Effect of organosolv pretreatment on biogas production from spruce and birch biomass

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INTRODUCTION

The increasing demands in biogas have made the exploitation of novel sources of raw material for anaerobic digestion very important. Lignocellulosic biomass (e.g. wastes and by-products from agricultural and forest based industry) could serve as potential raw materials for anaerobic digestion. Forest-based industry is an important part of Swedish economy and is under economic pressure which makes the use of their wastes for the production of methane an important source of extra income.

Aim of this work is the utilization of forest biomass, both softwood (spruce) and hardwood (birch) as raw material for anaerobic digestion.

MATERIALS & METHODS

Raw material: Spruce and birch chips

Enzymes: Cellic CTec2 from Novozymes

Microorganisms: Thermophilic anaerobic sludge from Boden biogas

Instrumetations: Cutting mill RETSCH-SM300, Organosolv batch, oven, AMPTS II

Experimental procedures: Wood chips were milled with a laboratory cutting-mill to a particle size of less than 1mm. The material was pretreated in different conditions of organosolv pretreatment in the presence or absence of an acid catalyst. Biochemical methane potential (BMPs) test took place in the AMPTS II system where the addition of cellulolytic enzymes was also examined.

RESULTS & DISCUSSION

Pretreatment of forest biomass

During the pretreatment trials, the effect of ethanol concetrations (50% and 60%) and holding time (60min and 103min) in the presence or absence of acid catalyst (1% H_2SO_4) was examined. All pretreatment took place at 182°C and liquid to solid ratio of 10 in a autoclave apparatus (Figure 1). At the end of the pretreatment, the materials were collected and filtrate in order to separate the solid from the liquid phase.

The solid phase was used for the BMP tests and mixed with the anaerobic sludge in order to achieve an inoculum to substrate ration equal to 2 in terms of VS (Volatile Solids). The effect of addition of cellulolytic enzymes was also examined in a concentration equal to 15 FPU/gVS.

Figure 1. Autoclave apparatus where pretreatment took place.

Effect of pretreatment conditions on methane yield

Spruce:

- ✓ Presence of the acid catalyst resulted in increase of the yield by 6.3 up to 25.3 times compared to absence of catalyst (Figure 2).
- ✓ Decrease of ethanol concentration from 60% to 50%, improved the methane yield.
- ✓ Prolonged treatment duration of 103min resulted in decreased yields.
- ✓ In comparison with the biogas production from hydrothermally treated spruce, the biogas production yield from organosolv treated spruce without the use of enzymes was approximately 30% higher (Matsakas et al., 2015).

Birch:

- ✓ The addition of the acid catalyst did not had any significant impact on the methane yields probably due to the presence of acetic acid formed by the birch itself.
- ✓ Increase of ethanol concentration to 60% resulted in improvement on the methane yield. Similarly with spruce
- ✓ Prolonged treatment had a slight negative impact.

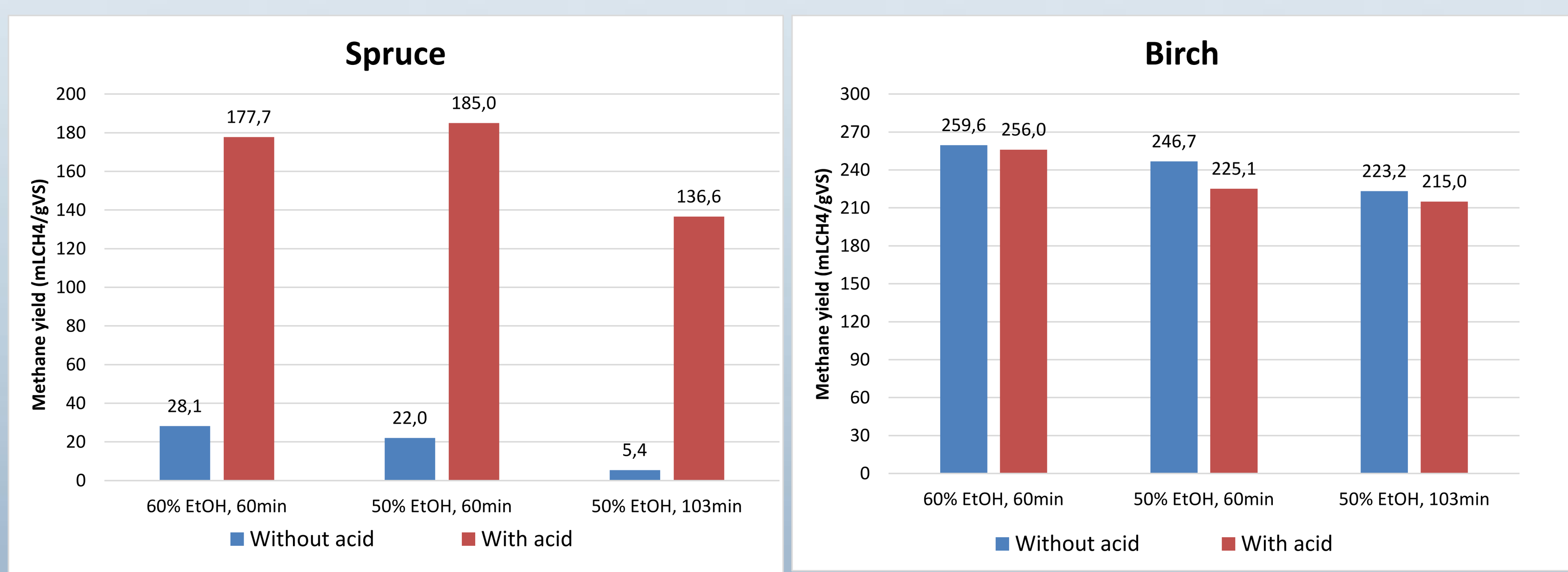

Figure 2. Effect of different pretreatment conditions on the methane yield from spruce and birch chips without the addition of enzymes.

