



**Tools and Resources**

***“Rocking Shades in   
the Winter”***

December 2018/January 2019

<http://www.acs.org/chemmatters>

**Teacher’s Guide:**



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**Tools and Resources**

***“Rocking Shades in the Winter”***

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# Connections to Chemistry Concepts

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| --- | --- |
| **Chemistry Concept** | **Connection to Chemistry Curriculum** |
| **Electromagnetic spectrum** | This article provides images and explanations of the electromagnetic spectrum, along with information on the wavelengths, frequencies, and energies of visible light and ultraviolet light. |
| **Ultraviolet radiation** | The primary focus of the article is explaining the deleterious effect of ultraviolet radiation on human eyes and how to effectively prevent that damage. |
| **Wavelength and frequency** | The article discusses the relationships among the wavelength, frequency, and energy of ultraviolet light and other electromagnetic radiations. |
| **Polarization** | The author explains, and provides an analogy of, polarization of light and discusses how preventing glare due to polarization is different from UV shielding. |
| **Polymers** | This article describes the polymer chemical commonly used in sunglasses to block UV rays and provides the chemical structure for polycarbonate. |
| **Reversible reactions** | The photochromic reaction of glasses that transition from clear to dark is a reversible chemical reaction that is explained (with chemical structures for naphthopyran) in a sidebar. |

# Teaching Strategies and Tools

## Standards

* Links to **Common Core Standards for Reading**:
  + **ELA-Literacy.RST.9-10.1:** Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.
  + **ELA-Literacy.RST.9-10.5:** Analyze the structure of the relationships among concepts in a text, including relationships among key terms (e.g., force, friction, reaction force, energy).
  + **ELA-Literacy.RST.11-12.1:** Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
  + **ELA-Literacy.RST.11-12.4:** Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11-12 texts and topics.
* Links to **Common Core Standards for Writing**:
  + **ELA-Literacy.WHST.9-10.2F:** Provide a concluding statement or section that follows from and supports the information or explanation presented (e.g., articulating implications or the significance of the topic).
  + **ELA-Literacy.WHST.11-12.1E:** Provide a concluding statement or section that follows from or supports the argument presented.

## Vocabulary

* **Vocabulary** and **concepts** that are reinforced in this issue:
  + Structural formulas
  + Crystalline structure
  + Environmental impacts of personal and societal decisions
  + Electromagnetic radiation
  + Colligative properties
  + Gas laws
* Consider asking students to read “Open for Discussion: A Slippery Slope” on page 4 to learn about concerns regarding using artificial snow prior to reading the article “What’s Artificial Snow, and How Is It Made?”
* Students from warmer climates may be unaware of the use of salt to melt ice on roadways. Ask them if they have ever traveled to cold climates and if they had trouble walking on icy sidewalks, or if they have seen this problem in movies or television. Show students the ACS Reactions video referenced on page 14 AFTER they have read the article to help them understand why salt is used to deice roads and how it works.
* Two of the articles relate to personal health (UV eye protection and cupping). Ask students how the articles might impact their decisions regarding their health and why.
* Two of the articles relate to environmental impacts of our decisions (artificial snow and salting roads). Ask students how the information from the articles might help them make decisions in the future, and factors they might consider as citizens asked to provide input on related projects.
* To help students engage with the text, ask students which article **engaged** them most and why, or what **questions** they still have about the articles, and what they would like to explore further.
* Ask students if they have questions about some of the issues discussed in the articles.

