Three-dimensional imaging with submolecular resolution by atomic force microscopy

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Intramolecular resolution accomplished by atomic force microscopy (AFM) has recently attracted considerable attention [1,2] because its potential to unveil the chemical structure of unknown molecules [3], characterise charge distributions [4] and bond ordering [5] within molecules, as well as to study chemical transformations [6,7] and intermolecular interactions [8,9]. So far, most of these achievements make use of planar molecules because high-resolution imaging of three-dimensional (3D) surface structures with AFM remains challenging.

Here we present a general method for sub-molecular imaging of non-planar molecules and the study of 3D surface systems with atomic resolution using a cantilever-based AFM. We demonstrate this method by characterising the step-edges of a TiO_2(101) anatase surface at atomic scale, by simultaneously visualising the chemical structure of a pentacene molecule together with the atomic positions of the substrate [Fig.1 left] , and by resolving the chemical structure of a C_{60} molecule [Fig. 1 right] with intra-molecular resolution.

References

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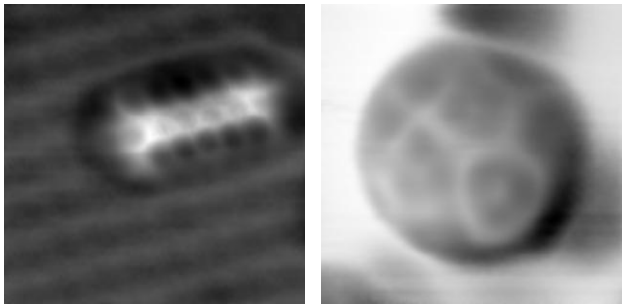

Figure 1. Atomic force microscopy images displaying intramolecular resolution in individual pentacene (left) and C_{60} (right) molecules (3x3 nm^2).