

Hair Coloring

History

The dying of hair is an ancient art. In ancient times, the dyes were obtained from plants. Some of the most well known are henna (*Lawsonia inermis*), indigo, Cassia oboyata, senna, turmeric and amla. Others include katam, black walnut hulls, red ochre, and leeks. The development of synthetic dyes for hair is traced to the 1860s discovery of the reactivity of PPD with air. Hair dying is now a multibillion dollar industry that involves the use of both plant-derived and synthetic dyes.

Hair coloring is the practice of changing the color of hair. Common reasons are to cover gray hair, to change to a color regarded as more fashionable or desirable, and to restore the original



hair color after it has been discolored by hairdressing processes or sun bleaching. In the 1661 book *Eighteen Books of the Secrets of Art & Nature*, various methods of coloring hair black, gold, green, red, yellow, and white are explained.

Types of hair coloring

The four most common classifications are *permanent*, *demi-permanent* (sometimes called *deposit only*), *semi-permanent*, and *temporary*.

Permanent Hair Coloring

The most popular way to achieve permanent hair coloring is through the use of oxidation dyes. The ingredients of these products include 1,4-diaminobenzene (historically) or 2,5-diaminotoluene (currently), a coupling agent, and an oxidant. The process is typically performed under basic conditions.

The mechanism of oxidation dyes involves three steps: 1) Oxidation of 1,4-diaminobenzene derivative to the quinone state. 2) Reaction of this diimine with a coupler (more detail below). 3) Oxidation of the resulting compound to give the final dye.

The preparation (dye precursors) is in the leuco (colorless) form. Oxidizing agents are usually hydrogen peroxide, and the alkaline environment is usually provided by ammonia. The combination of hydrogen peroxide and the primary intermediate causes the natural hair to be lightened, which provides a blank canvas for the dye.

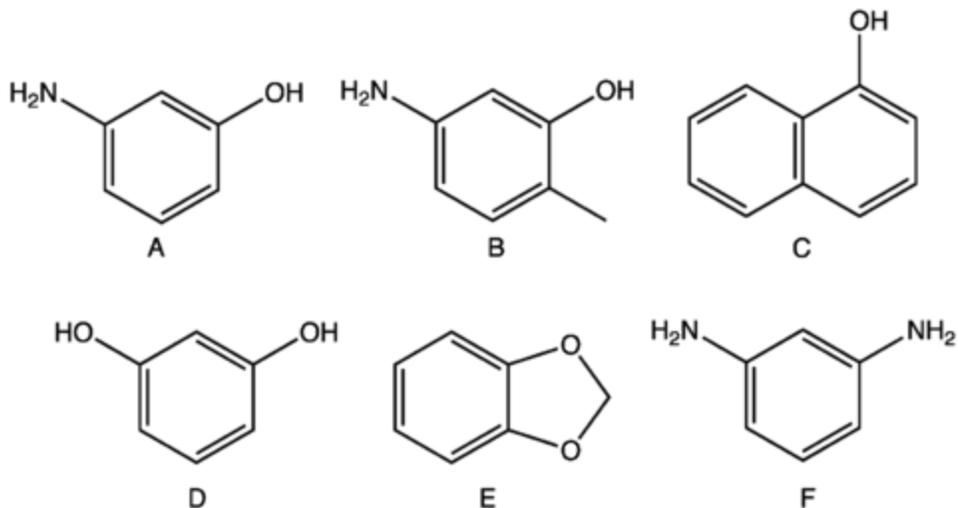
Ammonia opens the hair shaft so that the dye can actually bond with the hair, and ammonia speeds up the reaction of the dye with the hair.

Various combinations of primary intermediates and couplers provide a spectrum of shades of hair colors. The primary intermediates are aromatic para compounds, such as 1,4-



diaminobenzene or 4-aminophenol. The couplers are meta-substituted derivatives of aniline.

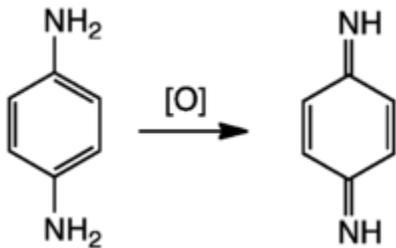
They come in three major classes based on the color that they produce when they react with the primary intermediate.



