

Electrolysis - Detection of acids and bases with red cabbage juice

Summary

Red cabbage juice is an example of an acid-base indicator. In chemistry, an indicator is a tool used to indicate the presence of a specific chemical or a specific type of chemicals. In this case, the red cabbage juice is used to indicate whether a solution is acidic or basic.

Materials

Red cabbage, vinegar, lemon juice, baking soda, detergent, ammonia, washing soda, club soda, 7 up, water, antacids, lye, Draino (Careful: lye and Draino are corrosive, avoid contact with skin). The red cabbage juice can be made by boiling some red cabbage in a non-metallic vessel (glass, corning ware etc.). Alternatively, one can let some red cabbage soak in hot water overnight. The red cabbage juice should look dark purple.

Procedure

Put the household products in separate plastic or glass cups. If the product is a liquid, it can be used as is. If the product is a powder, add a small amount of water to it.

Add the red cabbage juice to the different cups, observe the different color changes.

Tips

1. Students should be encouraged to test different household products with the supervision of an adult. The experiment works best if the test material is white or almost colorless.
2. In an aqueous solution (i.e., a solution with lots of water), there are two important ions, the positively charged hydrogen ion, H^+ , (to be exact, it is the hydronium ion, H_3O^+), and the negatively charged hydroxyl ion, OH^- . In a neutral solution, the concentration of hydrogen ion is equal to the concentration of the hydroxyl ion. In an acid, the concentration of the hydrogen ion is higher than that of the hydroxyl ion. In a base, the concentration of the hydrogen is lower than that of the hydroxyl ion.
3. The acidity or basicity of an aqueous solution is usually denoted by a quantity called pH, which is defined as negative logarithm to the base 10 of the hydrogen ion concentration, i.e., $-\log_{10}[H^+]$. In a neutral solution, the pH is 7. The pH of an acid is less than 7 and the pH of a base is higher than 7. A lower pH denotes a stronger acid. Hence, an acid with pH 1 is stronger than an acid with pH 5. On the other hand, a higher pH denotes a stronger base. Thus a base with pH 8 is considered a weak base, whereas a base with pH above 12 is considered a strong base. In the suggested test list, vinegar and lemon juice have pH about 2 - 3, water has pH of about 7, baking soda has pH of about 8 - 9, washing soda, ammonia and detergent have pH of about 10 - 12 and, lye and Draino have pH of about 13 - 14.
4. Red cabbage contains a chemical called anthocyanin, which changes color when hydrogen ions are added or removed from it. In an acid, red cabbage turns red. In a base, red cabbage juice turns blue, green or yellow, depending of the strength and nature of the base.
5. Club soda is an interesting one to try. Observe the color when red cabbage juice is added to club soda from a freshly opened can or bottle. Next, boil the red cabbage juice/ club soda mixture for a few minutes. Observe the color change. Initially, the club soda is slightly acidic because of the large amount of carbon dioxide dissolve in it. Boiling the club soda drives off the carbon dioxide and leaves the solution slightly basic because of the other chemicals remaining in it.
6. Observe the color change when red cabbage juice is first added to a small amount of acid (e.g., vinegar). Then add a base (e.g., household ammonia) to the red cabbage juice/vinegar mixture slowly. Note the point when the color of the solution changes to purple and then to a color characteristic of a base. When the solution turns purple, you have just added enough base to neutralize the amount of acid originally present. This is called a titration.

7. Use the red cabbage juice to show that an antacid such as milk of magnesia is a base. Explain that there is normally some acid in our stomach to help digest the food we eat. When we have acid indigestion, we have too much acid in our stomach. Antacids are used to neutralize the excess amount of acid in our stomach.
8. Instead of using red cabbage juice, try turmeric or extracts from red or violet flower petals. Observe the color change.

Reference

This experiment is adapted from a version described in *Chemical Activities*, by C.L. Borgford and L.R. Summerlin, American Chemical Society, Washington (1988).

For similar experiments using synthetic materials, see *Exploring Chemistry*, vol 1, Canadian Society for Chemistry (1996).