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nmRC CASE STUDY

CHARACTERISING BLEACHED HAIR DAMAGE

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Characterizing Bleached Hair Damage

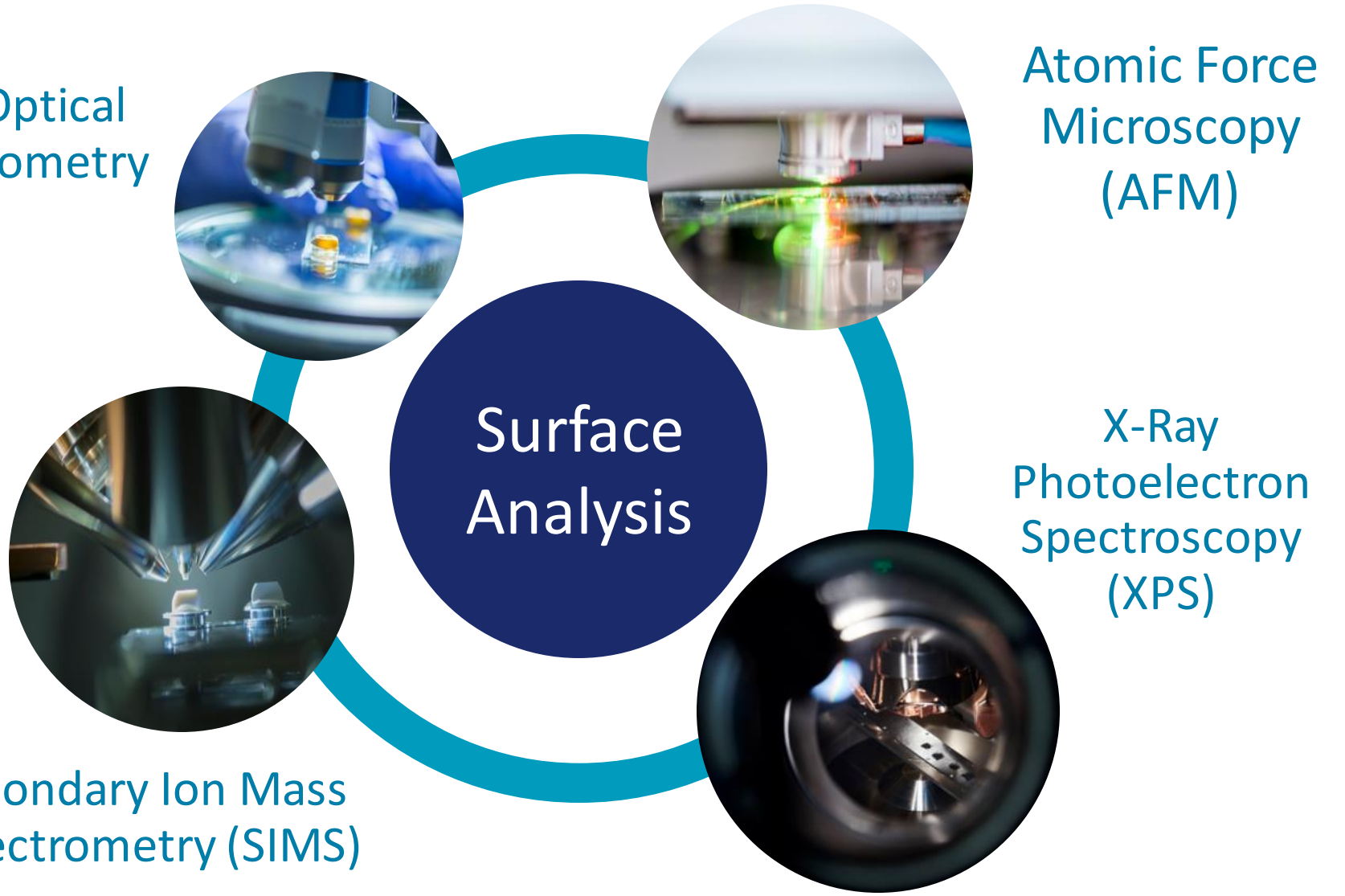
Materials Characterisation Case Study

INTRODUCTION

- Bleaching is a common cosmetic treatment used to eliminate or tone down the natural hair colour.
- However the process also causes damage to the hair fibres e.g. loss of hair cuticles, surface modification etc. that can impact hair feel, volume and longevity.
- Understanding the physical and chemical changes that occur to hair fibres during bleaching treatment plays an important role in the design and development of hair care products that can protect against or reverse some of this damage to preserve the hair state.
- This case study showcases the use of multiple surface analytical techniques to characterise the damage process.

