AFM and STM Studies of Monolayers of Ultrasmall Anatase TiO_2 Nanoparticles

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Nanoparticles of anatase TiO_2 are used in dye-sensitized solar cells, photocatalysis, (photo-) electrochromics, batteries, and other applications. A major drive in the field of nanoscience area is to be able to manipulate nanomatter into desired structure. In this presentation, we report on the synthesis and characterization of ultrasmall (~35 Å diameter) anatase TiO_2 nanoparticles and their assembly on atomically flat gold substrates. We also discuss applications of this unique arrangement.

TiO_2 nanoparticles were synthesized in the presence of acetylacetone during acid hydrolysis. This method yields monodisperse and non-aggregated nanoparticle solutions, which are stable for months. Atomically flat substrates were prepared by hydrogen-flame annealing of gold-on-glass substrates. These substrates were exposed to solutions of a bridging molecule that contains a thiol moiety on one hand and a carboxylic acid group on the other (e.g. mercapto-propionic acid). The thiol moiety of this molecule binds strongly to the gold surface leaving its carboxylic acid group exposed. The substrates were subsequently exposed to a solution of TiO_2 nanoparticles in ethanol. Atomic force microscopy (AFM) and scanning tunneling microscopy (STM) shows that the particles adsorb in a single monolayer as evident from atomic steps in the gold substrate, which are still visible through the particle layer. Figure 1 shows an STM image of a sample with a monolayer of adsorbed particles.

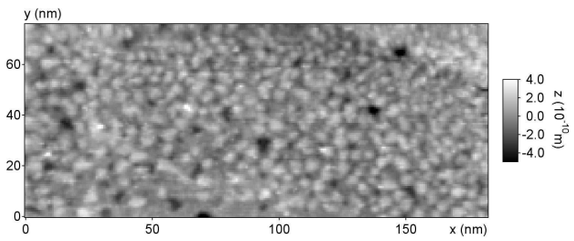

Figure 1. STM image of a monolayer of anatase TiO_2 nanoparticles on gold. An atomic step in the gold substrate is visible in the top-right corner of the image.