13.4 Chemical Sunset: Tyndall Effect

Subjects: Solutions, colloids, interactions of light and matter, scattering, precipitation reactions, sulfur chemistry

Description: Two solutions are mixed together producing a colloidal suspension of sulfur. White light is passed through the solution and projected onto a screen. Shorter wavelengths of light are scattered making the solution appear bluish, while longer wavelengths pass through the solution creating a "sunset" effect that appears on the screen.

Materials:
Overhead transparency projector* (works best). Doc cam, flashlight.
600 mL beaker
Cardboard with hole
Glass stir rod
Disposable plastic pipets
0.1 M (2%) Sodium Thiosulfate (~400 mL)
1 M Hydrochloric Acid (~20 mL)

*ISB does not have the old-fashioned transparency projectors. One can be borrowed from LGRT.
Note: The scattering of white light can also be demonstrated with a dilute solution of milk or creamer.

Procedure:
1. Place the cardboard with hole on top of the overhead projector or doc cam.
2. Turn on the light. Move and focus the projector to produce a focused bright spot on the screen or section of wall.
3. Place the beaker over the hole.
4. Add the thiosulfate solution to the beaker. Ask the students to make any observations about the solution.
5. Add the HCl and stir.
6. Observe the precipitation of sulfur and the corresponding color changes.

Discussion:
In this demonstration, colloidal sulfur is generated by the reaction of sodium thiosulfate and hydrochloric acid in a two- step process involving first the formation of thiosulfuric acid followed by its decomposition to sulfurous acid and colloidal sulfur[3].

$$2\ H^+\ (aq) + S_2O_3^{2-}\ (aq) \rightarrow H_2S_2O_3\ (aq)$$

$$H_2S_2O_3\ (aq) \rightarrow H_2SO_3\ (aq) + \text{colloidal sulfur}$$

Colloidal suspensions scatter white light strongly. Shorter wavelengths are scattered more while longer wavelengths (reds and oranges) are transmitted. Scattering is when a molecule absorbs a photon of light, exciting an electron into a higher energy state. When the electron returns to a lower energy state, the molecule emits a photon in a random direction. This randomness produces the scattering known as the Tyndall effect. As the sulfur precipitates the higher energy light from the projector will be scattered, making the solution look blue. Red and orange light transmitted through the solution will be projected onto the screen.

The colors observed during a natural sunset and sunrise are a result of the same principle. As the sun sets or rises, and is low on the horizon, the light from the sun must travel a much longer distance through the atmosphere (similar to the colloidal suspension in this reaction) than during midday. Much more of the blue light is scattered, but the red and orange light is transmitted through to our eye, so that we see the sky look orange and red.

Safety:
Use proper personal protective equipment including safety glasses and gloves.

Disposal:
Neutralize the solution and dispose of waste in the aqueous waste container in ISB 118.

References:
1. Shakashiri, B.Z. *Chemical Demonstrations: A Handbook for Teachers of Chemistry*, The University of Wisconsin Press, 1989, Vol 3, p. 353-357

2. Shakashiri, B.Z. *Chemical Demonstrations: A Handbook for Teachers of Chemistry*, The University of Wisconsin Press, 2011, Vol 5, p. 160-162 (non-chemical version)

3. NCSU Chemistry Demonstration page
http://ncsu.edu/project/chemistrydemos/Light/Chemical%20Sunset.pdf

4. Video: http://www.youtube.com/watch?v=l7y1GoCLeRs