

# International Journal of Innovative Research in Science, Engineering and Technology

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## Chemical Toxins in Hair Dyes and Their Hazards

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**ABSTRACT:** Given the worldwide popularity of hair dyeing, there is an urgent need to understand the toxicities and risks associated with exposure to chemicals found in hair dye formulations. Hair dyes are categorized as oxidative and nonoxidative in terms of their chemical composition and ingredients. For several decades, the expert panel's Cosmetic Ingredient Review (CIR) has assessed the safety of many of the chemicals used in hair dyes; however, a comprehensive review of hair dye ingredients and the risk of exposure to hair dyeing has not been documented. Herein, we review the safety of the various chemicals in oxidative and nonoxidative hair dyes, toxicities associated with hair dyeing, and the carcinogenic risks related to hair dyeing. While many compounds are considered safe for users at the concentrations in hair dyes, there are conflicting data about a large number of hair dye formulations. The CIR expert panel has ratified a number of coloring ingredients for hair dyes and banned a series of chemicals as carcinogenic to animals and unsafe for this application. The use of these chemicals as raw materials for producing hair dyes may result in the synthesis of other contaminants with potential toxicities and increased risk of carcinogenesis. It is an open question whether personal or occupational hair dyeing increases the risk of cancer; however, in specific subpopulations, a positive association between hair dye use and cancer occurrence has been reported. To address this question, a better understanding of the chemical and mechanistic basis of the reported toxicities of hair dye mixtures and individual hair dye ingredients is needed. It is anticipated that in-depth chemical and systems toxicology studies harnessing modern and emerging techniques can shed light on this public health concern in the future.

**KEYWORDS**-hair, dyes, hazards, risks, toxicity, chemicals, health

### I. INTRODUCTION

Skin absorption rates vary across body parts, with the forehead and scalp exhibiting higher absorption than the forearms. In the realm of hair coloring products, a crucial step towards informed choices is scrutinizing ingredient lists to mitigate potential risks. Join us on a journey as we explore eight common chemicals present in hair color formulations, shedding light on the importance of conscious ingredient assessment for the promotion of overall well-being.[1,2,3]

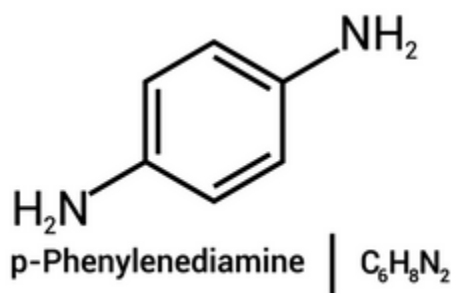
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## 1. P-phenylenediamine PPD



PPD is short for para-phenylenediamine. It is used as a dye for dark color shades and is made from coal tar, a petroleum-derived chemical that includes benzene, naphthalene, phenols, aniline, and other chemicals. It is also used as a wood preservative, and contact with skin is best avoided. PPD can cause reactions ranging from mild skin irritation to more severe allergic contact dermatitis.[1] Sensitive individuals may experience dermatitis—skin inflammation and irritation commonly called eczema. In more severe cases, there may be marked reddening and swelling on the scalp and the face. An allergy to PPD can result in widespread contact dermatitis, hives, and, in rare severe cases, anaphylaxis.

## 2. Hydrogen peroxide



Hydrogen peroxide is oxygen water. It is the activator that you add to the color cream when you dye your hair. Peroxide is used as the developer or oxidizing agent. It removes pre-existing color. Hydrogen Peroxide is said to change the hair structure and make it brittle, stripping it of its natural luster. [2]

## 3. Ammonia



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Ammonia is used to open up the hair's cuticle (the outer layer), so the dyes can come into the shaft (the inside of the hair).

Ammonia can cause skin irritation, and if it gets into your bloodstream, you could get sick. Ammonia can also impact the earth by endangering animals in the ocean and crops on the land.

#### 4. Ethanolamine



Ethanolamine is used in our demi-permanent hair colorants instead of Ammonia. Ethanolamine is similar to ammonia but can damage your hair more.[3] You may also notice more hair loss, and there can even be a risk of birth defects.

#### 5. DMDM hydantoin



DMDM hydantoin is a formaldehyde releaser or donor. It slowly releases the chemical formaldehyde as it breaks down in the product over time to prevent mold and bacteria from growing. It works by slowing or stopping the growth of potentially harmful microbes such as fungi, yeast, and bacteria. DMDM hydantoin has come under fire in recent years because it releases small amounts of formaldehyde. It may cause tissue irritation and affect the immune system.

