

# NON-FORMALDEHYDE BASED SMOOTHING TREATMENTS

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# OUTLINES OF THE STUDY

- INTRODUCTION
- HYPOTHESES
- LITERATURE REVIEW
- METHODOLOGY
- RESULTS & DISCUSSION
- CONCLUSIONS



# GLOBAL Hair Texture Charting System

P R O P E R T I E S	STRAIGHT			WAVY			CURLY			TIGHTLY CURLED		
	1A	1B	1C	2A	2B	2C	3A	3B	3C	4A	4B	4C
TEXTURE	Fine	Medium	Coarse	Fine / Thin	Medium	Coarse	Thin	Medium	Coarse	Fine	Medium / Coarse	Coarse
WAVE PATTERN - DRY	N/A	N/A	N/A	Wavy S-Pattern	Wavy S-Pattern	Wavy S-Pattern	Soft Loopy S-Curl	Medium Loopy S-Curl	Tight Loopy S-Curl	Tight Coils when stretched make an S Shape	Kinky Coils when stretched make an Z Shape	Very Kinky Coils when stretched make an Z Shape
WAVE PATTERN - WET	Straight	Straight	Straight	Straight	Straight	Wavy	Wavy	More Wavy	Wavier	Coiled	Tighter Coil	Tightest Coil
ELLIPTICITY # OF TURNS PER INCH	Low	Low	Low	High	High	High	High	High	High	Very High	Very High	Very High
STYLABILITY / MANAGEABILITY	Low	Medium	Medium	High	Low	Low	Low	Low	Low	Very Low	Very Low	Very Low
BODY	Low Body	Lots of Body	High	Medium	Medium	Medium	High	High	High	Very High	Very High	Very High
STRENGTH / ELASTICITY	Low Elasticity / Industrial Strength	Medium Elasticity / High Strength	High Elasticity / Highest Strength	Medium	Medium	Medium	High	High	High	Very Low - Fragile	Very Low - Fragile	Very Low - Fragile
FRIZZ TENDENCIES	Low	Low	Low	Medium	Medium	Medium	High	High	High	High	High	High
SHINE	High Octane Shine	High	High	Low vs. Type 1	Low vs. Type 1	Low vs. Type 1	Low vs. Type 1 Dull	Low vs. Type 1 Dull	Low vs. Type 1 Dull	Low	Low	Low
MOISTURE CONTENT	High	High	High	Medium	Medium	Medium	Low	Low	Low	Very Low	Very Low	Very Low
SCALP & HAIR - DRYNESS / OILINESS	Oily	Oily	Oily	Normal	Normal	Normal	Normal	Somewhat Dry	Somewhat Dry	Dry	Very Dry	Very Dry
POROSITY	Low	Low	Low	Low	Low	Low	High	High	High	High	High	High
SURFACE SMOOTHNESS	Very	Very	Very	Medium	Medium	Medium	Low	Low	Low	Low	Low	Low



# HISTORY

- HAIR STRAIGHTENING/SMOOTHING WITH FORMALDEHYDE WAS STARTED IN RIO DE JANEIRO, BRASIL IN AND AROUND 2003.
- THE SOLUTIONS OF FORMALDEHYDE @ 1.00% TO 4.5% LEVEL WERE USED TO STRAIGHTEN WAVY AND CURLY HAIR.
- FORMALDEHYDE WAS APPLIED TO HAIR AND HAIR BLOW-DRIED AND FLAT IRONED AT 450°F.
- IT RESULTED IN SMOOTH SHINY AND STRAIGHT HAIR.

# HUMAN HEALTH & FORMALDEHYDE

- FUMES EMITTED DURING THE STRAIGHTENING/SMOOTHING TREATMENTS CONTAINING FORMALDEHYDE CAN CAUSE:

–EYE IRRITATION, RESPIRATORY IRRITATION, AND IRRITATION TO NOSE AND THROAT.

(TOXICOLOGICAL PROFILES, 2010) + (AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY: TOXICOLOGICAL PROFILE FOR FORMALDEHYDE. IN TOXICOLOGICAL PROFILES. ATLANTA, GA.: DEPARTMENT OF HEALTH AND HUMAN SERVICES, 1999)

–BURNING OF EYES AND THROAT, WATERING OF EYES, DRY MOUTH, LOSS OF SMELL, HEADACHE AND FEELING OF “GROGGINESS”. (OSHA OREGON STUDY, 2010)

- **KNOWN HUMAN CARCINOGEN** (NATIONAL TOXICOLOGY PROGRAM. SUBSTANCE PROFILE: FORMALDEHYDE. 12TH REPORT ON CARCINOGENS, 2011)

# Formaldehyde & Government Regulations

- ANVISA (Brazil) + FDA (USA) + REACH (EU): allow the use of Formaldehyde from 0.02% to 0.10% active level as a preservative
- **OSHA** has three airborne exposure levels for formaldehyde:
  1. Permissible Exposure Limit (PEL) IS 0.75 ppm of formaldehyde in 8 hours.
  2. The action level (AL) for 8 hours is 0.50 ppm
    - Short Term Exposure Limit (STEL) of 15 minutes IS 2 ppm

# Formaldehyde & Government Regulations

## NIOSH (National Institute of Safety and Health)

- 8 - hour recommended exposure limit (REL) is 0.016 ppm
- 15 - minute recommended exposure limit (REL-C) is 0.1 ppm

