Silver Cyanate vs Silver Fulminate

Brief Description:

Demonstration of the difference between examples of isomers chemically proven in the early 1800's, AgOCN vs. AgCNO.

Purpose/Goal:

An introduction to the differences between compounds that have identical numbers of specific atoms bonded in different ways. Ideal for introduction to the topics of Lewis structures, isomers and resonance.

Explanation of Experiment:

One packet each of previously prepared silver cyanate and silver fulminate are carefully placed on an aluminum foil covered three inch iron ring on a heavy ring stand. Each is heated by a candle attached to a five foot metal rod - the former burns quietly while the latter explodes with a large bang.

Materials Preparation:

This compound can be prepared by the reaction of concentrated nitric acid with silver metal and ethanol, under careful control of the reaction conditions, to avoid explosion. Only very tiny amounts of silver fulminate should be prepared at once, as even the weight of the crystals can cause them to self-detonate.

The silver fulminate used in this demonstration is prepared by dissolving 8.4 g silver nitrate in 39.5 g concentrated nitric acid diluted with 8.4 g water, and heating a mixture of 1 part of this solution with 1.2 parts of ethanol to about 60°C until a precipitate forms.

The nitty griity little details: The above portions will give a stock solution that will make many batches on the scale needed. Use a 25 mm by 75 mm test tube as the reaction vessel. Have a hot water bath for the heating and an ice water bath for cooling (don't skimp on the cooling).

1. Add 10 mL of the stock solution to the test tube and 12 mL of 95% ethanol - mix the contents.
2. Hold the test tube in a spring clamp.
3. Place the test tube in the heating bath and swirl gently. Keep a close eye on the contents. At the first sign of bubbling/boiling, remove from the hot bath and cool. Err on the side of caution - the reaction is exothermic and will take off readily. One can always return it to the heating bath, but if the reaction gets out of control, the contents will boil over and create a big mess.
4. Keep cycling between the baths; eventually a white precipitate will form. Keep cycling until you cannot observe any additional precipitate forming.
5. Cool the contents of the tube to produce maximum precipitation.
6. Set up a small Buchner funnel and filter paper. Vacuum filter the contents and collect the precipitate on the filter paper.
7. The next step should be performed while the precipitate is still damp. Should it somehow dry out, wet it before any handling.
8. Prepare a weighing paper by folding it in half with a sharp crease. Unfold the paper so that it is at an approximate 90 degree angle and place it on the balance pan.
9. Add approximately 50 mg of the damp precipitate to the paper in the center against the crease.

10. Close the fold in the paper. Fold over each end of the paper and finally fold over the top of the paper. The silver fulminate should now be in the center of the weighing paper and all of the open edges folded over to contain it. Probably 5-10 of these packets can be made.
11. Store the packets in a padded Altoids metal box inside an approved plastic screw top pail labelled as shock sensitive until needed.

Presentation:

When ready to use a sample, open the metal container holding the sample packets, pick one up by the extreme edge with a pair of forceps, place the packet upon a foil covered iron ring and apply flame to the bottom of the foil to detonate.

Hazards:

Silver fulminate is shock sensitive - handle carefully to avoid premature explosion. Only very tiny amounts of silver fulminate should be prepared at once, as even the weight of the crystals can cause them to self-detonate. Use ear protection when detonating.

Disposal:

Filter paper from the synthesis can be placed on a three inch diameter aluminum foil covered iron ring and the residue detonated using a candle attached to a five foot metal rod. The spatula used during the weighing procedure can be held in a flame to detonate any residue remaining on it. Rinse all other equipment thoroughly!

Aluminum foil and ashes may be disposed of in the trash.

Primary Reference:

- D. Britton, J.D. Dunitz, Acta Crystallographica, Vol. 19, Part 4, October 1965, p. 662.

Silver fulminate is a primary explosive that has very little practical value due to its extreme sensitivity to impact, heat, pressure and electricity. The compound becomes progressively sensitive as it is aggregated, even in small amounts. Aggregation of larger quantities is impossible due to the compound's tendency to self-detonate under its own weight. Since its discovery, its only practical usage has been in producing non-damaging novelty noisemakers as children's toys and tricks.

Silver fulminate was first prepared in 1800 by Edward Charles Howard in his research project to prepare a large variety of fulminates. Since its discovery, its only practical usage has been in producing non-damaging novelty noisemakers as children's toys and tricks.

Isomerism was first noticed in 1827, when Friedrich Woehler prepared silver cyanate and noted that although its elemental composition was identical to silver fulminate (prepared by Justus von Liebig the previous year), its properties were quite different. This finding challenged the prevailing chemical understanding of the time, which held that chemical compounds could be different only when they had different elemental compositions. After additional discoveries of the same sort were made, such as Woehler's 1828 discovery that urea had the same atomic composition as the chemically distinct ammonium cyanate, Jöns Jakob Berzelius introduced the term isomerism in 1830 to describe the phenomenon.

Justus Freiherr von Liebig[2] (12 May 1803 – 18 April 1873) was a German chemist who made major contributions to agricultural and biological chemistry, and worked on the organization of organic chemistry. As a professor, he devised the modern laboratory-oriented teaching method, and for such innovations, he is regarded as one of the greatest chemistry teachers of all time. He is known as the "father of the fertilizer industry" for his discovery of nitrogen as an essential plant nutrient, and his formulation of the Law of the Minimum which described the effect of individual nutrients on crops. He also developed a manufacturing process for beef extracts, and founded a company, Liebig Extract of Meat Company, that later trademarked the Oxo brand beef bouillon cube.

Silver fulminate, often in combination with potassium chlorate, is used in trick noise-makers known as "crackers", "snappers", "whippersnappers", "pop-its", or "bang-snaps", a popular type of novelty firework. They contain approximately 200 milligrams of fine gravel impregnated with a minute quantity (approximately 80 micrograms) of silver fulminate. When thrown against a hard surface, the impact is sufficient to detonate the tiny quantity of explosive, creating a small shock from the supersonic detonation. Snaps are designed to be incapable of producing damage (even when detonated against skin) due to the buffering effect provided by the much greater mass of the gravel medium. It is also the chemical found in Christmas crackers. The chemical is painted on one of two narrow strips of card, with abrasive on the second. When the cracker is pulled the abrasive detonates the silver fulminate.