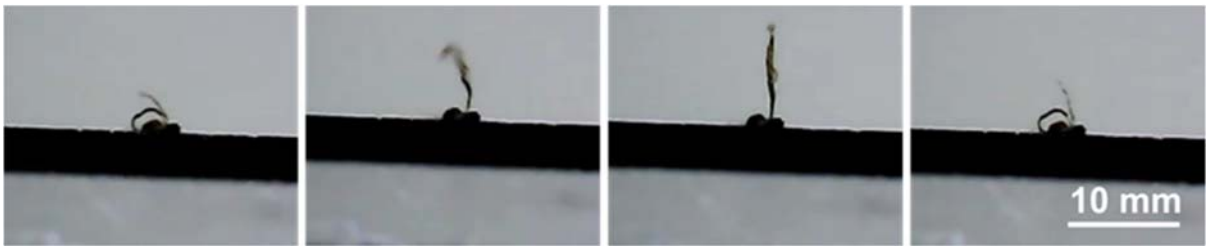
Topic 1

Advances in the mechanical properties of the scrolls and exploring their suitability as novel types of soft actuators

Realization of biomimetic, ceramic-based scrolls whose architecture resembles the three-dimensional structure of natural spicules aims at optimizing the mechanical properties of the scrolls and exploring their suitability as novel types of soft actuators. For these goals, it is important to achieve regularly structured scrolls of controllable diameter (up to several tens of micrometers) and with the ability to reversibly unfold without deterioration of the mechanical integrity. The required hybrid films will be prepared via a well-established fabrication process of the V_2O_5-scrolls.



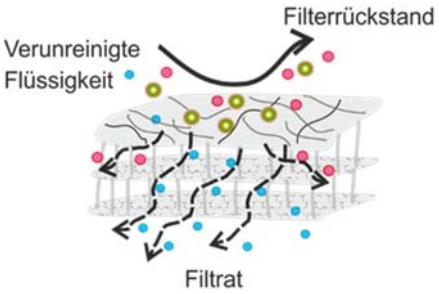
Photographs showing the electrostatic opening of a V_2O_5 scroll: from initial state, applying an electrostatic field by holding the field source above the scroll, fully opened scroll, after removing the field, the scroll returns to its initial state.

The scope of the thesis entails a detailed analysis of the microscopic structure, mechanical as well as actuation performance, crucial for identifying the microscopic mechanisms that underlie the mechanical stabilization of such nanostructured composites.

Topic 2

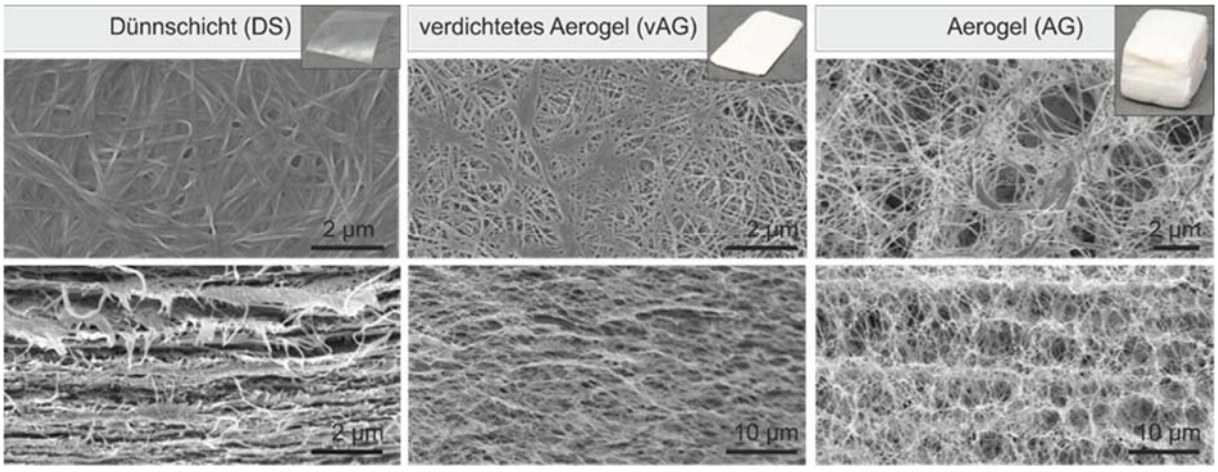
Biobased mechanically stable next generation cellulose membranes for water purification with nanoscale functional layers

This project aims at the development of novel, mechanically stable porous materials as efficient membranes for the water purification. The production of the membranes is a bio-based approach, which uses the synergy of bacteria and yeasts in Kombucha tea for the biosynthesis of nanocellulose fibers. For this purpose the formed bacterial cellulose (BC) pellicle, in which the nanofibers form a network within the layer structure, will be transformed into two different types of membranes and their structural and physicochemical properties should be characterized in detail.



Schematic representation of the project goal, which includes a suitable structuring of cellulose based materials to achieve a multi-stage liquid filtration

The synthesis of the highly porous aerogels, will be carried out by an ice-templating process. The main goal is to tailor the nano-/microstructure of the membranes by optimizing the process parameters in order to achieve the highest possible mechanical stability. In addition, incorporation of titanium dioxide (TiO_2) particles into the membrane structure should also result in higher mechanical stability. Of particular importance is the control of pore size and surface chemistry in order to effectively separate impurities by size-based exclusion or charge or chemically mediated interactions.



Electron microscopic images of the surface (upper row) and the cross-section (lower row) of the BC membrane types investigated here. In addition, a digital image of the respective membranes is shown, which illustrates their size in the centimeter range.

In addition, the increase of the hydrophobic character of the membranes can be achieved by a silanization process. The aim is to identify a membrane type that exhibits a synergy of mechanical stability, hydrophobicity and structured porosity. To accomplish these tasks, a systematic structural and physicochemical analysis of the produced membranes is required.

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