## ACGIH (American Conference of Governmental Industrial Hygienists)

- threshold limit value (TLV-C) ceiling is 0.3 ppm

# GLYOXYLOL CARBOCYSTEINE

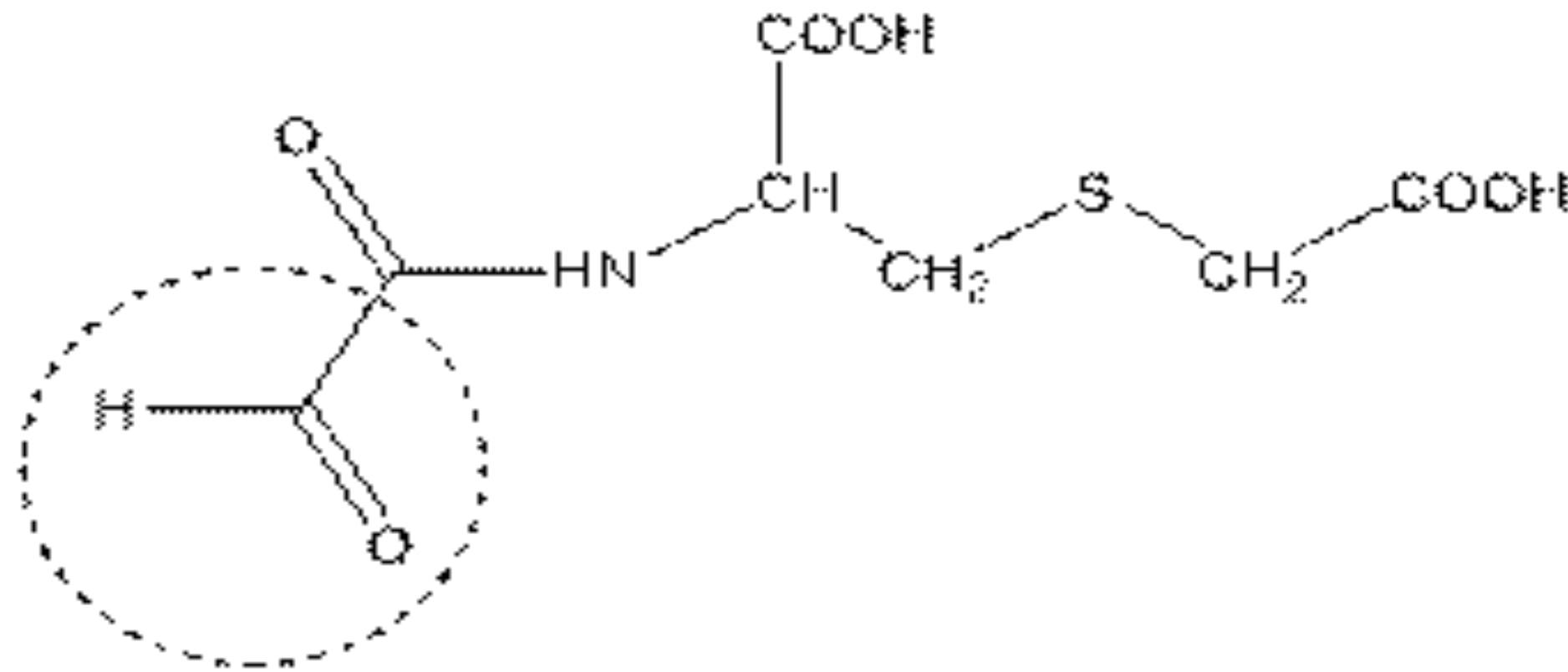
- GLYOXYLOL CARBOCYSTEINE WAS USED AS A SMOOTHING/  
STRAIGHTENING AGENT



# Glyoxylol Carbocysteine

The ingredient used in this study is Glyoxylol Carbocysteine (INCI)

- reaction product of Glyoxylic Acid + Cysteine + Acetic Acid



# Hypotheses

- Hypothesis 1 -The hair volume is reduced significantly.
- Hypothesis 2 – The properties of hair such as ease of combing, shine, and humidity resistance are significantly improved
- Hypothesis 3 – The bulk samples DO not contain formaldehyde.
- Hypothesis 4 – The air analysis during Restructuring liberates a small amount of formaldehyde

## Literature Review

- The use of formaldehyde in Industry and Chemical Reactions of Wool with formaldehyde.
- Analysis of fumes emitted during the treatment of hair fibers with formaldehyde based products – OSHA Oregon Study, Pierce et al Study

# REACTIONS OF FORMALDEHYDE WITH WOOL KERATIN

Formaldehyde can form crosslinks with keratin (1), such as

- —NH—CH<sub>2</sub>—NH— bridges, and
- between N-terminal cysteine and amine groups —S —CH<sub>2</sub>—NH—
- The best pH for the reaction is between 6.0 to 7.0.

1. Hinton, E. (1974). A Survey and Critique of the Literature on Crosslinking Agents and Mechanisms as Related to Wool Keratin. *Textile Research Journal*, p. 256.

## REACTION OF FORMALDEHYDE WITH WOOL KERATIN - continued

- According to Simpson (2002), side chains of amino acids of keratin such as ARG, LYS, TYR, HIS, AND
- amide derivatives of ASP, and GLU react with formaldehyde and some of these reactions can be bi-functional and mono-functional. The simple crosslinks are —CH<sub>2</sub>—.
- It is very difficult to verify the sites and the extent of formaldehyde – keratin reactions as most of the modified side chains of amino acids are not stable to hydrolytic reaction conditions (2).



