**Aligned hemp yarn reinforced biocomposites: porosity, water absorption, thermal and mechanical properties**

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The potential of natural fibres as reinforcement in composite materials is well recognized due to their attractive mechanical properties which enhance the possibility of producing eco-friendly materials. Natural fibres are already used in the automotive industry to reduce weight, cost and environmental impact. Hemp is an upcoming European industrial crop, with good mechanical fibre properties which can be cultivated with a low consumption of fertilizers and almost no pesticides. Concerning the matrix in the composites, the industrial trend for natural fibre composites is giving more importance to a thermoplastic matrix, rather than a thermosetting matrix.

Polylactic acid (PLA) is the most important biothermoplastic for applications requiring biodegradability. The mechanical properties of the PLA can be improved by using reinforcements like natural fibres in order to increase its potential use in many industrial applications. Therefore, because of the attractive properties of hemp fibre, it was used as reinforcement for PLA composite in the presented study.

The main application of natural fibres is in non-structural composites as they are mostly available as randomly oriented nonwovens. The fibre orientation (i.e. alignment of the fibres) must be controlled to ensure that the fibre mechanical properties are efficiently utilized in order to attract industrial interest as an alternative to the traditionally applied synthetic fibres. Natural fibres are naturally discontinuous; therefore natural fibre reinforcements reported so far are based on twisted spun staple yarns. These yarns tend to be highly twisted, which leads to fibre misalignment due to their helical paths around the yarn axis. This misalignment contributes negatively to the mechanical properties of the resultant composites. Another negative impact of yarn twist is that it tightens the yarn structure, rendering resin impregnation difficult.

In this study, hemp composites using uniaxial aligned hemp/PLA wrap spun yarns were fabricated with 30 mass% hemp using compression moulding. The yarns were produced by spinning PLA and hemp staple fibres, and then prepregs where produced by winding around a frame. The properties of composites in terms of hemp fibre orientation (aligned and random), off-axis angle and alkali treatment were investigated. Fabricated composites were characterised regarding porosity, water absorption at two different temperatures, mechanical and thermal properties (DMTA and DSC) and scanning electron microscopy (SEM). It was found that the testing direction influenced the mechanical properties of the composites. Compared with all the fabricated composites, the aligned alkali hemp/PLA yarn composite possessed the best mechanical properties, including tensile, flexural and impact strengths, lower porosity and water absorption. The water absorption was for all composites higher than for neat PLA. The composite from the nonwoven prepreg had the highest water gain value followed by the composite from untreated hemp yarn and the composite from alkali hemp yarn. The PLA in the composites had higher crystallinity, which was attributed to effective heterogeneous nucleation induced by hemp however, crystallinity of alkali hemp/PLA composite was higher. Based on SEM observation and theoretical analysis based on DMTA data, there was favourable interfacial adhesion in all composites.