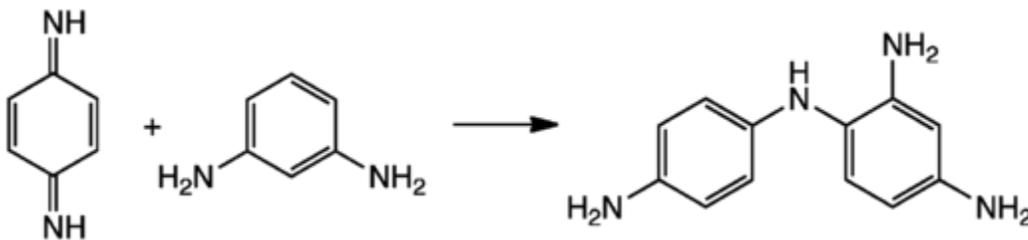
Couplers are chemical compounds that define the color of the hair dye. Shown here are three red couplers (A,B,C), two yellow-green couplers (D,E) and a blue coupler (F).

- Blue couplers include 1-3 diaminobenzene and its derivatives.
- Red couplers include phenols and naphthols, such as 3-aminophenol (CAS#591-27-5), 5-amino-2-methylphenol (CAS#2835-95-2) and 1-naphthol (CAS#90-15-3). The combination of 2,5-diaminotoluene with the coupler 3-aminophenol gives a magenta-brown dye, while the combination of 2,5-diaminotoluene with the coupler 1-naphthol gives a purple dye.
- Yellow-green couplers include resorcinol, 4-chlororesorcinol, and benzodioxoles. These compounds produce broad-band absorption when they react to form dyes, allowing for more natural-looking hair colors. The combination of 2,5-diaminotoluene with the coupler resorcinol gives a greenish brown dye.

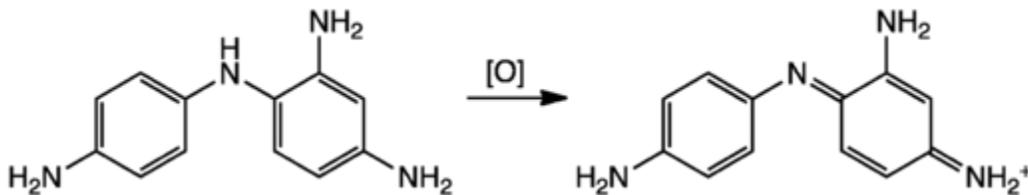
The first step shows the oxidation of p-phenylenediamine to the quinonediimine ($C_6H_4(NH)_2$):



This species exists in equilibrium with the monoprotonated form ($C_6H_4(NH)(NH_2)^+$) (not shown). The second step involves the attack of this quinonediimine on the coupler. In organic chemistry, this reaction is called electrophilic aromatic substitution::



In the third and final step, the product from the quinonediimine-coupler reaction oxidizes to the final hair dye.



The resulting hair dye is also much larger than the precursor molecules, which causes the dye to bond to the hair.

Bleaching

Bleaching is a chemical process for removal of some or all natural or synthetic color from hair. Hydrogen peroxide and ammonium hydroxide are common bleachants. Any color treatment to change to a lighter color requires bleaching.

Subsequent to bleaching, a light colored permanent or semi permanent dye or toner may be applied.

Bleaching has the side effect of raising of the cuticle, making the hair more porous.



Semi Permanent Hair Dye

Semi-permanent hair dye has smaller molecules than temporary dyes, and is therefore able to partially penetrate the hair shaft. For this reason, the color will survive repeated washing, typically 4–5 shampoos or a few weeks. Semi-permanents contain no, or very low levels of developer, peroxide or ammonia, and are therefore safer for damaged or fragile hair. However, semi-permanents may still contain the toxic compound p-phenylenediamine or other such ingredients. The U.S. Environmental Protection Agency reported that in rats and mice chronically exposed to PPD in their diet, it simply depressed body weights, and no other clinical signs of toxicity were observed in several studies.

The final color of each strand of hair will depend on its original color and porosity, so there will be subtle variations in shade across the whole head. This gives a more natural result than the solid, all over color of a permanent dye. However, it also means that gray or white hairs will not dye to the same shade as the rest of the hair. If there are only a few grey/white hairs, the effect will usually be enough for them to blend in, but as the gray spreads, there will come a point where it will not be disguised as well. In this case, the move to permanent color can sometimes be delayed by using the semi-permanent as a base and adding highlights.

