A chemically powered boat: a bubble boat race

Time

The problem could be set 2 weeks or more before the day of testing.

One or two 2 h sessions will be needed for making and testing models. It is hoped that some students may become motivated to try out and redesign their models in their own time. They will need access to water to do this.

30 minutes for judging (if a competition).

Curriculum links

Designing and making skills, production of carbon dioxide gas, properties of gases.

Group size

3– 4.

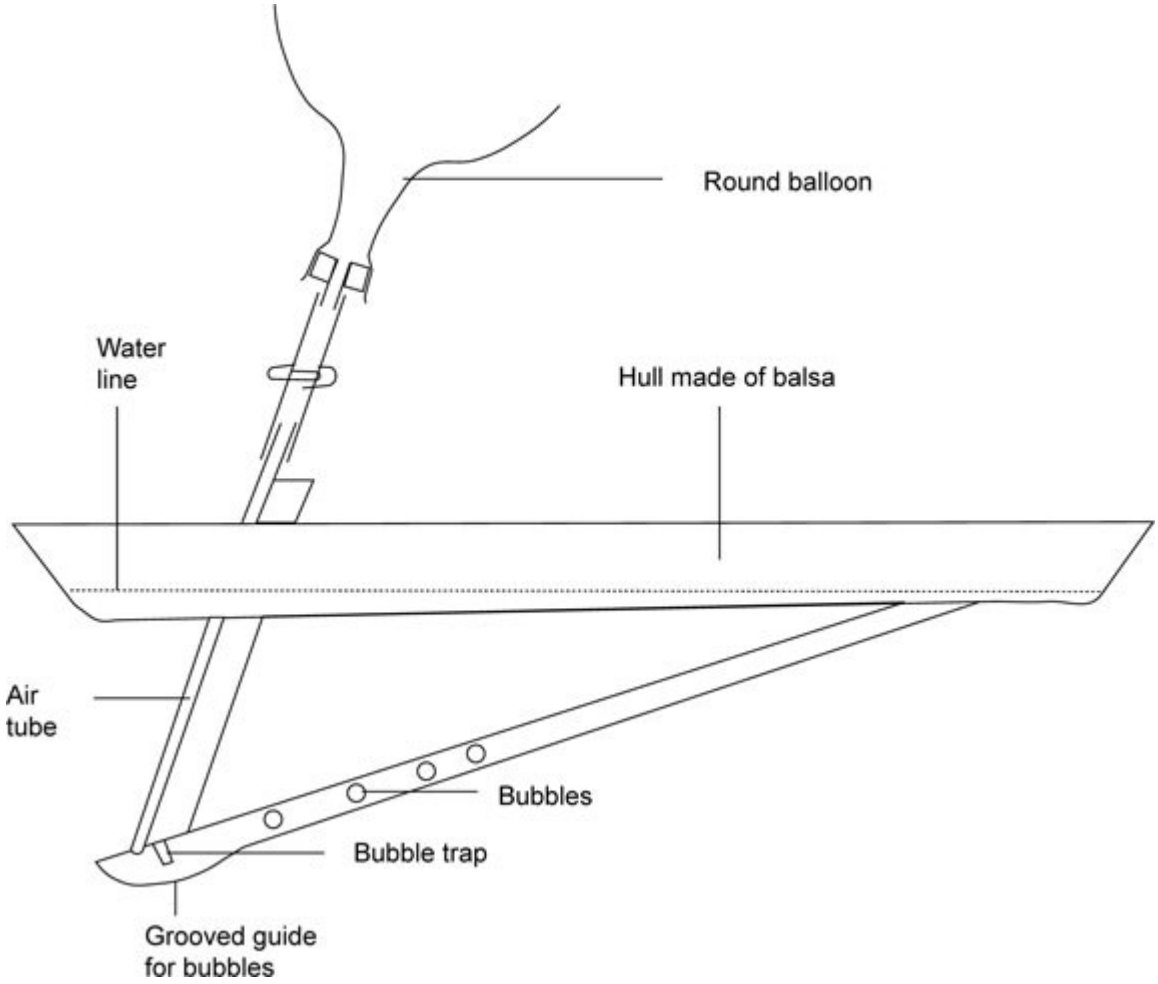
Materials and equipment

Materials per group

- 3 level teaspoons of sodium hydrogencarbonate
- 9 level teaspoons of citric acid.

Equipment per group

- items from the junk list (pXX)
- identical small plastic teaspoons
- balloons
- balsa wood
- tools for working balsa wood
- woodwork (PVA) or modelling glue
- thin card (cereal packets, postcards, *etc*)
- plastic drinking straws (straight and bendy)
- paper clips
- cocktail sticks
- plastic tubing (tubes from old ball-point pens might be useful)
- expanded polystyrene tiles
- sewing thread
- safety glasses
- access to an area of water.



Boats using the ‘bubble power’ principle can travel many metres. The danger of leaks and floods is likely to be a problem on upper floors. Sections of rain guttering of 3–4 m in length make a good race course but the guttering must be chosen with a deep cross-section if it is to take the deep-keeled bubble boat in the photograph. For preliminary trials a large sink may be used. Very large photographic dishes are also suitable.

Safety

Eye protection must be worn.

Citric acid is an eye irritant

Sodium hydrogencarbonate is of low hazard.

Risk assessment

It is the responsibility of the teacher to carry out a suitable risk assessment.