# OSHA OREGON STUDY

- The bulk sample analysis of smoothing/ straightening products with respect to formaldehyde contents was conducted by using EPA Method 8315.
- The exposures to the hairstylists, any bystanders in the salon, were conducted by using NIOSH 2016 Method.

3. McCarthy, K., McLaughlin, D., Montgomery, D., Munsell, P., Schuster, M., and Wood, M. (2010). *Keratin – Based Hair Smoothing Products And the Presence of Formaldehyde*. OSHA Oregon and CROET. [www.orosha.org/pdf/Final\\_Smoothing](http://www.orosha.org/pdf/Final_Smoothing)

## Pierce, et al Study

- The recent 2011 study of Pierce, et al has reported formaldehyde exposure of four professional hair straightening products where they have used similar methods of analysis:
- The study used EPA 8315 METHOD for bulk analysis of various brands. For hairstylists' exposure the NIOSH 2016 method was employed (6).
- This study utilized both passive and active sampling techniques during sample collections at various stages of the process.

# METHODOLOGY

- Hair Smoothing/Straightening by Visual Method
- Fiber Elasticity Measurements
- Hair Combing – Using Instron
- Moisture Contents– Using MicroWave Resonance Technique
- Hair Shine Using Digital CAMERA
- Analysis of Bulk Sample for Formaldehyde – EPA 8315 Method
- Analysis of Air During Restructuring – NIOSH 2016 METHOD

# Hair Smoothing By Visual Method

- The treated tresses are visually compared against untreated tress for the degree of straightening.
- The degree of smoothing is measured on a Likert Scale of 1 to 5. The '1' being very poor smoothing/straightening to '5' being very good smoothing/straightening.

## Fiber Elasticity Index by Using Dynamic Mechanical Analyzer

- In this test, each single fiber (gauge length = 14.82 mm) was mounted to the submersible fiber specimen clamp containing water. The fiber was stretched to a constant strain or 0.5% of its length for 0.1 minute and allowed to recover for 0.9 minute.
- This process of imposing the strain and allowing it to recover was repeated for a total of 10 cycles.
- Index = After / Before treatment

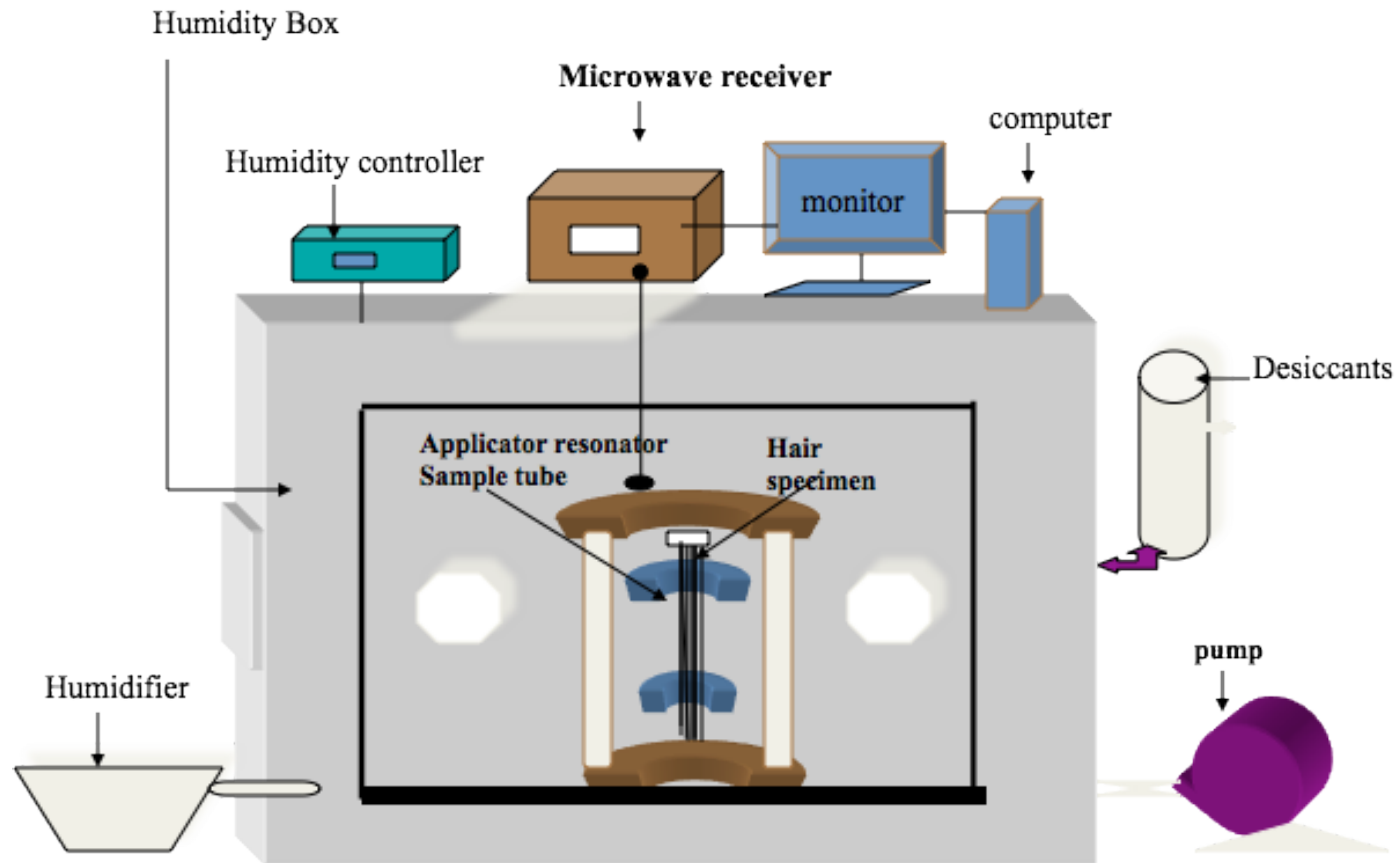
Index = 1.0 (no change); > 1.0 (strengthening); <1.0 (loss in strength)



