THERMOBONDED COMPOSITES MADE WITH COTTON (CO) AND POLYLACTIC ACID (PLA) FIBRES FOR TECHNICAL APPLICATIONS

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ABSTRACT
This paper describes two different thermobonded composites made with cotton and polylactic acid fibres. The fibre-reinforced plastics consist of cotton as the reinforcing fibre and the matrix made out of polylactic acid. The polylactic acid fibres are processed with the cotton fibres into a nonwoven. The thermoplastic fibres (PLA) are melted by a heat treatment and encase the cotton fibres. When cooled, the fibres consolidate and form a matrix.
The applications developed by the FIBRE are THERMOLINK and NEP CORES.
Application 1 (THERMOLINK) develops innovative products by a local heat treatment of the nonwoven materials. This method consolidates specific areas while others remain flexible and therefore create a hinge.
Application 2 (NEP CORES) are three-dimensional composite materials with neps for lightweight construction. The nep cores can be utilised with or without surface layers. Functions of the nep cores are acoustic and moisture absorption. Possible applications are for example in the architectural field as tiling for offices or as a substitute for chipboards as furniture.

FIBRE-REINFORCED PLASTICS
Fibre-reinforced plastics are used for lightweight design and consist of the reinforcing fibres and a polymer matrix. The reinforcing fibres absorb and distribute the weight that the matrix transmits. Further functions of the matrix are the protection of the fibres from external influences and dimensional stability.
The combination of the two components create functions that the components alone cannot establish. Common reinforcing fibres are glass or carbon fibres, but also natural fibres are used as a reinforcement. The fibres can be incorporated in continuous or discontinuous length and are embedded in a polymeric matrix. The matrices can be thermosetting or thermoplastic. (Mallick, 2007)
The orientation of the fibres and therefore the anisotropy and isotropy of the fibre reinforced-plastics can be controlled. (Agarwal, 2006)

MATERIALS FOR THERMOBONDED COMPOSITES
In this research nonwovens made with cotton and polylactic acid fibres are used as a base material for the thermobonded composites.
Despite the many advantages of plastics, depending on fossil fuels has many negative effects, especially on the environment. Hence bioplastics as alternative materials that are renewable, sustainable and biodegradable were developed. (Pilla, 2011)
Polylactic acid is a thermoplastic bioplastics that is mainly used for food packaging and 3D printing. The performance of the bioplastics depends on the proportion of D- and L-enantiomers.
Polylactic acid is obtained by fermentation or chemical synthesis of renewable resources. (Ashter, 2016) The renewable resources are sugar or starch which are obtained from plants like sugar beets or corn and then fermented into lactic acid. The

produced granules are processed further into filaments by melt spinning. The filaments are cut into staple fibres to be further processed with the cotton fibres into nonwovens by needling. The manufacturing process is portrayed in figure 1.

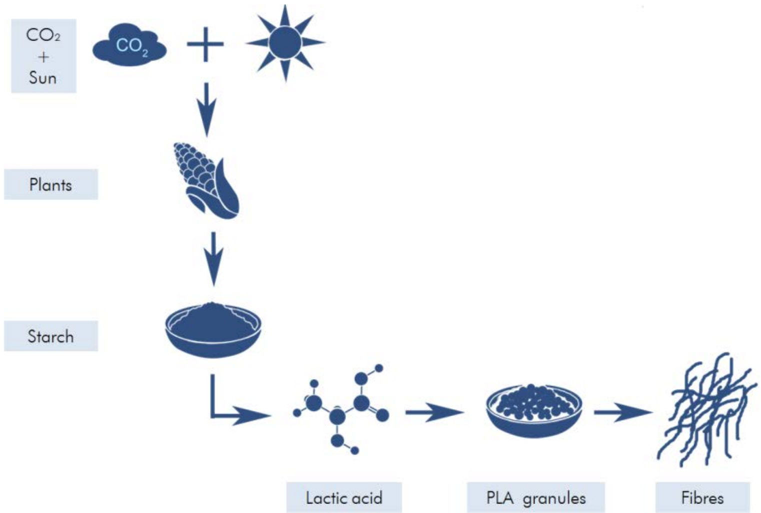

Figure 1. Manufacturing Process of Polylactic Acid Fibres

APPLICATION 1: THERMOLINK

The research project THERMOLINK develops innovative products by local consolidation of the nonwoven by a heat treatment. The thermoplastic polylactic acid fibres melt and form a matrix when cooled down. The thereby arising hardened parts build the form of the products. The areas where no heat was applied remain flexible and form a hinge. (Figure 2.)

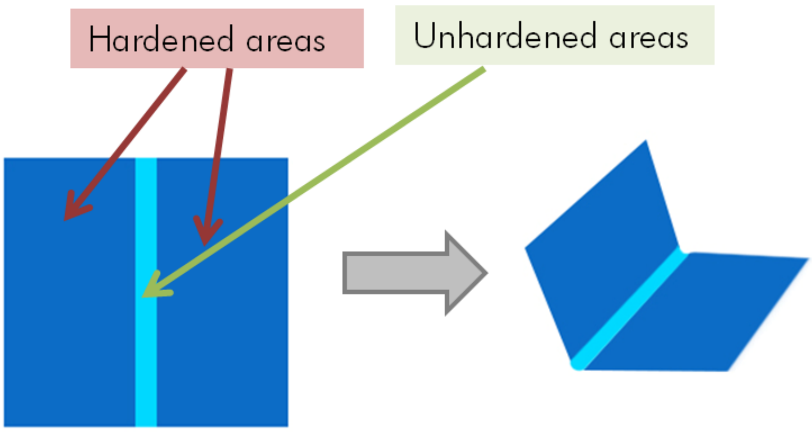

Figure 2. Concept of THERMOLINK

The heat treatment of the nonwoven takes place under compression. To shorten the processing time the heat is applied at 200 °C, about 25 °C above the melting temperature of the polylactic acid fibres. Therefore it is possible to melt the thermoplastic fibres in 90 seconds. The insert of the press is structured so that the compound is only in contact with the hot surface on the areas that should be consolidated. The areas that are not in contact with the heated press and remain flexible.

