



Catalysis: Homogeneous and Heterogeneous

CATALYSIS: HOMOGENEOUS AND HETEROGENEOUS

Hydrogen peroxide solution is inert with respect to disproportionation into water and oxygen gas until a catalyst is added to it. Iodide ion produces a slow evolution of oxygen bubbles. The reaction is more rapidly catalyzed by a solid (Ag_2O). Bubbles are vigorously evolved at the surface of the catalyst, but at the end of the reaction, the solid catalyst is unchanged.

MATERIALS

3% hydrogen peroxide
0.1 M potassium iodide solution
1 M sodium hydroxide solution
silver oxide
5 50-mL beakers or a Corning 6-well Cell Well™
small spatula
small stirring rod
overhead projector
transparency made from last page of this form

PRESENTATION

- Place the containers on the transparency.
- Add enough hydrogen peroxide to each to give a depth of 4-5 mm. Do nothing more to the first container. This will be the comparison standard for H_2O_2 .
- To the second and third containers, add 1 drop of NaOH . The second shows that the reaction is not the result of adding base.
- To the third container, add 5 drops of KI solution and stir. Bubbles of oxygen will become visible in 2-4 minutes.
- Using the spatula, drop a few grains of silver oxide into the fourth container. It may be necessary to use the spatula to force the grains of solid to sink to the bottom. A vigorous evolution of gas will begin immediately and will continue for some time, at which

time the grains of silver oxide will be visible (adjust the focus of the projector) if they were large enough to see initially. If possible, retrieve the grains and drop them into the fifth container to show that the material is still catalytically active.

DISCUSSION

A catalyst is a substance that changes (usually increases) the rate of a reaction without undergoing any permanent chemical alteration. Catalysts are generally divided into two types, those that are in the same phase as the reactants (homogeneous catalysts) and those that belong to a different phase (heterogeneous catalysts).

The first of the two reactions in this demonstration is an example of a **homogeneous catalyst**. Hydrogen peroxide reacts vigorously as an oxidizing or reducing agent with a number of chemicals. Although the disproportionation reaction below has a strong driving force, it will not proceed at room temperature if free of impurities.



Iodide ion is a fairly effective catalyst for the reaction. The mechanism is...



Both steps are faster than the rate of the direct reaction. The initial appearance of oxygen bubbles is slow because oxygen is fairly soluble in water, and its solubility has to be exceeded before bubbles will form.

The second demonstration, where the overall reaction is the same, is an example of **heterogeneous catalyst**. The addition of Ag₂O provides a surface upon which a crucial step in the catalyzed reaction can take place. The reaction appears to be taking place much more rapidly than in the heterogeneous case, but it must be appreciated that the reaction is taking place at a few isolated centers and is more obvious there.

HAZARDS (MSDS links)

3% Hydrogen Peroxide: <http://www.sciencelab.com/msds.php?msdsId=9924298> [1]

0.1M Potassium Iodide: http://sargentwelch.com/pdf/msds/Iodine_Solution_0.1M_356.00.pdf [2]

1M Sodium Hydroxide:
[http://www.reagent.co.uk/uploads/msds/SODIUM%20HYDROXIDE%201M%20\(1N\).pdf](http://www.reagent.co.uk/uploads/msds/SODIUM%20HYDROXIDE%201M%20(1N).pdf) [3]

Silver Oxide: <http://www.sciencelab.com/msds.php?msdsId=9924938> [4]

Silver Nitrate: <http://www.sciencelab.com/msds.php?msdsId=9927411> [5]

REFERENCES

Lee R. Summerlin and James L. Ealy, Jr., "Chemical Demonstrations: A Sourcebook For Teachers", American Chemical Society, Washington, D. C., 1985, p. 71.

Doris Kolb, "Introduction to Overhead Projector Demonstrations", *Journal of Chemical Education*, **1987**, *64*, 348.

NOTES

If Ag₂O is not available, it may be prepared by dissolving 0.5 g of silver nitrate in 20 mL of water then adding 5 mL of 1 M NaOH solution. Filter out the dark precipitate, wash it with water, and allow it to dry. MnO₂ may be substituted for Ag₂O, but if it is very finely divided, the reaction is harder to see.

This demonstration is commonly done without the addition of a base. However in that case, an amber color develops in the reaction as the result of the oxidation of I₋ to I₂. The perceptive student might object that the catalyst was not supposed to undergo a permanent chemical change. Addition of base suppresses the coloration, presumably by suppressing the reaction

HOI + I⁻ http://quiz2.chem.arizona.edu/preproom/Demo%20Files/Single_

[Undergraduate](#)^[6]

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Source URL (retrieved on 01/12/2013 - 5:56am): http://www.chem.arizona.edu/lecture_demos/cu-zn_battery

Links:

[1] <http://www.sciencelab.com/msds.php?msdsId=9924298>

[2] http://sargentwelch.com/pdf/msds/Iodine_Solution_0.1M_356.00.pdf

[3] [http://www.reagent.co.uk/uploads/msds/SODIUM%20HYDROXIDE%201M%20\(1N\).pdf](http://www.reagent.co.uk/uploads/msds/SODIUM%20HYDROXIDE%201M%20(1N).pdf)

[4] <http://www.sciencelab.com/msds.php?msdsId=9924938>

[5] <http://www.sciencelab.com/msds.php?msdsId=9927411>

[6] <http://www.chem.arizona.edu/taxonomy/term/11>