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Polymers with hydro-responsive topography identified using high throughput AFM of an acrylate microarray†

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Atomic force microscopy has been applied to an acrylate polymer microarray to achieve a full topographic characterisation. This process discovered a small number of hydro-responsive materials created from monomers with disparate hydrophilicities that show reversibility between pitted and protruding nanoscale topographies.

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minimal. A full description of the high throughput AFM (HT-AFM) methodology is available in the ESI (section ESI2†). Tapping mode images were acquired in both air and a liquid environment. In air, silicon tips with a resonant frequency of approximately 300 kHz and a force constant of approximately 40 N m⁻¹ were used (Tap300AL, Budget Sensors, Sofia, Bulgaria). In liquid and for contact mode measurements, silicon nitride tips with a resonant frequency of approximately 7 kHz and a force constant of approximately 0.6 N m⁻¹ were used (DNP-S, Bruker AXS, Cambridge, UK).

As a first pass analysis of the data, the roughness parameter Rq was used to numerically assess the sample without considering the content of the images from which this was derived. The Rq values measured in air for all materials, presented in Fig. 1a, were used to identify materials with features that deviated from the flat surface required for simple assessment of material-cell interactions. No correlation between Rq and water contact angle (WCA) was observed for this simple assessment of material-cell interactions. No correlation between Rq and water contact angle (WCA) was observed for this simple assessment of material-cell interactions. No correlation between Rq and water contact angle (WCA) was observed for this simple assessment of material-cell interactions. No correlation between Rq and water contact angle (WCA) was observed for this simple assessment of material-cell interactions.

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In summary, HT-AFM has been performed on a 576 member polymer microarray to assess roughness and to classify materials by their topography. This demonstrates a key new tool for high throughput materials characterisation with which to physically characterise material microarrays. Spots with pitted topology in this library were discovered to be nano-structured hydro-responsive materials that switched between a pitted and bumpy nanoscale topography when immersed in water. This was a result of phase separation of hydrophilic monomer at the depressions dispersed as small spheres within the bulk hydrophobic monomer. This discovery allowed the investigation of roughness and topography for a library of 576 materials. Without such a large sample set it is unlikely that the materials exhibiting this interesting phenomenon (10 out of 576) would have been discovered.

Acknowledgements

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Fig. 4 The height (○) and diameter (▲) of the surface features (either pits or protrusions) imaged on the surface of polymer composed of 75% (v/v) monomer 16 and 25% (v/v) monomer A after repeated wet-dry cycles. Error bars represent one standard deviation unit, n = 20.

Fig. 3 Surface coverage of pits (dry) or protrusions (wet) (%) plotted versus minor monomer content for copolymers of 16 and A dry (○) and wet (▲) state. Error bars represent one standard deviation unit, n = 3.

The y = x line is drawn as a guide.
Notes and references