

It's a Mellow-Yellow Reaction



Introduction

Pour water into a series of five beakers. Students observe a variety of color changes as the solution is transferred through the line of beakers until the final “mellow-yellow” color is produced.

Concepts

- Oxidation and reduction
- Coordination chemistry
- Transition metal complex ions

Materials

Ammonium thiocyanate solution, 3 M, 12 drops

Iron(III) chloride solution, 1 M, 15 drops

Oxalic acid solution, saturated, 10 mL

Tannic acid solution, saturated, 12 drops

Water, distilled, 150 mL

Beakers, 250-mL, 5

Graduated cylinder, 10-mL

Pipets, Beral-type, 3

Safety Precautions

Iron(III) chloride is a skin/tissue irritant. Ammonium thiocyanate is moderately toxic by ingestion and dangerous when heated to decomposition (170 °C) or when in contact with acids, as fumes containing cyanide may be produced. Tannic acid is slightly toxic by ingestion, inhalation, and skin absorption. Oxalic acid is moderately toxic by ingestion and corrosive to body tissues. Wear chemical splash goggles, chemical-resistant gloves, and a chemical-resistant apron. Please consult current Material Safety Data Sheets for additional safety, handling, and disposal information.

Preparation

1. Prepare a 1 M solution of iron(III) chloride by dissolving 13.5 g of $\text{FeCl}_3 \cdot 6\text{H}_2\text{O}$ in 50 mL of distilled water.
2. Prepare a 3 M solution of ammonium thiocyanate by dissolving 11.5 g of NH_4SCN in 100 mL of distilled water.
3. Prepare a saturated solution of tannic acid by dissolving 14.3 g of tannic acid in 10 mL of distilled water.
4. Prepare a saturated solution of oxalic acid by dissolving 15 g of oxalic acid in 100 mL of distilled water.

Procedure

1. Arrange the five 250-mL beakers across the demonstration table.
2. Place 15 drops of iron(III) chloride solution into Beaker 1.
3. Place 2 drops of ammonium thiocyanate solution into Beaker 2 and 10 drops of ammonium thiocyanate solution into Beaker 3.
4. Place 12 drops of tannic acid into Beaker 4.
5. Using a 10-mL graduated cylinder, measure 10 mL of oxalic acid and transfer it to Beaker 5.
6. Pour about 150 mL of distilled water into Beaker 1. The solution should be pale yellow. Express disappointment that the desired “mellow-yellow” was not produced.
7. Pour the solution from Beaker 1 into Beaker 2. The solution should be light orange-red. Express disappointment again.
8. Pour the solution from Beaker 2 into Beaker 3. The solution should be a deep blood red color. Express your disappointment.
9. Pour the solution from Beaker 3 into Beaker 4. The solution should be bluish-black. Continue to express your disappointment.

10. Pour the solution from Beaker 4 into Beaker 5. Rejoice when the bright “mellow-yellow” color is produced!

Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures, and review all federal, state and local regulations that may apply, before proceeding. The resulting solution may be rinsed down the drain with excess water according to Flinn Suggested Disposal Method #26b.

Connecting to the National Standards

This laboratory activity relates to the following National Science Education Standards (1996):

Unifying Concepts and Processes: Grades K–12

Evidence, models, and explanation

Content Standards: Grades 5–8

Content Standard B: Physical Science, properties and changes of properties in matter

Content Standards: Grades 9–12

Content Standard B: Physical Science, structure of atoms, structure and properties of matter, chemical reactions, motions and forces, conservation of energy and increase in disorder, interactions of energy and matter

Tips

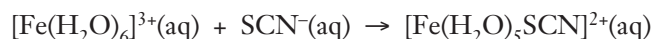
- Vary the amounts of solutions used the five small beakers until you find the combination that produces the best colors.
- Be creative when performing this demonstration and make up a story about why you want to produce the mellow-yellow solution. You might say that you want to make a fizzy yellow soft drink for yourself, and you can even try adding a piece of an Alka-Seltzer tablet to the final beaker to make the final solution a bit effervescent.
- This demonstration can be used for a fun diversion after a big test or at the end of the school year, or it can be used to teach coordination chemistry, depending on the level of your students.
- The four solutions may be stored in dropper bottles to be used later.

Discussion

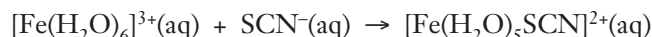
Beaker 1: Iron(III) ions are present in the solution in Beaker 1. These ions form a complex ion with the water molecules, the hydrated iron(III) ion, with its characteristic orange color. When the solution is diluted with 150 mL from the large beaker, it becomes a pale yellow color.



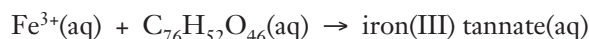
Beaker 2: Thiocyanate ions, SCN^- are present in limited quantities in Beaker 2. When mixed with the $[\text{Fe}(\text{H}_2\text{O})_6]^{3+}$ complex ion from Beaker 1, one thiocyanate ion will replace one of the water molecules surrounding the iron, forming small amount of the iron(III) thiocyanate complex ion. This results in a light orange-red color.



Beaker 3: Additional thiocyanate ions are added to the solution from Beaker 2, and these ions react with the excess hydrated iron(III) ions left over from Beaker 1. This results in the formation of additional iron(III) thiocyanate complex ions, and the solution becomes a blood red color.



Beaker 4: When the mixture of iron(III) ions in Beaker 3 are mixed with the tannic acid in Beaker 4, iron(III) tannate is produced, giving the solution a bluish-black color.



It's a Mellow-Yellow Reaction *continued*

Beaker 5: When the iron(III) tannate is mixed with oxalic acid, an iron(III) oxalate complex is formed, resulting in the final “mellow-yellow” color.



Acknowledgment

Special thanks to Peg Convery of Farmington High School, Farmington, MI for bringing this demonstration to our attention.

Materials for *It's a Mellow-Yellow Reaction* are available from FlinnScientific, Inc.

Catalog No.	Description
A0065	Ammonium Thiocyanate, 100 g
F0006	Iron(III) Chloride, 100 g
T0002	Tannic Acid, 100 g
Q0005	Oxalic Acid, 100 g

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.