

**Teacher’s Guide**

**How Safe are Hair Dyes?**

***February 2021***

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Activate students’ prior knowledge and engage them before they read the article.

[Reading Comprehension Questions](#_Student_Reading_Comprehension) 3

These questions are designed to help students read the article (and graphics) carefully. They can help the teacher assess how well students understand the content and help direct the need for follow-up discussions and/or activities. You’ll find the questions ordered in increasing difficulty.

[Graphic Organizer 5](#_Graphic_Organizer)

Thishelps students locate and analyze information from the article. Students should use their own words and not copy entire sentences from the article. Encourage the use of bullet points.

[Answers 6](#_Answers_to_Reading)

Access the answers to reading comprehension questions and a rubric to assess the graphic organizer.

[Additional Resources 8](#_Additional_Resources_1)

Here you will find additional labs, simulations, lessons, and project ideas that you can use with your students alongside this article.

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# Anticipation Guide

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Directions: *Before reading the article*,** in the first column, write “A” or “D,” indicating your **A**greement or **D**isagreement with each statement. Complete the activity in the box.

As you read, compare your opinions with information from the article. In the space under each statement, cite information from the article that supports or refutes your original ideas.

|  |  |  |
| --- | --- | --- |
| **Me** | **Text** | **Statement** |
|  |  | 1. Hair color chemistry has changed dramatically in the first part of the 21st century. |
|  |  | 1. Consumers should do a skin-patch test before using synthetic hair dyes because of the possibility of contact allergic reactions. |
|  |  | 1. Hydrogen peroxide has two different roles in the hair dyeing process. |
|  |  | 1. Ammonia is used in most permanent hair dyes because it is acidic. |
|  |  | 1. Only one step is needed to apply permanent hair color. |
|  |  | 1. Nonreactive hair dyes are semipermanent and last for about six washings before fading. |
|  |  | 1. Endocrine-disrupting chemicals are found in many personal care products. |
|  |  | 1. More studies are needed to determine if there is a causal relationship between endocrine-disrupting chemicals and breast cancer. |
|  |  | 1. Scientists are working on a milder permanent hair color effect using electrostatic and polar surface interactions. |
|  |  | 1. Polydopamine, a synthetic melanin, is a polymer containing carbon, hydrogen, oxygen, and nitrogen. |

# Student Reading Comprehension Questions

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Directions**: Use the article to answer the questions below.

1. How long do reactive dyes last in hair?
2. Who developed the first synthetic hair dye?
3. Explain the probability of being exposed to hair-color chemicals through the scalp.
4. What were the results of Llanos’ 2017 Women’s Circle of Health study?
5. Explain the results of the NIEHS Sister Study.
6. Explain the benefits and drawbacks of using permanent hair dye.
7. What is the chemical formula for *p*-phenylenediamine?
8. What are the two primary components in reactive hair dye and how do they function?
9. How are semipermanent hair colors different from permanent hair dyes?
10. What synthetic melanin are researchers studying and how is it created?

**Student Reading Comprehension Questions, cont.**

**Questions for Further Learning**

***Write your answers on another piece of paper if needed.***

1. How does an alkaline ingredient get color into a strand of hair?
2. Products marketed to Black women may contain high levels of endocrine-disrupting chemicals. Research and explain the impacts of endocrine-disrupting chemicals.

# Graphic Organizer

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Directions**: As you read, complete the graphic organizer below to describe the purpose of chemicals found in permanent hair dye.

|  |  |  |
| --- | --- | --- |
| **Chemicals** | **Structural Formula** | **Purpose** |
| ***p*-phenylenediamine (PPD)** |  |  |
| **Hydrogen peroxide** |  |  |
| **Ammonia** |  |  |
| **Resorcinol** |  |  |
| **Indoaniline dye** |  |  |
| **Polydopamine** |  |  |

**Summary:** Write a short email to a friend who uses permanent hair dye describing what you learned from the article.

# Answers to Reading Comprehension Questions & Graphic Organizer Rubric

1. **How long do reactive dyes last in hair?**

*Reactive dyes last for several weeks or until new growth makes it necessary to add color.*

1. **Who developed the first synthetic hair dye?**

*Eugene Schueller developed the first synthetic hair dye.*

1. **Explain the probability of being exposed to hair-color chemicals through the scalp.**

*The probability of being exposed to hair-color chemicals through the scalp is about 1%.*

1. **What were the results of Llanos’ 2017 Women’s Circle of Health study?**

*Black women who used dark hair dye had a 51% increase in breast cancer risk and a 72% increased risk of estrogen receptor-positive breast cancer as compared with Black women who did not color their hair.*

1. **Explain the results of the NIEHS Sister Study.**

*The study found that permanent-dye use was associated with a 45% higher risk of breast cancer for Black women and a 7% higher risk for White women when compared with participants who did not color their hair.*

1. **Explain the benefits and drawbacks of using permanent hair dye.**

*Permanent hair color is popular because it provides consistent results and lasts for long periods of time.*

*Drawbacks are that using permanent hair dye damages hair, can cause skin sensitization and can canse allergic reactions.*

1. **What is the chemical formula for *p*-phenylenediamine?**

*The formula for* p*-phenylenediamine is C6H4(NH2)2*

1. **What are the two primary components in reactive hair dye and how do they function?**

*The two primary componets in hair dye are an alkalizing agent and an oxidizer. An oxidizer removes electrons from other reactants. An alkalizing agent is a substance that can buffer against a change in pH.*