# Possible Student Misconceptions

1. **“Expensive sunglasses provide better protection than cheap ones.”** Price is not a good predictor of sunglass quality or effectiveness. Even inexpensive sunglasses can offer good eye protection. The most important criteria include both checking the label to assure that the glasses block 100% of ultraviolet radiation—both UVA and UVB—and assuring the glasses fit well and completely shield your eyes.
2. **“Sunglasses that eliminate glare also stop UV rays.”** Not true! Polarized glasses block glare (as explained in the article). Glare improves your vision by reducing the amount of light reaching the eye and improving contrast. However, unless the polarized glasses are also designed to block UV rays, the light that reaches your eyes can still cause eye damage. Good sunglasses have both UV protection and polarization.
3. **“Sunglasses are only needed in the hot summer.”** As the article explains, exposing your eyes to UV rays can cause serious injury—regardless of the time of year or location. The UV rays bouncing off snow, water, or other reflective surfaces can all cause the same damage to the eyes. In addition, at higher altitudes the thinner atmosphere is less effective at blocking UV rays. So, cold winter snow sports in the mountains may expose your eyes to more UV rays than other activities in the hot summer.
4. **“Children don’t need sunglasses.”** Typically, children and teens spend more time (perhaps up to three times as much) outdoors in the sun than many adults. Research indicates that significant eye damage can occur before the age of 18. Also, children’s eyes don’t filter UV rays as well as adults’ eyes. So, everyone—children, teens, and adults—should wear sunglasses every time they are outside.
5. **“Sunglasses are not normally needed on cloudy or rainy days.”** Even on cloudy or rainy days, UV rays are still present and can injure your eyes. Many teens have suffered a sunburn on a cloudy day because they mistakenly thought that the clouds blocked the UV rays that cause sunburns. So, if there are sufficient UV rays to cause a sunburn on cloudy or rainy days, there are enough UV rays to injure your eyes.

# Anticipating Student Questions

1. **“Do darker sunglasses provide more UV protection that lighter ones?”** While it might seem reasonable that darker sunglasses would be better than lighter-colored sunglasses, this is not true. The level of UV protection is dependent upon the lens coatings or the type of polymer lens material. The lens color (gray, brown, blue, etc.) or shade of darkness of the sunglasses is not an indication of the level of UV protection. Read the labels to determine how effectively the sunglasses block UVA and UVB rays.
2. **“Does the size or the style of the sunglasses make a difference?”** Yes! Small lenses provide less protection than larger lenses because they shield less of the eye and don’t block as many UV rays from the eye. Also, sunglass styles that wrap around the sides of the eyes are more effective at blocking light from the eyes. Studies show that sunglasses that fit closer to the eyes provide better UV protection. Style is important in looking good, but be sure that style does not outweigh protection and function.
3. **“Does wearing a hat or cap protect my eyes from UV damage”** A hat may shade some sunlight (including some UV rays) from reaching your eyes, but it does not block all the UV rays that cause eye damage. Light reflected off surfaces like water, pavement, snow, etc. allow UV rays to reach your eyes underneath you hat. The best protection comes from wearing good sunglasses.
4. **“My eye doctor says that too much UV light can cause cataracts. What are cataracts?”**Cataracts are the leading cause of blindness in the world. A cataract occurs when the eye’s lens becomes cloudy. Most cataracts are related to aging, and they may be caused by proteins clumping in the lens, which clouds the eye. As the cataract grows, the lens becomes cloudier, making it harder to see. In addition to aging, cataracts may be related to smoking and diabetes, and it is known that to exposure to UV radiation increases the risk of cataracts. Research shows that the UV rays entering the eyes may damage proteins in the lens that leads to the clumping and poor vision.
5. **“Why is it hard to see my cell phone screen, some TVs, or LCD screens when wearing polarized sunglasses?”**When looking from certain angles, LCD displays may be difficult to see or may disappear when wearing polarized sunglasses. The LCDs (liquid crystal displays) used on ATMs, TVs, cell phone screens, etc. have a polarizer in the screen to produce the images and print that you typically see. So, if the polarizer in the display and the polarizer in your sunglasses are aligned roughly perpendicular to each other, the display will be difficult to see or may appear as a dark screen.
6. **“Why can boaters see underwater better when they are wearing polarized glasses?** Much of the light reflected off the surface of water is horizontally polarized. If the boaters’ glasses are polarized vertically, the glare is reduced allowing better vision into the water. Fishermen can spot fish and underwater objects more clearly if they are wearing polarized glasses. Of course, wearing polarized sunglasses allows boaters to both reduce the glare off the water and protect their eyes from damaging UV rays (a “win-win” situation).

# Activities

**Labs and demos**

**“Everyday Engineering: UV or Not UV? That Is a Question for Your Sunglasses”:** While this lab from the National Science Teachers Association (NSTA) is written for grades   
5–8, it may be appropriate for higher grades; it uses egg carton cubicles, UV sensitive beads, and sunglass lenses to test the ability of the lenses to filter UV light. (<https://learningcenter.nsta.org/resource/default.aspx/?id=10.2505/4/ss14_037_07_12&a=reviews>. Note that this link takes you to a brief abstract only; the full article is available to purchase or is free to NSTA members.)

