Product inhibition of enzymatic hydrolysis of cellulose: are we running the reactions all wrong? - DTU Orbit (22/12/2018)

Product inhibition of enzymatic hydrolysis of cellulose: are we running the reactions all wrong?
Enzyme catalyzed deconstruction of cellulose to glucose is an important technology step in lignocellulose-to-ethanol processing as well as in the future biorefinery based production of novel products to replace fossil oil based chemistry. The main goals of the enzymatic biomass saccharification include high substrate conversion (maximal yields), maximal enzyme efficiency, maximal volumetric reactor productivity, minimal equipment investment, minimal size, and short reaction time. The classic batch type STR reactions used for enzymatic cellulose hydrolysis prevent these goals to be fulfilled. This is because the currently used Trichoderma reesei derived cellulases, i.e. exoglucanases (mainly the cellobiohydrolases Cel7A and Cel6A), endo-1,4--glucanases, and now boosted with α-glucosidase and other enzymes, now considered the “industry standard” enzymes, are significantly inhibited by the products cellobiose and glucose. The reported KI for glucose on the T. reesei cellulases and -glucosidase varies from 0.04 to 5 g/L. The type of inhibition is debated, and probably varies for different -glucosidases, but with a required goal of sufficient glucose concentration to support ethanol concentrations of minimum ∼5–6% v/v, the glucose product concentrations exceed the critical limit for product inhibition. Hence, regardless of the recent progress in enzyme development for cellulose hydrolysis, the glucose product inhibition remains an issue, which is exacerbated as the reaction progresses, especially at high substrate loadings in batch reactions. Hence in addition to understanding product inhibition and develop new cellulytic enzymes that are more resistant to product inhibition, much can be gained from proper reaction design and continuous removal of the product(s) in enzymatic cellulose hydrolysis. Based on cellulose inhibition kinetics the talk will illustrate the suitability of membrane reactor technology for improving cellulose substrate conversion efficiency.

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