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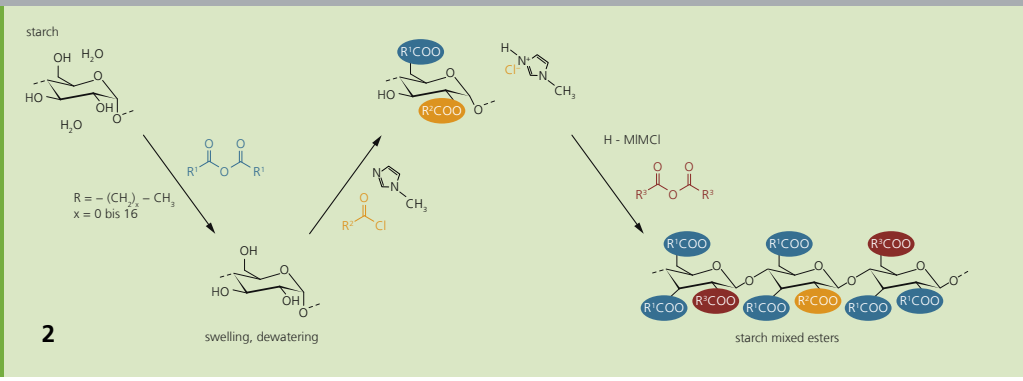

1 *Color and transparency of starch mixed esters.*
2 *Reaction scheme for preparing starch mixed esters.*

NOVEL THERMOPLASTIC STARCH MIXED ESTERS

An innovative synthesis pathway for biobased commodity materials

Background

Starch-based thermoplastic materials, mainly used in the packaging industry, have the advantages of biodegradability and low price. However, high moisture absorption and brittleness of such materials prevent high quality applications. By chemical modification of starch these disadvantages can be reduced and thermoplastic materials with significantly improved properties are developed. Esterification of starch has been extensively studied over the last two decades. Starch mixed esters with high stiffness and at the same time good elongation at break were developed and promise to be very good thermoplastic materials.

New synthesis pathway

At Fraunhofer IAP a new synthesis method for the preparation of different starch mixed esters was developed. Thereby an ionic liquid is produced in situ in low amounts and catalyze the reaction with different carboxylic acid anhydrides and acid chlorides (Fig. 2).
The kind, ratio and sequence of the used carboxylic acid anhydrides allows a controlled substitution pattern of each ester substituent at the anhydro glucose unit. In general a substitution pattern of DS(R1) > DS(R3) >> DS(R2) is produced.

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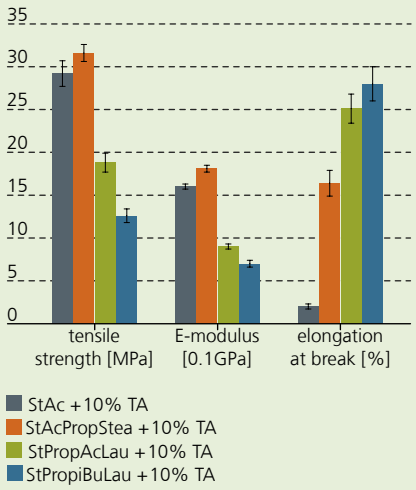
Improved mechanical properties

By this synthesis it is possible to influence the mechanical properties of these starch derivatives in a broad range (Fig. A).

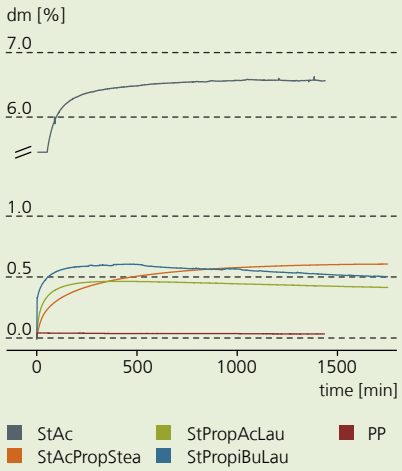


A *Mechanical properties of different starch mixed esters plasticized with 10 mass percent of triacetin.*

So the elongation at break can be increased by 500 percent in contrast to pure starch acetate (grey) by inserting a propionat and stearat substituent (dark orange) without any loss in tensile strength and stiffness (modulus). By using further internal plasticizer in form of different ester substituents like laurate and i-butyl groups the material gets more and more flexible (green, blue).

Less water uptake and less discoloration

Besides the good mechanical properties these novel starch mixed esters stand out with lower water uptake and less discoloration (Fig. 1 and Fig. B). While powdery starch acetate with a degree of substitution of 2.6 takes up 6.5 weight percent of water, for the fully substituted starch mixed esters the water uptake is just around 0.5 weight percent. After the treatment of the starch esters in an extruder and with an injection molding machine the specimen of starch acetate are dark brownish while the mixed esters are clear and transparent.



B *Water vapor sorption of starch mixed esters.*

Conclusion

The novel and effective production of starch mixed esters delivers a material with better thermoplastic processability as well as better mechanical properties of the final product compared to known starch systems. Through recovery of the IL catalysts the production method is economically competitive.