EFFECTS OF VISCOELASTICITY AND SURFACE ROUGHNESS ON RUBBER ADHESION

L. Dorogin [a, b*], A. Tiwari [a, c], G. Heinrich [b], B. N. J. Persson [a, d]
* l.dorogin@fz-juelich.de
[a] PGI, FZ-Jülich,
D-52425 Jülich, Germany
[b] Leibniz Institute for Polymer Research Dresden,
P.O. Box 120 411, D-01005 Dresden, Germany
[c] Department of Mechanical and Industrial Engineering, Norwegian University of Science and Technology,
Richard Birkelandsvei 2B, N-7491 Trondheim, Norway
[d] Multiscale Consulting,
Wolfshovener Straße 2, D-52428 Jülich, Germany

KEYWORDS
adhesion; viscoelasticity; roughness; rubber

ABSTRACT
Adhesion between glass and various types of rubber is investigated experimentally and analyzed theoretically. The work of adhesion during pull-off appears to vary strongly depending on the system, where the two effects, namely viscoelastic energy dissipation close to the opening crack tip, and surface roughness play the main role. Adhesion during multiple repeated contacts can be affected by molecular transfer from the rubber to the glass.

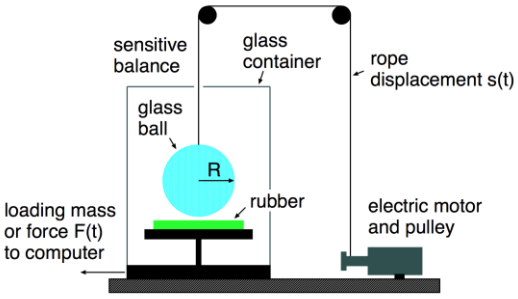

Fig. 1. Schematics of the experimental set-up for measurements of adhesion.

In general, we have distinguished the three major contributions to rubber adhesion acting at different length scales: bulk viscoelasticity, roughness and molecular mobility. The time-dependent viscoelastic contribution leads to higher adhesion for the softer compounds at the same velocities. The roughness contribution can have different sign depending on the stiffness of the rubber compound. This different behavior can be explained by the additional elastic energy stored while contact formation of the stiffer rubber with the rough surface and the additional contact area in the case of the compliant softer rubber. Mobile molecules in the weakly cross-linked structures can get attached to the countersurface and are pulled out from the substrate accompanied with energy dissipation and the increased work of adhesion.

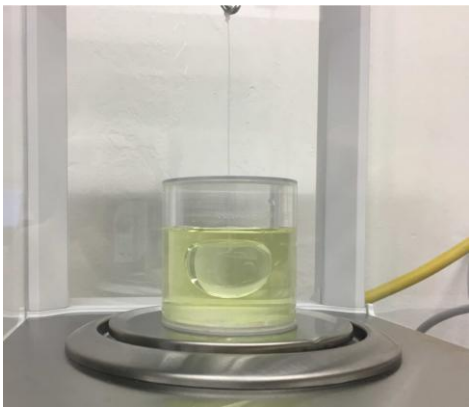

Fig. 2. Experimental set-up for adhesion studies in fluids (in this case water+soap; the light yellow fluid).

REFERENCES
[1] Lorenz, B., Krick, B. A., Mulakaluri, N., Smolyakova, M., Dieluweit, S., Sawyer, W. G. and Persson, B. N. J., "Adhesion: role of bulk viscoelasticity and surface roughness", J. Phys.: Condens. Matter 25 225004.
[2] Tiwari, A., Dorogin, L., Bennett, A. I., Schulze, K. D., Sawyer, W. G., Tahir, M., Heinrich, G. and Persson, B. N. J., "The effect of surface roughness and viscoelasticity on rubber adhesion", submitted to Soft Matter.