Building a chemically-powered boat

- Your task

Design, and make a boat. The boat is to be propelled by the reaction between 1 teaspoon of bicarbonate of soda (sodium hydrogencarbonate) and 3 teaspoons of citric acid. As far as possible, the boat is to be constructed from 'junk' materials.

The winner is that boat which travels the furthest distance.

- Your final device must be loaded with chemicals, and be ready to start the experiment when the judges say so.

Based on a suggestion by P. Borrows.

Time

It is suggested that either:-

an entire morning be devoted to the problem (*eg* on the last day of term), which would allow 2 hours for practical activities and 30 minutes for judging

or

the problem be given to the class as a homework exercise 2 weeks or so before the judging. Judging could then take place in a normal double science lesson, allowing 45 minutes for repair and final adjustments, and 30 minutes for judging.

(The exercise is better as a pre-set problem for younger students.)

Group size

3–4.

Equipment & materials

Eye protection.

Items from the 'junk' list (see ‘In search of solutions additional handout’.) - to encourage creativity.

A testing tank: depends on what is available in your laboratory.

However, the type of tank will determine how you evaluate the distance travelled by the boats (see possible approaches below).

Per group
Identical teaspoons (can be plastic).

Sodium hydrogencarbonate (maximum amount = 3 level teaspoons), citric acid (maximum amount = 9 level teaspoons), access to water.

Health & Safety notes

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/*].

Citric acid is an eye irritant. Wear eye protection.

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

Curriculum links

Production of carbon dioxide gas.

Possible approaches

A suitable long tank may be constructed from stout cardboard, lined with heavy duty polythene, or by using plastic guttering. The distance each boat travels can then be measured. Alternatively, a plastic washing-up bowl could be used. A clampstand is placed in the centre of the bowl and the boat attached to the clampstand by a piece of cotton, so that it is free to sail round the bowl. The number of times the boat goes round the clampstand is then measured. In summer months, you could use a children's paddling pool as an outdoor testing tank. (Some students will do some re-designing when they realise that in a washing up bowl the biggest boat is not the best!)

"A good exercise with wide access across the age range". Younger age groups may need guidance about why water is needed for the reaction. The fuel could be carried on the boat or gas could be generated separately and stored in a balloon.

Evaluation of solution

These are suggestions only:

1 The final device must be loaded with chemicals, and be ready to start the experiment when the judges say so.
2 The judges will provide each group with the levelled teaspoons of chemicals for the test. (Judges may prefer to weigh out the relevant amounts.)
3 The boat will start with the rearmost structure at the end of the tank and the distance travelled will be measured from the end of the tank to the rearmost part of the boat or alternatively, the number of revolutions will be measured.
4 The winner is the boat which travels the furthest.
5 In the event of a tie, the judges should take into account the elegance of the solution, given the requirement that the device shall be constructed mainly from 'junk' materials.

Extension work

To increase the chemical content the task could be extended by prior (or subsequent) experimentation, to select best choice of gases/chemicals.

Credits

Health & safety checked September 2014

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