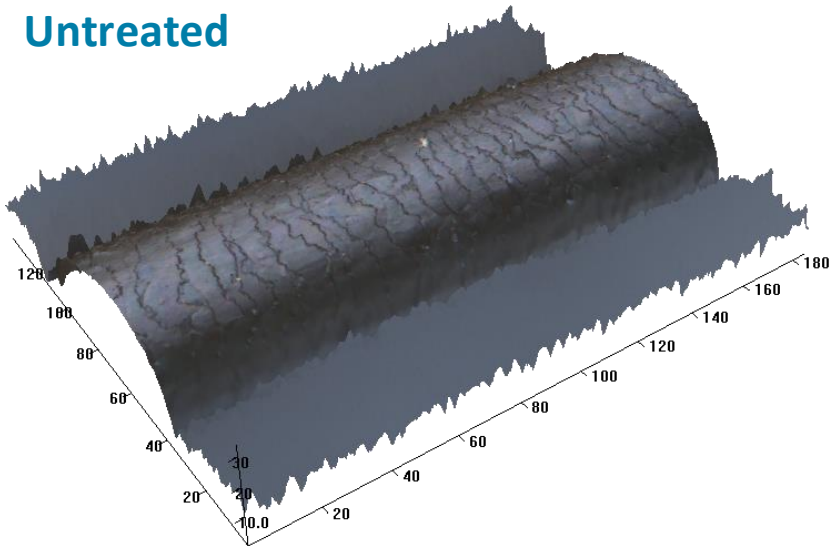
CONFIDENTIAL

INTRODUCTION

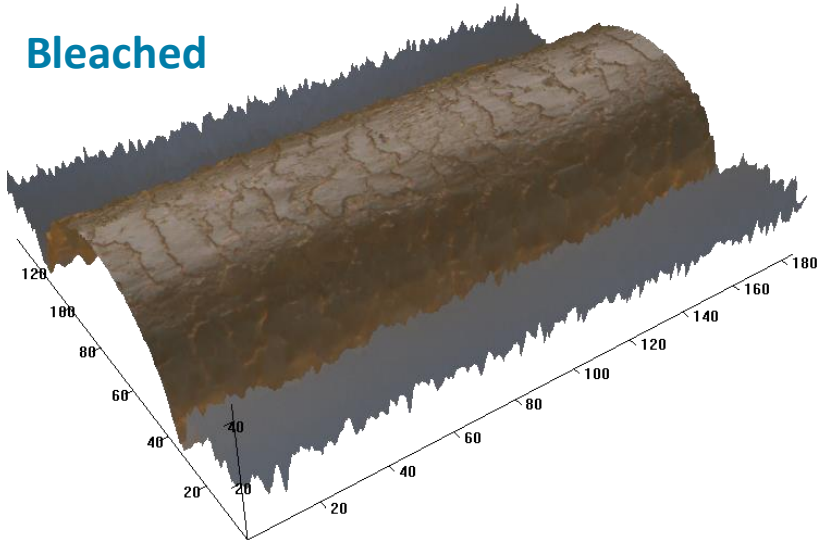


3D OPTICAL PROFILOMETRY

Untreated



Bleached

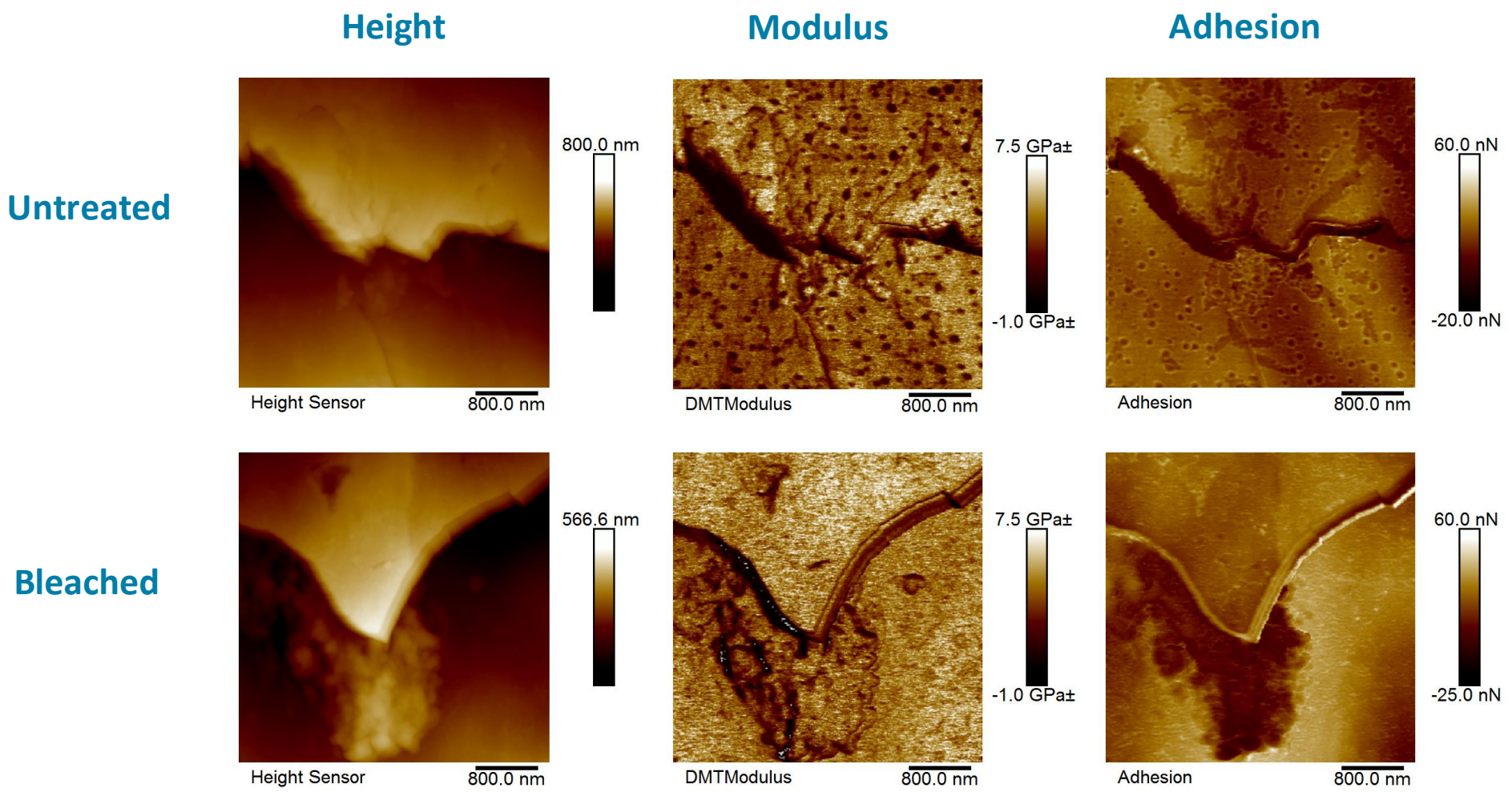


- **Optical profilometry provides true colour 3D imaging of a hair fibre and allows a quick overview of morphological features.**

- The colour of a hair is toned down after bleaching as expected.
- Damage to the hair cuticles after bleaching can be easily identified by comparing the 3D images of untreated and bleached hair fibres.

ATOMIC FORCE MICROSCOPY (AFM)

- **AFM provides nano- and micro-scale characterisation of hair fibre morphology on a cuticle by cuticle basis.**



ATOMIC FORCE MICROSCOPY (AFM)

