

Drying kinetics of nanoscale polymer films

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Thin micrometer to nanometer thick functional polymer films are used in a wide variety of applications such as sensor devices, printed electronics and the functionalization of surfaces. An efficient way to produce such layers is a solution-based process where the active components are dissolved in a solvent, applied to a substrate via established coating routines and subsequently dried. Often, this last step is crucial to device performance, since a desired functionality evolves during the drying process.¹ Therefore, it is of utmost importance to know the mass transport parameters, i.e. phase equilibrium and diffusion coefficient, that determine the kinetics of solvent removal in such systems.

At the transition from the micrometer- to the nanometer-scale the properties of thin polymer films deviate from their respective bulk behavior due to a relative increase of interface effects (Fig1). At the free interface polymer chains can move freely, whereas at the bottom, depending on the substrate interactions, polymer chains can be pinned and less mobile. This effect is known to change the glass transition temperature, crystallization dynamics and mechanical properties. The influence on mass transport parameters and the mechanisms that govern solvent mobility in such thin layers are only understood to a limited extent.^{2,3}

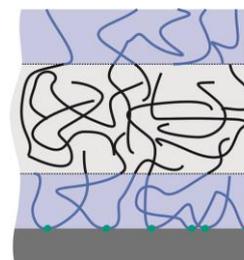


Fig. 1: Interface effects in thin polymer layers

In this work we investigate the influence of polyvinylacetate film thickness on the swelling dynamics upon exposure to methanol vapor and compare them to bulk data. The swelling is measured by means of a Quartz Crystal Microbalance (QCM) in combination with a precise method to adjust the gas phase solvent activity. The experiments were conducted on different substrates in order to investigate the influence of the surface material on the sorption dynamics. Compared to bulk data the solvent diffusion coefficient in a thin film decreases by orders of magnitude. A fit to the data indicates that the diffusion process is not entirely governed by Fickian diffusion dynamics. Therefore, in this work, we discuss the results of sorption experiments on nanometerscale films and the applicability of different models.

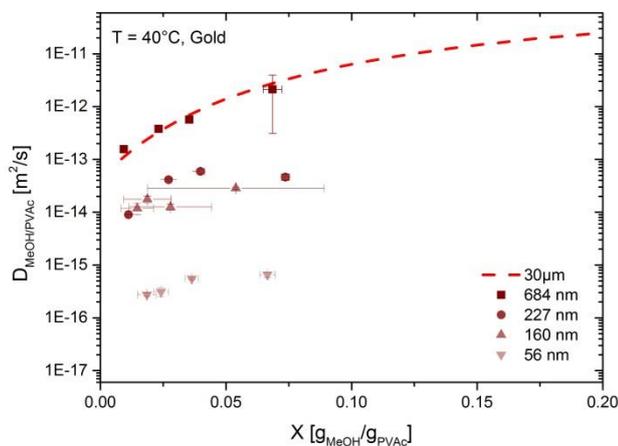


Fig. 2: Concentration- and thickness-dependent diffusion coefficient (F. Buss et al., *publication in preparation*)

References

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