IOP
Institute of Physics

Rutherford Scattering

Properties of Matter

Estimating the size of a molecule using an oil film

Practical Activity for **14-16** PRACTICALPHYSICS

Nuffield Foundation

created in partnership with the Nuffield Foundation

Demonstration

Finding the thickness of an oil film enables an estimate of the size of atoms to be made.

Apparatus and Materials

- Oil film kit
- Olive oil in a bottle, and some small dishes
- Lycopodium powder and dispenser
- Paintbrush, soft, 5 cm
- Vegetable black, 250 g
- Paraffin wax, white, 3 kg
- Tin can
- Bucket
- Metre rule
- Camphor in a bottle

- Retort stand
- Hand lens
- Paper towels, large pack

Health & Safety and Technical Notes

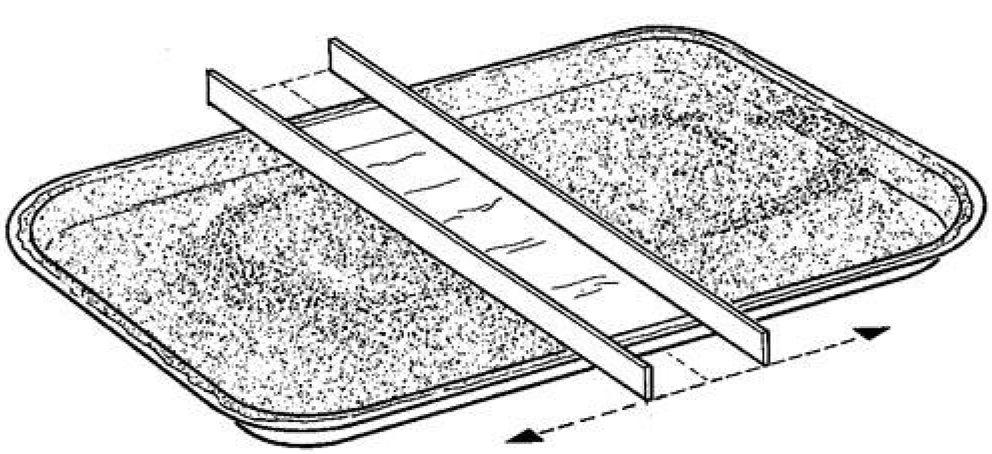
Almost every class will contain several asthmatics. Lycopodium powder is dried pollen. See CLEAPPS guide L77 for advice on use of pollen.

Read our standard health & safety guidance

To empty a tray, put a bucket under the hole and release the bung. The trays should be washed carefully in a detergent solution and then flushed with cold tap water for a considerable time before storing with, for example, some card separating tray from tray.

Store the lycopodium away from the olive oil.

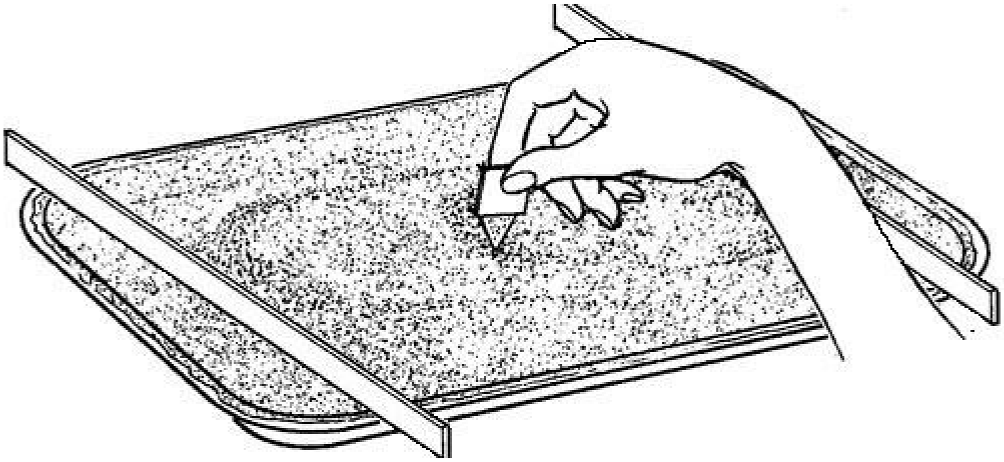
Procedure



1. Place the tray on the bench, with the corner that has the drain hole hanging over the bench edge. Close the hole with the rubber bung from below. Partially fill the tray with clean tap water and then level it by careful use of the wedges. Fill the tray to over-brimming with further levelling. Finally, clean the water surface by slowly moving the metal booms from the middle to the two ends of the tray. Leave them there. The advantage of this arrangement is that it makes it easy to clean the water surface.
2. Take the loop of very thin wire and dip it into the olive oil to catch a small drop.

Image courtesy of Mike Vetterlein

3. Hold the loop in the special holders at eye level in a clamp stand. Adjust the position of the loop so that the drop can be clearly seen against the 0.5 mm graticule through the magnifying glass. Using a second loop of wire which has also been dipped in oil, tease the original drop or run several drops together until it is 0.5 mm in diameter.
4. If there is an excess of oil on the loop, it can be wiped with filter paper.



5. Lightly dust the clean water surface with the powder and touch the 0.5 mm drop of oil onto the water.

Image courtesy of Mike Vetterlein

6. Use a rule to measure the maximum diameter of the patch of oil. (With some water supplies, the patch contracts to a smaller size soon after it has formed. This is probably due to water-softening agents attacking the oil, though this is not certain. Whatever the cause of the contraction, the proper measurement to take is the initial maximum diameter.)
7. Place the booms, touching together, in a part of the water surface free from oil and then move them slowly apart to produce a fresh clean surface. Another student can then try the experiment.

Teaching Notes

- It is important that each student has an opportunity to do their own experiment.
- Students need to realize that if the oil has spread out to produce a patch that does not reach the edges of the tray, the film on the surface is likely to be one molecule deep. Furthermore, these chain molecules have one end in the water and the other in the air. They also need to realize that the volume of the oil film is the same as the volume of the initial drop.
- From the 0.5 mm width (d) of the drop, its volume can be found, even if it is taken as a cube by students not capable of dealing with the volume of a sphere. From the diameter (D), the area of the oil film and its thickness can then be calculated. If the drop was treated as a cube, the area should be taken as a square. (Approximating to a cube and a square only involves a factor of 2/3 less than the more accurate result.)
- Typical results:

- $d^3 = D^2$ x *length of the molecule*
- 0.5 x 0.5 x 0.5 = 250 x 250 x *length of molecule*
- So the *length of the molecule* = 2 x 10^{-9} m
- There are approximately 12 atoms in the olive oil chain so the size of an atom is approximately 1.7 x 10^{-10} m.

This experiment was safety-tested in August 2007