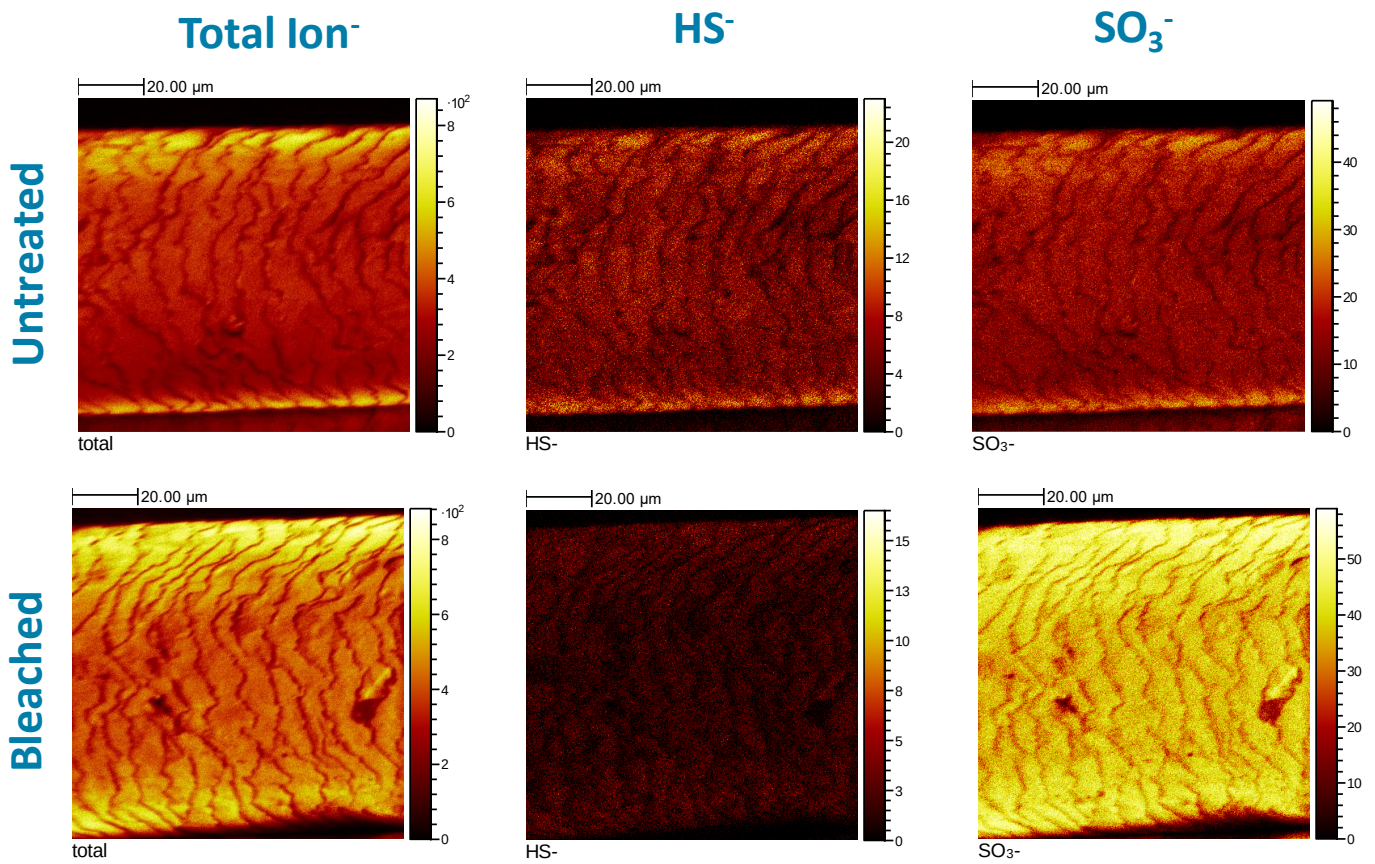
- **Simultaneous mapping of chemical and physical properties of the hair (such as adhesion and stiffness [Young's Modulus]) can be performed using technical variants.**

- While AFM topographic images may show little difference between the surfaces of untreated and bleached hair fibre cuticles, the stiffness and adhesion data highlight variation induced by the bleaching process.
- Bleaching can be seen to have removed some native hair structure and modified the cuticle surface.

