Self-assembly of polycationic polymers with viruses for advanced biomaterials

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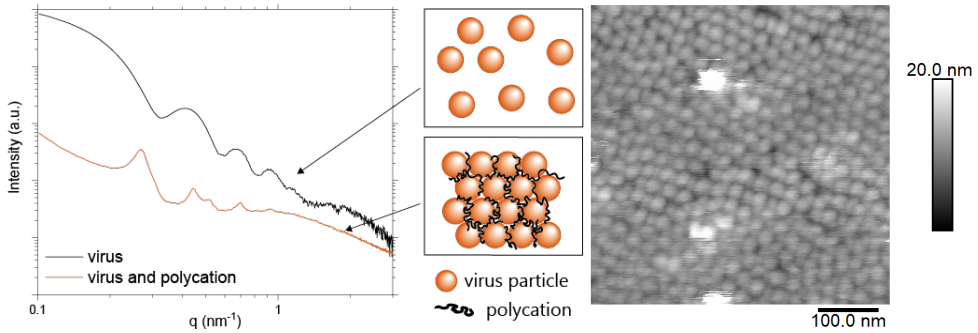
Waterborne viruses are responsible for numerous deaths and epidemics.[1] Their nanoscale size makes them too small for commonly used size-exclusion water purification processes. Polycationic polymer materials can help removing negatively charged viruses from water by adsorption and inactivation. [2] However, the underlying colloidal interactions that can guide the design of advanced antiviral materials have not yet been studied in detail. [3] This work demonstrates the design and precision synthesis of polycationic polymers for virus adsorption and deciphers their colloidal interactions. The results provide essential knowledge for the design of advanced materials for various applications.



Small-angle x-ray scattering (SAXS) with numerical data analysis shows the presence of core-shell protein nanoparticles with a dimension of around 30 nm (left figure), in agreement with results from dynamic light scattering (DLS). Upon addition of the polymer, a composition- and polymer length-dependent aggregation was discovered. SAXS demonstrated the arrangement of the viruses into geometrically organized colloidal crystals with lattice dimensions around 30 nm under certain conditions. These colloidal crystals could be imaged with atomic force microscopy (AFM) under aqueous environment (right figure). Further in-situ multi-angle DLS studies of the aggregation process show a fast gain in size from 30 nm to 1 µm.

The polymer-triggered assembly of the virus into micron-sized aggregates is driven by electrostatic interactions. The highly monodisperse virus dimensions further allowed the formation of colloidal crystals. The findings on composition-dependent structure and interaction from this study can guide the design of antiviral materials for applications including wastewater treatment. Moreover, the development of these systems into advanced nanopatterned bio-interfaces is also discussed. These interfaces may be additionally functionalised using surface or core-modified virus particles to trigger interactions with specific cells or for controlled drug release.

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[2] S. Watts, K. Maniura-Weber, G. Siqueira, S. Salentinig, et.al. *Small*, **2021** *17*, 2100307.
[3] S. Watts, B. Tran, S. Salentinig, *Chimia,* **2022**, *76*, 846