# Ease of Hair Combing

- The combing test was performed on hair tress using an *Instron Materials Testing System* model 5542, hooked-up to a computer and equipped with Bluehill software
- Load cell capacity of 50 Newton or 5.1Kg.
- Each hair tress was combed before and after treatment. The amount of total energy (milli Joules) required to comb each hair tress was measured.
- the highest force or peak load (gmf) was used to measure the relative ease or difficulty to detangle .
- Five consecutive combing readings were taken from each tress.
- The combing Index (After Treatment / Before Treatment) was calculated FOR 5 TRESSES weighing approximately 4 gm and 7 inches in length
- Combing Energies were noted and compared.

# MOISTURE CONTENTS



**Set-up for measuring the moisture content of hair using  
The microwave resonance frequency**

# MICROWAVE RESONANCE

- MICROWAVES RESONATE IN AN EMPTY CHAMBER.
- INSERTING EACH HAIR SPECIMEN ONTO THE APPLICATOR TUBE SHIFTS THE RESONANCE DOWN AND INCREASES THE BANDWIDTH THAT ENABLE US TO OBTAIN THE MICROWAVE RESONANCE VALUES.
- THESE RESONANCE VALUES WERE CALIBRATED AGAINST A DIRECT LABORATORY REFERENCE GRAVIMETRIC ANALYSIS FROM HUMIDITY RANGE OF 35% TO 80% RH. THE R-SQUARE VALUE OBTAINED FROM THE MEASURED RESONANCE VALUES AND MOISTURE CONTENT OF HAIR WAS 0.96.

# Hair Shine by Digital Camera

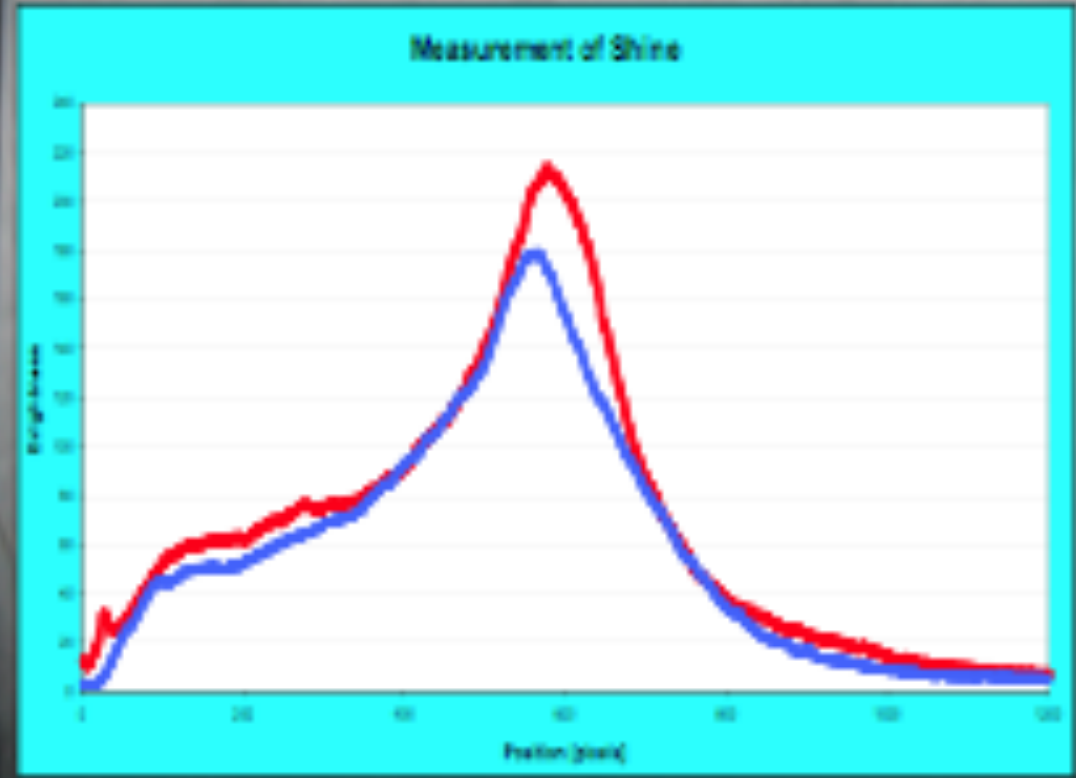
- A LEVEL OF SHINE IS REFLECTED FROM A SURFACE OF THE HAIR TRESS.
- THE DIGITAL CAMERA CAPTURES THE IMAGE THAT IS TRANSFERRED TO AN IMAGE ANALYSIS SOFTWARE (IMAGE PRO 5.1), WHICH CAN PRECISELY ESTIMATE THE BRIGHTNESS AND THE LIGHT INTENSITY OF DIGITAL IMAGE.
- A SELECTED RECTANGULAR AREA OF THE IMAGE IS CROPPED AND THE LIGHT INTENSITY ALONG THIS RECTANGULAR AREA IS MEASURED.
- THE MEASUREMENT PRODUCES THE LIGHT INTENSITY CURVE WITH ONE SIGNIFICANT MAXIMUM. THE HEIGHT  $H$  AND THE HALF-WIDTH OF MAXIMUM  $W$  ARE USED IN CALCULATING A FACTOR  $FS = H/W$ , WHICH IS ADDITIONALLY MULTIPLIED BY 0.729.
- THE SHINE FACTOR FOR THE PERFECT TRESS WOULD BE EQUAL TO 1.