Semi-permanent color cannot lighten the hair.

Demi-permanent hair color

Demi-permanent hair color is permanent hair color that contains an alkaline agent other than ammonia (e.g., ethanolamine, sodium carbonate) and, while always employed with a developer, the concentration of hydrogen peroxide in that developer may be lower than used with a permanent hair color. Since the alkaline agents employed in demi-permanent colors are less effective in removing the natural pigment of hair than ammonia these products provide no lightening of hair's color during dying. As the result, they cannot color hair to a lighter shade than it was before dyeing and are less damaging to hair than their permanent counterpart.

Demi-permanents are much more effective at covering gray hair than semi-permanents, but less so than permanents.

Demi-permanents have several advantages as compared with permanent color. Because there is essentially no lifting (i.e., removal) of natural hair color, the final color is less uniform/homogeneous than a permanent and therefore more natural looking; they are gentler on

hair and therefore safer, especially for damaged hair; and they wash out over time (typically 20 to 28 shampoos), so root regrowth is less noticeable and if a change of color is desired, it is easier to achieve. Demi-permanent hair colors are, in essence, permanent color and the darker shades in particular may persist longer than indicated on the packet.

Temporary Hair Color

Temporary hair color is available in various forms including rinses, shampoos, gels, sprays, and foams. Temporary hair color is typically brighter and more vibrant than semi-permanent and permanent hair color. It is most often used to color hair for special occasions such as costume parties and Halloween.

The pigment molecules in temporary hair color are large and cannot penetrate the cuticle layer. The color particles remain absorbed (closely adherent) to the hair shaft and are easily removed with a single shampooing. Temporary hair color can persist on hair that is excessively dry or damaged in a way that allows for migration of the pigment to the interior of the hair shaft. It lasts for about a few hours to 1 day.

Application techniques



Hair color was traditionally applied to the hair as one overall color. The modern trend is to use several colors to produce streaks or gradations, either on top of the natural color or on top of a single base color. These are referred to as:

- **Highlighting**, where sections of hair are treated with lighteners, usually to create blonde streaks.
- **Lowlighting**, where sections of hair are treated with darker hair color.

These can be applied by the following methods:

- **Foiling**, where pieces of foil or plastic film are used to separate off the hair to be colored; especially when applying more than one color.
- **Cap**, when a plastic cap is placed tight on the head and strands are pulled through with a hook.
- **Balayage**, where hair color is painted directly onto sections of the hair with no foils used to keep the color contained.

All application techniques can be used with any type of color. For highlights, the hair will usually have to be bleached before coloring.

Alternative hair colorants

A minority of hair coloring products are designed to create hair colors not typically found in nature. These are available in almost any color imaginable, including green and fuchsia.

These dyes are typically sold in punk-themed stores (such as comic book and music stores), with brand names like "Beyond The Zone", "Splat", 'Fudge Paintbox' 'Crazy Colors' "Clairol Jazzing", "Manic Panic", "Special Effects", "Punky Colour", "Stargazer", "La Riche Directions". A permanent alternative in some colors (such as bold red and dark, inky purples and blues) are

available from big haircare brands. Some alternative color shades are blacklight reactive, to show up under nightclub lighting.

The chemical formula of alternative color dyes typically contain only tint and have no developer. This means that they will only create the bright color of the packet if they are applied to light blond hair. People with darker hair (medium brown to black) will need to use a bleaching kit prior to tint application. Some people with fair hair may benefit from prior bleaching as well. Gold, yellow and orange undertones in hair that has not been lightened enough can adversely affect results, especially with pinks, blues and greens. Although alternative colors are semi-permanent in the cases of some colors, such as blue and purple, it could take several months to fully wash the color from bleached or pre-lightened hair.

Adverse effects of hair coloring

Hair coloring involves the use of chemicals capable of removing, replacing and/or covering up pigments naturally found inside the hair shaft. Use of these chemicals can result in a range of adverse effects, including temporary skin irritation and allergy, hair breakage, skin discoloration and unexpected hair color results.

Additionally, there is ongoing debate regarding more serious health consequences of hair color usage, including lead poisoning.

