and synthetic polymers, we should see them as what they are, a valuable resource: many applications rely on their outstanding properties. But at the same time, this resource is being used irresponsibly. Through the manufacture of short-lived disposable

items, a poor recycling and waste management system, plastics end up in the environment and lead to vast amounts of macroscopic and microscopic plastic waste (cf. MacLeod et al., 2021). It will be a long way to make plastics a sustainable resource (cf. Science to enable sustainable plastics 2020). In addition to strategies such as increased improvement of recycling techniques, it is essential to switch to biodegradable solutions for certain applications in which the entry into the environment cannot be avoided or can only be avoided with great difficulty (cf. Bauchmüller et al. 2021).

In this talk we deal with one promising material class for this application, the very changeable and versatile class of biological gels. The focus is on a material driven design research approach (Karana et al., 2015) that starts with understanding the material. What is a gel, how can we work with it, what are the aesthetic qualities of those materials?

1. What is a gel? — Gels are exciting materials, made up of a solid phase in which a liquid is embedded, they are kind of hybrid and do not belong completely to one of both states. Gels can be produced synthetically, but nature also relies on gel-like materials, as they bring stability to organic structures, store water and are binders and shapers for organisms. When these hydrogels dry, they show other special features: they form films (xerogels) with plastic-like properties that belong to the material class of (bio)polymers. The focus of this talk is on natural gelling agents such as alginate, pectin, gelatin and others. We will discuss possible applications of gels and biopolymers, such as being alternatives to conventional synthetic polymers.

2. Qualities of gels — After an introduction to the scientific background of gels, we will take a closer look at the material properties of gels, including aspects such as viscosity, homogeneity, processability and biodegradability. First experiments with gels led to the knowledge of how to control the viscosity of the hydrogel and how to produce more homogeneous gels; also how fast these gels dry or how to treat them to prevent mold formation. The last aspect in particular is an indication of the desired biodegradability, which of course should not take place too quickly. These first attempts also include understanding the aesthetic qualities of

natural gels: processing and smell can remind us of cooking, but the resulting gels with their unique consistency evoke also other associations, the colorless or faintly colored to deep amber-colored gels appear less food-like and have almost disgusting properties due to their penetrating sticky consistency. The dried foils, on the other hand, are pleasant to the touch, depending on their composition they vary from plastic-like artificial to organic skin-like. The dried films can also absorb and store water again by swelling. They remain water-stable and waterproof to a certain extent and can also withstand a certain water pressure.

3. Experimenting with and processing gels — In the third part of the talk, experiments with gels are presented, as well as the processing of gels and dried biopolymers. In general, five different methods to work with the gels and films are introduced:

a) Encapsulation of hydrogels in order to preserve their gel character.

b) Laser cutting of foils to change the optical and haptic properties and to produce 3D bodies from 2D materials by skillfully selecting the cutting pattern.

c) 3D printing by using a paste printer.

d) Formation of foams by introducing air with interesting qualities that differ significantly from the foils. These show excellent shape behavior and could also be promising for 3D printing in addition to casting techniques.

e) Fabrication of composite materials made of gel and other substances. Different mixing ratios with other natural substances make it possible to modify the composite materials for a wide variety of applications.

Bauchmüller, V., Carus, M., Chinthapalli, R., Dammer, L., Hark, N., Partanen, A., et al. (2021). BioSinn-Products for Which Biodegradation Makes Sense; nova-Institut für politische und ökologische Innovation GmbH: Hürth.

Karana, E., Barati, B., Rognoli, V., & Zeeuw Van Der Laan, A. (2015). Material driven design (MDD): A method to design for material experiences. International Journal of Design, 9(2), 35-54.

MacLeod, M., Arp, H. P. H., Tekman, M. B., & Jahnke, A. (2021). The global threat from plastic pollution. Science, 373(6550), 61-65.

Science to enable sustainable plastics - A white paper from the 8th Chemical Sciences and Society Summit (CS3), (2020), rsc.li/sustainable-plastics-report

Steffen, W., Broadgate, W., Deutsch, L., Gaffney, O., & Ludwig, C. (2015). The trajectory of the Anthropocene: the great acceleration. The Anthropocene Review, 2(1), 81-98.