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Biomass Waste Streams to Produce Cellulose Acetate

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Introduction

Cellulose acetate was produced from hemp fibres as the biomass source. The aim is to produce cellulose acetate at a cost lower than the current market price so that it can partially replace fossil fuel based polymers.

The study focused on two main areas:

- Production of pulp using aqueous sodium hydroxide (minimum degree of polymerization (DP) 600, and minimum alpha-cellulose content 96wt%)

- Production of cellulose diacetate from hemp pulp (minimum DP 150)

Why cellulose acetate?

- Environmentally friendly relative to fossil fuel based polymers. (Relative CO_2 emission shown in graphs below)
- Sustainable resources (agricultural raw material)
- Non-toxic

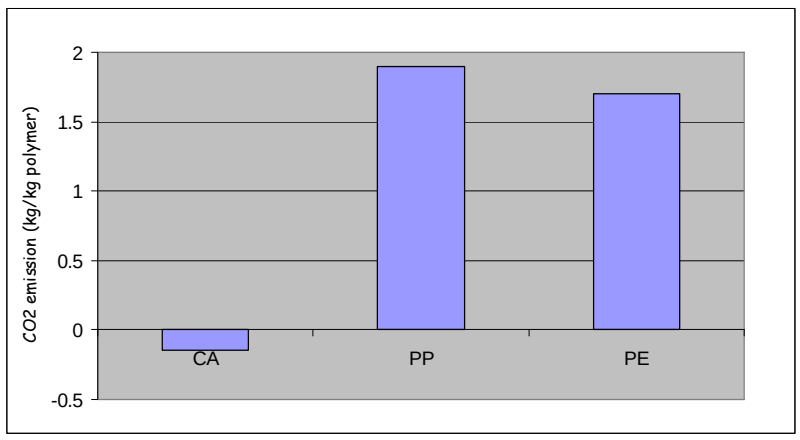
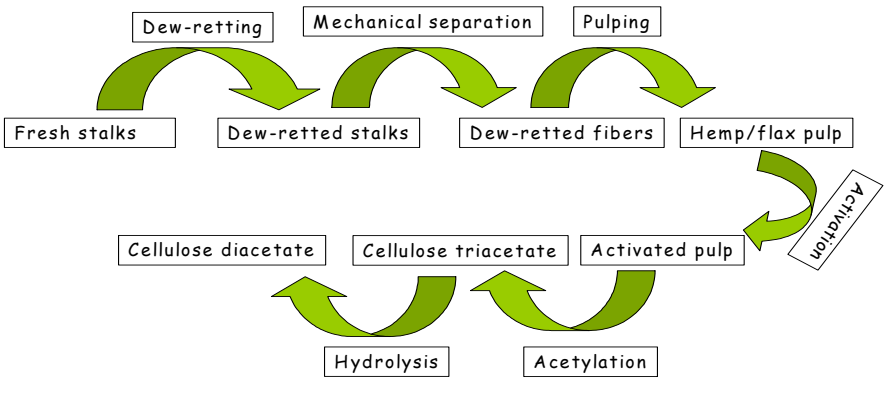


Figure 1: Relative CO_2 emission of cellulose acetate (CA), polypropylene (PP) and polyethylene (PE)

General process steps



Pulp production

The influence of NaOH concentration and temperature on the pulp was investigated with regards to the degree of polymerization, yield and Kappa number for a total pulping time of about 1 hour.

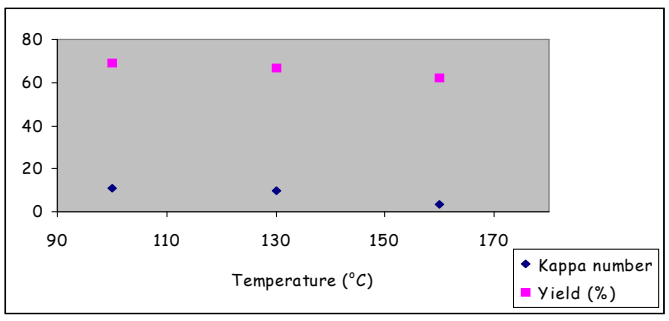


Figure 2: Influence of temperature on kappa number and yield (15% NaOH)

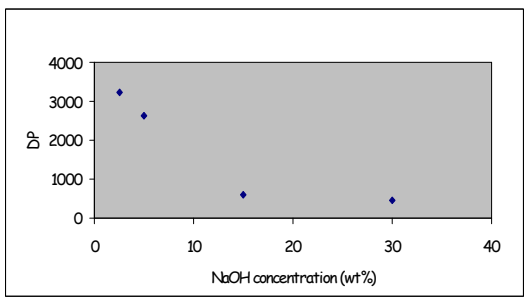


Figure 3: Influence of NaOH concentration on DP

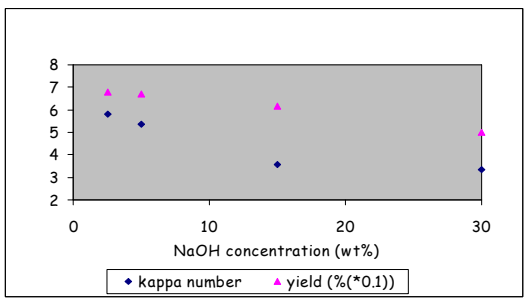


Figure 4: Influence of NaOH concentration on Kappa number and yield

All samples had an alpha-cellulose content above 96wt%

Recommended pulping conditions: 160°C for 30 – 45 minutes using 7.5wt% aqueous NaOH (6:1 liquor to fiber ratio on mass basis)

Cellulose diacetate from hemp pulp

Cellulose acetate samples with a degree of polymerization from 160 to 270 and a degree of substitution of 2.8 were prepared from hemp pulp.

Economic feasibility

An initial feasibility study of the process on the basis of a 30TPD cellulose diacetate plant was carried out. The following conclusions could be drawn:

- Hemp pulp could be produced at a price comparable to the price of wood dissolving pulp depending on the kind of technology employed and capacity. The yield of the hemp pulping process (mass basis) is about 65% as compared to wood dissolving pulp at 35%.

- The manufacturing cost of cellulose diacetate is strongly dependent on the cost of acetic anhydride. The relative proportions are illustrated in the figures below:

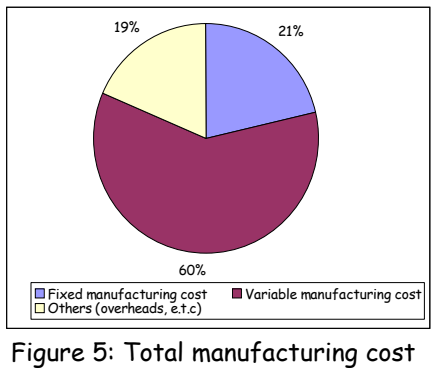


Figure 5: Total manufacturing cost

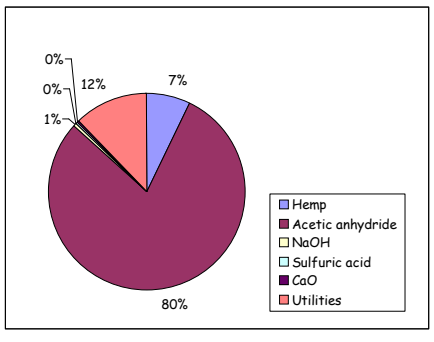


Figure 6: Variable manufacturing cost

Future work will focus on the optimization of process conditions for cellulose acetate production.

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