Teacher Notes - Food Storage

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Aim

The experiment is suitable for students from years 7 to 10. It can be modified to suit different achievement levels of students.

In this experiment, students will study the reaction of different metals with hydrochloric acid in an attempt to find the best metal to be used in food cans.

The reason for doing this experiment is because food and juice contain different types of acids which would eventually chemically react with the material of the can and form other unwanted chemical products.

In their experiment, students will find the least reactive metal and assign it as the best suitable material to be used as a food or juice can.

Plan

The reaction between the metal and the acid highly depends on the reactivity of the metal, in this experiment students will be using a number of metals and observe their reaction with 2 mol L^{-1} HCl. If the metal is reactive it will react with the acid and a gas will evolve. Students will be asked to find which gas has emerged using the splint or match test.

This experiment is written in quite an open level of inquiry. If you would like to conduct this experiment at a more prescribed demonstration, you can allow students to watch a YouTube video to prepare them for the experiment and to give them an idea about what they are expected to see. A useful link that could be watched is https://www.youtube.com/watch?v=l0U7VDSxGHk another link for the hydrogen pop test is at https://www.youtube.com/watch?v=4uqlaVTKy4U

It is important that the teacher discusses with the students the safety issues before starting the experiment. This experiment has many risks including the use of a corrosive acid, match flames and glassware. Make it clear that they should not smell or taste any of the constituents, and that they should wear safety goggles, gloves and a laboratory coat or apron at all times.

Conduct

This experiment is a mix of structured inquiry and open inquiry. Students are given the question. They will then sharpen the plan and conduct the experiment.

In this experiment, students are looking for a chemical reaction between different metals and hydrochloric acid. This type of reaction between a metal and an acid would yield a salt (a metal chloride) and hydrogen gas. However, it is best not to tell this to the students and leave it to them to decide which gas has been made using the splint test. As students will discover this themselves, they are more likely to retain this knowledge.

The teacher can tell the students that hydrochloric acid in water contains hydrogen, oxygen and chlorine. The student notes provide the students with what they are expected to see with the splint test if any of these gases has evolved.

The first step in the experiment is to clean the piece of metal with sandpaper. The reason for this is to get rid of any impurities or any oxide layer that might interfere with the results. This can be a good way to link in the effect of surface area on the reaction rate by questioning them on why they think they are cleaning the metal.

It is safer to not test the reactivity of sodium for younger classes because of the very vigorous reaction that occurs. The teacher can either choose to do this part of the experiment as a demonstration or show the reaction via a YouTube video, found at https://www.youtube.com/watch?v=YbA7L0CYM6U

It is important not to use a concentrated solution of hydrochloric acid to avoid the reactants spitting out from the test tube.

Students will conduct the splint test by adding a stopper at the top of the test tube after adding the HCl in order to keep any gases from escaping. The way to do this is to light a splint, remove the stopper from the top of the test tube and then quickly placing the flame at the top.

For more advanced classes, they can use the rate of evolution of hydrogen gas as a measure of reactivity by measuring the time needed to start the reaction. The teacher can also add an extension to the experiment by comparing how fast the reaction starts for a piece of aluminium foil compared to aluminium powder. In this case, it is important to make sure students are using the same mass of aluminium.

This experiment can even be extended to suit **year 12 students** by asking them to predict whether a metal will react with the acid and produce hydrogen gas using the standard reduction potential table. If the metal cannot displace hydrogen according to the table, it will not be oxidized and will remain insoluble. They can also find the number of moles of the metal reacting using the equation,

$$number\ of\ moles = \frac{mass\ of\ metal\ in\ grams}{Molecular\ weight\ of\ the\ metal}$$

and measure the time required for the reaction to be completed.

Analyse

The order of reactivity of the metals used from highest to lowest is sodium, calcium, magnesium, aluminium, zinc and copper.