# Measurement of Shine

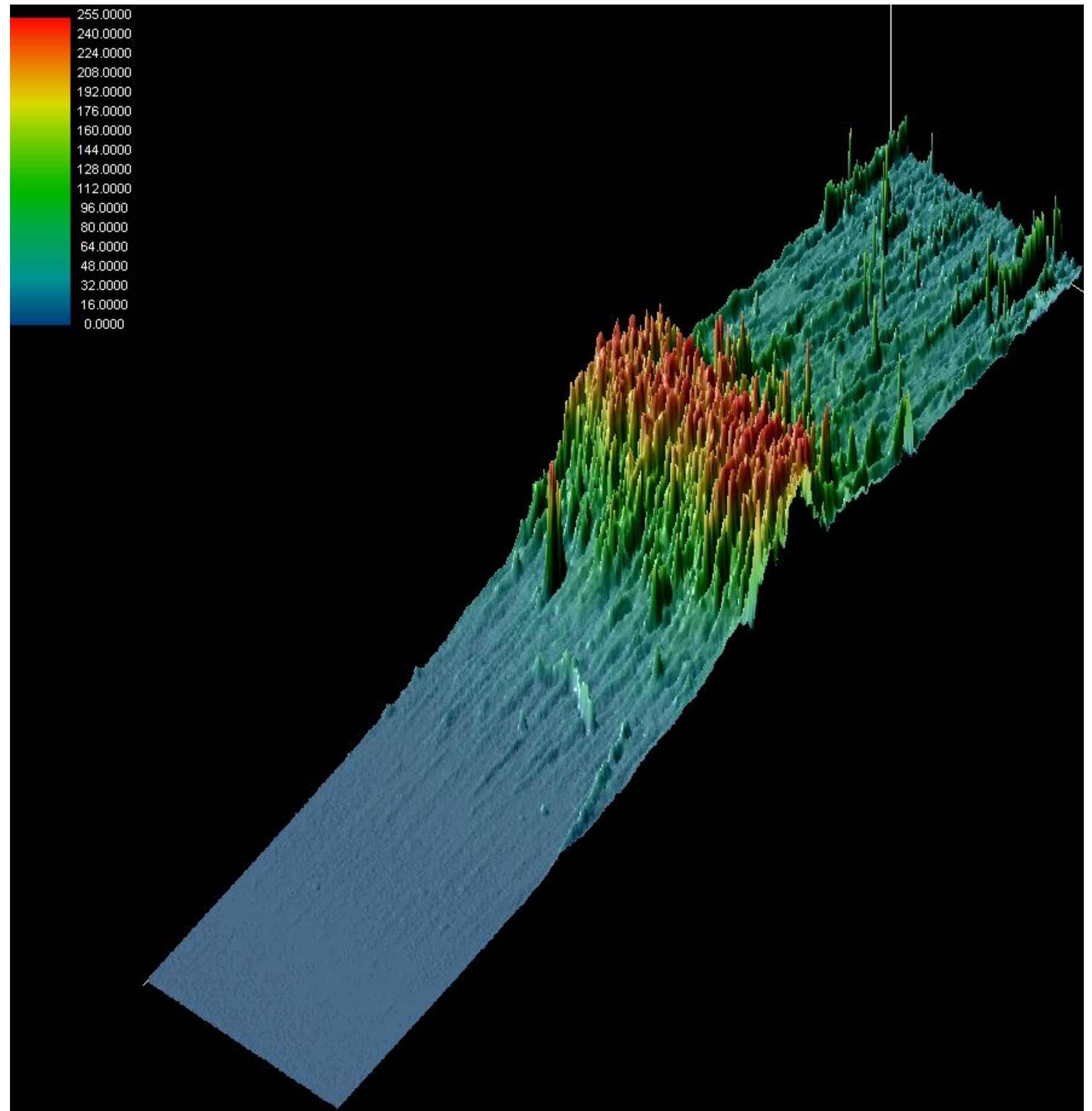
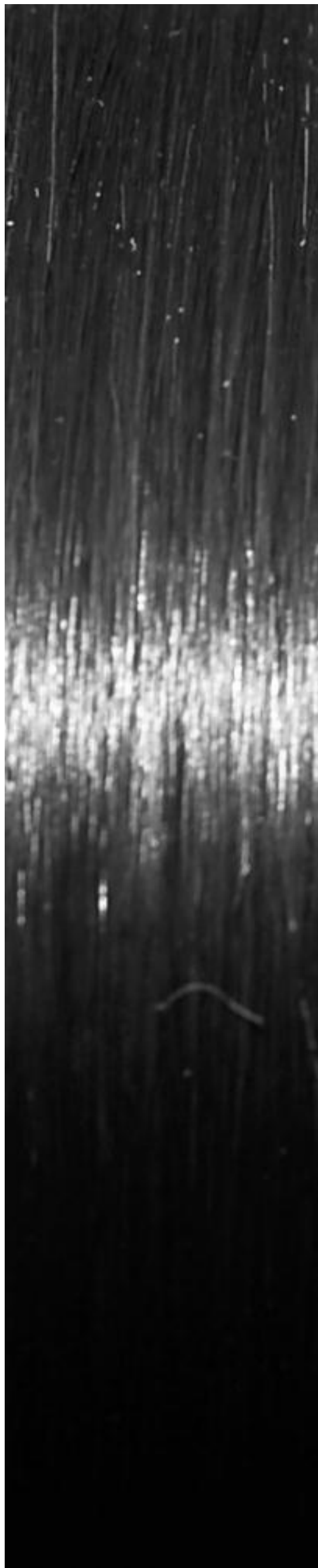


