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## A GISANS study of bio-hybrid films: Influence of pH on spray-coated $\beta$ -lactoglobulin:TiO<sub>2</sub> film morphology for bio-templated titania nanostructures

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Nanostructured metal oxides such as TiO<sub>2</sub> play a major role in hybrid photovoltaics. They can serve as the inorganic charge acceptor of the active layer. For this, a designed structure is of high importance to address different challenges on different length scales. This includes mesoscopic pores for an eased backfilling of the organic donor material and a high interfacial area between donor and acceptor domains, having domain sizes of tens of nanometers for efficient charge carrier separation. A hierarchical morphology of high surface-to-volume ratio is hence beneficial for the device performance. Diblock copolymer directed sol-gel chemistry offers a way to fabricate templated TiO<sub>2</sub> films on an industrially relevant scale, e.g. by spray-coating. However, involved organic solvents lead to a restricted potential in environmentally friendly processing. To overcome this issue, we investigate water-based sol-gel templating with the use of biopolymers. The bovine whey protein  $\beta$ -lactoglobulin is known to form differently structured aggregates by denaturing at different pH values. In combination with a water-based TiO<sub>2</sub> precursor, different bio-hybrid film morphologies are obtained by spray-coating. The influence of pH on the film morphology is investigated by bulk and surface-sensitive grazing incidence small-angle neutron scattering (GISANS). The obtained results are complemented by real-space imaging with scanning electron (SEM) and atomic force microscopy (AFM).

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