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Fabrication of All-Cellulose Composites from End-of-Life Textiles

Authors : Behnaz Baghaei, Mikael Skrifvars

Abstract : Sustainability is today a trend that is seen everywhere, with no exception for the textiles 31 industry. However, there is a rather significant downside regarding how the textile industry currently operates, namely the huge amount of end-of-life textiles coming along with it. Approximately 73% of the 53 million tonnes of fibres used annually for textile production is landfilled or incinerated, while only 12% is recycled as secondary products. Mechanical recycling of end-of-life textile fabrics into yarns and fabrics was before very common, but due to the low costs for virgin man-made fibres, the current textile material composition diversity, the fibre material quality variations and the high recycling costs this route is not feasible. Another way to decrease the ever-growing pile of textile waste is to repurpose the textile. If a feasible methodology can be found to reuse end-of life textiles as secondary market products including a manufacturing process that requires rather low investment costs, then this can be highly beneficial to counteract the increasing textile waste volumes. In structural composites, glass fibre textiles are used as reinforcements, but today there is a growing interest in biocomposites where the reinforcement and/or the resin are from a biomass resource. All-cellulose composites (ACCs) are monocomponent or single polymer composites, and they are entirely made from cellulose, ideally leading to a homogeneous biocomposite. Since the matrix and the reinforcement are both made from cellulose, and therefore chemically identical, they are fully compatible with each other which allow efficient stress transfer and adhesion at their interface. Apart from improving the mechanical performance of the final products, the recycling of the composites will be facilitated. This paper reports the recycling of end-of-life cellulose containing textiles by fabrication of all-cellulose composites (ACCs). Composite laminates were prepared by using an ionic liquid (IL) in a hot process, involving a partial dissolving of the cellulose fibres. Discharged denim fabrics were used as the reinforcement while dissolved cellulose from two different cellulose resources was used as the matrix phase. Virgin cotton staple fibres and recovered cotton from polyester/cotton (polycotton) waste fabrics were used to form the matrix phase. The process comprises the dissolving 6 wt.% cellulose solution in the ionic liquid 1-butyl-3-methyl imidazolium acetate ([BMIM][Ac]), this solution acted as a precursor for the matrix component. The denim fabrics were embedded in the cellulose/IL solution after which laminates were formed, which also involved removal of the IL by washing. The effect of reuse of the recovered IL was also investigated. The mechanical properties of the obtained ACCs were determined regarding tensile, impact and flexural properties. Mechanical testing revealed that there are no clear differences between the values measured for mechanical strength and modulus of the manufactured ACCs from denim/cotton-fresh IL, denim/recovered cotton-fresh IL and denim/cotton-recycled IL. This could be due to the low weight fraction of the cellulose matrix in the final ACC laminates and presumably the denim as cellulose reinforcement strongly influences and dominates the mechanical properties. Fabricated ACC composite laminates were further characterized regarding scanning electron microscopy.

Keywords : all-cellulose composites, denim fabrics, ionic liquid, mechanical properties
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