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Investigation of hydrolysis of lignocellulosic fiber suspensions with in-situ and ex-situ multi-scale physical metrologies

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-abstract-

In the context of biofuels and chemicals production of petroleum substitutes from renewable carbon, bioconversion of lignocellulose biomasses is currently a major challenge. The limited knowledge of liquefaction and saccharification mechanisms stands as the main factor which penalizes bio-refinery progress. The present work is centred on the development of in-situ and ex-situ physical measurements of suspension rheometry and particle granulometry together with biochemical analysis in order to expand our understanding of the destructurement mechanisms of lignocellulose fibres.

Corresponding to favourable conditions, hydrolysis of soft-wood (coniferous) and hard-wood (deciduous) extruded paper-pulp was investigated over 24h in a mixing system (fixed rotation frequency 100 rpm) using two substrate concentrations, 1% and 3%w/v and two enzyme/substrate ratio, 0.1 (5-6 FPU) and 0.5 (25-30 FPU) mL enzyme/g cellulose. The same enzyme cocktail, well suited for lignocellulosic material, was used for all experimentations (ACCELLERASE® 1500 Genecor).

Our scientific results allow:

- to propose and validate the in-situ measurements of the suspension viscosity and chord length distribution together with its conversion into particle size distribution.
- to establish phenomenological models for rheological behaviour of initial suspensions and to confirm their visco-plastic behaviour,
- to demonstrate the impact of the substrate nature and concentration and of the enzymatic ratios on the evolution of physical- and biochemical parameters during hydrolysis. Their impacts on transfer phenomena were quantified,
- to define a critical time t^* , in order to obtain a unique dimensionless viscosity-time curve, thus allowing to propose a strategy for high dry matter content hydrolysis,
- to differentiate solubilisation and fibre morphology modifications in the viscosity reduction process during hydrolysis,
- to describe all physical (viscosity, particle size) and biochemical (substrate and product) kinetics by second order reaction models.