ANALYSIS OF HEALTH HAZARDS ASSOCIATED WITH HAIR DYES AND CHARACTERIZATION OF TOXIC ELEMENTS PRESENT IN THE DYED HAIR SAMPLE – A CRITICAL REVIEW

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ABSTRACT

At present scenario, the production and usage of hair dye is increasing globally. Due to this, the harmful chemicals present in the in the hair dye product are not only altering the hair structure but also causing severe medical condition like Contact Allergic Dermatitis, Lupus, disruption of CNS function, disruption in endocrine system, which on heavy exposure or chronic amount can become life threatening.

In this paper, different techniques used to analyse the dyed hair samples have been reviewed and the toxic elements present in the hair dyes have been studied. Efforts have been made to suggest some techniques that are non-destructive and can be employed in characterizing toxic elements present in the dyed hairs.

Keywords: *Hair, Contact Allergic Dermatitis, Lupus, Hair Dye, ATR-FTIR*

INTRODUCTION

In forensics, hair is very well known for its property of non-degradable corroborative evidence due to the presence of keratin protein. In general, every human being has different texture and colour of hair which can differentiate race due to the presence of melanin pigment in hair. These pigments are altered by consumers for varied purpose with the help of hair dyes. There are some historical remains which gives footprints about the usage of hair colour naturally (vegetables and minerals). The hair of an ancient Egyptian mummy was discovered to be coloured with Henna.

These days,synthetic dyes occupied the market globally because of acceptability of the population and achieving variant shades of synthetic hair colour due to **"AUREOLE"**. Aureole is a penetrating colour was invented by Eugene Schuller in 1907, a French chemist who developed synthetic hair colour. It could lighten and tint hair in one process.

Before synthetic dyes comes into existence some other chemicals are used by the people to get the desired colour or lighten the hair colour such as copper filing or leeches marinated in wine gives darker hair colour, wood ash, sodium bicarbonate to lighten hair colour.

CLASSIFICATION OF HAIR DYES

1. Temporary
2. Semi-permanent
3. Permanent

1. Temporary hair colour

Temporary hair colour is acidic and water soluble. They are less toxic in nature as it does not penetrate hair cuticle layer but absorbed to the follicle which may be readily cleaned later with the use of hair shampoo. Temporary hair colour is generally not preferred by the consumers because of its lower fastness properties (fades faster). Temporary hair dye mostly belongs to azo-compounds, diazo-compounds, nitrocompounds, anthraquinones and aminoanthraquinines, xanthene they produce vibrant colour to the hair.

2. *Semi Permanent hair colour*

Semi-permanent hair colours are made of synthetic materials and are only used to cover grey hair (Draelos 1991). The majority of these products are made up of coal tar dyes with low and medium molecular weights (Draelos 1991). These hair colours have a modest degree of fastness in penetrating the hair shaft. Nitro dyes, basic dyes, and acid dyes are the three kinds. Nitro dyes are aminophenols, aromatic amines, and aminophenyl ethers with nitro groups in their chemical structure.

3. *Permanent (Oxidative) Hair Colour*

Permanent hair colourants, also known as oxidative dyes, are the most widely used type of hair dye. Modern oxidative dyes are made up of a variety of chemicals that serve diverse purposes. This hair dye is made up of two chemicals that are mixed together: ammonia and hydrogen peroxide. Hydrogen peroxide is a bleaching agent that removes the natural colour while also releasing oxygen, allowing the chemical reaction to occur. The ammonia breaks away the hair's outermost layer, known as the cuticle, allowing the other chemical to enter the hair and begin the colour development process. These chemicals are abrasive and can cause hair to stiffen and thin, as well as irritate the skin. Some irritants are ethanolamine, resorcinol, sodium lauryl sulphate, lead acetate, para-phenylenediamine (PPD).

HARMFUL CHEMICALS IN HAIR DYES:

1. PPD (Paraphenylenediamine): PPD is used in all oxidative or permanent hair dyes, related to diamine. A solid form of PPD is also called as a “Henna stone” from the bank of Nile River, which gives instant black colour for body art and require less preparation than natural henna. Black hair dye contains PPD in higher concentration though all colour contains PPD. Black henna is used for body art which contain PPD in higher concentration.
2. Resorcinol: It is used in hair dyes and other cosmetic products. If used in higher concentration or doses it is toxic and can disrupt the function of CNS and leads to

respiratory problem, Skin and eye irritant, skin sensitizer, organ system toxicity and disrupting endocrine system.

3. Ammonia: It is one of the harmful chemical or component used in hair dyes to deposit the colour through Hair cuticle. Due to the above action the hair cuticle become damage and degrades the hair structure. This result in dry brittle and unhealthy hair. As ammonia is an alkaline chemical which used to raise the pH level of hair which in result lift the cuticle of the hair that protects the inner part of the hair. Ammonia is used to lighten the natural pigment of hair so that it can recoloured.

EFFECTS OF DYES:

1. PPD (para-phenylenediamine)

i. Lupus
ii. Non-Hodgkin lymphoma
iii. Allergic reactions (contact allergic dermatitis)
iv. Rhabdomyolysis

i. Lupus

Also known as Systematic lupus erythematosus. In oxidative hair dye lupus initiating chemicals are used called aromatic amines (PPD) and Hydrazine. It is inflammation causing disease that occurred when immune system attacks its own tissue (autoimmune condition). Lupus use to damage certain body parts/organs such as joints, skin, blood cells, kidneys, brain, lungs and heart.

Lupus is of two types:

1. **Discoid Lupus**: It generally affects the skin which causes rashes. These rashes start in small area and can spread wider on the skin.
2. **SLE (Systematic lupus erythematosus):** It generally affects different body parts /organ which can be mild or severe.