**“Thionin—The Two-Faced Solution” demonstration:** This demonstration shows how light energy is used to induce a reversible chemical reaction with a color change, a process similar to the change in photochromic sunglasses—but in reverse, with the chemical going from colored to colorless. (<https://www.flinnsci.com/api/library/Download/1e347e52d1fa4253b324d388aea826d1>)

**Simulations**

**“Wave Interference” (PhET):** This simple student simulation includes an option **for** investigating light traveling through one or two barrier slits producing constructive and destructive interference to better understand the behavior of waves. (<https://phet.colorado.edu/en/simulation/legacy/wave-interference>)

**“Polarization of Light” (oPhysics: Interactive Physics Simulations):** Students can manipulate light waves traveling through filters with one or more slits and adjust the angle of one slit to study the polarization of light. (<https://ophysics.com/l3.html>)

**Media**

**“Electromagnetic Waves and the Electromagnetic Spectrum”, video (11:01):** This Khan Academy lesson defines and explains electromagnetic (EM) waves, portions of the EM spectrum, and energies of visible light. (<https://www.khanacademy.org/science/physics/light-waves/introduction-to-light-waves/v/electromagnetic-waves-and-the-electromagnetic-spectrum>)

**“How Do Polarized Sunglasses Work?” video (6:21):** The Science Asylum provides an upbeat look at how light is polarized and how polarization is used in producing effective sunglasses. (<https://www.youtube.com/watch?v=c9ew1J0PY-M>)

**Lessons and lesson plans**

**“Electromagnetic Waves: How Do Sunglasses Work?”:** This one-hour high-school lesson ties engineering to the activity, which compares polarized and non-polarized lenses, and supports teachers by supplying NGSS standards, a lesson plan, content, links to teacher and student materials, and assessment strategies, and extension activities. (<https://www.teachengineering.org/lessons/view/mis-2231-light-properties-sunglasses-electromagnetic-waves-polarization>)

**“Polarization”:** This lesson (part of the “Light Waves and Color” tutorial) supplies content, videos, illustrations, and a basic check for student understanding for polarizing light by reflection, refraction, or scattering, as well as providing a link to the related lesson “The Electromagnetic and Visible Spectra”. (<https://www.physicsclassroom.com/class/light/Lesson-1/Polarization>)

**Projects and extension activities**

**“Experiments with Polarized Light”:** This activity can be conducted at home using polarized sunglass lenses, an LCD computer screen, and common household objects; the article provides explanations with diagrams for how polarization works. (<http://www.physics.iitm.ac.in/~ph5060/manuals/polarization.pdf>)

**“Electromagnetic Spectrum Book” activity/project:** Students research and “create a book that describes all of the individual parts that make up the electromagnetic spectrum.” The activity provides student and teacher materials and a rubric; it suggests that the project takes from 2 days to a week to complete. (Access is restricted to AACT members, but the article will be available for free until February 1, 2019 at <https://teachchemistry.org/classroom-resources/electromagnetic-spectrum-book>.)

# References

**The references below can be found on the *ChemMatters* 30-year DVD, which includes all articles published from the magazine’s inception in October 1983 through April 2013; all**

**available Teacher’s Guides, beginning February 1990; and 12 *ChemMatters* videos. The DVD is available from the American Chemical Society for $42 (or $135 for a site/school license) at this site:** [***http://www.acs.org/chemmatters***](http://www.acs.org/chemmatters)**. Click on the “Teacher’s Guide” tab to the left, directly under the “*ChemMatters Online"* logo and, on the new page, click on “Get 30 Years of *ChemMatters* Magazine!” (the icon on the right of the screen).**

**Selected articles and the complete set of Teacher’s Guides for all issues from the past three years are available free online at the same Web site, above. Click on the “Issues” tab just below the logo, *“ChemMatters Online”*.**



“A Light of a Different Color” describes ultraviolet light, its uses, and interesting characteristics including fluorescence. (Rohrig, B. A Light of a Different Color. *ChemMatters*. 1999, *17* (2), pp 4–6)

“Spectroscopy: Sensing the Unseen” provides readers with information on the electromagnetic spectrum, diffraction, and ultraviolet light, along with illustrations to enhance understanding. (Miller, S. Spectroscopy: Sensing the Unseen. *ChemMatters*. 2001, *19* (Special Issue 1), pp 4–6)

Ozone’s beneficial and detrimental roles in the atmosphere, including shielding the Earth from UV rays, are germane to the current article about sunglasses. (Kimbrough, D. Ozone: Molecule with a Split Personality. *ChemMatters*. 2001, *19* (Special Issue 1), pp 7–9)

