Investigations of the time-dependence of pH-changes in human hair

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This research was carried out, first, with the objective to monitor and model the time-dependent H\(^+\)/OH\(^-\) uptake of human hair in different pH environments. Second, changes to the hair due to ion uptake were investigated using Modulated Differential Scanning Calorimetry (MDSC) in water.

For the investigation H\(^+\)/OH ion uptake of untreated, commercial, Caucasian hair from solutions of defined initial pH (liquor ratio 1000:1 or 100:1) were investigated over the experimentally accessible pH-range and for a period of 24 hours. The change in solution pH over time was monitored and converted to ion-uptake. It could be shown that the changes follow in all cases a 1\(^{st}\)-order kinetic model between two limiting values. In the acid region, characteristic times for the H\(^+\) -uptake are largely independent on pH and about 2 – 3 hours. In the alkaline region, the equivalent OH\(^-\) -uptake occurs by an order of magnitude faster. Equilibrium values for ion-uptake for the pH-range were determined from the model fits.

DSC measurements in water yield the keratin denaturation enthalpy \(\Delta H_D\), which relates to the thermal stability of the keratin intermediate filaments (KIFs), and the denaturation temperature \(T_D\), which depends on the properties of the keratin associated-proteins (KAPs). To determine potential effects of dialysis during the DSC experiment, a methodology was developed to apply low liquor ratios down to 1:1. The results show the significance of liquor ratio in the DSC-pans. An increase of \(T_D\) is observed at pH1, compared to the untreated hair, which steadily decreases as pH increases to 11. The change to \(\Delta H_D\) is negligible in this pH-range. However, when the low liquor ratio is employed in the DSC-pans, an increase is seen at low pH. Only beyond pH 12 an increase in \(T_D\) and a decrease in \(\Delta H_D\) are observed, which are attributed to lanthionine crosslink formation in the matrix and pH-induced thermal instability of the helical sections in the filaments.