Lowering thermoplastic starch processing temperature by means of acid hydrolysis

Kouka S.[1], Gajdosova V.1, Strachota B.1, Slouf M.1

[1] *Institute of Macromolecular Chemistry CAS, Prague, Czech Republic*

Acid hydrolysis (AH) was investigated as a means to enhance the processability of thermoplastic starch (TPS), a biodegradable and renewable material that ~~often~~ requires relatively high processing temperatures [1]. By ~~partially depolymerizing starch~~ means of partial AH, the goal was to reduce molecular weight in order to lower the melt viscosity and processing temperature, without compromising the homogeneity or mechanical performance of the final product. Starch powder was hydrolyzed for varying durations (0, 15, 30, and 60 minutes), then neutralized, dried, and ~~processed~~ converted to TPS using ~~a~~ our two-step preparation protocol [2]. The impact of hydrolysis on morphology and microstructure was examined using polarized light microscopy (PLM) and scanning electron microscopy (SEM), which revealed progressive disruption of starch granules with increasing AH ~~treatment~~ time. The mechanical and rheological behavior was characterized by dynamic mechanical thermal analysis (DMTA), ~~and~~ microindentation hardness testing (MHI), and oscillatory shear rheometry at 120 °C, showing a gradual increase in stiffness-related ~~parameters~~ properties (G', G'', E_{IT}, and H_{IT}) for more extensively hydrolyzed samples. These trends were consistent with wide-angle X-ray scattering (WAXS) results, indicating increased crystallinity with longer hydrolysis times. Despite this moderate stiffening effect, hydrolyzed starch exhibited significantly reduced melt viscosity and required lower processing temperatures. In situ measurements performed during melt mixing (Fig. 1) confirmed this reduction, supporting the idea that shorter polymer chains formed during hydrolysis acted as an internal lubricant~~s~~. Overall, the study has demonstrate~~s~~d that the controlled acid hydrolysis c~~an~~ould effectively ~~balance ease of processing with~~ decrease the processing temperature while maintaining ~~desirable~~ mechanical properties and homogeneity of the final TPS.~~, making it a promising modification route for thermoplastic starch materials.~~

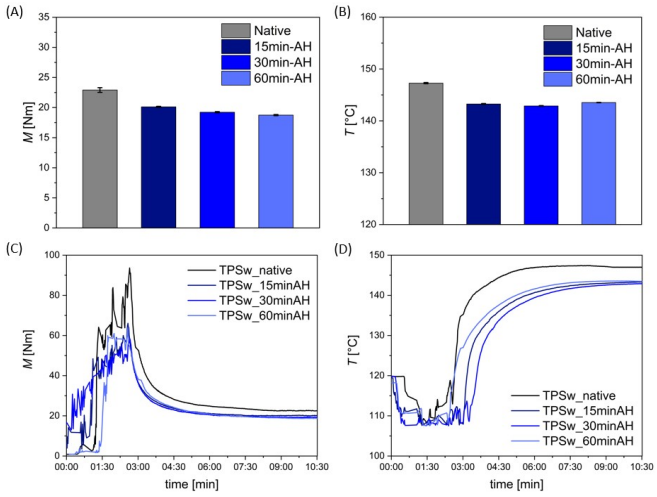

Fig. 1: In-situ measurements of torque moments (a, c) and processing temperatures (b, d) of TPS with different times of acid hydrolysis.

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References

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