Using bacteria to create novel composites: Natural fibre reinforced cellulose nanocomposites

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Considering the current environmental, societal and political issues especially in the way we use materials, a pressing need for innovative, sustainable and recyclable materials can be identified. Industry and consumers needs to move to greener materials to divert materials from waste streams. However, such materials should meet the physical performance of conventional engineering materials. The most abundant renewable material available is cellulose. We are aiming to produce composites, which combine different cellulosic materials to obtain all-cellulose hierarchical composites. Hierarchical composites or fibre reinforced nanocomposites are a combination of conventional reinforcing fibres and a nanoscale reinforcement within a polymeric matrix. This will allow us to create a new class of materials with both superior mechanical, environmental, and chemical performance, as well as significantly reduced through-life costs.

The design, optimisation and control of composite interfaces is the most crucial issue in composite engineering and more so in green composites, because of the known incompatibility of the natural fibres and many polymers used as matrix. Here we will present a novel route to tailor interfaces in natural plant fibre reinforced cellulose. We have developed a truly green technique of modifying a variety of natural fibre surfaces to improve the interaction between the fibres and matrix by attaching nano-scale bacterial cellulose to the fibre surfaces. Nano-scale bacterial cellulose was successfully attached to the fibres by culturing a strain of cellulose-producing bacteria, Gluconacetobacter xylinus strain BPR 2001, in presence of natural fibres. Commercially available microcrystalline cellulose powder was dissolved in a non-derivative co-solvent (dimethylacetamide/LiCl) and subsequently regenerated to form the cellulose matrix. The attaching bacterial cellulose to the fibres enhances the effective fibre surface area of the fibres which is anticipated to lead to greater interaction with the regenerated cellulose matrix. The composite performance can be tailored by tuning the degree of crystallinity of the regenerated cellulose matrix, which is a function of the processing time during dissolution. The presence of the nano-cellulose attached to the fibre surfaces lead to composites with improved mechanical performance. All-cellulose hierarchical composites might be able to substitute traditional based glass fibres reinforced polymers in a near future.