The Future of Plastic

The effect of deacetylation on chitin nanocrystals for the production of chitin-PLA nanocomposites

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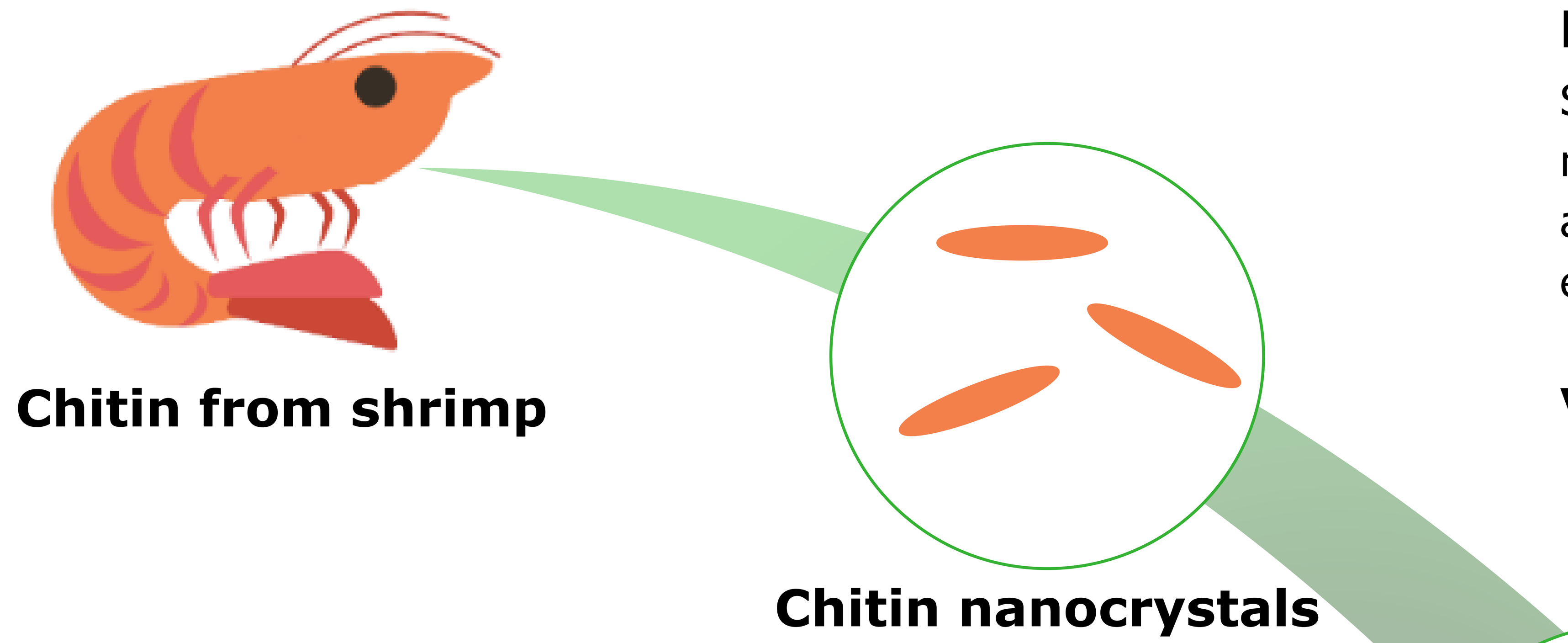
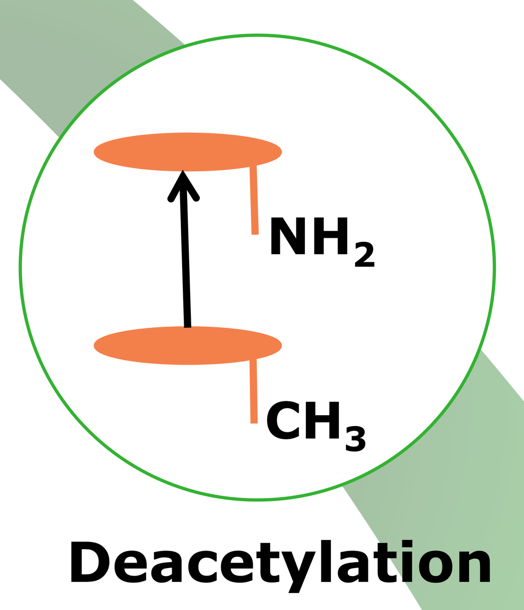
Relevance and objective

The replacement of traditionally used fossil fuel based plastics with bioplastics would contribute to the transition to a more sustainable circular economy. Unfortunately, bioplastics often do not meet requirements in terms of strength and barrier properties and are therefore unsuited to function as food packaging material. In this research, we aim at improving properties of a promising bioplastic, polylactic acid (PLA), by the incorporation of chitin nanocrystals. The major focus lays on the effect of deacetylation on the properties of the chitin nanocrystals. During deacetylation, acetyl groups on the chitin nanocrystals are replaced by amino groups.

