ReNEW
Resource innovation Network for European Waste

Investing in Opportunities
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INTERREG IVB

Waste Paper → Value Added BioChemicals

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Approach

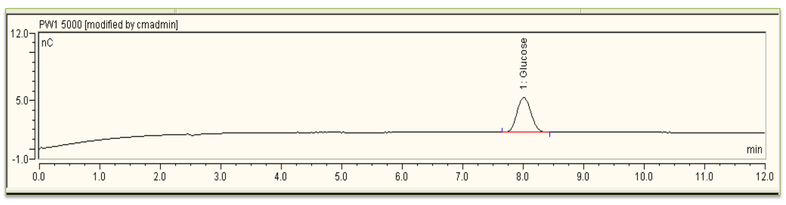
The first stage in Waste Paper up-cycling is enzymatic digestion. This strategy facilitates virtually complete conversion of the waste paper to provide a simple sugar mix which is then used in fermentation to produce the value added bio-chemicals such as Butanol and Succinic acid.

Enzymatic Treatment

Step 1: Fungal Cultivation
NUI Galway strains of industrially relevant fungi were induced to produce elevated levels of target enzymes selected specifically to hydrolyse paper.

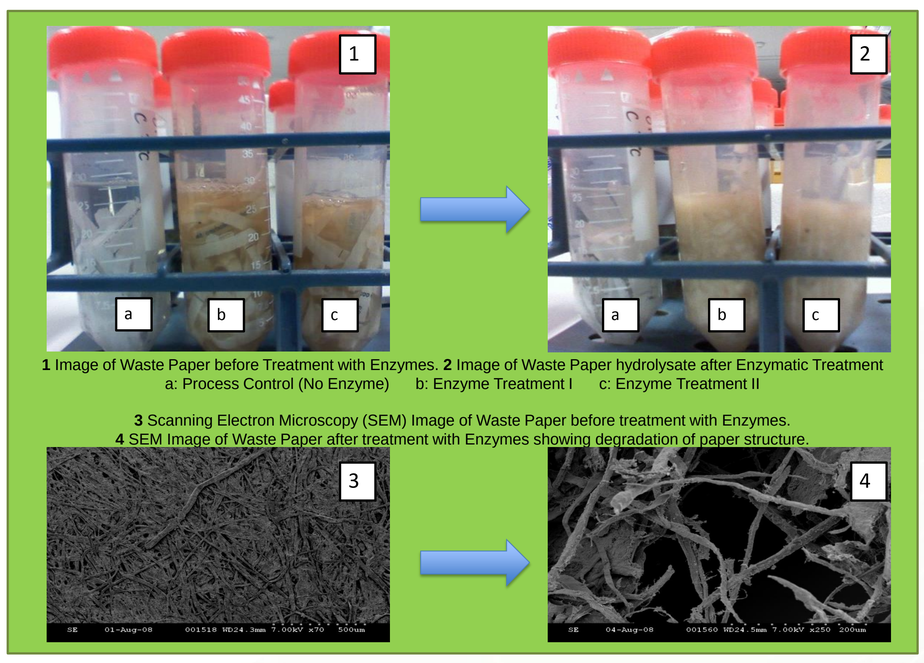
Step 2: Paper Hydrolysis
Waste paper was incubated with the selected enzyme preparation for 72 h at 60^{o}C and 150 rpm. This resulted in almost complete solubilisation of the complex carbohydrates in paper (e.g. cellulose, hemicellulose).

Step 3: Biochemical Analysis of the resulting hydrolysate included measuring Total Dissolved Carbohydrate (Dubois), Reducing Sugars (DNS) and Monosaccharides (HPLC)



Results: Yield: 420 g sugar per Kg Waste Paper.
Sugar composition: primarily glucose (determined by HPLC)

Step 4: Concentration of sugar mix to provide a sugar rich syrup for Butanol and Succinic acid fermentation.



1 Image of Waste Paper before Treatment with Enzymes. **2** Image of Waste Paper hydrolysate after Enzymatic Treatment
a: Process Control (No Enzyme) b: Enzyme Treatment I c: Enzyme Treatment II

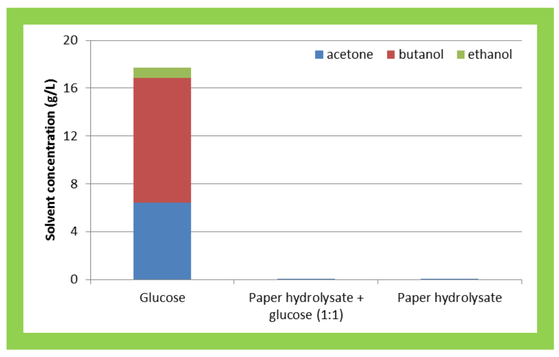
3 Scanning Electron Microscopy (SEM) Image of Waste Paper before treatment with Enzymes.
4 SEM Image of Waste Paper after treatment with Enzymes showing degradation of paper structure.

Fermentative Production of Butanol

Set-up: Solvent production on waste paper hydrolysate was compared to that on synthetic sugars in shake flask experiments.

Results: Production of solvents was clearly inhibited on the paper hydrolysate.

Cause: Like the sugars, the buffer salts used in enzymatic treatment were more concentrated. This resulted in unfavourable conditions for butanol production.



Solution: Different process conditions were applied in the enzymatic process.

Results: The total conductivity and acetate concentrations were strongly reduced, while sugar levels were maintained in the same range required for the fermentation process.

Parameter	Paper hydrolysate 1	Paper hydrolysate 2
Total sugars	103 g/L	64 g/L
Glucose	47 g/L	TBD^
Acetic acid	63 g/L	TBD^
pH	5.4	TBD^
Conductivity	67 mS/cm	16.7 mS/cm *

* Before 10 fold concentration ^To Be Determined

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Conclusions

The poster illustrates results of a transnational case study in which a low cost enabling enzyme technology was applied to solubilise waste paper (from a mixed waste stream) and produce a feedstock with potential for production of high value biochemicals and biofuels.

The enzymes are very effective in deconstructing the fibrous structure of the paper, reducing it to a thick sugar-rich slurry. The liquor recovered from the enzymatically pulped paper consisted mainly of a single sugar (glucose), and was concentrated to produce a sugar-rich syrup for downstream fermentation. The complexity of the feedstock (e.g. presence of metal ions and other non-sugar components) may require different conditions during enzymatic treatment or separation and/or some purification to improve bio-product yields.

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