Skin Irritation and allergy

In certain individuals, the use of hair coloring can result in allergic reaction and/or skin irritation. Symptoms of these reactions can include redness, sores, itching, burning sensation and discomfort. If any of these symptoms occur, alert your hair colorist immediately so that they can

remove the color. Symptoms will sometimes not be apparent immediately following the application and processing of the tint, but can also arise after hours or even a day later. To help prevent or limit allergic reactions, the majority of hair color products recommend that the client conduct a patch test before using the product. This involves mixing a small quantity of tint preparation and applying it directly to the skin for a period of 48 hours. If irritation develops, manufacturers recommend that the client not use the product. A skin patch test is advised before the use of every coloring process, since allergies can develop even after years of use with no reaction.

Hair Breakage

Hair that has been damaged by excessive exposure to chemicals is considered *over-processed*. This results in dry, rough and fragile hair. In extreme cases, the hair can be so damaged that it breaks off entirely. This is especially true for Afro-Caribbean hair, especially if used in combination with relaxers. Treatments are available but the only real solution is to stop the use of chemicals until new hair grows and the damaged hair is cut off.

It is advised that colored hair be deep conditioned regularly, and washed and conditioned with gentle products specifically designed for color-treated hair. This will help keep the hair intact and minimize color fading.

Skin Discoloration

Skin and fingernails are made of the same type of keratinized protein as hair. That means that drips, slips and extra hair tint around the hairline can result in patches of discolored skin. This is more common with darker hair colors and persons with dry absorbent skin.

This discoloration will disappear as the skin naturally renews itself and the top layer of skin is removed (typically takes a few days or at most a week). A good way to prevent dye discoloration is to put a thin layer of Vaseline or any oil-based preparation around the hairline. It is recommended that latex or nitrile gloves be worn to protect the hands.

Unpredictable color results

Several factors influence the final color of the hair following the coloring process.

- For semi-permanent and demi-permanent color, the final color is a blend of the natural color of the hair and the dye color.
- Bleached hair will often require pre-pigmentation before a color application. Dyeing bleached hair brown can result in grey or very ashy (grey sheen) hair.
- Previously color treated hair can react unpredictably with subsequent color treatments.
- Previous use of shampoos which deposit a layer of plastic on the hair can block the action of the dye.
- Presence of minerals, salts, chlorine or other contaminants in the water used in the coloring process
- Certain prescription drugs can alter hair chemistry
- Coloring dark hair to achieve a desirable shade of blond requires bleaching, followed by a secondary color treatment. Bleached hair can still have a yellow or coppery shade. A violet-based color can cancel out yellow tones, and a blue-based shade will cancel out coppery orange.
- Porosity of hair can affect the final shade. Usually porous hair 'soaks' up the color more, therefore often turning out darker than expected.

Professional hair colorists have a number of products to correct or deemphasize unintended hair coloring outcomes.

Health Concerns

- A PPD lead acetate (the active ingredient in gradual darkening products such as Grecian formula) is toxic if ingested.
- Articles link the development of some forms of cancer (including leukemia, non-Hodgkin's lymphoma, bladder cancer, blood cancer, and multiple myeloma) with use of hair color. More specifically, prolonged use of permanent dark hair dyes can double a person's risk of getting some types of blood cancer.
- In 2004 a known human carcinogen, 4-aminobiphenyl or 4-ABP, was found in some hair dyes that one can get off the shelf. However, evidence is limited and inconsistent for the link between cancer from hair dye.

Plant-based dyes

Henna is an orange dye commonly used as a deposit-only hair color whose active component, lawsone, binds to keratin. It is therefore considered semi-permanent to permanent, depending on a person's hair type. Most people will achieve a permanent color from henna, especially after the second dye. With repeated use the orange color builds up into red and then auburn. While "natural" henna is generally a red color, variations exist. These variations usually contain ingredients from other plants and even synthetic dyes.

Indigo is natural dye from a plant (*Indigofera tinctoria*, *suffruticosa*, or *arrecta*) that can be added to henna or layered on top of it to create brown to black colors in the hair. On the color

wheel, henna is orange, and indigo is blue, so as complementaries, the two colors work together to create brown tones. Like henna, indigo may fade after one application, but it becomes permanent on the hair with repeated use.

Using a plant-based color such as henna can cause problems later when trying to do a perm or permanent hair color. Pure imported body art quality henna is claimed not to cause such problems, but most store-bought henna is mixed with additives which can lead to unpredictable results if the hair is later colored. Although it may not be visible on darker hair, the staining from henna will remain for several months and this may only be realized when dyeing is attempted and an unpleasant, permanent orange color results.

