B3: Influence of nanofillers on the properties of polymer latex films

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Presentations

- 4 oral IRTG
- 6 posters IRTG
- 3 oral other
- 6 posters other

Publications

[1] A. Kiessling, V. Le Houérou, C. Gauthier, E. Bartsch (in preparation).

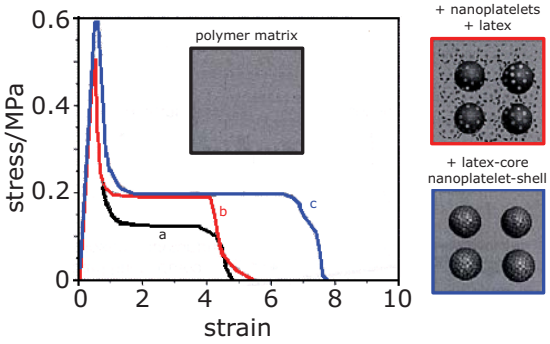
[2] V. V. Lesnichii, N. V. Petrov, and P. A. Cheremkhin, *Opt. Spectrosc.* **2013**, *115*, 557.

Other activities

- Invitation and organization of seminars by P. Lutz, M. A. Winnik and A. Veniaminov (A. Kiessling)
- Participation in presentation of the French-German University, Doc Days 2011, Science Days 2012 (A. Kiessling)
- Head of the organizational committee of the IRTG Experience Transfer Training Camp 2014 (V. V. Lesnichii)

Motivation

High performance coatings from core-shell particles in polymer matrices



Stress-strain curves for coatings from a) pure polymer, b) pure polymer with nano-platelets and latex, c) pure polymer with latex-core nano-platelet-shell particles.[3]

Key question: microscopic origin of the mechanical performance

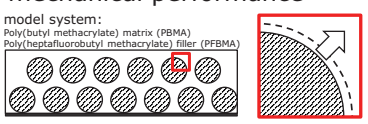
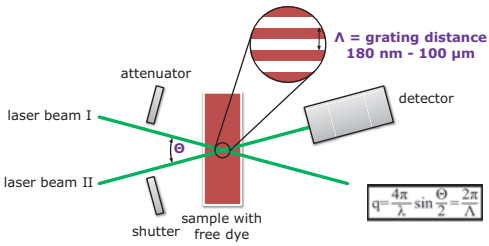


Illustration of a coating (PBMA matrix, PFBMA filler) resulting from a PFBMA core – PBMA shell latex. Such coatings show improved properties, e.g. enhanced scratch resistance.[3]

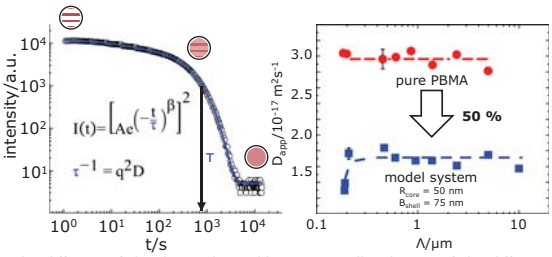
[3] T. Wang, P. J. Colver, S. A. F. Bon, J. L. Keddie *Soft Matter* **2009**, *5*, 3842.

Tracer diffusion studies

of nanoscale structural heterogeneities via Forced Rayleigh Scattering (FRS)[2]



Schematic illustration of the FRS experiment. Through the superposition of two laser beams a holographic grating is created. Depending on the angle Θ between the beams I and II, the grating distance Λ can be adjusted.

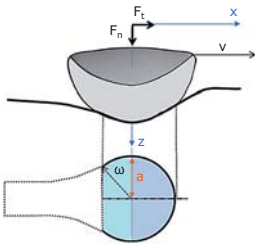


The diffusion of the dye is detectable as time decay of an optical Bragg scattering signal. The diffusion coefficient D_{app} can be calculated from the relaxation time, as shown in the inset.

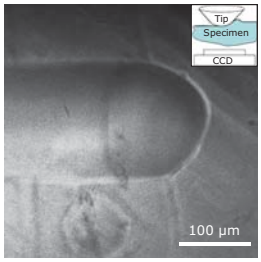
An overall reduction of the diffusion coefficient is observed. A stronger reduction close to the filler size suggest a layer of restricted mobility.

Mechanical performance

Does the observed nanoscale filler effect influence the macroscopic properties?

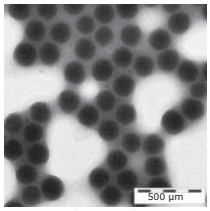


Schematic illustration of a hard sphere sliding on a viscoelastic polymer. The contact area is defined by the length a and the angle ω.[4]

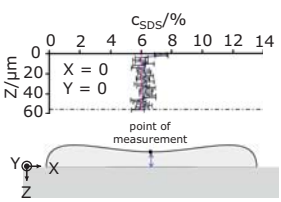


Picture of a tribological measurement of a coating resulting from a core-shell latex measured in the Gauthier group at v = 10^{-4} m/s, θ = -10°C, F_n = 2 N.

→ Tailored surfactant-free coatings in correspondence with the group of C. Gauthier



TEM image showing the structure of a core-shell latex coating. It strongly affects the performance.



Research in progress with Confocal Raman in the Holl group to map the nano-structure of the coatings.[5]

→ Resolved problems in film formation with the expertise of the group of Y. Holl

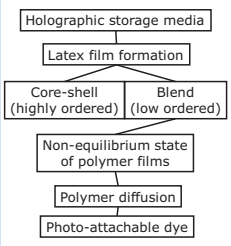
[4] G. Klein, V. Le Houerou, R. Muller, C. Gauthier, Y. Holl, *Tribol. Int.* **2012**, *52*, 142.
[5] C. Arnold, F. Thalmann, C. Marques, P. Marie, Y. Holl, *J. Phys. Chem. B* **2010**, *114*, 9135.

Conclusion & outlook

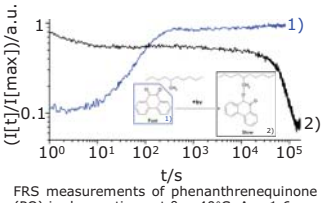
Both the mechanical performance and microscopic properties change depending on the size ratio of core and shell.

→ **Clear indications for the supposed layer of restricted mobility**

Continuation



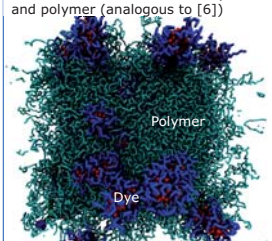
Proof of principle



FRS measurements of phenanthrenequinone (PQ) in dry coatings at θ = 40°C, Λ = 1.6 µm (1) and θ = 50°C, Λ = 185 nm (2) showing PQ tracer and polymer diffusion. The Photoreaction is shown in the inset.

Collaboration with H. Meyer

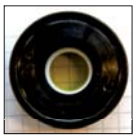
Simulation of diffusion of the dye and polymer (analogous to [6])

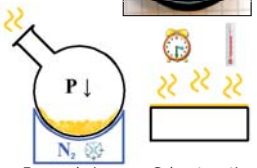


[6] M. Durand, H. Meyer, O. Benzerara, J. Baschnagel, O. Vitrac, *J. Chem. Phys.* **2010**, *132*, 194902.

Future work

Modifications of the polymer film preparation procedure





Freeze drying, grinding, melting with optical glass surfaces pressure

Solvent casting, melting with optical glass surfaces pressure