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ABSTRACT:

Bridging Wetting and Adhesion: A New Paradigm in Soft-on-Soft Contact Mechanics

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In between classical wetting and contact adhesion lies an enormous material landscape that can be harnessed by tuning material elasticity and adhesion. These material interactions often exhibit intermediate static and dynamic responses that challenge the classical description of solids and liquids. For instance, using reflection interference contrast microscopy, we demonstrated that when the underlying substrate is very soft, contact deformation of a rigid probe often yields wetting ridge signatures beyond Hertzian formalism [1]. However, only tuning the substrate elasticity does not provide a holistic understanding of all the intermediate morphologies and deformation signatures realizable for such contacting systems. Consequently, to explore an extensive set of interactions, we chose to investigate the interfacial mechanics of soft-on-soft contacting systems, which are the main focus of the present work. In this work, we demonstrate a systematic static and dynamical study of soft-on-soft contacting systems using acrylamide and PDMS as contacting pairs across a wide range of effective elasticity, and consequently across a wide range of the characteristic elastoadhesive parameter. First, using equilibrium measurements of contact radii and contact angles, we reveal how the contact morphology evolves from obeying Hertzian mechanics at high elastoadhesive parameters to a transition zone at moderate values, and eventually converges to wetting-like morphologies at the zero limit [2]. Further, using density functional theory, we reveal that this transition is driven by a switch in the interaction potential from attractive to repulsive at a critical value of the effective elasticity [3]. Furthermore, dynamic experiments using high-speed imaging reveal a contact/wetting trajectory that is largely different from that of Newtonian or weakly elastic liquids [4]. Finally, we demonstrate an intriguing outcome at a distinct value of effective elasticity: soft microspheres spontaneously roll down a perfectly vertical soft substrate [5]. Beyond scientific curiosity, these findings shed light on the evolving concept of elastowetting and open new avenues for material design in soft robotics, 3D printing, and flexible electronics.

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