to date. Similarly, SWNT–enzymes added to paints also reduced protein adsorption by more than 90%.

Another attractive aspect of this work is that it may be possible to use these composites to degrade other biopolymers such as bacterial polysaccharides, which are sugars that protect bacterial colonies attached to surfaces. SWNT composites containing enzymes that degrade these polysaccharides could catalyse the breakdown 30 times faster than films with identical amounts of enzymes attached to graphite supports.

Also promising is the ability to combine different enzymes on the SWNT support to fight various surface contaminants by active ‘self-cleaning’. This is in contrast to the current passive methods based on surface modification strategies, such as PEG brushes, that aim to prevent protein

adsorption rather than clean the surface. Furthermore, this approach is attractive for a wide range of potential applications because it is simple to produce, is stable and has a well-sustained enzyme activity over a broad range of conditions.

Researchers working on medical devices often talk about the ‘race for the surface’ as macromolecules, cells and bacteria compete with each other to attach to the devices implanted into the body⁶. A material that can sustain the active degradation of unwanted proteins at surfaces and direct the race in favour of cells and tissue is, therefore, highly desirable.

A number of major challenges need to be overcome for both the active and passive approaches before they can become a practical reality. Although *in vitro* studies, such as those reported by Dordick and

colleagues, can effectively help us identify how well materials prevent fouling, the biggest challenge is to demonstrate their long-term anti-fouling performance *in vivo*. As with the passive approaches, stability is also an important consideration because, under realistic conditions, materials are susceptible to chemical degradation. Nevertheless, this new work presents a general route towards cleaner surfaces.

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SURFACE SCIENCE

Resolving the identity crisis

The chemical forces measured by an atomic force microscope (AFM) as it scans across a surface are full of information about the atoms that make up the surface, so it should be possible, in theory at least, to identify different atomic species. Unfortunately, because the tip of the AFM tends to change shape over time, the details of the force measurement change as well. Identifying atoms with confidence can require time-consuming comparisons between the experimental data and the results of theoretical models and simulations.

What is needed is a reliable ‘standard’ for distinguishing atoms, akin to the element-specific forms of spectroscopy that have been used to study surfaces for years and that can work under a range of conditions. Writing in *Nature*, Oscar Custance of Osaka University in Japan and colleagues in Spain and the Czech Republic describe a robust approach to identifying atoms on a surface with AFM (*Nature* **446**, 64–67; 2007).

To demonstrate their technique, Custance and co-workers prepared a single layer of a lead–tin–silicon alloy on a silicon surface. Distinguishing between these three different atoms (indicated in the image by different colours) with standard topographic AFM approaches is difficult because they have very similar electronic structures and tend to sit in similar positions on the silicon surface. Instead, the group measured the maximum attractive chemical force between each atom and the AFM tip as it approached the surface. They

showed that the maximum force for tin and lead relative to that of silicon, used here as a ‘reference’ atom, provides a sort of element-specific fingerprint that allows them to identify all three atoms. Moreover, even when the structure or chemistry of the tip changes, these force ratios are preserved.

This calibration technique can be performed at room temperature and, in principle, can be extended to other

types of atoms, although it will always be necessary to first extract reference measurements and to minimize the contribution from long-range forces. The importance of the work lies in its ability to identify atoms quickly and reproducibly, which will greatly improve the ability of the AFM to manipulate atoms into useful structures.

Jessica Thomas