This is an open-ended problem solving activity, so the guidance given here is necessarily incomplete. Teachers need to be particularly vigilant, and a higher degree of supervision is needed than in activities which have more closed outcomes. Students must be encouraged to take a responsible attitude towards safety, both their own and that of others. In planning an activity students should always include safety as a factor to be considered. Plans should be checked by the teacher before implementing them.

You must always comply with your employer’s procedures and in some cases may decide that a particular activity is inappropriate in your situation. Further information on Health and Safety should be

obtained from reputable sources such as CLEAPSS [http://science.cleapss.org.uk/] in England, Wales and Northern Ireland and, in Scotland, SSERC [https://www.sserc.org.uk/].

Commentary

This egg race is an extension of the boat race described in a previous publication.[1] The designs reported so far have all been based on jet propulsion.[2,3] The boats (often floating plastic bottles) zoom along the surface of the water, even tending to take off; however, the gas is soon exhausted and they do not go very far. Models built on a similar principle will travel along a flat solid surface.

This challenge uses 'bubble power' to drive the model. The version in the photograph is a catamaran which can travel at a stately pace for over 30 minutes and cover a considerable distance. It was one of several models built by Alan Stevens of Loughborough University. The design is based on the Bubble Cat catamaran[4] in which the bubbles of gas slide backwards up a wedge-shaped keel. The buoyancy of the bubbles produces a forward thrust on the keel and the boat is designed to reduce the drag of the water as much as possible. During trialling students came up with versions of their own and in one institution the problem became a joint venture between the science and technology departments.

Procedure

This activity is designed to be fun. The drawings and photograph are included to suggest a possible approach. Complete instructions for a successful model are given in the book referred to above.[4]

Extension

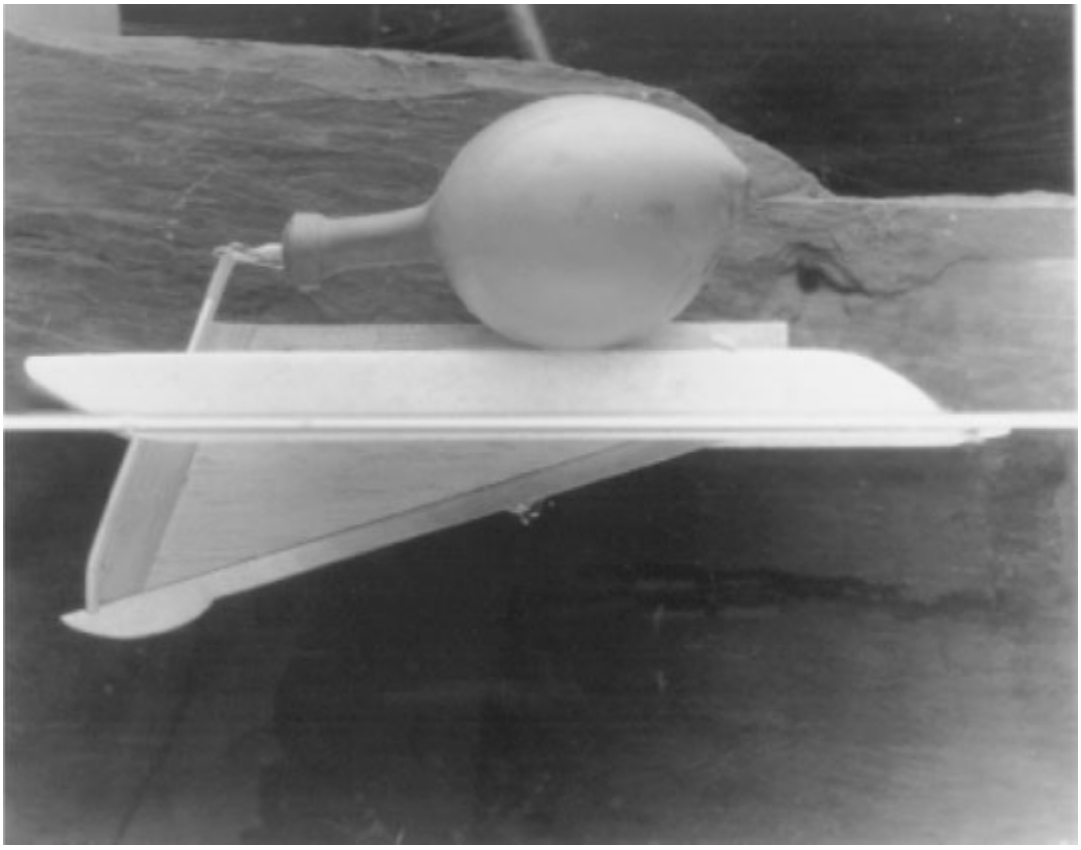
The students may check the stoichiometry of the reactants and may try varying the quantities to inflate a balloon an optimum amount. They may also like to adapt the model so that it can be loaded with chemicals at the start.

References

1. K. Davies, *In search of solutions.* London: RSC, 1990.
2. L. J. Wygoda, *Chem. 13 News*, September 1992.
3. W. Martin, *The Science Teacher*, May 37, 1991.
4. P. Holland, *Amazing models! – balloon power*. London: Argus Books, 1989.

Acknowledgements

Alan Stevens of Loughborough University produced the first successful model boat. Berinda Banks and her pupils at Mill Hill School designed and built other versions.



Credits

Health & safety checked May 2018

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