$S_F = 0.77$



$S_F = 0.57$





## Analysis of Bulk Sample for Formaldehyde – EPA 8315 Method

- In this method, the aldehyde present in a product forms its derivatives with 2, 4-dinitrophenyl hydrazine and the RESULTANT derivative is a hydrazone (3). One drop of the bulk is weighed and diluted to 10 milliliters in water.
- Then 200 microliters of this solution are added to 2 milliliters of 2, 4-dinitrophenyl hydrazine solution in acetonitrile. The resultant mixture is analyzed by reverse phase High Performance Liquid Chromatography (HPLC) using a methanol/water eluent with a C 18 column and a diode array detector.

4. Kazuhiro Kuwata, et. al (1979). Determination of Aliphatic and Aromatic Aldehydes in Polluted Airs as 2,4-Dinitrophenyl Hydrazones by High Pressure Liquid Chromatography. *Journal of Chromatic Sciences*, Vol17, p. 264.

## Analysis of Air During Processing of Hair with Restructure – NIOSH 2016

THE UMAX 100 PASSIVE SAMPLERS (CATELOG NO. 500-100 BY SKC INC.) were utilized. This sampler comes in the form of a small BADGE filled with sorbent material that can be easily attached to the collar of the person who is being tested for formaldehyde or can be placed in an area under test. More details can be found on web site [www.skcinc.com](http://www.skcinc.com).

The COLLAR BADGE contains 2, 4-dinitrophenyl hydrazine on silica gel and reacts with any aldehydes present in the air or the fumes from the product under use. The time of exposure is noted. The contents of the BADGE are placed in auto sampler vials and desorbed in 2 milliliters acetonitrile. The tubes are then analyzed by reverse phase High Performance Liquid chromatography on a C 18 column with a methanol/water eluent. The detection is made at 353 nanometers with a diode array detector.

# GLYOXYLOL Carbocysteine Based Smoothing System

I.Shampoo

II.Fiber Restructuring Lotion

III.Conditioning Mask

## ii. Fiber Smoothing Treatment Lotion

- It is based upon Glyoxylol Carbocysteine and Amino Acids at 15% active level
- pH of the product is 1.50 – 1.70
- It is left on the hair for 20 to 30 minutes, blow dried in and then flat ironed at 230°C.
- Hair is rinsed with water, shampooed gently, conditioned, and blow dried and flat ironed for final style.