1. **How are semipermanent hair colors different from permanent hair dyes?**

*Semipermanent hair colors coat the hair shaft while permanent hair dyes penetrate the cuticle of the hair.*

1. **What synthetic melanin are researchers studying and how is it created?**

*Researchers are studying polydopamine. Polydopamine is created through the oxidation of dopamine.*

**Questions for Further Learning**

1. **How does an alkaline ingredient get color into a strand of hair?**

*Alkalline ingreidients get color into hair by swelling the outer hair layer or cuticle, allowing the dye and hydorogen peroxide into the middle layer off the hair. The hydrogen peroxide the oxidizes melanin to make it colorless so only the dye molecules are seen.*

1. **Products marketed to Black women may contain high levels of endocrine-disrupting chemicals. Research the impacts of endocrine-disrupting chemicals. Select one endocrine-disrupting chemical and create an infographic to explain its impact on the endocrine system.**

*Student responses will vary but should clearly describe the impact of the endocrine-disrupting chemical on the endocrine system.*

**Graphic Organizer Rubric**

If you use the Graphic Organizer to evaluate student performance, you may want to develop a grading rubric such as the one below.

|  |  |  |
| --- | --- | --- |
| **Score** | **Description** | **Evidence** |
| 4 | Excellent | Complete; details provided; demonstrates deep understanding. |
| 3 | Good | Complete; few details provided; demonstrates some understanding. |
| 2 | Fair | Incomplete; few details provided; some misconceptions evident. |
| 1 | Poor | Very incomplete; no details provided; many misconceptions evident. |
| 0 | Not acceptable | So incomplete that no judgment can be made about student understanding |

# Additional Resources

**Labs and demos**

**Under the Microscope: Forensic Hair Analysis:** This lab guide explains how to mount hair to a slide and differentiate between animal and human hair. <https://www.carolina.com/teacher-resources/Interactive/forensic-hair-analysis-activity/tr10879.tr>

**Lessons and lesson plans**

**Chemistry of Permanent Hair Dyes:** This poster provides information about the different chemical compounds used to create different colors of hair dye. <https://www.compoundchem.com/wp-content/uploads/2015/05/The-Chemistry-of-Permanent-Hair-Dye-Colours.png>

**Dyes and Dying:** In this lesson plan students test dyes on different types of fabrics. <https://www.flinnsci.com/api/library/Download/c46ad9cfbff64e9cae7caf3aed645692#:~:text=Dyes%20are%20organic%20compounds%20that%20can%20be%20used,important%20role%20in%20how%20and%20why%20dyes%20work>.

**Endocrine Disruptors:** In this lesson students perform research to learn about endocrine disruptors and their impact on society. <http://sciencenetlinks.com/lessons/changing-world-1-endocrine-disruptors/>

**Other Resources**

**A Close Look at the Properties of Hair and Scalp:** Students can use this website to learn more about the structure of hair. <https://www.texascollaborative.org/hildasustaita/module_files/overview.html>

**Faces of Chemistry:** Hair Colourants: This video explains how hair dyes are used to color hair. <https://youtu.be/eQBbEThc1Po>

**Evolution of Materials Science:** In this activity, students are tasked with creating a video about the development of a current-day product. Additional personal care products related to hair and/or hair dye could be a topic to assign students. <https://teachchemistry.org/classroom-resources/the-evolution-of-materials-science-in-everyday-products>

**Correlation vs. Causation:** A classics website that helps students depict the common misnomer of the two concepts. <https://www.tylervigen.com/spurious-correlations>

# Chemistry Concepts, Standards, and Teaching Strategies

**Connections to Chemistry Concepts**

The following chemistry concepts are highlighted in this article:

* Electrochemistry: Oxidation
* Molecules & bonding: Covalent bonding, intermolecular forces
* Organic Chemistry: Molecular structure

**Correlations to Next Generation Science Standards**

This article relates to the following performance expectations and dimensions of the NGSS:

**HS-PS1-3**

Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.

**HS-ETS1-3**

Evaluate a solution to a complex real-world problem based on prioritized criteria and tradeoffs that account for a range of constraint, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.

**Disciplinary Core Ideas:**

* PS1.A: Structure and Properties of Matter
* ETS1.C: Optimizing the Design Solution

**Crosscutting Concepts:**

* Cause and Effect: Mechanism and explanation.
* Structure and Function

**Science and Engineering Practices:**

* Analyzing and interpreting data
* Constructing explanations and designing solutions

**Nature of Science:**

* Science addresses questions about the natural and material world.

**Correlations to Common Core State Standards**

See how *ChemMatters* correlates to the[**Common Core State Standards**](https://www.acs.org/content/acs/en/education/resources/highschool/chemmatters/teachers-guide.html)  at www.acs.org/chemmatters.

**Teaching Strategies**

Consider the following tips and strategies for incorporating this article into your classroom:

* **Alternative to Anticipation Guide:** Before reading, ask students if they use permanent hair dye or know someone who does. Ask students if they know what chemicals are in hair dye, and if they have ever wondered if hair dye is safe.
  + As they read, students can find information to confirm or refute their original ideas.
  + After they read, ask students what they learned about hair dyes (and other personal care products) and how they will use their new understanding to make decisions about using personal care products.
* Before or after reading the article, consider showing the 5-minute ACS Reactions Video: How Does Hair Dye Work? <https://youtu.be/zeReQ1wlcis>. The information in the video complements the information in the article relating to the hair dyeing process, but there is no mention of possible risks of using permanent hair dye.