Development of an NMR Method for the Quantification of Phthalimidoperoxycaproic acid (PAP) in Tooth Whitening Products

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Introduction: Nowadays, tooth whitening is often not done by dental specialists but rather by end consumers themselves with the use of commercially available tooth whitening products.
Phthalimidoperoxycaproic acid (PAP) is a recently developed organic peroxide which has shown to be a milder alternative with less side effects compared to traditional active ingredients such as hydrogen peroxide and carbamide peroxide.[1][2] As a result, PAP based formulations have become increasingly popular in recent years as can be seen by the wide range of PAP-containing products on the market. Therefore, a reliable quantification method for PAP is important for the quality control of these rather expensive products.

Aim: The classical analytical technique for the measurement of peroxides is iodometric titration.[3] However, this method has multiple downsides. The main issue is that the method is non-selective for PAP but rather indicates the total concentration of oxidizing species in the sample. Other drawbacks are that undissolved remains of the sample can interfere with the titration and comparatively high amounts of sample (several hundred milligrams to multiple grams) are needed depending on the PAP content and the concentration of the used titrant solution.[4]
Thus, the goal of this project is to develop an NMR based analysis method — either based on direct measurement of the sample via High Resolution Magic Angle Spinning (HR-MAS) or analysis of liquid extracts — for PAP in tooth whitening products.

Results: In a first step, PAP was synthesized for use as reference and external calibration. Solution state NMR measurements on liquid extracts of tooth whitening pastes showed that PAP is detectable and quantifiable via resonance integration with high reproducibility. Furthermore, it is possible to distinguish between PAP and its decomposition product phthalimidocaproic acid. This is not only important for a reliable quantification but also sets the basis for indication of the stability of PAP in a given product. Corresponding kinetic studies were performed.
First results obtained with direct HR-MAS NMR of pastes show that the found PAP concentrations are clearly lower than the ones in liquid extracts of the same samples. This indicates that a direct measurement of PAP via the HR-MAS technique is not easily possible, as the compounds visibility seems to be at least partially suppressed by the sample matrix.

Outlook: In further experiments the reproducibility and accuracy of the quantification via liquid extracts has to be determined. Furthermore, it needs to be evaluated whether the extraction efficiency of PAP is comparable between different PAP formulations to assure a wide applicability of the method.

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