PROGRESS REPORT

Experiment SC-2112 on beamline ID13

'Deformation mechanisms in keratinous tissues using microbeam scanning SAXS/WAXS'

1 Purpose

The aim of this study is to obtain quantitative information on structural changes induced by deformation in hard alpha-keratin samples of hair and nails. For this purpose, we used a novel technique developed at ID13 combining microindentation and microdiffraction.

2 Methods

Single hair fibres of ~ 85 µm in diameter and nail sections were deformed in the lab using the Vickers microindenter developed for in situ studies at ID13. The ideal load-range for such fibers is within 500 – 1000 mN at room temperature. Two fibers were selected and indented at 500 mN and 1000 mN, at a rate of 10 $mN.s^{-1}$ and with a holding time at maximum load of 10 s. Similarly, a nail section was indented under a load of 1000 mN with the same loading conditions. This resulted in small and large indents corresponding respectively to a deformation localized in the central part of the hair or extending across the whole fiber diameter.

Scanning microdiffraction experiment were performed around the deformation zone using a 13 KeV monochromatic beam of 1 µm in diameter in steps of 1(h)x1(v) $µm^2$. For this purpose, the samples were glued at the end of a glass capillary and placed vertically in the beam. The scanning was performed in two directions, normal and parallel to the direction of indentation to monitor the extent of the deformation along these directions. The measurements were carried out immediately after indentation and mounting in order to minimize possible viscoelastic relaxation effects. The scattering patterns were recorded using a MARCCD camera 2Kx2K. The data were azimuthally and radially integrated using Fit2D and the 1D profiles were analyzed using a custom software.

3 Results and Discussion

A decrease in the scattering intensity in the vicinity was observed in both cases indicating an overall decrease in crystallinity. In addition, systematic displacements of the diffraction peaks along the radial directions were found as well as an enlargement of the peaks FWHM indicating the presence of locked strains (fig.1). Detailed studies are currently being pursued in order to assess the strain level within the in the plastically deformed samples.

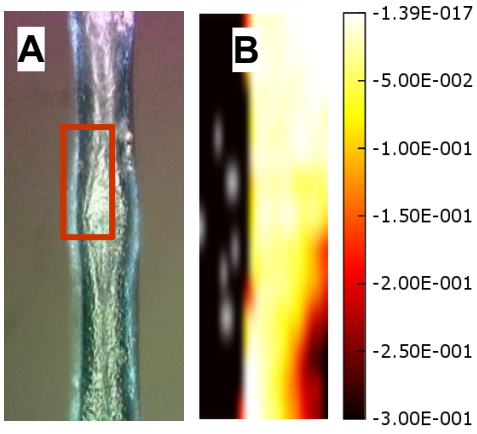

Fig. 1: A- optical micrograph of a hair deformed under a 1000 mN load; B- shift in peak position in the upper quarter of the plastically deformed sample.

4 Conclusions

The preliminary data of the present study demonstrate that the extent of the deformation in keratinous fibers is relatively limited as compared to other synthetic fibers. Locked strains and texture can be observed but only to a limited extent, thus suggesting more efficient energy dissipation mechanisms in these natural materials.