After the heat treatment, the material is transferred to a cooling press and hardens under compaction.
Possible applications for THERMOLINK are products with hardened and unhardened areas like foldable boxes, collapsible suitcases, knee guards, window blinds, underwire bras or smart phone cases. Those application commonly use two different material compounds which are for example adhered together to achieve the functions.

APPLICATION 2: NEP CORES

The application NEP CORES is used in lightweight construction. Three different variations of the nep cores are portrayed in figure 3. The first figure shows the nep core without any surface layer. This application provides acoustic absorption and moisture regulation. It can be used in the architectural sector as tiling for offices and halls. The nep cores can also substitute chipboards when placed between two surface layers. With this approach furniture or dividing walls for offices and booths can be built out of nep cores. The low specific weight benefit those purposes.
Another possibility is adding a grid-like structure on top of the neps. Those structures can functionalise the neps to hold cables and wires for example in offices, by maintaining the other properties like acoustic and moisture absorption.

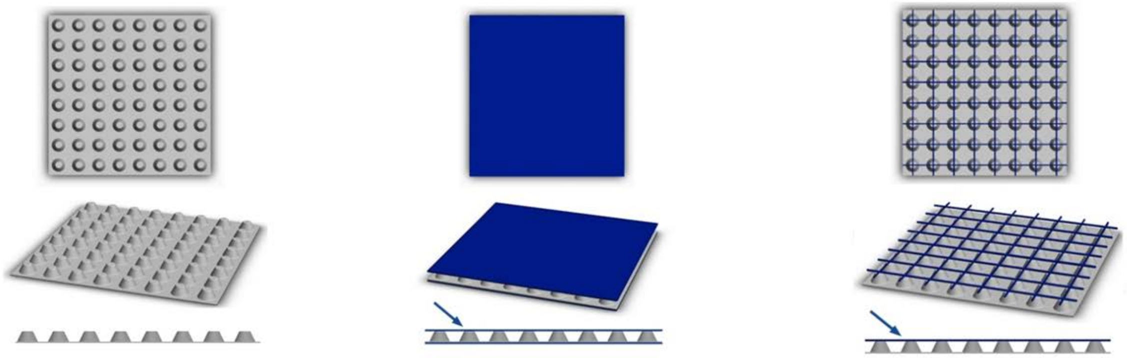

Figure 3. Variations of Nep Cores

The base material of the nep cores is nonwoven made with polylactic acid and cotton fibres. The amount of cotton and polylactic acid can be varied. Thereby the parameters of the fibre-reinforced plastics are adjustable. Cotton absorbs the moisture and provides acoustic absorption. The strength of the compound raises with a higher ratio of polylactic acid. The utilised amounts of cotton and polylactic acid depend on the application of the nep cores.
The nep cores consist of different laminate structures. The laminate structure can not only add weight to the compound, but also adds functions to the nep cores. In figure 4. (1) a uniform laminate structure is shown. Each layer has the same amount of cotton and polylactic acid fibres. In the diverse laminate structure (figure 4. (2)) the outside layers of the compound consist of more cotton than polylactic acid whereas the inside layer has a high amount of polylactic acid. With this composition of the nep cores, the functions of the cotton (moisture and acoustic absorbency) are substantial. Yet also the strength that the inside layer provides is present. After the heat treatment the layers are not visible.

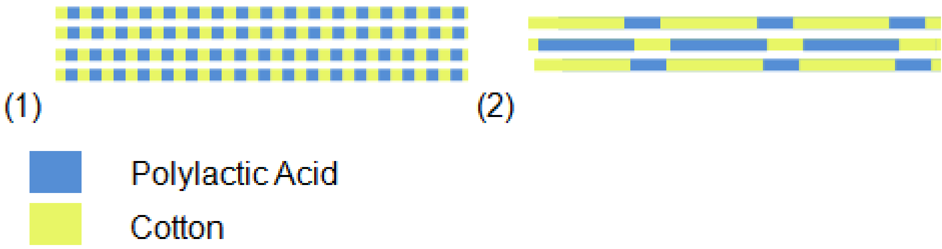

Figure 4. Uniform (1) and Diverse (2) Laminate Structure

The geometry of the nep cores is variable to fit to purpose. The top of the neps can be flat or pointy. When adding a surface layer to the neps, flat tops assure a large contact face to connect the neps to the layers.

To fabricate the nep cores, the nonwoven made with thermoplastic polylactic acid and cotton fibres are treated with heat under compaction. The thermoplastic fibres (polylactic acid) melt and the textile is transferred to a cooled press where the material is moulded under pressure into nep cores. The insert of the second press forms the two-dimensional fabric into a three-dimensional fibre-reinforced plastic while simultaneously cooling the material. This process solidifies the compound. The parameters of the process are similar to the parameters of THERMOLINK.

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