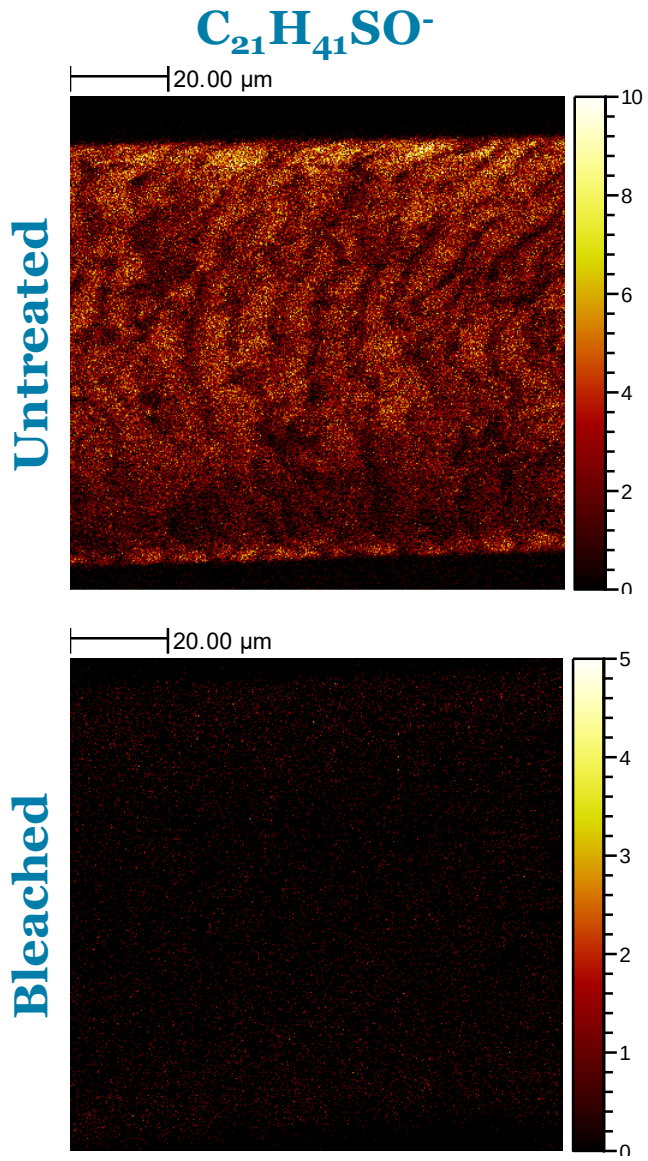
TIME-OF-FLIGHT SECONDARY ION MASS SPECTROMETRY (ToF-SIMS)

- **ToF-SIMS allows analysis on chemical changes between the surfaces of untreated and bleached hair fibres.**

- Significant oxidation is suggested at the bleached hair by the enhanced SO_3^- ion intensity and spatial distribution coupled with the suppression and and absence of the HS^- ion intensity relative to the untreated hair.



