e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
(Peer-Reviewed, Open Access, Fully Refereed International Journal)
Volume:06/Issue:04/April-2024 Impact Factor- 7.868 www.irjmets.com

A REVIEW: HAIR AND ITS THERMAL DENATURATION

Pramod Mali*1, Vikram Hankare*2

*1Affiliation, Department Of forensic, Yashwantrao Chavan Institute of Science, Satara, Maharashtra, India.

*2Affiliation, Department Of forensic, Yashwantrao Chavan Institute of Science, Satara, Maharashtra, India.

ABSTRACT

Hair as trace evidence plays an important role during the forensic investigations. Human and animal's hairs both are often recovered from the scene of crime. Human hair is a vital biomaterial, principally grows as follicle in dermal layer of skin comprises of protein, particularly keratin. Hairs are made up of keratin protein which is potentially affected by the various denaturing agents (Heat, PH, Detergent, soapy water). Hair is approximately consisting 90% of protein. This short review gives an overview about thermal denaturation of keratin protein of bleached-damaged as well as control hair and the analytical techniques that are used to monitor structural changes during thermal denaturation of keratin structure. Hair bears the high range of temperature due to that it has potential to resist the heat provided to hair. However, Continuous transformation of heat can be damaged the integrity of hair structure. It is important to determine what are the actual thermal properties of hair exists.

Keywords: Hair, Forensic Investigation, Crime scene, Keratin, Denaturing agents

I. INTRODUCTION

Human hair is a legitimate and generous source of keratin protein and keratin associated proteins such as KAP and 6-30 KDAa . Hair is complex biological structure that comprises the different nano-fibers and it can vary according to different ethnicities (1).These keratin proteins and keratin associated proteins are abundantly affected by different contaminant agents, which are present on the scene of crime. There are various contaminant agents present on the field namely heat, PH (2), detergent, soapy water etc. In this short paper we are taking the overview of structure of keratin in accordance with the heat as a denaturing agent. Hair is the bio-material which defines the characteristic of mammals. Part of hair under skin known as hair follicle which when taken from the skin known to be the bulb. Hair follicles situated under the dermis layer of skin that holds the stem cells which are not merely re-grows the hair subsequently after hair falls. The part of hair just above the skin known as hair shaft. As per the literature, hair shaft consists the nuclear DNA which supposed to be localized in the region of cuticle (Outer layer) (3). Hair shaft consist most of the keratin protein and made by three layers as cuticle, medulla and cortex.

1. Cuticle: Cuticle is the outer layer of hair shaft which is transparent in nature. Cuticle is made up of scales that are overlap one another to protect the inner structure of hair. It consists two ends younger end and older end, noticeable while examining under microscope.
2. Medulla: Medulla is a center core of cells and filled with the hair. It is a center part of hair having hollow tube-like structure and filled with cells. Medulla sub-divided into three types namely Continuous, Fragmented and interrupted.
3. Cortex: cortex consist large part of the hair shaft. Cortex mainly protected by an outer cuticle layer and it having pigment granules such as melanin that gives color to the hair. Cortex also contains large oval-shaped structure called ovoid bodies.

Structurally, hair having a mesh likes structure due to the alpha helix nature of a keratin formed by an ionic force, Vander Waals force and di-sulphide bonds presents inside the hair. Hair consists 7-20% cystine and alpha helix structure providing outstanding mechanical and protective properties to the hair (5). Keratin associated proteins are globular proteins that consist the high Sulphur material and it behaves as a matrix to crosslink and providing stability to the cortex of hair fiber (6). Keratin is a key protein that are sub-classified as Acidic type-1 and Neutral type-II. These both proteins are coiled together to form alpha helical structure which is known to be pro-filaments. Generally, seven to ten pairs of pro-filaments clusters together to form intermediate filament structure (7). Denaturation enthalpy is correlated with the structural integrity of an intermediate filament while the keratin denaturation is correlated with the cross-linking density of keratin associated proteins. High temperature providing to the hair can disrupt the non-specific bonds that are present within the protein and modifies its

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native structure. Thermal properties that are possess by the hair are- Heat Refusal: Hair is strongly refusing the temperature at a certain limit. Prolonged heat exposure alters and modifies hair structure noticeably. Melting point: Hair possesses a high melting point, which is around 215-235^0 C. Temperature above than mentioned changes the shape of hair. Thermal conduction; Hair does not transfer heat from one object to another as it is poor conductor of heat. Thermal property of hair protects the hair scalp from damage.

