8.5 Luminescence: Fluorescent Minerals and Household items

Subjects: Luminescence, fluorescence, phosphorescence, electromagnetic radiation, electronic structure, energy

Description: Seemingly average materials, including rocks, are exposed to UV light, producing emission of various colors

Materials:
Collection of purchased Fluorescent minerals (Calcite, Tirodite with Tremolite, Fluorite, Wernerite, Sodalite)*
Two fluorescent minerals (Calcite and Willemite/Calcite)* from Peter Lillya
Tonic Water and/or Mountain Dew
Detergent with whiteners
UV Lamp
Dry ice bath
Isopropanol

Procedure:
1. Dim the lights in the room
2. Expose the different materials to the UV light and view the emission that is produced
3. Try to find students who have clothes that have been washed with detergents that include brighteners
4. Cool the calcite (from Peter Lillya) sample using a dry ice/alcohol bath prior to class. This should produce a green emission under long-wave UV.

Discussion:
When certain molecules are exposed to ultra-violet light, that energy is absorbed. The absorption of energy causes an electronic transition from a lower energy state to a higher energy state. The absorbed energy will be transformed in one or more different processes. 1. The energy can cause a chemical transformation in the molecule; 2. It can be lost as heat, and/or 3. It can be emitted as visible light. The latter process is called luminescence.

Luminescence can be either fluorescence or phosphorescence. Fluorescence occurs very shortly after absorption (10^{-9} to 10^{-5} s) while phosphorescent emission takes longer to occur (10^{-4} s to hours). The immediate glow emanating from the minerals and other items in this demonstration is primarily fluorescence.

The speed of fluorescence is due to the fact that the electron in the higher energy state does not undergo a spin change. If the spin flips then the electron cannot return quickly to a lower energy state, causing a delay in emission, which is phosphorescence. In both cases, the molecule will typically lose some energy through collisions or heat loss before emission. Thus the emitted light is usually lower in energy, and in the visible region.

Safety:
Avoid looking directly at the UV light and avoid shining light towards the students.

Disposal:
None

References:
1. Shakashiri, B. "Chemical Demonstrations: A Handbook for Teachers of Chemistry". Vol 5. University of Wisconsin Press. 2011. p. 223-226

2. **<u>From Veronica Matthews Minerals, printed on box</u>**

- <u>Calcite</u>, $CaCO_3$ (Creamy white longwave). Fluoresces in a variety of colors.

- <u>Tirodite</u>, $Mn_2(Mg,Fe)_5Si_8O_{22}(OH)_2$ (red longwave) with <u>Tremolite</u> $Ca_2(Mg,Fe)_5Si_8O_{22}(OH)_2$ (orange longwave). They emit light when rubbed together = triboluminescence

- <u>Fluorite</u>, CaF_2 (creamy yellow or bright purple longwave, depending on locality). Used as toothpaste and water additive, and also used in steel, aluminum, and chemical industries.

- <u>Wernerite</u> (A name for a mineral of the Scapolite group)(yellow longwave). One of the brightest longwave fluorescent minerals. Pale or does not fluoresce under short wave.

- <u>Sodalite</u>, $Na_4(Si_3Al_3)O_{12}Cl$ (orange longwave). Sodium aluminum silicate with chlorine. One of the few fluorescent minerals that is brighter under longwave UV light than shortwave, though it is not always fluorescent.

<u>3. From Peter Lillya</u>

- <u>Willemite</u> (Zn_2SiO_4) and Calcite ($CaCO_3$) from Franklin NJ. Brown under daylight, and green under short-wave UV. The activator is Mn_2^+, in tetrahedral crystal field. The calcite is white in daylight and red under shortwave UV. The fluorescence happens by (a) UV absorption by Pb^{2+} impurity, (b) energy transfer within a crystal, and (c) light emission from Mn^{2+} impurity.

- <u>Calcite</u> from Coahuila, Mexico. It shows whitish blue fluorescence and phosphorescence under short-wave UV, and pink fluorescence under long-wave UV. There is also green fluorescence/phosphorescence under long-wave UV if it is cooled to dry ice temperature or below. Activator unknown.