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### 6. SLS



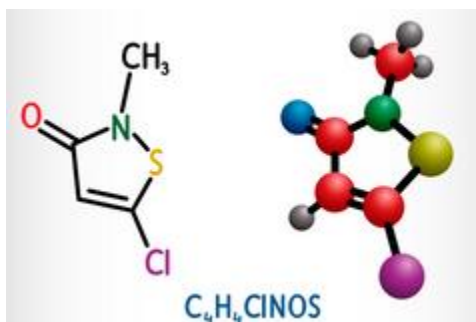
Before you use your go-to hair color, check for these ingredients: sodium Laureth sulfate, sodium lauryl sulfate, or sodium chloride. These ingredients act like a deep-cleaning detergent that can strip your hair of its new color. It strips your hair of dirt and essential, natural oils that can leave your hair weak and prone to breakage. Continuous exposure to sodium Laureth sulfate can even cause skin irritations.[4,5,6]

### 7. Resorcinol



Resorcinol (or benzene-1,3-diol) is a chemical commonly used in hair color, hair dyes, skin peels, and during acne treatments. It reacts with the peroxide-containing developer to give the required color or shade. Resorcinol is a toxic dye that can cause scalp irritation and is an allergen affecting the endocrine system.

### 8. Methylchloroisothiazolinone



Methylchloroisothiazolinone is a preservative in many skin care products, household cleaners, and hair dye products that stop fungi, yeast, and bacteria from growing. Methylisothiazolinone engages your immune system and irritates

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your skin.[4] Once this happens, you may become permanently allergic to methylchloroisothiazolinone the next time you are exposed.

## II. DISCUSSION

Many people use hair dyes, which can contain different types of chemicals. Studies have looked at hair dyes as a possible risk factor for various types of cancer. Here is what the research shows so that you can make choices that are comfortable for you.

### Types of hair dyes

Hair dyes vary greatly in their chemical make-up. There are 3 main types of hair dyes:

- Temporary: Temporary dyes cover the surface of the hair but don't penetrate into the hair shaft. They generally last for 1 to 2 washings.
- Semi-permanent: Semi-permanent dyes do penetrate into the hair shaft. They typically last for 5 to 10 washings.
- Permanent (oxidative): Permanent dyes cause lasting chemical changes in the hair shaft. They are the most popular types of hair dyes, because the color changes last until the hair is replaced by new growth. These dyes are sometimes referred to as coal-tar dyes because of some of the ingredients in them. They contain colorless substances such as aromatic amines and phenols. In the presence of hydrogen peroxide, these substances go through chemical reactions to become dyes. Darker hair dyes tend to use more of these coloring agents.

Most of the concern about cancer risk has been with the semi-permanent and permanent dyes. Because darker dyes have more of some chemicals that may cause cancer, these products are of greatest potential concern.

### How are people exposed to hair dyes?

When people dye their hair or have it dyed, some chemicals in the hair dyes can be absorbed in small amounts through the skin or inhaled from fumes in the air.

People who work around hair dyes regularly as part of their jobs,[7,8,9] such as hairdressers, stylists, and barbers, are likely to be exposed more than people who just dye their hair on occasion. Many of the concerns about hair dyes possibly causing cancer have focused on people who work with them.

### Do hair dyes cause cancer?

Researchers have been studying a possible link between hair dye use and cancer for many years. Studies have looked most closely at the risks of blood cancers (leukemias and lymphomas), bladder cancer, and breast cancer.

### What do studies show?

Researchers use 2 main types of studies to try to figure out if a substance can cause cancer. A substance that causes cancer or helps cancer grow is called a carcinogen.

- Lab studies (studies done using lab animals or cells in lab dishes)
- Studies in people (epidemiologic studies)

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In most cases neither type of study provides enough evidence on its own, so researchers usually look at both human and lab-based studies when trying to figure out if something might cause cancer.

Studying hair dyes can be hard because not all hair dyes are the same – they can contain any of thousands of different chemicals. On top of this, the ingredients in hair dyes have changed over time. Early hair dyes contained chemicals, including some aromatic amines, which were found in the late 1970s to cause cancer in lab animals, so hair dye manufacturers changed some of them in their products. Studying exposure to hair dyes from decades ago may not be the same as studying current exposures. In fact, many studies classify personal hair dye use based on whether it took place before or after 1980.