Effect of the addition of cellulolytic enzymes on methane yield

- ✓ Addition of cellulolytic enzymes during the anaerobic digestion step (Figure 3) improved the methane yields in all the examined pretreatment conditions for both materials compared to experiments without addition of enzymes (Figure 2) .
- ✓ As observed before the addition of the acid catalyst had a positive effect on spruce whereas no effect was observed when birch was used.
- ✓ In contrary with before, when spruce was used increase of ethanol concentration from 50 to 60% significantly improved the methane yield. On the other hand, prolonged treatment duration resulted in decrease of the yield.
- ✓ When birch was used the same trend was observed with higher ethanol concentration to result in slight higher methane yield.

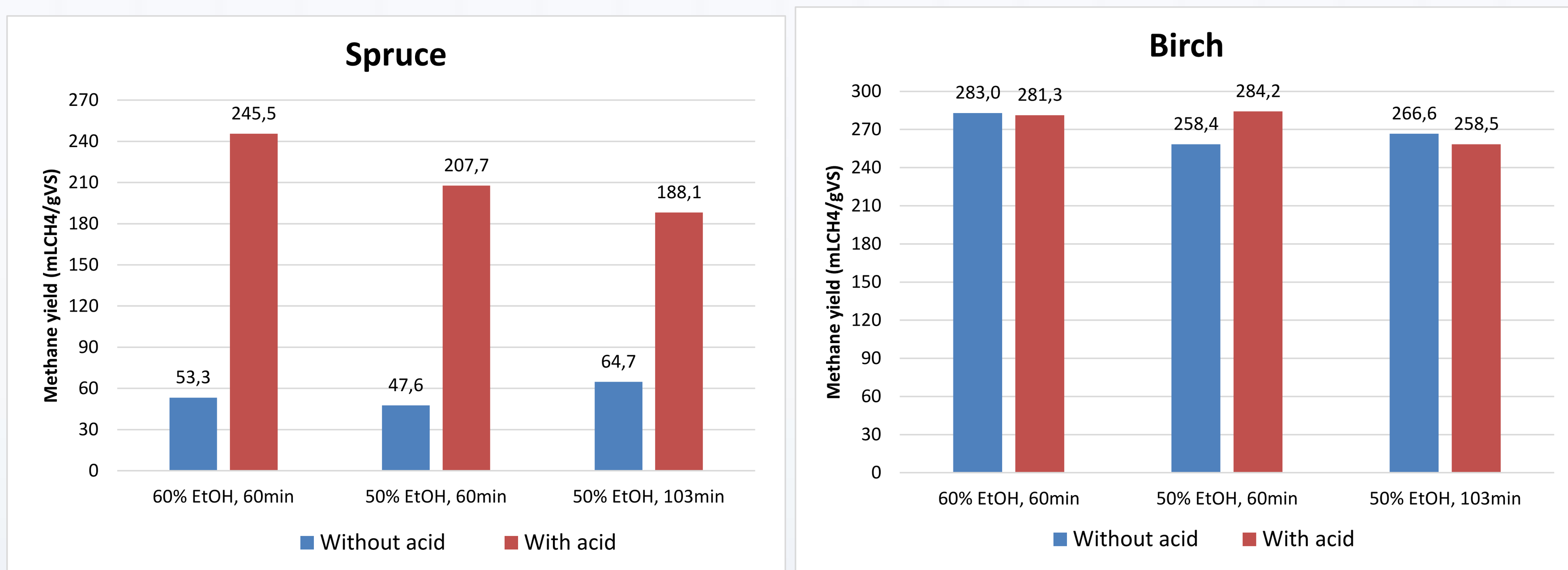

Figure 3. Effect of different pretreatment conditions on the methane yield from spruce and birch chips with the addition of enzymes.

Comparison with literature

Material	Pretreatment	Yield of untreated	Yield of pretreated	% Improvment	Reference
		(mL CH_4/gVS)			
Spruce	Alkali	30	50	74	Mirahmadi et al., 2010
Spruce	Ionic liquids	66	245	271	Teghammar et al., 2012
Spruce	Hydrothermal	10	276	2660	Matsakas et al., 2015
Spruce	NaOH/thiourea	30	210	600	Mohsenzadeh et al., 2012
Spruce	Organosolv	10	246	2450	Present work
Birch	Alkali	250	460	83	Mirahmadi et al., 2010
Birch	Hydrothermal	18	305	1594	Matsakas et al., 2015
Birch	NaOH/thiourea	230	360	57	Mohsenzadeh et al., 2012
Birch	Organosolv	18	284	1478	Present work

Conclusions

During this work it was demonstrated that organosolv pretreatment is an efficient method to treat both spruce and birch so as to be used as raw materials of anaerobic digestion. The addition of acid catalyst during the organosolv pretreatment improved the yields in spruce, whereas it did not affected the yields in birch. The concentration of ethanol had an impact on the yield with lower concentration to be favorable for spruce and higher for birch. Improved methane yield were also observed for reduced treatment duration time which also has a positive impact on the process cost. Finally, the addition of cellulolytic enzymes during the anaerobic digestion stage further improved the methane yield for all treatment combinations resulting in a highest methane yield of 245.5 mL CH_4/gVS for spruce and 284.2 mL CH_4/gVS for birch.

References:

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Mirahmadi et al. (2010) *BioResources* 5, 928-938

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