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Influence of ionic cross-linking on polymer interdiffusion in water-borne pressure-sensitive adhesives

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Pressure-sensitive adhesives (PSAs) adhere to surfaces upon application of light mechanical pressure and are used as tapes or labels. PSAs are based on styrene-isoprene block copolymers, natural rubber or acrylates/acrylics with a glass transition temperature, T_g, below 0°C. Fine-tuning of viscoelastic properties is necessary to adjust cohesion and adhesion. This research targets the film formation of water-borne acrylic PSA dispersions. Polymer dispersions consists of polymer particles dispersed in water which are stabilized by surfactants. Film formation of dispersions consists in compaction, particle deformation and interdiffusion. [1] Acrylics in PSA dispersions have a low T_g, therefore particle deformation and polymer interdiffusion are fast, even at room temperature. Due to their low T_g, acrylates are already tacky but lack cohesion, and thus have to be cross-linked. Cross-linking impedes polymer interdiffusion and can lead to the formation of a fragile film. We study film formation of industrially relevant acrylic PSA dispersions provided by BASF SE by employing Förster resonance energy transfer (FRET, reporting interdiffusion) and intensity of scattered excitation light (reporting particle deformation). To use FRET, dispersions were prepared twice, once with fluorescing donor-labeled polymer chains and once with acceptor-labeled chains. By analyzing how the shape of donor decays obtained on a blend of donor- and acceptor-labeled latexes change over film formation time, the progress of polymer interdiffusion, quantified by the fraction of intermixing (*fm* in Figure 1) can be followed. [2] Particularly impact of polymer cross-linking on interdiffusion was studied. A dispersion with uncross-linked chains was blended with the ionic cross-linker, aluminum acetylacetonate ($Al(acac)_3$), to explore its influence on polymer interdiffusion. Interdiffusion studies suggest that most of chains are uncross-linked in the wet dispersion and that Al^{3+} ions interconnect the polymer chains during interdiffusion when acetylacetone evaporates. The final film has a gel content of 75%, proving reversible polymer cross-linking.

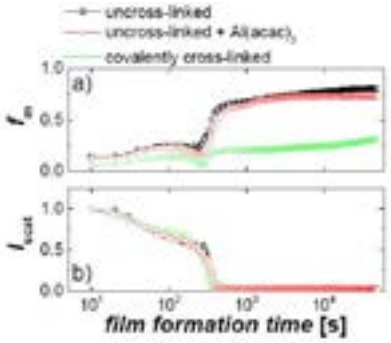

Figure 1: Impact of polymer architecture on film formation of PSA dispersions. a) Progress of polymer interdiffusion reported by FRET data ("fraction of intermixing" *fm*), b) Progress of drying and particle deformation reported by intensity of scattered excitation light, I_{scat}. $Al(acac)_3$ = aluminum acetylacetonate.

Recent Publications:

1. Keddie, J. L., Routh, A. F. (2010) Fundamentals of Latex Film formation, Springer.
2. Wang, Y., Zhao, C.-L., Winnik, M. A. (1991) Molecular diffusion and latex film formation: An analysis of direct nonradiative energy transfer experiments, J. Chem. Phys. 95, 2143–2153.
3. Wahdat, H., Hirth, C., Johannsmann, D., Gerst, M., Rückel, M., Adams, J. (2018) Film Formation of Pressure-Sensitive Adhesives (PSAs) Studied with Förster Resonance Energy Transfer (FRET) and Scattering Intensity, Macromolecules 51, 4718-4726.

4. Kimber, J. A., Gerst, M., Kazarian, S. G. (2014) Fast Drying and Film Formation of Latex Dispersions Studied with FTIR Spectroscopic Imaging, Langmuir 30, 13588–13595.
5. Czech, Z. (2003) Crosslinking of pressure sensitive adhesive based on water-borne acrylate, Polym. Int. 52, 347–357.

Biography

Hares Wahdat is a Ph.D. student since 11/2016 in the field of chemistry at the Institute of Physical Chemistry, Clausthal University of Technology in Germany in the group of Dr. Jörg Adams. His research targets the film formation of pressure sensitive adhesive, investigated with Förster resonance energy transfer in co-operation with BASF SE, Ludgwigshafen, Germany. He obtained his M.Sc. degree in chemistry from Clausthal University of Technology in 2011–2016. During his studies, he performed a research internship in the Netherlands at the Institute of Physical Chemistry and Soft Matter at Wageningen University, in which thermo-responsive block copolymer membranes were prepared and investigated. After finishing his Ph.D. in 2019, Hares Wahdat seek a post-doc in the industry.

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