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UNIVERSITI TEKNOLOGI MARA

ISETC2025

2 ND INTERNATIONAL SCIENCE, ENGINEERING AND TECHNOLOGY COLLOQUIUM



THE POWER OF SCIENTIFIC INNOVATION

INTELLIGENT SOLUTIONS FOR A SUSTAINABLE WORLD

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EDITORS

Dr. Emi Norzehan Mohamad Mahbob
Dr. Saiyidah Nafisah Hashim
Ms. Lili Widarti Zainuddin
Ms. Nurul Nazwa Mohammad
Ms. Rozaina Saleh

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PREFACE

Welcome to the 2nd International Science, Engineering and Technology Colloquium 2025 (ISETC 2025)!

It is with great pleasure that we present this year's colloquium, a distinguished gathering of scholars, researchers, and professionals dedicated to the advancement of applied sciences. Held virtually on 9th July 2025, ISETC 2025 serves as a platform to highlight cutting-edge research, foster meaningful networking, encourage collaborations, and explore innovative solutions to global challenges.

This year's theme, "The Power of Scientific Innovation: Intelligent Solutions for a Sustainable World" highlights our shared goal to solve global challenges through applied science. It celebrates innovation as a key to building a more sustainable and resilient future. We're proud to feature keynote speakers and presenters who bring fresh insights, bold ideas, and breakthroughs shaping tomorrow's world.

We would like to extend our heartfelt appreciation to the Faculty of Applied Sciences, Universiti Teknologi MARA, Perak Branch, Tapah Campus, for their outstanding support and assistance throughout the planning and execution of the event. Their dedication has been instrumental to the success of this colloquium. We would like to sincerely thank all participants and researchers for their valuable contributions. We also appreciate the reviewers for their careful evaluations and helpful feedback. Your hard work and support mean a lot to us.

As editors, we are proud to present this collection of proceedings. It is an honour to bring together the interesting and meaningful work of our speakers and authors. We hope the ideas shared will lead to new discoveries, encourage more research, and help solve global challenges through science and innovation.

Warm regards,

Dr. Emi Norzehan Mohamad Mahbob
Dr. Saiyidah Nafisah Hashim
Ms. Lili Widarti Zainuddin
Ms. Nurul Nazwa Mohammad
Ms. Rozaina Saleh

ISETC 2025 Proceedings Editors

IMPACT OF AGE, GENDER AND CHEMICAL TREATMENTS ON HAIR DAMAGE CHARACTERISTICS: INSIGHTS FOR FORENSIC ANALYSIS

Ummu Sa'adah Abdurahman[1], Mohamed Izzharif Abdul Halim[2*], Umi Kalsum Abdul Karim[2]

[1]*School of Chemistry and Environment, Faculty of Applied Sciences, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia*
[2]*Faculty of Applied Sciences, Universiti Teknologi MARA, Perak Branch, Tapah Campus, 35400 Tapah Road, Perak, Malaysia*

**Corresponding author: izzharif@uitm.edu.my*

Abstract: This study investigates the structural characteristics of human scalp hair to understand the impact of age, gender and chemical treatments on hair damage using compound light microscopy. Hair samples were collected from both male and female which across various age groups and including subjected chemical treatments such as dyeing, rebonding and curling. The samples were analyzed at different segments (top, mid and end) to observe the damage patterns by observing the cuticle, cortex and medulla. Results revealed that younger individuals exhibited intact cuticle layers and uniform shaft morphology, while older age groups showed progressive damage such as cuticle erosion, fraying and pigments loss. Next, due to grooming habits, gender-based differences indicated more frequent surface damage in females. Chemically treated hair demonstrated the most severe structural alterations including disrupted cuticles and uneven pigmentation. These findings highlight how light microscopy and scanning electron microscopy can help forensic investigations, especially when DNA evidence is limited or unavailable by providing structural indicators of age, gender and hair treatments.

