BI-CARB AND VINEGAR POWERED CAR

Teachers Notes

Overview

Subject: Science and Technology

Grade: Years 7 – 9

Topics: Conversion of energy (chemical)
Relationship between speed, distance, and time
Interaction between energy and materials

Curriculum: Physical Sciences

- Energy appears in different forms including movement (kinetic energy), heat, light, chemical energy and potential energy; devices can change energy from one form to another (VCSSU104)
- The description and explanation of the motion of objects involves the interaction of forces and the exchange of energy and can be described and predicted using the laws of physics (VCSSU133)

Science Inquiry Skills

- In fair tests, measure and control variables, and select equipment to collect data with accuracy appropriate to the task (VCSIS109)
- Analyse patterns and trends in data, including describing relationships between variables, identifying inconsistencies in data and sources of uncertainty, and drawing conclusions that are consistent with evidence (VCSIS138)
- Communicate scientific ideas and information for a particular purpose, including constructing evidence-based arguments and using appropriate scientific language, conventions and representations (VCSIS140)

Objectives

1. Construct a car propelled by the product of the chemical reaction of bicarbonate soda and vinegar, that can travel 5m distance or more.
2. Gain an understanding of energy conversion, chemical reactions, and aerodynamics, and use that to improve design and maximise car performance.
3. Construct a range of representations, including tables and graphs, to display data and analyse patterns or relationships.
4. Summarise and draw conclusions based on data found through investigation.

Key Concepts

Energy. The capacity for doing work. It can exist in potential, kinetic, thermal, electrical, chemical, nuclear, or other various forms. (Britannica)

Chemical Energy. The energy stored within the bonds of chemical compounds. Chemical energy is typically released during the time of a chemical reaction, where there is a production of gas or precipitation, change in colour, or change in temperature. In relation to the bi-carb soda and vinegar reaction, it is classified as an exothermic reaction, as less energy is required to break the bonds than what is released from the forming of new bonds. (Britannica)

For this car model, the vinegar (dilute acetic acid) reacts with the bi-carb soda (sodium bicarbonate) to form carbonic acid. Given that carbonic acid is an unstable compound, it immediately breaks into carbon dioxide (CO_2) and water (H_2O). this decomposition reaction builds gaseous pressure when contained in an air tight vessel.

Potential Energy. The stored energy in an object due to its position relative to some zero location. For example, the cars potential energy is the chemical reaction that is happening within the bottle. The more carbon dioxide gas is built up in the bottle, the more potential energy is created.

Additional Resources

- An investigational video as to how the car works (variations inclusive) can be found at:

https://video.deakin.edu.au/media/t/0_j3hobgzn

- An instructional video on how to construct the model car can be found at:

https://video.deakin.edu.au/media/t/0_n58zvyih

- Further resources:

https://www.britannica.com/science/chemical-energy

http://www.inquiryinaction.org/chemistryreview/chemical_change/

Materials

650ml Litre Powerade bottle
Different nozzles (must fit Powerade)
Drinking straws
Bamboo skewers
Toy truck wheels (multiple size variations)
Extra paper and/or cardboard for shape variations
Bicarb Soda
Vinegar

Tools

Ruler or measuring tape
Scissors
Hot glue gun
Extra hot glue gun glue
Safety glasses
Rubber/latex gloves

Risk Management/Hazards

The main hazard is the hot glue gun, the front part of the gun can get quite hot and the glue itself can cause minor burns. Students are instructed to keep hands away from all hot surfaces/materials.

While cutting the bamboo skewers and paddle pop sticks, sections may fly off unexpectedly. Students must wear safety glasses to prevent any pieces from hitting them in the eyes.

During the experimental stage when the bicarb soda combines with the vinegar, pressure builds up rapidly in the bottle. Student must wear the appropriate safety gear and be cautious of minor, non-flammable explosions.

Activity

Students follow the instructions in CONSTRUCTING A BI-CARB SODA AND VINEGAR CAR resource. Once the car has been successfully completed the students will make alterations to different parts of the car, including but not limited to, altering the aerodynamic properties, altering the ratio of bi-carb soda to vinegar and altering the nozzle to achieve different pressures and outputs.

Students will measure the distance travelled by the car for each variation in a table. These results will then be graphed.

Expected Results

The original design of the car will likely not travel far without an optimal ratio of bi-carb soda to vinegar or the correct nozzle for output. Changing the ratios will likely not improve the acceleration and distance travelled.

During our investigation, it was found a 1:2 ratio (vinegar - cups: bi-carb soda - tablespoons) would cause the car to propel more than 5m. The nozzle provided on the Powerade bottle (many small holes around the circumference) showed to build the most pressure for optimal output, compared to that with one single and central hole for output.

Closing the bottle and retaining as much of the gas as possible resulted in a more powerful propulsion.

Overall, 1 cup of vinegar to 2 tablespoons of bi-carb soda resulted in greatest distance travelled and most rapid acceleration. When this combination was paired with the nozzle that had numerous small holes for output, the car was more than capable of reaching 5 metres, so long as the integrity of the build was adequate.

Difficulties

Ensuring that the addition of bi-carb soda to the bottle containing the vinegar is a relatively seamless process, is challenging. This is essential to maximise the amount of gaseous pressure that is built up in the bottle, to optimise output and propulsion. A large gap between the wheels and the straw will make the wheels wobble, causing the car to veer left or right and overall reducing the distance travelled. Ensuring that the straw and skewer are the similar in length will provide stability and allow the car to stay in a straight line, though a small gap must be left to ensure the axle can rotate freely. Experimenters should take caution when the bi-carb soda and vinegar have mixed, and the bottle has been shaken. The car should be placed on the ground in position and the nozzle should be opened in a timely manner, so the pressure does not cause an explosion rather than propulsion.

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