There are 86 morphological features of human hair that does not change over time and there is also evidence that the effects of low temperature and ultra-violet irradiation do not exclude the possibility of establishing an origin of the investigated hair from a particular person (8).

Hair is primarily used in determination of elements and medicines content such as organic substances, narcotic substances and metabolites, also hair are valuable source of information concerning exposure to toxic metals such as cadmium, lead or arsenic (9). First study on detection of metal through hair analysis was date back into 70| S and followed by a group of articles confirming the relevance of metal concentration in hair as a proxy of body content in various contexts such as an environmental contamination, occupational exposure or even to assess micronutrient status (10). Hair analysis is potentially used in the detection of long-term use of non-steroidal anti-inflammatory drugs and its relation to gastrointestinal hemorrhage (11). Studies have shown that an acute administration of a drug could be identified with the help of hair analysis when the strand of hair sample after three or four weeks of administration and only 2cm proximal part was highlighted while other segments are negative (12). Hair mineral analysis purely indicates the mineral composition accumulated over a long-time span which is proportional to the level of elements in the body and state the chemical calendar of minerals accumulated (13).

Whole Hair shaft is largely contaminated by the exogenous sources or showing extreme resistance to the contaminant or both (14). At room temperature keratin consist remarkable amount of water which is an integral part of hair keratin structure. Thermal properties of hair are strongly affected by the water content present inside the hair.

At temperature about 100^0 C the liberation of water and breakdown of loosely bonds are observed whereas temperature just above 140^0 C neglect the strong bonds that binds the structural integrity together. Keratin structure is largely affected by the temperature interval of 200^{0}C-250^{0}C also the chemical treatment and water content plays an important role in the structural integrity of an alpha helix protein and keratin associated proteins (15). Temperature affected by the water content, conditioners, polymers and heating mode (16). Hair also significantly affected by different washing protocols and changes self-concentration internally.

II. ANALATYCAL TECHNIQUIS USED FOR HAIR THERMAL ANALYSIS

1. **Differential Scanning Calorimetry (DSC**)

   DSC is a thermoanalysis techniques that maintains the sample and reference at equal temperature during the physical transformations of the sample, either more or lesser amount of heat is required to be applied on the sample present inside reference sample span (18).

   A. Power compensated DSC

   B. Heat compensated DSC

   C. Modulated DSC

   D. Hyper DSC

   E. Pressure DSC

2. **THERMOGRAPHY (TG)**

   Thermogravimetric analysis or thermal gravimetric analysis (TGA) is a thermal analysis process that monitors the changing mass of sample while providing the heat.

   Measurement of mass provides information about physical phenomena, such as phase transitions, adsorption as well as chemical phenomena including chemical adsorption, thermal decomposition and solid-gas reaction. TG provides information about the changes in mass as a function of time and under certain atmospheric temperature and the curves occurs shows the information about thermal stability and composition of sample (20).

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1.AFM AND SEM

Atomic Force Microscopy is the imaging technique used in the field of biology to create high-resolution, three-dimensional image of the sample and gives information about the mechanical, electrical and magnetic properties of a sample that sample. Atomic Force microscopy provides the insights into the structure and properties of a sample at a molecular level. Scanning Electron Microscope (SEM) is a type of microscopy which uses an electron instead of light to visualize and magnify the surface of specimen at high resolution. It provides the three-dimensional view of that specimen by the scattering of light inside the microscope.

III. CONCLUSION

This review article summarizes an information that are important by the perspective of forensic science and general science too. Hair is an important biomaterial that consist the Nuclear DNA(NuDNA) and Mitochondrial DNA (MtDNA) in its native protein structure. An outer cuticle layer of hair gives the protection to the hair and maintains the structural integrity of hair shaft but when the hair comes in contact with a decomposing or denaturing agents at that point of time an outer cuticle layer loses its strength and destructs the structure of hair. Hair possesses high temperature range but prolonged temperature transformation alters its composition. In this study, we can conclude that hair has best mechanical, chemical and physical properties which keeps hair protected. It having the foremost thermal properties and showing moderate resistant to the heat.

ACKNOWLEDGEMENTS

We are thankful to the Department of Forensic Science, Yashwantrao Chavan Institute of Science, Satara, India for the valuable and enlightening guidance and for the provoking and cooperative behavior towards us and allowing us to write the review on this topic.

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