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 ΔH_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 ΔH_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 ΔH_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.