THE ROYAL SOCIETY OF CHEMISTRY

9. Franklin's teaspoon of oil

Time

1 h.

Curriculum links

Bond lengths.

Group size

1–2.

Commentary

The students are invited to interpret a historical experiment based on a full and interesting account of Franklin's contribution to surface chemistry written by Professor Charles Giles[1] whose researches show that the site of the experiment was the Mount Pond on Clapham Common. Franklin's communications were published in the *Philosophical Transactions* of the Royal Society.[2]

Calculation

If it is assumed that the oil forms a monomolecular layer then the thickness of the film should correspond to the height of a molecule of triolein lying on the surface of the water. Franklin estimated that one teaspoonful of olive oil spread to cover half an acre of the pond's surface.

Half an acre = 2420 yd^2 = 2420 x 0.9144^2 m^2

One teaspoonful, say 2 cm^3 = 2 x 10^{-6} m^2

Hence the thickness of the film when one teaspoonful covers one half acre is:

(2 x 10^{-6})/(2420 x 0.9144^2) = 9.9 x 10^{-10} m

Extension

This experiment is the forerunner of the classical 'oil drop experiment'.[3] Although teachers will probably have met this, it may be unfamiliar to students who could be asked to repeat Franklin's experiment on a small scale. Designing an experiment in which the pond is replaced by water contained by the sides of a flat tin tray would provide several opportunities for problem solving.

Historical background

The earliest recorded observations of adding oil to water seem to date back to the 18th century BC in Babylon. Today this region is known as Iraq. The phenomena observed when oil was poured into a bowl of water were seen as omens for the future and descriptions of the phenomena and the events they foretold were inscribed in cuneiform on clay tablets.

In a more recent publication on the history of surface chemistry[4] Giles and his co-authors refer to the researches of Tabor[5] who describes the Babylonian texts on the spreading of oil on water.

Franklin's account stimulated further work on the European continent. This has been researched by Scott[6] who describes the incentive offered by Frans van Lelyveld.

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There are many references in classical literature to the way in which oil forms a thin film on water. Pliny is mentioned at the beginning of the passage quoted. Franklin did not claim to have made a discovery, he designed what is probably the first scientific experiment on a thin oil film and made observations that he communicated to the scientific world of 18th century Europe.

Franklin's interpretation stopped short of a simple calculation that might have led him to speculate on the size of particles of matter. At that time scientists were more excited by the idea that it might be possible to use oil to calm waves in stormy seas. In 1775 a Dutchman, Frans van Lelyveld, offered a prize of 30 ducats for the best suggestion as to how this could be done.

A few years later Franklin fell out of favour with the British public because he enlisted France's help for the American cause in the War of Independence. The British press attacked him and it seems that his scientific achievements were also belittled. Franklin's researches in surface chemistry became disregarded by British scientists although several papers were written on the continent on the subject of wave-damping. Interest in surface chemistry did not revive in Great Britain until the end of the 19th century.

Two hundred years after Franklin's experiment the historical researches of another surface chemist, Professor Charles Giles, enabled him to identify the pond, which still existed on Clapham Common. He repeated Franklin's experiment taking photographs of the effect. The area which is 'as smooth as a looking glass' shows the extent of the oil .

References

1. C. H. Giles, *Chem. Ind.*, 1969, 1616.

2. B. Franklin, *Phil. Trans. R. Soc. London*, 1774, **64,** 445.

3. R*evised Nuffield physics teacher's guide years 1 and 2.* London: Longman, 1978.

4. C. H. Giles, S. D. Forrester, G. G. Roberts, *Langmuir Blodgett Films*, G. Roberts (ed). London: Plenum, 1990.

5. D. Tabor, *J. Colloid and Interface Sci.*, 1980, **75**, 240.

6. J. C. Scott, *History of technology, Vol. 3.*, A. R. Hall, and N. Smith (eds). London: Mansell, 1978.

Acknowledgements

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Some remarkable outdoor experiments were carried out in the 1770s by Benjamin Franklin who was staying in London representing America in affairs of state. In 1776 he was one of the signatories of the Declaration of Independence. He was a man of genius who was both an international statesman and a scientist. To this day he is remembered for flying a kite in a thunderstorm to show that thunderclouds are electrified. He and some of his friends were interested in the effect of oil on the surface of water. The following extracts are taken from letters read to the Royal Society in 1774.

"…But recollecting what I had formerly read in Pliny, I resolved to make some experiment of the effect of oil on water, when I should have opportunity...

…At length being at Clapham where there is, on the common, a large pond, which I observed to be one day very rough with the wind, I fetched out a cruet of oil, and dropt a little of it on the water. I saw it spread itself with surprising swiftness upon the surface; but the effect of smoothing the waves was not produced; for I had applied it first on the leeward side of the pond, where the waves were largest, and the wind drove my oil back upon the shore. I then went to the windward side, where they began to form; and there the oil, though not more than a teaspoonful, produced an instant calm over a space several yards square, which spread amazingly, and extending itself gradually till it reached the leeside, making all that quarter of the pond, perhaps half an acre, as smooth as a looking-glass.

After this, I contrived to take with me, whenever I went into the country, a little oil in the upper hollow joint of my bamboo cane, with which I might repeat the experiment as opportunity should offer; and I found it constantly to succeed.

In these experiments, one circumstance struck me with particular surprise. This was the sudden, wide, and forcible spreading of a drop of oil on the face of the water, which I do not know that anybody has hitherto considered. If a drop of oil is put on a polished marble table, or on a looking-glass that lies horizontally; the drop remains in its place spreading very little. But when put on water it spreads instantly many feet round, becoming so thin as to produce the prismatic colours, for a considerable space and beyond them so much thinner as to be invisible, except in its effect of smoothing waves at a much greater distance…"

▼ Find out what you can about the dimensions of a molecule of olive oil by making calculations using the information contained in the historical account above. The capacity of 18th century teaspoons has been estimated to be *ca* 2 cm^3 and olive oil is mainly triolein (1,2,3-Tri-*cis*-9-octadecenoylglycerol).

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Clapham pond before a drop of oil is added

Clapham pond after a drop of oil is added