### Studies done in the lab

Some of the ingredients used in hair dyes (including certain aromatic amines) have been shown to cause cancer in lab animals, usually when the animals were given large amounts of the dyes over a long period of time. Although studies have shown that some of the dye applied to an animal's skin is absorbed into the bloodstream, most have not found a link between skin application and cancer risk.

It's not clear how these results might relate to people's use of hair dyes.

### Studies in people

Most of the studies looking at whether hair dye products increase the risk of cancer have focused on certain cancers such as bladder cancer, non-Hodgkin lymphoma, leukemia, and breast cancer. These studies have looked at 2 groups of people:

- People who use hair dyes regularly
- People who are exposed to them at work

**Bladder cancer:** Most studies of people exposed to hair dyes at work, such as hairdressers and barbers, have found a small but fairly consistent increased risk of bladder cancer. However, studies looking at people who have their hair dyed have not found a consistent increase in bladder cancer risk.

**Leukemias and lymphomas:** Studies looking at a possible link between personal hair dye use and the risk of blood-related cancers such as leukemia and lymphoma have had mixed results. For example, some studies have found an increased risk of certain types of non-Hodgkin lymphoma (but not others) in women who use hair dyes, especially if they began use before 1980 and/or use darker colors. The same types of results have been found in some studies of leukemia risk. However, other studies have not found an increased risk.

**Breast cancer:** Results of studies looking at a possible link between personal hair dye use and breast cancer have been mixed. Many studies have not found an increase in risk, although some more recent studies have.[10,11,12] Some studies have also suggested possible links with certain subtypes of breast cancer but not with others.

**Other cancers:** For other types of cancer, too few studies have been done to be able to draw any firm conclusions.

Many people use or work with hair dyes, so it is important that more studies are done to get a better idea if these dyes increase cancer risk.

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What expert agencies say

Several national and international agencies study substances in the environment to determine if they can cause cancer. The American Cancer Society looks to these organizations to evaluate the risks based on the available evidence.

Based on studies in people and studies done in the lab, some of these expert agencies have classified hair dyes or their ingredients as to whether they can cause cancer.

The International Agency for Research on Cancer (IARC) is part of the World Health Organization (WHO). One of its major goals is to identify causes of cancer. IARC has concluded that workplace exposure as a hairdresser or barber is “probably carcinogenic to humans,” based on the data regarding bladder cancer. (The evidence for other types of cancer is considered mixed or inadequate.) But IARC considers personal hair dye use to be “not classifiable as to its carcinogenicity to humans,” based on a lack of evidence from studies in people.

The US National Toxicology Program (NTP) is an interagency program of the National Institutes of Health (NIH), the Centers for Disease Control and Prevention (CDC), and the Food and Drug Administration (FDA). The NTP has not classified the potential of hair dyes to cause cancer. However, it has classified some chemicals that are or were used in hair dyes as “reasonably anticipated to be human carcinogens.”

(For more information on the classification systems used by these agencies, see Determining if Something Is a Carcinogen and Known and Probable Human Carcinogens.)

Are hair dyes regulated?

In the United States, the Food and Drug Administration (FDA) regulates the safety of cosmetics, including hair dyes, but by law there are limits on what the FDA can do. For example, the FDA does not approve each ingredient used in hair dyes before it goes on the market, and in general the responsibility for the safety of products and ingredients falls to the manufacturers.

The FDA can take action if any cosmetics are found to be harmful or in violation of the law (such as being mislabeled). This includes any new ingredients to be used in hair dyes. However, many of the older ingredients in hair dyes (some of which are still in use) were excluded when the FDA was initially given the power to regulate these products back in the 1930s.

If cosmetics (including hair dyes) or their ingredients are found to be unsafe, the FDA can request that the company recall the product, although it can’t require a recall. The FDA can, however, take further steps if needed, such as getting a federal court order to stop sales, requesting that US marshals seize the product, or initiating criminal action.

Should I avoid or limit my exposure to hair dye?

It’s not clear how much personal hair dye use might raise cancer risk, if at all. So far, most studies have not found a strong link between hair dye use and cancer, but more research is needed to help clarify this issue.