# Results





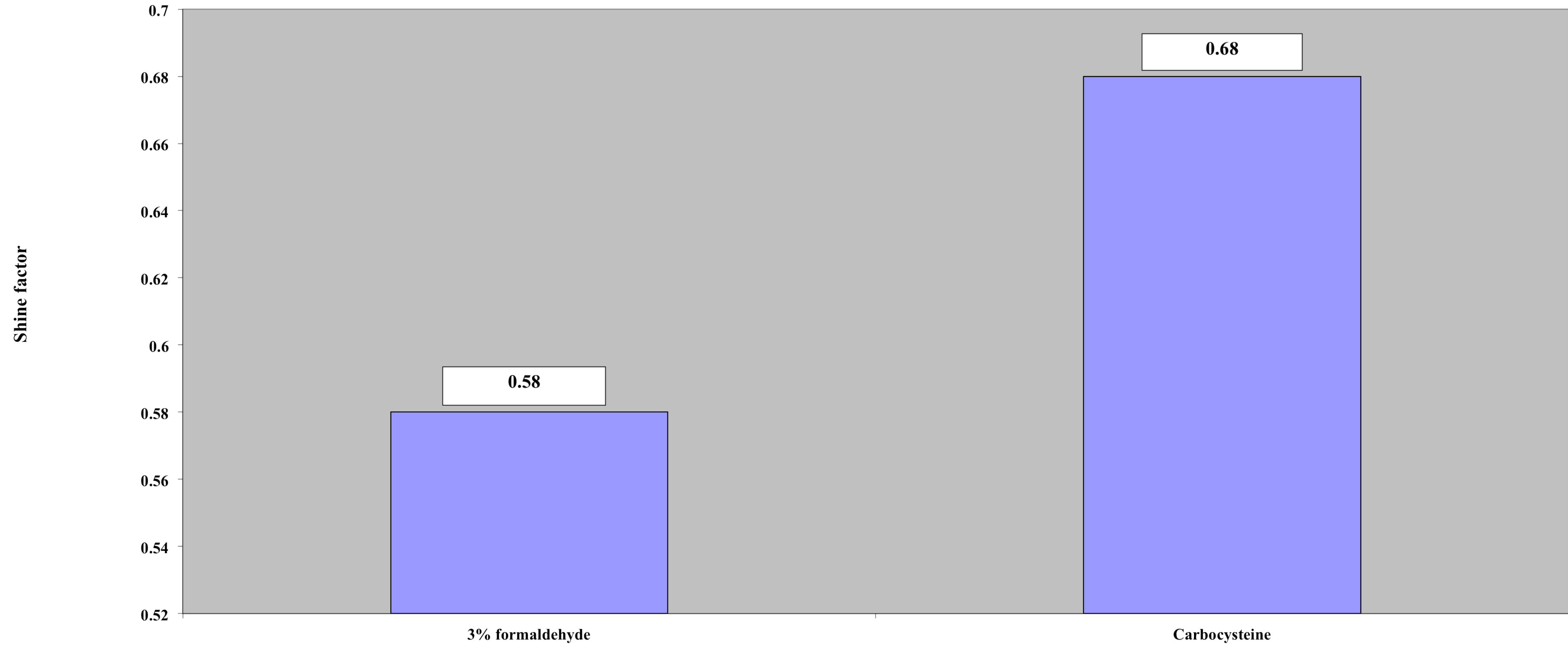




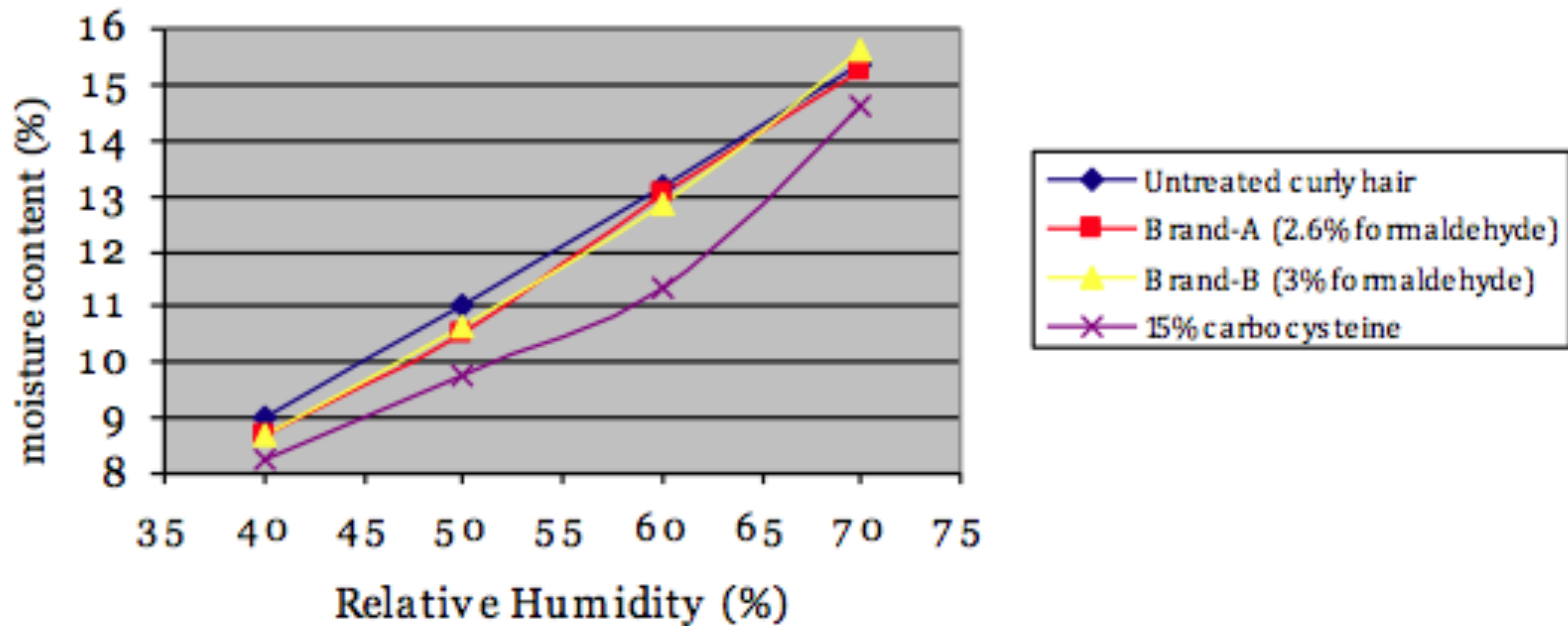




# Hair Shine Comparison – Formaldehyde Vs. Glyoxylol Carbocysteine



Moisture Content v.s. Humidity



# Smoothing System Summary

- Less damaging straightening systems
- Hair volume is reduced significantly for Type 2A, 2B, 2C, and 3A hair types
- Hair is very easy to comb during wet and dry combing
- Hair is resistant to humidity and less prone to frizz
- Hair has radiant shine
- Daily hair styling and manageability of hair is remarkably easy

# Bulk Sample Analysis for CarbonYL Compounds via HPLC

ANALYTE NAME	QUANTITY	MRL (METHOD REPORT LIMIT) (PARTS PER BILLION)
FORMALDEHYDE	UNDETECTED	80,000 PPB
ACETALDEHYDE	UNDETECTED	80,000 PPB