“Studying the Energy of the Universe” provides an activity to make Schönbein paper used to test ozone levels. (Siegel, P. Studying the Energy of the Universe. *ChemMatters*. 2002, *20* (Special Issue 1), pp 6–9)

In “A Super Vision for Airport Security”, the electromagnetic spectrum is explained and Figures 1 and 2 nicely illustrate the electromagnetic spectrum, wavelength, and frequency. (Tinnesand, M. A Super Vision for Airport Security. *ChemMatters*. 2012, *30* (1), pp 14–16)

“Polymers: The Lucky Polymer” in the “Did You Know?” department briefly describes polycarbonate, the plastic in many sunglasses, especially as it is used in making CDs and DVDs. (Blaszcyk, R. Polymers: The Lucky Polymer. *ChemMatters*. 2013, *31* (1), p 4)

This article contains more information regarding ozone’s role as sunscreen for the Earth. (Carlowicz, M. The Ozone Layer: Our Global Sunscreen. *ChemMatters*. 2013, *31* (2), pp 12–14)

# Web Resources for More Information

**Sunglasses**

HowStuffWorks explains in detail the science of sunglasses including photochromic lenses, tints, various coatings, polarization, safety, and fashion.

(<https://science.howstuffworks.com/innovation/everyday-innovations/sunglass.htm>)

This is an infographic about the chemistry of sunglasses including lens material, UV protection, and photochromic chemistry.

(<https://www.compoundchem.com/2016/05/09/sunglasses/>)

**Photochromic eyeglasses**

This site gives additional information on how photochromic glasses work.

(<https://www.scienceabc.com/innovation/how-do-photochromic-photochromatic-glasses-work.html>)

ACS provides information on self-darkening lenses, the dyes used, and the chemical reaction.

(<https://pubs.acs.org/cen/science/87/8715sci5.html>)

**Polycarbonate**

This article describes the uses, manufacture, and possible future developments of polycarbonate plastic; it also includes numerous chemical structures.

(<http://www.essentialchemicalindustry.org/polymers/polycarbonates.html>)

Read this article to learn more about polycarbonate lenses used in glasses.

(<https://www.allaboutvision.com/parents/polycarb.htm>)

**Cataracts**

This article explains facts about cataracts including causes, effects on vision, and treatment.

(<https://nei.nih.gov/health/cataract/cataract_facts>)

An update in this article explains how UV rays may cause or contribute to cataract formation.

(<https://nei.nih.gov/news/briefs/uv_cataract>)

**Nonsurgical cataract treatment**

New research indicates that a nonsurgical treatment for cataracts may be possible, using special eye drops, to dissolve the clumped proteins which cause most cataracts.

(<https://www.sciencedaily.com/releases/2015/11/151105143817.htm>)

**Ultraviolet (UV) radiation**

Detailed Information about UV radiation can be found in this article.

(<https://www.fda.gov/radiation-emittingproducts/radiationemittingproductsandprocedures/tanning/ucm116425.htm>)

Learn about the health effects of UV on the eyes, including photoconjunctivitis, photokeratosis, pterygium, cancer, and cataracts.

(<http://www.who.int/uv/faq/uvhealtfac/en/index3.html>)

**Electromagnetic spectrum and energy**

Readers can review the electromagnetic spectrum using text and illustrations.

(<https://imagine.gsfc.nasa.gov/science/toolbox/emspectrum1.html>)

The mathematical equation for calculating the energy of a photon and a brief explanation of the relationship between wavelength and energy are provides at this site.

(<https://www.e-education.psu.edu/meteo300/node/682>)

**Polarized light**

For more information on the polarized light, visit this link.

(<https://www.microscopyu.com/techniques/polarized-light/introduction-to-polarized-light>)

**Ozone**

This site provides review of the science of stratospheric ozone and how it shields UV radiation.

(<https://www.ozonelayer.noaa.gov/science/basics.htm>)

**Visible light and color**

This site provides classroom-ready PDF file worksheets to help comprehend light and color.

(<https://www.physicsclassroom.com/curriculum/light>)

**Solar sunglasses**

Solar glasses that can generate power from light may lead to new applications in sunglasses where the power could power microdisplays on the sunglass lenses.

(<https://www.sciencedaily.com/releases/2017/08/170802102800.htm>)