Challenges

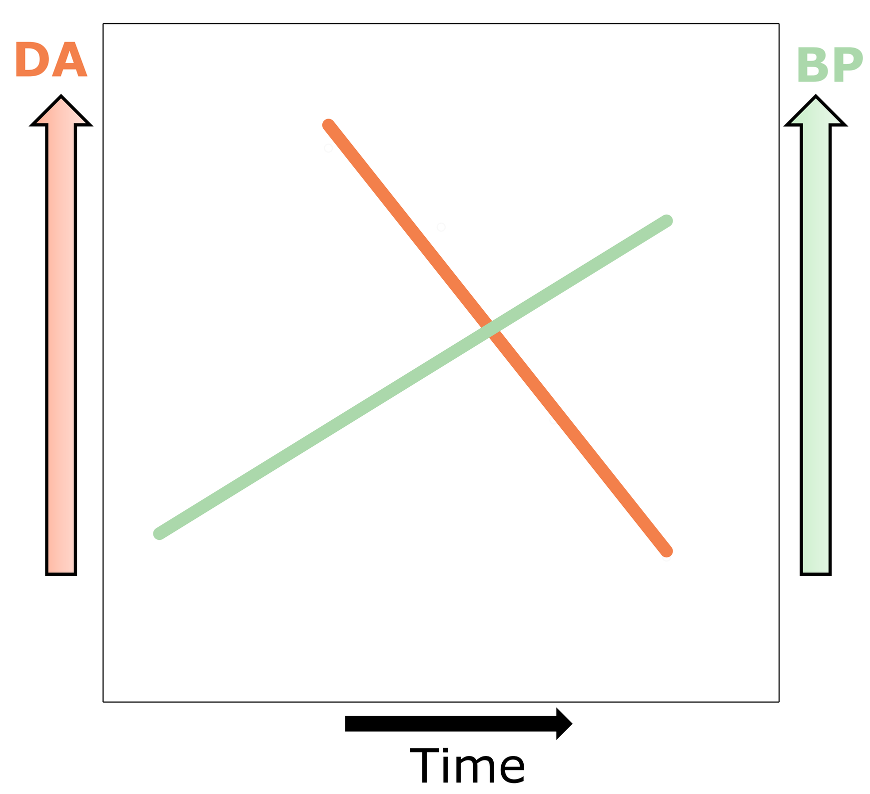
As chitin nanocrystals are hydrophilic, they tend to aggregate once they are added to the hydrophobic PLA matrix. Modification of the chitin nanocrystals affects the hydrophobicity of the nanocrystals and therewith the potential to disperse in PLA. Therefore, modification of the chitin nanocrystals will influence not only nanoparticle properties but bioplastic properties as well.





Measuring deacetylation

The degree of acetylation (DA) has a major position within this research. Therefore a simple, cheap and effective method, the use of UV spectrometry, was further developed. The formation of a by-product (BP) during the measurement hindered the correct calculation of the DA. The improved method consists of an UV measurement at 210 and 280 nm to determine the DA and BP, respectively.



In the corrected calculation, which is shown below, the DA is determined while taking the decrease of DA caused by BP formation into account ($\frac{x_{DA}}{x_{BP}}$). As the amount of BP formed is dependent on the starting weight of the substrate, a factor is included to correct for differences in starting weight (x_{conc}). In the formula, A_{280nm} represents the absorbance at 280 nm, a measure for the amount of formed by-product.

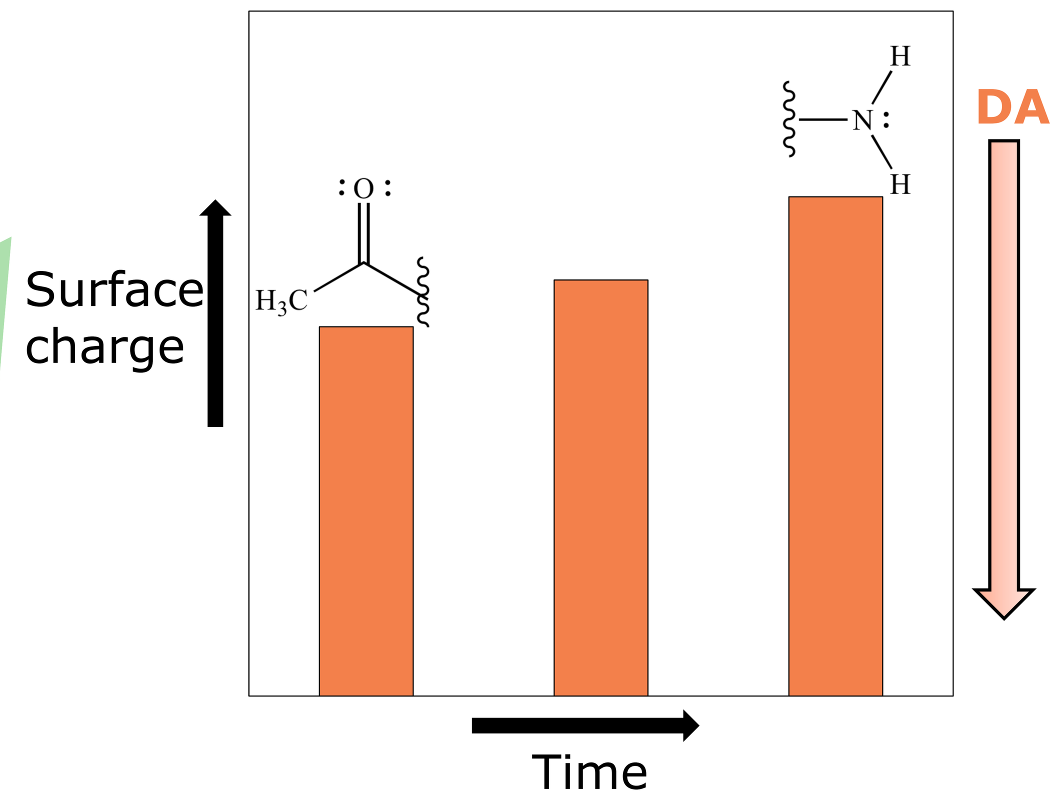
$$DA_{corrected} = DA_{found} + x_{conc} \cdot \frac{x_{DA}}{x_{BP}} \cdot A_{280nm}$$