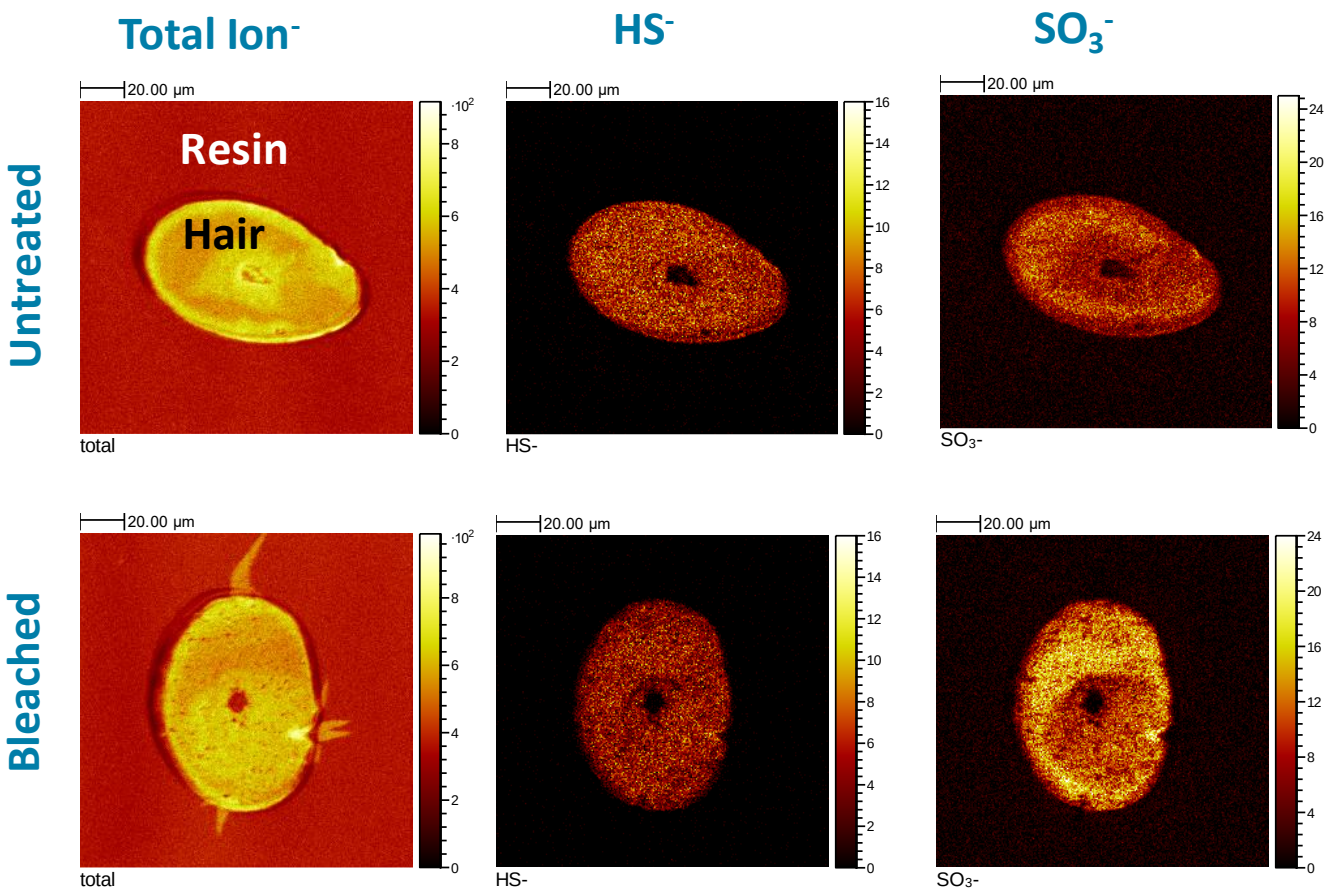
TIME-OF-FLIGHT SECONDARY ION MASS SPECTROMETRY (ToF-SIMS)



- **Specific chemistries can be mapped for by isolating characteristic secondary ions**

- 18-MEA (18-methyleicosanoic acid) on the surface of the hair plays an important role in surface hydrophobicity, which makes hair feel smooth.
- The distribution of $C_{21}H_{41}SO^-$ which is a characteristic ion of 18-MEA on the hair fibre samples shows that bleaching removes 18-MEA from the surface of native hair.

TIME-OF-FLIGHT SECONDARY ION MASS SPECTROMETRY (ToF-SIMS)

