ChemBam

Gold standards for sensing

AIM

To make a self-assembled monolayer on a silver surface, and to see how this nanoscale layer affects the hydrophobicity (water-loving property) of the surface. (Silver is used as it is much easier and safer to deposit silver onto glass, than gold.)

YOU WILL NEED

- (Tollens' solution)
- (0.3 M glucose (aq) solution)
- (Glass microscope slides)
- Petri dish / watch glass / larger beaker
- 0.1 mM ethanolic dodecanethiol (DDT) solution
- Paper towels
- Ethanol
- Deionised water
- Tweezers
- Plastic pipettes

Students only need the items in brackets if they are going to silver their own slides. Alternatively, each group of students needs 2 pre-silvered glass slides.

PROCEDURE 1 – making your own silver-plated slides

If your glass slide is fresh out of a new packet, use it as is, being careful to handle it by the edge so as not to get grease on the surface. Otherwise, wash your slide with soap and water, and dry with a paper towel. Wash with ethanol, and dry.

Place 2 glass slides into separate petri dishes/ large beakers/ onto watch glasses, so that they can lie flat. Using a plastic pipette, drop ~4 drops of glucose solution onto each glass slide, followed by ~12 drops of the Tollens' solution, and agitate for 3-5 min - You should see a silver mirror forming on the glass.

Pick the slide up with tweezers, and carefully wash off the solution with deionised water, followed by ethanol, and place onto a paper towel (silver side up), to dry.

Wash out your petri dishes, and wash all the Tollens' waste down the sink with plenty of water.

PROCEDURE 2 – forming the SAM on the silvered slide

If you have made your own silver-plated glass slide, dry your petri dishes with a paper towel, and place one slide back into a petri dish. *This experiment can also be performed with slides that are already silver-plated for you. In this case, take a provided silvered slide, and place it into a petri dish, and another onto a paper towel.* Label this petri dish 'DDT on silver', and label the paper towel on which the other slide sits, as 'bare silver'.

Take the 'DDT on silver'-labelled slide, and add ~10 drops of ethanolic dodecanethiol (DDT) solution onto the surface. Agitate to cover the slide, and leave for 5 min. Pick up the slide with tweezers, and wash it thoroughly with ethanol, leaving it to dry on a paper towel.

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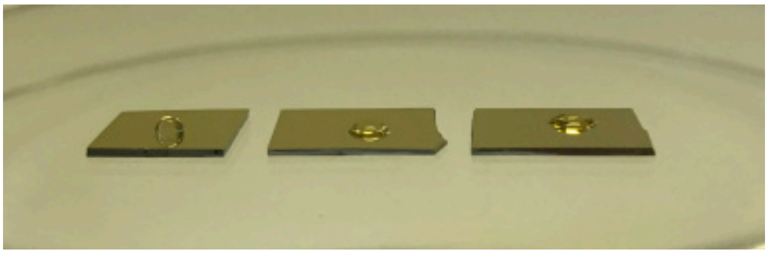
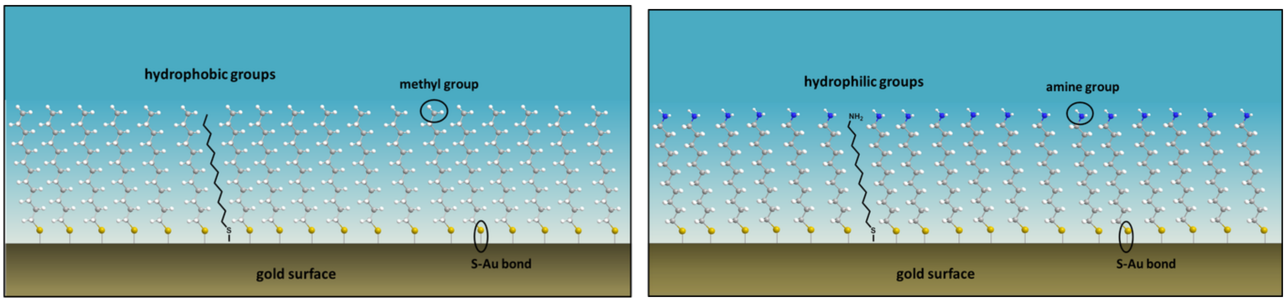
Now test the surfaces for their hydrophobicity. To do this, add a few drops of deionised water onto each silver slide, and observe what happens.

QUESTIONS

1. Can you see the single nanoscale layer of molecules that are deposited on the surface of the silver? Do the two surfaces look any different?
2. When you drop water onto each slide, do they behave differently?
3. Which surface likes water, and which surface repels water?
4. The SAM (self-assembled monolayer) of dodecanethiol has a terminal -CH_3 group on its surface, which is hydrophobic. Why do you think that water prefers polar surfaces, such as clean metal surfaces that have negative surface charge, rather than a non-polar monolayer of organic molecules?
5. In the research lab chemists build SAMs on gold surfaces. Why do you think this is? (The bond dissociation energies of Au-S and Ag-S at 298 K are 253 kJ mol^{-1} and 217 kJ mol^{-1} respectively.)
6. The image below shows SAMs on three gold surfaces. Describe the difference in the droplet shapes, and explain why you think this is happening?



Three gold surfaces coated in dodecanethiol(left), bare (centre) and 11-amino-undecanethiol (right), each with a 4 μL droplet of water on top, surfaces prepared by Abduljabbar Rushdi



Dodecanethiol SAM (left) and11-amino-undecanethiol SAM (right)

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