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Hydrodynamic effects in adhering vesicles on periodically modulated substrates

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Vesicles on substrates play a crucial role in various biological transport processes, including neurotransmitter release at the synapse, transport between cells, and drug delivery using synthetic vesicles. The adaptive adhesion of the vesicles to a biological substrate is crucial for all these processes. Although in shape similar to droplet wetting, vesicle adhesion is fundamentally different as it is governed by the membrane's bending rigidity, whereas wetting is driven by surface tension.

In this study, we investigate the dynamics of permeable vesicles on substrates with periodically modulated adhesion strength using coarse-grained molecular dynamics (MD) simulations. The volume-enclosing membrane, which distinguishes vesicles from droplets, deforms during the adhesion process, inducing fluid flow both inside and outside the vesicle. This interaction between membrane deformation and hydrodynamics is complex and significantly affects the shapes observed during adhesion. A key factor in this process is the membrane's permeability.

By combining periodically modulated adhesion strength with a selected permeability, we modulate the vesicle-substrate contact, providing an effective control mechanism for both the contact time and area. Moreover, the hydrodynamic flows generated in the course of adhesion may enhance the transport of molecules toward the membrane, making this a vital element for controlling transport in biological vesicles.

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Sitzung Einordnung: Short Talks