Nanotribology for the Design of Speciality Chemicals

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Abstract:

Friction force microscopy (FFM), a variant of scanning probe microscopy, measures adhesive and frictional forces with nanometre spatial resolution on surfaces where speciality chemicals are deposited. Unlike other chemical analysis methodologies, nanotribological approach is a versatile toolbox for the development of complex structural formulation in both ambient and liquid environments. The unique capability of FFM is demonstrated with the following three studies.

1. Detergent formulation for fibres

To evaluate the performance of detergent formulation developed, nanofriction measurements over 1 *μm* by 1 *μm* area were carried out at different locations of individual cotton fibres treated with various washing processes and detergent formulations.[1] Coefficients of Friction (CoF) were found to increase with the number of wash cycles due to the loss of natural wax layer, but reduced by treatment of fabric conditioner. Such trend is valid in both ambient (controlled humidity) and liquid tested. Furthermore, distribution of CoF as a function of washing cycles effectively reflects the damages caused by the detergents within the yarn.

2. Lubrication characteristics of polymeric coating

To optimise the lubrication characteristics of biocompatible polymer surface coating, poly(2-(methacryloyloxy)ethyl phosphorylcholine) (PMPC), nanotribological studies were performed considering the following parameters: thickness of the polymer film, solvent quality, and chemical functionality of the surface in contact.[2,3,4] We have shown that the configuration of molecules at the interface is dependent on their solvation state, which consequently influence the lubrication characteristics and contact mechanics, e.g. osmotic pressure increases in a good solvent and yield a reduced tendency for the polymer layer to deform under applied load.

3. Optimising concentration of specialty chemicals

For any developed speciality chemicals, it is vital to control its density upon adsorption to the target surfaces. Using photolithography approach, we contrasted polymer brushes with various density on a glass substrate, as shown in the figure below. Using FFM, it was possible to measure the effect of the polymer density on both the heights and the frictional properties of the resulting nanostructured brushes.[5] The coefficient of friction was found to decline as the brush height increased, with a smooth variation in both parameters being observed as a function of the density of initiator sites, which demonstrates that FFM could be a unique approach to optimise the concentration of specialty chemicals in the formulation.

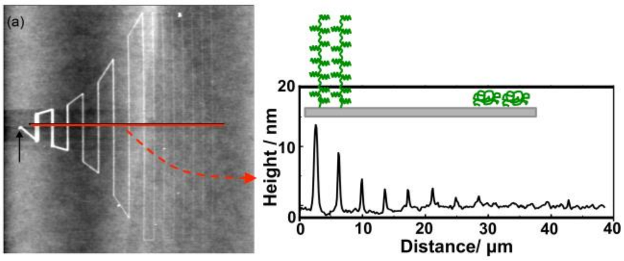

Figure 1. SPM image of patterned PMPC polymer brushes with corresponding sectional analysis showing the transition of molecular configuration.

Reference:

1. Zhang et al. *J. Mater. Chem.* 2010 **20** 8531
2. Zhang et al. *Langmuir* 2011 **27** 2514
3. Zhang et al. *Langmuir* 2013 **29** 10684
4. Zhang et al. *Langmuir* 2016 **32** 5048
5. Zhang et al. *Langmuir* 2017 **33** 706