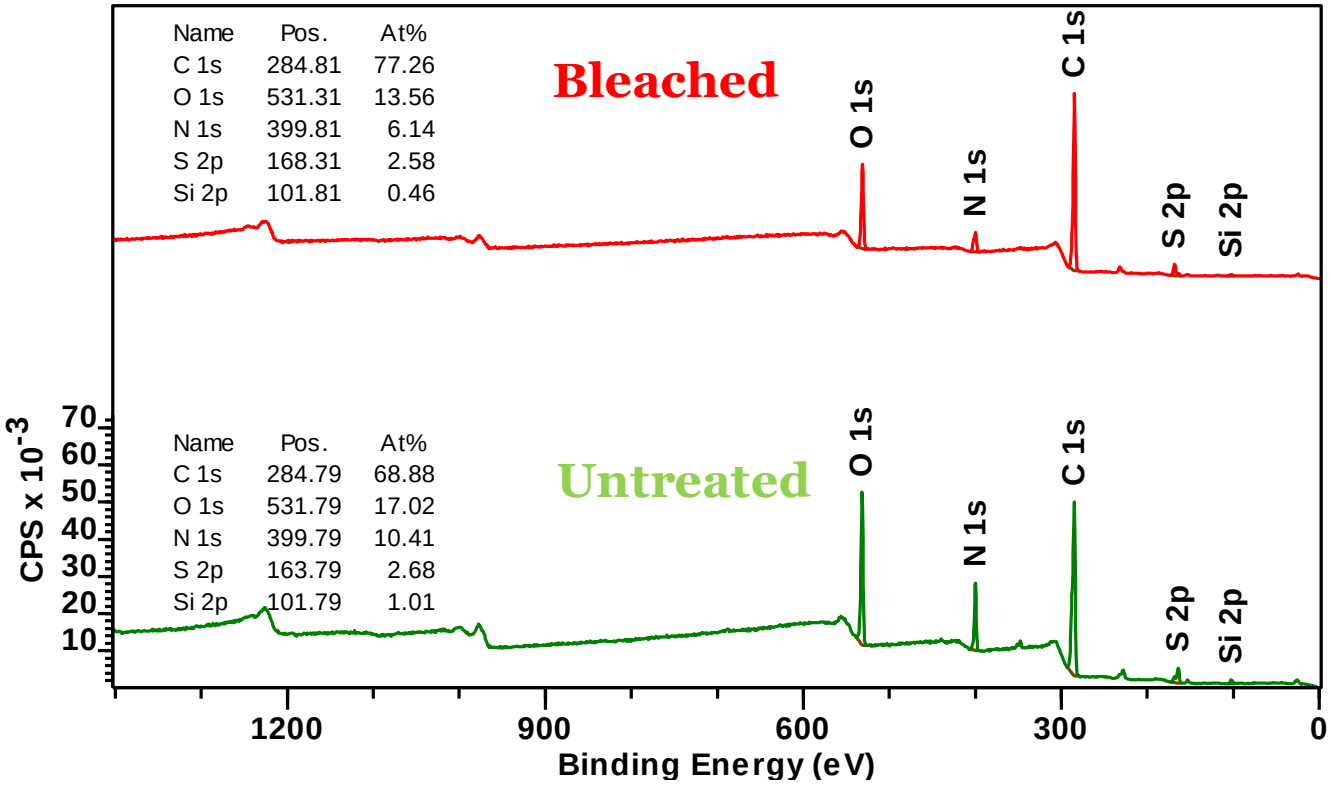


- **Hair fibres could be sectioned using an ultramicrotome allowing the chemical mapping of hair cross sections.**

- After bleaching, the content of SO_3^- is enhanced significant in the near surface region of a hair fibre.

X-RAY PHOTOELECTRON SPECTROSCOPY (XPS)

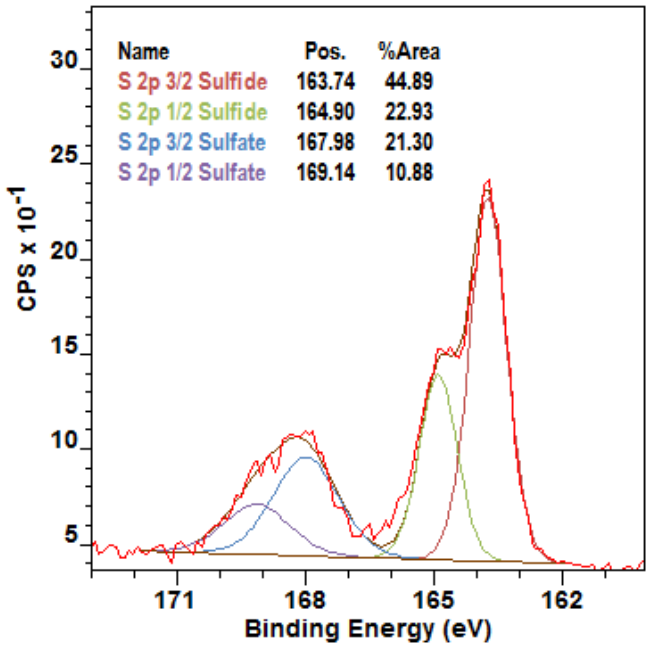
- **XPS is used to measure the elemental composition at hair surface and provide information on chemical state changes.**