Metal	Result of combining acid with metal	Result of the lighted match	Order of reactivity (from least reactive to most reactive)
Copper			
Zinc			
Aluminium foil			
Aluminium powder			
Magnesium			
Calcium			
sodium			

Calcium and magnesium will strongly react with hydrochloric acid and students can observe how instant and strong the reaction is. They will be able to watch the bubbles of hydrogen being produced once they add the acid. Aluminium and zinc will show a slower reaction rate whereas copper will not show any reactivity with the hydrochloric acid.

Problem solving and discussion

Students will explain that not all metals have the same reactivity. The least reactive metal from the list they are given is copper. Students can recommend copper to be the best metal to be used in food or juice cans. However, to engage students in researching this topic further, you can ask them if reactivity is the only factor taken into consideration when choosing a suitable metal for food storage. They can search on the internet and in libraries about toxic metals that cause health issues when ingested.

In the case of the splint test, if hydrogen is released it will burn with oxygen, forming water and releasing a huge amount of heat which will make the gas particles expand really quickly and cause the pop sound. You can show the students the formation of water droplets at the top of the tube after conducting the splint test. This is a characteristic test for the release of hydrogen gas.

Students will discuss if it was easy for them to find the order of reactivity and whether it agrees with the reactivity series of metals. If not, what could have gone wrong or is there a way to produce more accurate results? Some of the factors include: how clean is the surface of the metal, are all the metals in a solid form with the same surface area or are some of them broken into smaller pieces (see the explanation of the effect of surface area on the reaction rate in the next paragraph), do the reactions happen so fast that the students can't determine which test started sooner (in this case, they can compare the time taken for the reaction to be completed)?

In case of the two aluminium materials, the powder should react faster than the foil. The reason for this is that the surface area of the powder is much higher than the foil, allowing the reaction to occur more rapidly.

Year 10 students are expected to explain chemical reactions using worded chemical equations;

Magnesium + Hydrochloric Acid → Magnesium Chloride + Hydrogen Gas

For more advanced classes, the teacher can ask the students to search the reactivity series or the standard reduction potential and explain to them that anything below hydrogen in the series will not react with hydrochloric acid to produce hydrogen. For senior classes, this can be explained by the fact that metals below hydrogen will not be able to be oxidised and displace hydrogen in hydrochloric acid.

For senior classes, students can write a balanced equation and compare the time taken for the whole reaction to be completed according to the molar ratio.

$Mg\ (s) + 2\ HCl\ (aq) \rightarrow MgCl_2\ (aq) + H_2\ (g)$

One of the things they have to think about would be if there is enough moles of both reactants to react or if the reaction ends faster because there is not enough of any of the reactants.

Conclusion

The students should reflect on their initial question and make a conclusion about which metal has the lowest reactivity, they should also be able to identify that this represents the best choice for minimal food spoilage.

This is an exciting experiment. Students may choose to take a video of the reactions and photos of the different steps to represent it in class or in a school fair. They can even upload a YouTube video.

It is also an extendable experiment for senior classes and they can submit a poster for their school about their discussions to be used as a demonstration in class for new senior students.

Photo reference:

https://www.flickr.com/photos/paigggeyy/5533236567/in/photolist-6G7zMC-p3GmuN-9qXhst-71Ewbs-hn5Tar-6CahEM-57fv5t-8VQq55-hn4jUt-hn4jHX-2UXyAt-bpqKod-3FRjz4-7kthNQ-bscyH3-prWwf1-57fu5t-e3pCyq-8GHpo1-e3pJzy-TmdPGJ-nQS5L3-7n8Lg8-cYAHxJ-cYAD9U-cYAFSS-cYADgy-cYACuo-cYAHrb-cYADH7-cYAHGb-cYAE37-cYACkf-cYAKJ3-cYAJPG-cYADSs-cYAEH9-cYAKXd-cYADyG-cYAEYN-cYAERy-cYACQA-6D6K3Z-dhHJKs-bjKiEo-pFG2jT-83y2X4-cYAJEN-8UFRsU-cYAEyS/ Author Paige Powers Licence https://creativecommons.org/licenses/by/2.0/