Hair highlighting/lowlighting refers to changing a person's hair color, using lightener

Basic foil highlighting

Foil highlighting is the process of using foil to separate strands of hair which will be lightened from strands of hair which will remain its natural color. The process is done by applying lightener to the hair that has been woven and separated using an applicator brush. The foil is then folded as to protect the hair and surrounding area during the "processing" time. This is the amount of time required to achieve the desired results. In highlighting hair [hydrogen peroxide](#) mixed with pigment is used to change the color of the strand^[2] This process is also used in applying "lowlights" to the hair. In this process, hair dyes are used to create strands of hair that are darker than the natural color. The foils are **often used to separate hair strands for high and low lights** during the same process. or haircolor to color strands of the hair in varying sizes. There are four basic types of highlights: foil highlights, hair painting, frosting, and chunking.

Highlights can be done in natural or unnatural colors. Color highlights come in four categories: temporary, semi-permanent, demi-permanent,¹ and permanent. Hair lightened with bleach is considered permanent.

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Hair painting

Hair painting is a method of highlighting hair that may be done at home. Hair painting methods are often permanent and employ a simple hair-painting brush. Hair painting is also used with temporary and semi-permanent types of brushes. While brushes are commonly used in hair painting, one may also use combs to paint or highlight thin-sized strands of hair. **Balayage** is a technique referring to free-form painting on clean, styled hair. The results are subtle, and more natural looking than foiling or chunking.

Frosting

Frosting refers to the process of free-hand lightening the tips of the hair, and is generally performed on men with short hair.

Chunking

Chunking refers to a style of highlight which is larger and thicker than a traditional highlight, rather than to a method of creating highlights. Chunky highlights are generally offered in a wider variety of bold natural colors, as well as a large number of artificial, or unnatural, colors and are used to create more contrast, rather than subtle texture, as in traditional, thinner highlights.



Choosing a Hair Color

Time was when your hair color choices were blonde, red, brunette, and black, but those days are long gone! Each basic hair color comes in a full array of choices from platinum blonde to jet-black. Moreover, the modern consumer must choose from non-traditional hair colors that range from hot pink to chartreuse. However, the wrong hair color choice can give you the blues and leave you red in the face!



First Hair Color Choices

The best method in choosing a hair color is first to choose the results you want from it.

Depending on whether you are covering gray, highlighting a natural hair color, or using hair color to completely change your image, knowing what you want helps you to narrow down hair coloring choices.

Before you get down to choosing a hair color, first decide on your commitment to hair coloring. Temporary hair colors wash out in a shampoo or two, semi permanent products typically last for a couple of months, while permanent dyes may either give you grow-out pains or necessitate frequent root touch ups.

Choosing a Compatible Hair Color

After you've decided on results and made your commitment, it's time to get out the color wheel. Beauty experts tell us that we're either "cool" or "warm" depending on our skin tone, eye color, and natural hair color.

	Cool Category	Warm Category
Eyes	Dark Brown, Black-Brown, Gray Blue, Dark Blue, or Hazel with white gray or blue flecks	Golden brown, Green, Green-Blue, Turquoise, Hazel with gold or brown flecks
Hair	Blue black, Deep brown, Ash brown, Ash Blond, Platinum Blond	Deep brown with gold or red highlights, Red, Strawberry Blond, Gray-Yellow, Natural Golden Blond
Skin	Very dark brown, True olive, Medium pale, Medium with golden undertones, Pale, Bronze	Brown with pink or golden undertones, Peachy or with peachy undertones, Pale with gold undertones, Freckled, Ruddy

Although this is good advice, if you've just finished a tanning session, if you have some complexion problems (Rosacea, liver spots, blemishes), or if your hair color is already not what

nature intended (in other words previously tinted or more salt than pepper), it may be difficult to determine by examining your skin tone and hair color. Don't despair! There is a shortcut!

Examine your wardrobe. Cool hues are green, blue, and violet. Warm hues are reds, oranges, and yellows. Chances are, your wardrobe is a mix with either cool or warm hues in the majority.

Clothing colors that look good on you and make you feel comfortable probably indicate if you're in the cool or warm category. For instance, if olive drab makes you fade into the woodwork, then cool tones like ash blonde (ash tones contain green) are probably not for you.

In addition, most commercial hair colors have aids on the box, yet if you have a hard time deciding which group is your group, you may want to seek the advice of a professional hair stylist.