Other than recommendations that apply to everyone (such as not smoking, eating a healthy diet, being physically active, and getting routine screening exams), there is no specific medical advice for current or former hair dye users. Smoking is a known risk factor for bladder cancer and some types of leukemia (as well as many other cancers and other diseases), and quitting smoking can improve your health, regardless of whether or not you use hair dyes.[13,14,15]



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Some people might want to avoid or limit their exposure to hair dyes for other reasons. For example:

- Some of the ingredients in hair dyes can cause serious allergic reactions in some people.
- Hair dyes can cause hair loss in some people.
- Some doctors advise women to avoid having their hair dyed during pregnancy (or at least until after the first trimester). Not enough is known about hair dye use during pregnancy to know for sure if this is a problem, but doctors might recommend this just to be safe.

For people who want to dye their hair but are concerned about safety, the FDA has some guidelines:

- Follow the directions in the package. Pay attention to all “Caution” and “Warning” statements.
- Be sure to do a patch test for allergic reactions on your skin before putting the dye in your hair. Do a patch test before every use. (Some people become more allergic to certain ingredients the more they are exposed. You may not have an allergic reaction the first time you use a product but you may the second or even third time, so it's important to keep checking.)
- Wear gloves when applying hair dye.
- Don't leave the dye on your head any longer than the directions say you should.
- Rinse your scalp thoroughly with water after use.
- Never use hair dye to dye your eyebrows or eyelashes. This can hurt your eyes. You might even go blind. The FDA does not allow hair dyes to be used for eyelashes and eyebrows.
- Keep hair dyes out of the reach of children.
- Do not scratch or brush your scalp for three days before using hair dyes.
- Do not dye your hair if your scalp is irritated, sunburned, or damaged.
- Wait at least 14 days after bleaching, relaxing, or perming your hair before using dye.

Some hair dye products are vegetable based. These products may have some drawbacks, such as not being able to change hair color drastically or having the color fade sooner than is seen with permanent dyes (unless they contain some of the same ingredients as the permanent dyes). But they could be another option for those people concerned about hair dye safety.

### III. RESULTS

Hair dyes and their ingredients have moderate to low acute toxicity. Human poisoning accidents are rare and have only been reported following oral ingestion. Contact sensitisation to hair dyes has been a safety issue, mainly as a consequence of unprotected professional exposure. Although the use of hair dyes has dramatically increased in industrialised countries during the last decades, the prevalence of sensitisation to hair dyes in the general and professional populations has stabilised or declined. In vitro genotoxicity tests on hair dye ingredients frequently had positive results, although their correlation with in vivo carcinogenicity for the chemical class of oxidative hair dye ingredients (aromatic amines) is uncertain. Positive in vivo genotoxicity results on hair dyes are rare. Studies in man found no evidence of genotoxic effects of hair dyes or their ingredients. On the basis of mechanistic studies, some in vivo positive hair dye ingredients (p-aminophenol, Lawsone) have been shown to pose no or negligible risk to human health. Although a recent case-control epidemiology study suggested an association of hair dye use and bladder cancer, a number of other studies, including prospective investigations on large populations, found no or negative correlations for bladder or other cancers. Although in vivo topical carcinogenicity studies on hair dye ingredients or commercial formulations yielded no evidence for systemic toxicity or carcinogenicity, oral carcinogenicity studies on hair dye ingredients at oral doses up to the maximum tolerated dose (MTD) suggested that some ingredients are carcinogenic in rodents.[16,17,18] Human systemic exposure to various <sup>14</sup>C-labelled oxidative hair dyes under conditions of use was



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below 1.0% of the amount applied. Conservative risk assessments suggested no or negligible cancer risk, including for ingredients that were found to be positive in oral carcinogenicity studies. The results of reproductive toxicity studies and epidemiological investigations suggested that hair dyes and their ingredients pose no risk of adverse reproductive effects. In conclusion, the weight of evidence suggests that consumer or professional exposure to hair dyes poses no carcinogenic or other human health risks.

Glowing hair reflects a person's state of health, as well as creates that beautiful look that we all want to keep forever!

If you are thinking about coloring your hair, it's worth exploring natural options to bring out highlights, to add a little shading or to cover gray. Using a natural product, such as Color by Nature Lustrous Henna® is very safe and beneficial to your hair than a conventional hair dye that may completely damage your hair and scalp with prolong use.

