ChemBam

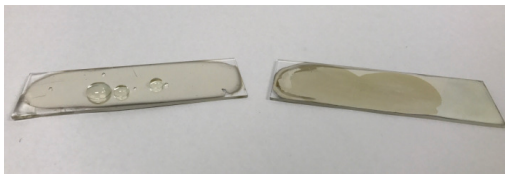
Gold standards for sensing (teacher guide to exercises and experiments)

AIM

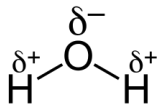
- For students to make their own nanoscale SAM (self-assembled monolayer) on a silver surface
- For students to appreciate how small the SAM is (nanometers high), and thus they cannot see in with their eyes
- For students to be able to relate macroscopic observations with nanoscale chemistry; they cannot 'see' the SAM, but they can see immediately how it affects the hydrophobicity of the surface
- For students to appreciate that SAMs are used in research to make nanoscale devices that can sense and detect various compounds, such as disease markers in our blood

EXPERIMENT QUESTIONS– answer guide for teachers

1. No, you cannot see the SAM by eye, and the two surfaces look the same
2. Yes, the behave very differently:
   The water of the DDT-coated slide beads (left), whereas it soaks in on the bare silver surface (right)



3. The bare silver surface likes the water, and is hydrophilic, whereas the DDT-SAM-silver surface repels the water and makes it bead to minimise its exposure to the surface, as it is hydrophobic.
4. Water is a polar molecule, with partial positive charge on the hydrogens, and a partial negative charge on the oxygen. Polar molecules are stabilised by other polar molecules / surfaces, therefore they like the bare silver surface which has negative charge at the surface. The water spreads across the surface to maximise its contact with the surface. Polar molecules do not, however, like non-polar molecules, and hence why water and oil do not mix. The non-polar $-CH_3$ terminal groups of the dodecanethiol SAM, that face the water, are not as effective as stabilising the partial charges as other water molecules, so the water is repelled, to minimise contact with the surface, and maximise water-water intermolecular forces.



5. S-Au bonds are stronger, so SAMs are more resistant to damage, more robust, and the SAMs are more ordered.
6. The DDT-SAM on the gold is the most hydrophobic surface, thus the water droplet stands proud from the surface. The 11-amino-undecanethiol SAM has $-NH_2$ terminal groups that face the water; these are polar and can also hydrogen-bond with water molecules, so the water spreads out and tries to maximise the contact with the SAM on the surface, which is very hydrophilic. The bare gold is still quite hydrophilic, and water spreads on the surface, due to its negative surface charge.