Symptoms:

a. **Pain in joints:** One of the main symptoms of lupus suffering patients are joint pain, swelling and stiffness. Lupus may cause permanent change and damage to the shape of joints. People may also suffer from joint hypermobility conjoining lupus. Joint hypermobility occurs when joints are very pliable which can lead to joint pain, dislocation, poor balance.

b. **Rashes on skin:** when some body parts exposed to sun it develops rashes mostly on face and hands. On face the butterfly shaped rashes over checks which is commonly in lupus. On hand the fingers change their colour, first Pale, Blue, and then Red during cold weather. This phenomenon happens due to narrowing of the blood vessels which on result reduces the blood supply to limbs (finger and toes).

c. **Blood:** People having lupus may suffer from low number of platelets (responsible for blood clotting). Lupus can also cause anaemia (lack of red blood cells which carry oxygen to all over body) due to which person can suffer from shortening of breadth and gets tired fast.

d. **Kidney:** People suffering from lupus have problem with their kidney function. As it plays lots of vital role such as removing of toxins from the blood. It causes high blood pressure. There are no visible or severe symptoms are noticeable until kidney gets damaged severely.

ii. Non-Hodgkin Lymphoma

Non- Hodgkin lymphoma is also called as lymphoma which is a type of Cancer that affects human lymphatic system (part of immune system). Initiation site in body where lymphoma can show its affect. Lymph tissues are the most probable site to start lymphoma, these are:

i. **Lymph nodes:** These nodes are bean shaped and size up to 0.1 to 2.5cm long. The job of lymph node is to collect lymphocytes (WBC's) and other immune cells all over the body which are connected to lymphatic vessels such areas are chest area, abdomen, pelvis are involved.

ii. **Spleen:** The organ helps to make lymphocytes and other immune cells also helps to store new blood cells and remove out or filter damaged or cell waste, bacteria.

iii. **Bone marrow:** Bone marrow is a tissue present in the centre (medullary cavity) of long flat bones such as the Sternum and hip bone where new blood cells are made.

iv. **Thymus:** Thymus located behind the sternum also called breastbone but between the lungs. Almost top of the Heart which is along trachea. Thymus gland secretes thymosin hormone which is responsible for maturation of helper T-Cell.

v. **Tonsils and Adenoids**: Also known as nasopharyngeal Tonsil. These are located at the back of the throat which helps to make antibodies against the foreign matter which gets entered in through breathing or swallowing something.

vi. **Digestive tract:** Certain organs that comes under digestive system such as stomach, intestine, etc. have lymphatic tissue which can be targeted by Non-Hodgkin Lymphoma.

iii. Contact Allergic Dermatitis

Contact allergic dermatitis due to PPD present in hair dyes ranges from mild to severe life-threatening symptoms. As the name suggest it occur when an allergic substance comes in contact to sensitive area on skin. The area which it gets severely affect are:

- Face, cheeks, nose, neck, Hands
- PPD can also affects eyelids
- It affects neck scalp skin

iv. Rhabdomyolysis

It is also known as rhabdo. When some broken or damaged muscle further break and release muscle fibre (myoglobin protein) content into blood stream. Which may further cause kidney damage. Other symptoms associated with Rhabdomyolysis are Muscle stiffening, Muscle pain, Red and dark brown colour urine, Weight gain, Weakness etc

v. Resorcinol

The harmful effect associated with resorcinol are:

a. Disruption of CNS function also leads to respiratory problem.
b. It disrupt endocrine system.
c. Irritant (skin, eye, organ system toxicity)

ANALYTICAL INSTRUMENTS FOR DETECTION OF HAIR DYE COMPONENTS

1. *HPLC (High Performance Liquid Chromatography):*

HPLC is one of the most acceptable analytical technique used to separate mixture of compounds, including different types of stationary phase and selective types of mobile phase followed by varied range of detectors. Reverse phase HPLC combine with UV detection is used (Ghosh et al. 2008).

2. *Gas Chromatography-Mass Spectrometry:*

The most significant technology for analysing volatile components is gas chromatography (GC). In permanent hair dyes, GC was used to examine three hazardous diamines, including p-phenylenediamine, 2,5-diaminotoluene, and 2,4-diaminoanisole. (1980, Choudhary) (Ghosh and colleagues, 2008).

3. *ATR-FTIR:*

Attenuated total reflection- Fourier transformation infrared spectroscopy is one of the non-destructive techniques with less or no sample preparation for the analysis of the sample.
ATR-FTIR technique is used to determine the concentration or quantity regarding functional groups present in each compound and its spectrum is considered as a fingerprint of compound**.** It is also one of the efficient techniques used in characterization of organic compounds. (Manheim et al, 2016).

CONCLUSION

The increase usage of hair dyes by the consumers and adopting the Morden lifestyle may result in the certain life-threatening events such as lupus, non-Hodgkin lymphoma, rhabdomyolysis, contact allergic dermatitis etc due to present of harmful components in the hair dyes mostly ppd, resorcinol and ammonia and many more which are not present in standardized amount in

local hair dyes. Due to the above concern problems, there are certain analytical instruments which have been used for analysis such as HPLC, GC and ATR-FTIR.

Out of various analytical technique like HPLC, MS, GC/GCMS, ATR-FTIR, ATR-FTIR is the most efficient, sensitive technique with less or no sample preparation and less time-consuming technique for the analysis of toxic elements present in the dyed hair sample.

ATR-FTIR technique is very useful for forensic investigation because this technique needs very less quantity of sample, and less time consuming for the result outcome, also do not need any complex sample preparation. Further it allows very thin sampling path length and depth of penetration of the IR beam into sample. It is also non-destructive technique for identification and characterization of different types of dyes. Dyed hair sample is used to differentiate the hairs which can be found at crime scene in trace amount.

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