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Enzymatic treatment of bast fibres for improvement of the mechanical characteristics of reinforced thermoplastic composites

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Motivation

The application of natural fibres for reinforcing of thermoplastics and thermo sets is obviously connected with a number of technological and environmental benefits. Natural fibres are obtained from a wide range of resources, including stem (bast) and leaf fibres e.g., from flax, hemp, jute, ramie, sisal and other fibre crops. Correspondingly, high tensile strength and stiffness was found in isolated bast and leaf fibres. The hollow structure of fibre cells is the reason for low density, typically ranging between 1.15 and 1.6 g mm³. Therefore bast and leaf fibres allow reinforcing of composites classified as light weight materials. Natural fibre composites are also claimed to offer environmental advantages such as reduced dependence on non renewable energy/material sources, lower pollutant emissions, lower greenhouse gas emissions, enhanced energy recovery, and end of life biodegradability of components.

Aim

The processing of natural fibres is connected with some critical aspects which need further consideration: (i) poor chemical and physical homogeneity of the raw material, (ii) low degree of degumming and elementarization of fibre bundles, (iii) weak adhesion between bio-fibres and matrices, (v) considerable capacity of moisture sorption and desorption. The objective of the present study, therefore, was to establish the effect of the pectolytic treatment (i) on filament size, (ii) on tensile characteristics of the fibres and (iii) on composite characteristics when refined fibres were used instead of untreated ones.

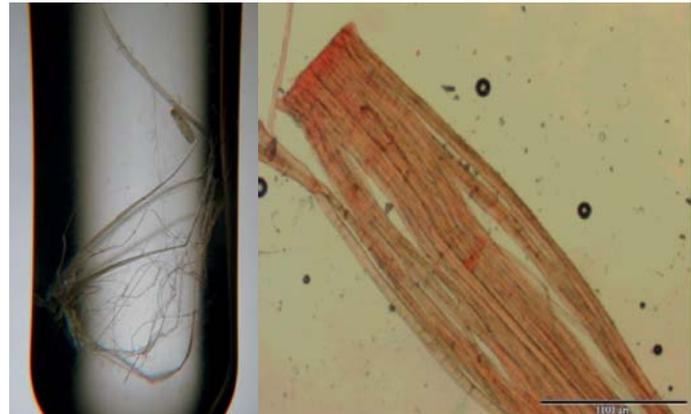


Fig. 1: Enzymatic refining

Fig. 2: Single fibre after treatment with pectinases

Approach

Up to now, reinforcing potential of natural fibres has not been exhausted as the fibre are bundled and therefore, homogenous distribution of fibres and matrix has not been possible.

There are various ways for refining natural fibres:

- steam explosion
- alkali solution treatment
- ultrasonic breakdown
- enzyme treatment

Enzyme treatment

The exposure of pectinases leads to decomposition of the middle lamellae selectively and to elementarization of fibre bundles.

Treatment conditions

- enzyme concentration: 3 - 5%
- temperature: 35 °C
- processing time: 4 h

The Compounding

The degummed fibres were integrated into polypropylene by means of co-rotating twin-screw extruder.

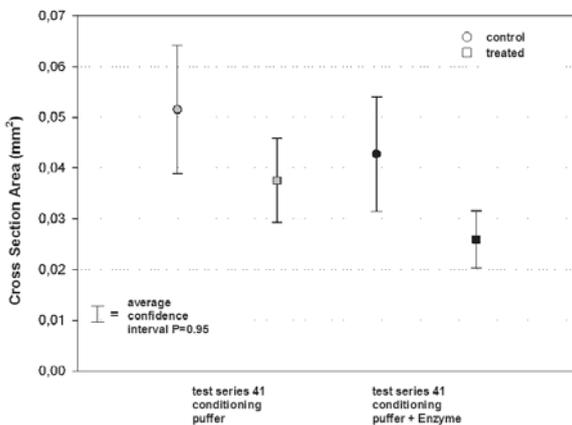


Fig. 3: Influence of the treatment with pectinases on the width area of hemp fibre

Results

- Natural fibre could be refined by treating with pectinases.
- The mechanical properties of the fibres do not changed as a result of the treatment.
- The tensile strength of NF-PP-composite with 25% degummed fibres is 45% higher than that with untreated fibres, the E-modulus thereby to be doubled.

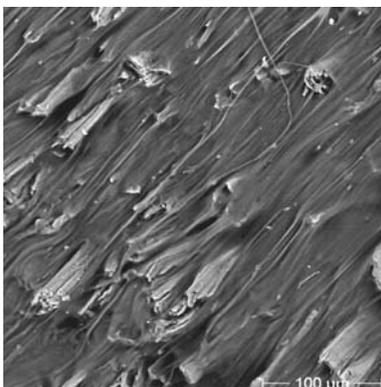


Fig. 6: REM image of an enzymatic refined NF-PP-composite

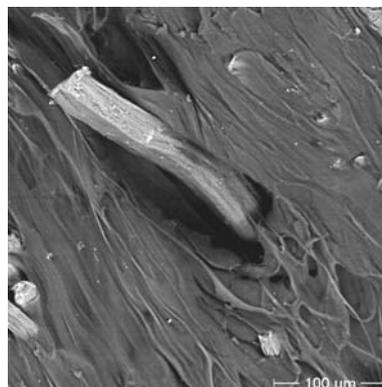


Fig. 7: REM image of an NF-PP-composite with mechanical refined fibres

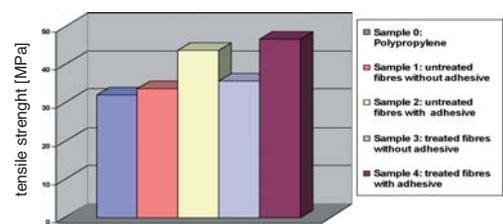


Fig. 4: Influence of the refining on the tensile strength from NF-PP-composite

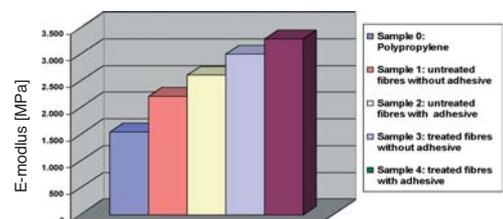


Fig. 5: Influence of the refining on the E-modulus from NF-PP-composite