The University of Texas at Austin
Department of Chemistry
College of Natural Sciences

Conductivity of Strong & Weak Acids

Performer's Version

Safety Hazards

- Personal Protective Equipment:
  - Safety glasses/goggles
  - Nitrile gloves
  - Neoprene gloves
  - Chemical & flame retardant lab coat
- Physical Hazards
  - Exposed wiring carries live current and can deliver a hazardous shock if touched while the circuit is powered. Extreme caution must be taken to prevent accidental contact with energized components.
- Chemical Hazards
  - Hydrochloric acid is corrosive, may cause eye and skin damage; irritant, may cause severe respiratory irritation.
  - Acetic acid causes severe skin burns and eye damage.

Materials

- 3x 250mL glass beakers
- Lightbulb apparatus
- Extension cord/surge protector
- Deadman switch
- 100mL 1M Hydrochloric acid
- 100mL 1M Acetic acid
- 100mL deionized water
- DI water spray bottle
- Polypad
- Paper towels

Safety Data Sheet(s)

- Hydrochloric acid
- Acetic acid

Procedure

1. On a large polypad mat, place three clearly labeled beakers down, leaving ample room in between. Set the roll of paper towels and DI water spray bottle to the side.
2. Set up the electrical components: Plug the surge protector in, and turn it on and back off again to ensure that it's working. *Keep the surge protector turned off while setting up the demonstration.* Plug the Deadman switch into the surge protector. Plug the lightbulb apparatus into the Deadman switch. Make sure that the wires are pulled through the rubber stopper enough that they will reach the level of solution in each of the beakers.
3. Pour the three solutions into their respective beakers.
4. Place the rubber stopper securely into the first beaker.
5. Make sure nobody is touching the table or electrical equipment. Open the circuit: Turn the surge protector on. Step on the Deadman switch. Observe the lightbulb.
6. Close the circuit: Step off the Deadman switch. Turn off the surge protector.
7. Remove the rubber stopper from the beaker. Thoroughly spray and wipe down the wires with deionized water and paper towels.
8. Repeat with each solution.

Note: Be sure to COMPLETELY close the circuit in between each solution. Step off the Deadman switch and turn off the surge protector before approaching the table and making contact with the rubber stopper.

Pedagogy/Supplemental Information

In this demonstration, the extent of acid dissociation in aqueous solutions is visually and effectively illustrated comparing the electrical conductivity of deionized water, 1 M acetic acid, and 1 M hydrochloric acid. The principle underlying the demonstration is simple: the conductivity of a solution depends on the concentration and mobility of ions present. When an electric current is applied through a solution via submerged electrodes, the presence of free ions allows the current to pass, and the solution's conductivity can be detected – often through an indicator such as a glowing bulb, a digital meter, or visible electrode reaction. The brightness or strength of the response is directly related to the number of charged particles available to carry the current.

Deionized water, though often perceived as pure H_2O, contains only a very small concentration of hydronium (H_3O^+) and hydroxide (OH^-) ions from autoionization – approximately 10^{-7} M each at 25°C – making it a very poor conductor of electricity. In this demonstration, it serves as a baseline for minimal conductivity. When 1M acetic acid is introduced, the solution's conductivity increases, but only moderately. Acetic acid is a classic example of a weak acid, meaning it does not fully dissociate into ions in water. In fact, at 1M concentration, acetic acid typically dissociates to only about 1.3%, producing relatively few hydronium and acetate ions. As a result, its conductivity remains limited.

In contrast, 1M hydrochloric acid produces a dramatic increase in conductivity. HCl is a strong acid, meaning it dissociates completely in aqueous solution to yield hydronium (H_3O^+) and chloride (Cl^-) ions. The solution becomes densely populated with charge carriers, enabling a robust flow of current. This difference in dissociation behavior is rooted in acid strength, which reflects the equilibrium position of acid dissociation in water. Strong acids lie entirely to the right of the dissociation equilibrium, whereas weak acids establish a reversible equilibrium with a significant proportion of undissociated molecules.

This demonstration is not only visually striking but also pedagogically rich. It reveals the molecular-level distinctions between strong and weak acids and underscores the importance of ionization – not just concentration – in determining chemical behavior in solution. In real-world contexts, these principles have significant implications. Acid strength affects reaction rates, corrosion potential, and biological compatibility. For instance, pharmaceuticals containing weak acids must account for partial ionization in physiological conditions, while industrial processes that require precise pH control or electrochemical efficiency often rely on strong acids for their complete dissociation. Understanding the distinction between strong and weak electrolytes equips chemists to make informed decisions in research, manufacturing, and environmental applications.