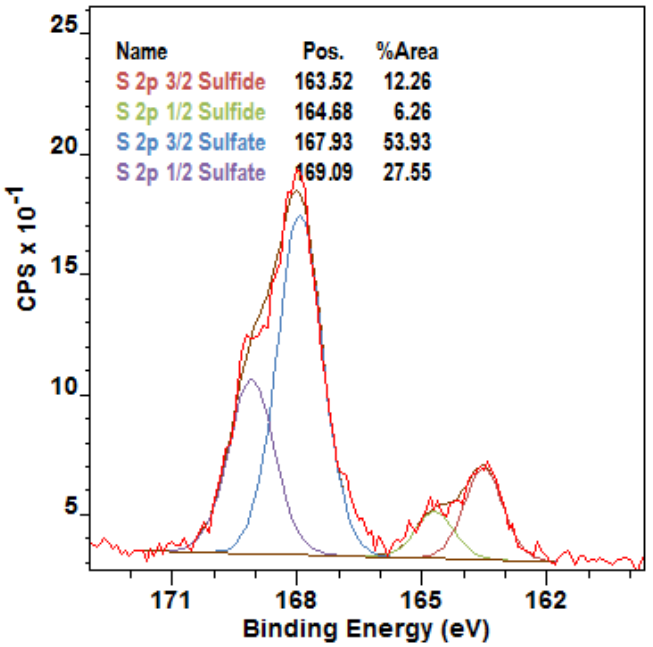
- XPS wide scan data and elemental quantifications show that bleaching has lowered the atomic percentage of both oxygen and nitrogen at the hair surface, potentially indicative of protein degradation.

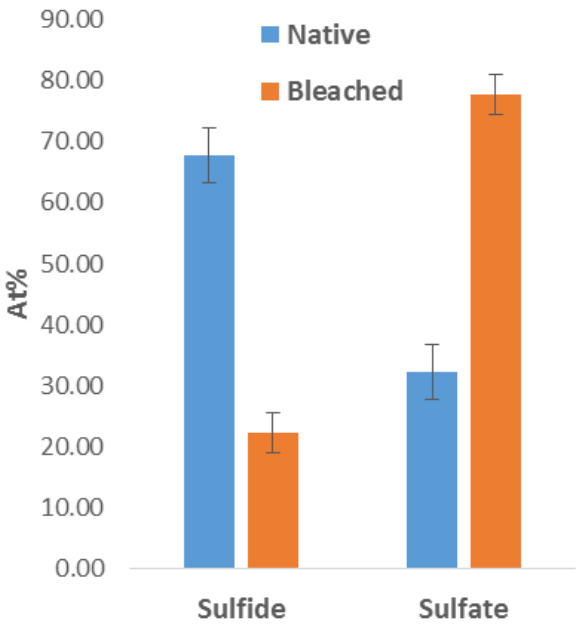
X-RAY PHOTOELECTRON SPECTROSCOPY (XPS)

Untreated



Bleached





- High resolution scans show that after bleaching the chemical state of the sulfur content of the hair surface has changed dramatically. Sulfate proportionality increases from 37 At% to 78 At%, while the sulfide proportionality decreases from 68 At% to 22 At%.
- The chemical state of sulfur can indicate the level of damage to the hair: the higher the sulfate content the higher degree of aging or oxidation.

CONCLUSIONS

- 3D Optical profilometry shows that, while eliminating the hair pigment, bleaching induces obvious alteration to hair cuticle morphology on the micron-scale.
- ToF-SIMS shows substantial differences caused by bleaching on the top surface chemistry of the hair. These include significant oxygenation of sulphur groups and a loss of native hair state ion markers (e.g. 18-MEA).
- XPS suggests that chemical damage to the hair caused by bleaching could include protein degradation and supports the evidence for significant oxidation in the hair structure.
- AFM reveals that bleaching also removes native surface coatings from the untreated hair and causes nano-scale alterations to topography.
- Multi-technique surface analysis enables a comprehensive understanding of the effects of bleaching treatment on native hair.

ADDITIONAL INFORMATION

- We hope the information provided in this case study is of interest.
- If you wish to get in touch with us to discuss any of the information provided, raise a query/concern or provide feedback then please use any of the methods listed below:

nmRC Commercial Services
Nanoscale & Microscale Research Centre
University Park
Nottingham
NG7 2RD

Telephone: +44(0)115 951 5046
Email: nmcs@nottingham.ac.uk
Fax: +44 (0)115 846 7969
Website: www.nottingham.ac.uk/nmrc-commercial