Deacetylation of nanocrystals

Surface modification is used to influence the hydrophobicity of the nanocrystals (NC). Deacetylation, the exchange of an acetyl group for an amino group, is performed under a variety of conditions to assess the effect of deacetylation on the size and surface charge of the nanocrystals.

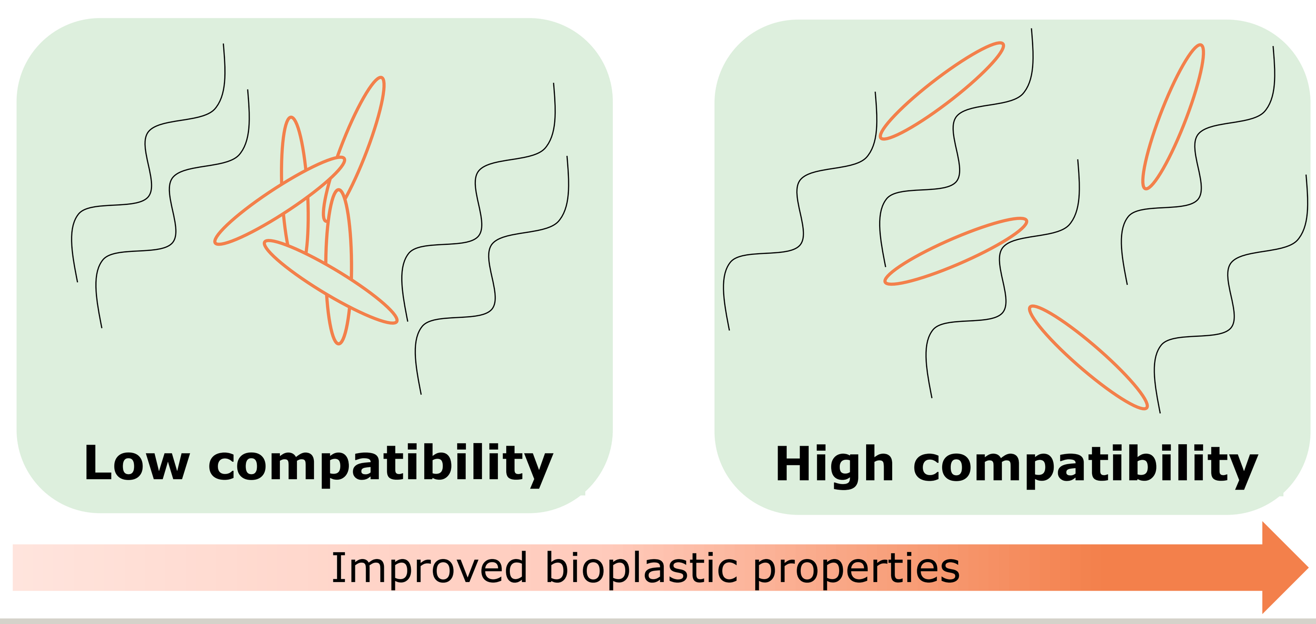
Varying conditions: Heating method | NC wet or dried | NaOH (%) | T (°C) | Time

The size and morphology of the nanocrystals were hardly affected by deacetylation, while an increase in surface charge was observed. This indicates the presence of protonated amino groups and thereby assures the occurrence of deacetylation. Overall, deacetylation in a sonication bath, with 33 w/v% NaOH, wet nanocrystals, at a temperature of 80°C is the advised method to produce deacetylated chitin nanocrystals.



Bioplastic (nanocomposite)

Incorporation of chitin nanocrystals in PLA, created strong and stable bioplastics. No visible aggregation was observed, ensuring proper compatibility. Measuring the material strength and chitin – PLA compatibility is part of the follow-up research.



Acknowledgements
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