# FORMALDEHYDE ANALYSIS x VARIOUS STAGES

VARIOUS STAGES	RESULTS IN PPM
RESTRUCTURING LOTION APPLICATION (AVE: 19 MINS)	NOT DETECTED
DRYING RESTRUCTURING LOTION ON HAIR (AVE: 18.25 MINS)	NOT DETECTED
FLAT IRONING: RESTRUCTURING LOTION (AVE: 65.4 MINS)	0.14
TOTAL EXPOSURE (8 HOURS TWA)	0.05



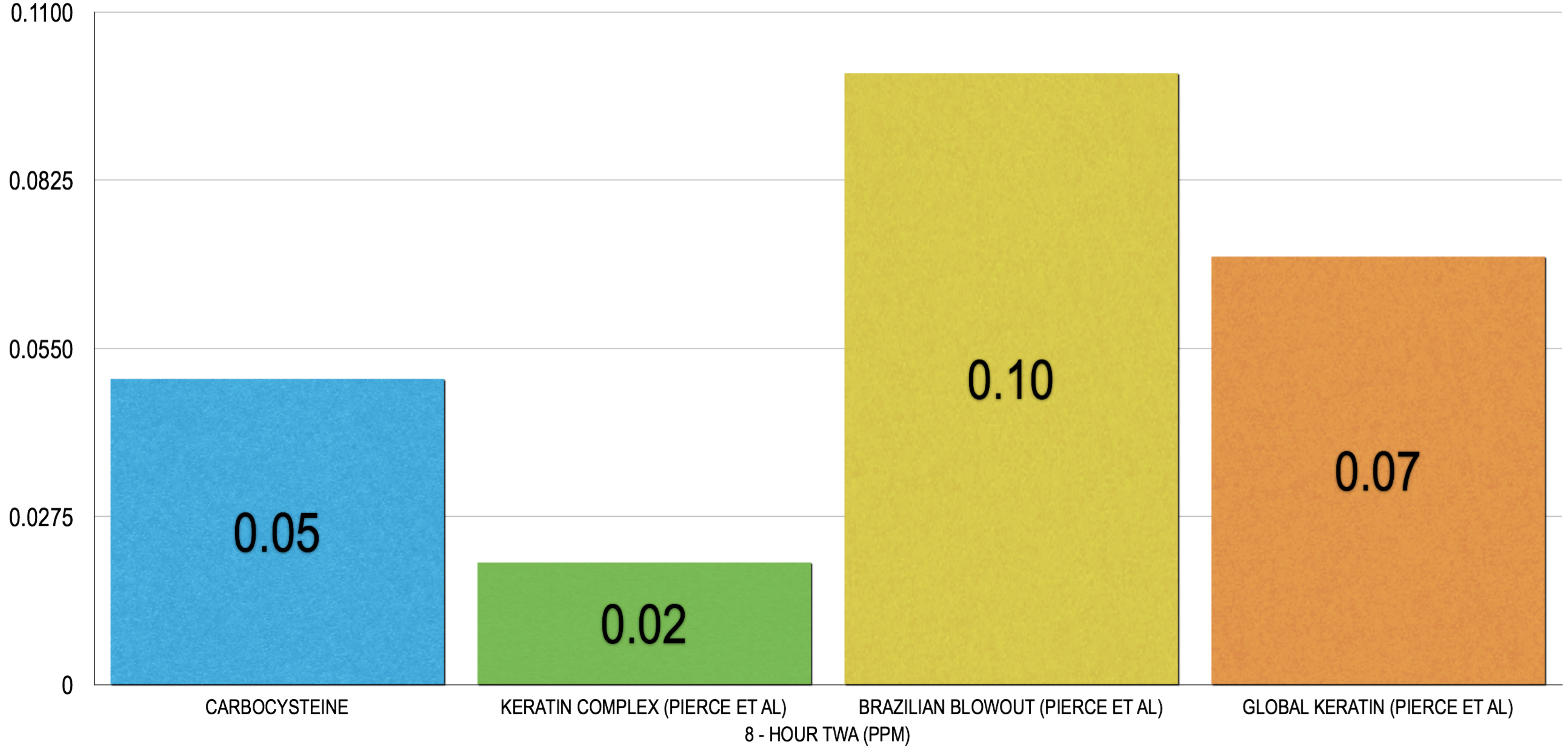


OSHA STEL

ACGIH TLV-C

NIOSH REL-C

# EXPOSURE: RECEPTION AREA + BYSTANDERS



# CONCLUSION

- Glyoxyloil Carbocysteine is very effective in straightening Type 2 European and Hispanic hair.
- The elasticity after straightening with Glyoxyloil Carbocysteine is less than formaldehyde but formaldehyde is not as good OF A straightening agent.
- Also Formaldehyde products have to be left in the hair for 72 hours for better straightening
- The ease of combing of Type 2 hair increases significantly after the treatment.
- The hair shine is significantly higher than formaldehyde treated hair.
- The hair is more resistant to humidity absorption when treated with Glyoxyloil Carbocysteine.
- The presence of formaldehyde is not detected in the bulk sample of Restructuring Lotion containing Gloxyloil Carbocysteine
- The formaldehyde emitted is well within the OSHA guidelines during heat treatment with Restructuring Lotion containing Glyoxyloil Carbocysteine.

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Our Hair Stylists in the our Test Salon



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