***Keywords*:** *Hair structure, light microscopy, chemical treatment damage*

INTRODUCTION

Hair is often encountered in forensic investigations due to its resistance to decomposition and ease of transfer (Nolan & Linacre, 2024). In circumstances where DNA analysis is not viable, morphological examination of hair can offer valuable insights (Ohira et al., 2018). Previous research has highlighted the influence of intrinsic factors such as age and gender, and extrinsic factors like chemical treatments, on hair structure (Adav et al., 2023). The structural components of hair are cuticles, cortex, and medulla. These can exhibit damage patterns that reflect an individual's demographic and grooming history (Funes et al., 2023). This study aims to (i) investigate the effect of age, gender and chemical treatments on the structure of human scalp and (ii) compare the effectiveness of compound light microscopy (CLM) and scanning electron microscopy (SEM) in examining the structure of human scalp hair.

MATERIALS AND METHODS

Scalp hair samples were collected from individuals across various age ranges (7-68 years) consist of both females and males. Chemically treated samples were categorized into dyed and rebonded hair from adults aged 20-30 years. Samples were cleaned with deionized water and air-dried. Each hair strand was sectioned into top, mid and end regions. Next, the sample was mounted on slides using nail polish. Then, the hair samples were observed under a compound light microscope at 10x and 40x magnification. In addition, scanning electron microscope was used to enhance the result with 1.5kx magnification. At last, structural damage was categorized by observing the key structural features including the cuticle layer integrity, cortex thickness and the visibility of medulla across the groups.

RESULTS AND DISCUSSION

Table 1. Summary of hair damage characteristics under microscopy method

Variable	Condition	Cuticle	Cortex	Medulla	Damage Level
Age	Young	Smooth, clearly defined	Uniform pigment	Central, continuous	Low
	Old	Frayed, eroded	Pigment loss, thinning	Discontinuous/unclear	High
Gender	Male	Smooth or slightly rough	Uniform pigment	Usually absent	Low to Moderate
	Female	Rough, signs of styling damage	Irregular pigment distribution	Usually absent	Moderate to High
Chemical Treatment	Natural	Clear, overlapping, intact	Uniform pigment	Central and visible	Low
	Dyed	Rough, cracked, lifted scales	Patchy pigment, stress marks	Blurry	High
	Rebonded	Cracked, eroded, missing areas	Cortex exposed, uneven structure	Hard to identify	Very High

Age-Based Differences

Younger hair (< 10 years) showed smooth cuticles, uniform pigmentation, and continuous medulla (Alsafy et al., 2024). In contrast, older hair (60–70 years) displayed frayed cuticles, pigment loss, and slightly degraded medulla structures. Age-related deterioration was most visible at the end of the hair. These results align with prior findings where aging was associated with increased cuticle damage and pigment depletion (Funes et al., 2023).

Gender-Based Differences

Male hair generally had smoother cuticles and more consistent pigmentation as less exposure to damaging grooming practices (Yang et al., 2014). Female hair samples, especially from individuals who frequently styled or dyed their hair, showed rougher surfaces, cuticle splitting, and uneven pigmentation. These differences are likely influenced by behavioral grooming patterns rather than inherent biological variation (Davis et al., 2019).

Chemical Treatment Effects

Natural hair maintained structural clarity with intact cuticles. Dyed hair revealed cracked or lifted cuticles and disrupted pigment with cortical stress marks (Hassan et al., 2024). Rebonded hair was the most damaged, showing fractured cuticles and exposed cortex, consistent with high-temperature and chemical exposure effects. Hence, hair subjected to chemical treatments showed significantly higher structural damage compared to untreated hair, especially in dyed and rebonded samples (Lee et al., 2020).

Microscopy Comparison

CLM was effective for initial screening providing visibility of cortex pigmentation and medulla positioning but lacked detail on surface damage. SEM provided high-resolution images showing micro-cracks, lifted cuticles, and erosion patterns. CLM is more accessible for basic labs, while SEM offers higher forensic value due to its precision (Ohira et al., 2018).

CONCLUSIONS

This research confirms that compound light microscopy can effectively reveal structural differences in human scalp hair caused by aging, gender-related grooming behavior, and chemical treatments. CLM shows only general features like pigment and medulla position while for the SEM, it reveals clearer damage like cracks, lifted cuticles and erosion. These structural patterns may be used as forensic indicators when DNA profiling is not possible. This approach adds value to forensic investigations by enabling demographic inference and supporting crime scene reconstructions based on hair morphology alone.

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Sekian, terima kasih.

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