"Conventional dyes contain high level of toxic chemicals that can be absorbed through the scalp, where there is a rich blood supply. Then these chemicals circulate throughout your body, where they can be stored in the tissues and cause adverse health effects," says Marianne Marchese, ND, who practices natural medicine at a Woman's Time Clinic in Portland, Oregon.

A recent study conducted at Yale University found a link between permanent hair dye and Non-Hodgkin's lymphoma. One study for example, suggested that woman over the age of 50 who have used permanent hair dyes for ten or more years have an increased risk of breast cancer. Yet another discovered that users of permanent hair dyes are 2:1 times more likely to have bladder cancer. Other studies have linked the use of hair dyes to allergies and skin disorders like eczema and to far more serious diseases like leukemia and ovarian cancer.

Such study results should not be surprising when one considers the number of toxic ingredients used by both salon and consumer hair coloring formulas. In one analysis of popular brands and formulations, Consumer Reports found nearly 20 different ingredients that were classified as potential human carcinogens. The suspects included such heavy oncological hitters as coal tar derivatives, para-phenylenediamine (PPD), (which can also cause blindness), bezenediamine dihydrochloride, and aminonline dihydrochloride. Other hazardous ingredients include, ammonia, peroxide and lead, a heavy metal commonly found in products that gradually color hair over time with many repeated applications.

Fortunately, a nontoxic alternative to synthetic hair colorants does exist, in addition to the many ready-made formulas like henna.

## IV. CONCLUSION

Chemical hair dyes have become a popular choice for people looking to enhance their appearance and change their hair color, but they come with several negative effects that are harmful to both the hair and the person using them.

One of the biggest concerns with chemical hair dyes is the presence of harsh chemicals like ammonia, hydrogen peroxide, and parabens, which can cause damage to the hair and scalp. For instance, ammonia can make hair dry and brittle, while hydrogen peroxide can strip the hair of its natural oils and leave it dull and prone to breakage. Additionally, these chemicals can lead to itching, redness, blisters on the scalp, and even permanent hair loss.

Additionally, chemical hair dyes may pose a long-term risk to health. Studies have shown that some of the chemicals in hair dyes may increase the risk of cancer and be carcinogenic. They can also trigger allergies, skin sensitivities, and breathing difficulties.

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Furthermore, frequent use of chemical hair dyes can negatively affect the hair's appearance and health, making it dull, lifeless, and prone to breakage, leading to the need for more frequent hair cuts and styling, which can be time-consuming and costly.

In conclusion, while chemical hair dyes offer the convenience of instant color change, they can also have negative consequences on the hair, scalp, and overall health. It's important to consider alternative hair coloring options like herbal or natural dyes, which are gentler and have fewer side effects. By making informed choices, you can have healthy, beautiful hair that looks and feels great.

The natural alternative to chemical hair dye, Indigo powder

Indigo powder is a natural hair dye that has been used for centuries for hair coloring. Here are some of the benefits of using indigo powder for dying hair:

1. **Safe and Non-Toxic:** Indigo powder is made from a natural plant and is free of harsh chemicals and toxins that can harm the hair and scalp. This makes it a safe alternative to chemical hair dyes.
2. **Long-lasting Color:** Indigo powder can provide a long-lasting, deep blue-black color that is vibrant and natural looking. The color can last for several weeks and will gradually fade over time, allowing for a more natural transition to a new color.
3. **Nourishes Hair:** Unlike chemical hair dyes that can strip the hair of its natural oils, the indigo powder can actually nourish and strengthen the hair. This is because it contains natural compounds that can improve the hair's overall health and condition.
4. **Promotes Hair Growth:** Indigo powder has been known to promote hair growth and reduce hair loss. This is because it can improve the scalp's health and promote blood circulation, which is essential for healthy hair growth.[19]
5. **Environmentally Friendly:** Indigo powder is made from a sustainable and renewable source, making it a more environmentally friendly option compared to chemical hair dyes.
6. **Easy to Use:** Indigo powder is simple to use and can be mixed with other natural ingredients, such as henna, to create custom hair colors. It is also readily available and can be purchased online or at natural health stores.

In conclusion, the indigo powder is a natural and safe alternative to chemical hair dyes. It can provide long-lasting, vibrant color, nourish the hair, promote hair growth, and is environmentally friendly. If you are looking for a natural hair coloring option, the indigo powder is definitely worth considering.[20]

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