Carbon fibers from Lyocell filaments – Understanding and overcoming the limitations of cellulose as precursor

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Carbon fibers have found wide-spread applications as lightweight and strong materials for energy-efficient mobility, green energy harvesting, and long-lasting construction. Natural cellulosic fibers were used as precursors for short carbon fibers already in the 19th century by Thomas A. Edison and Joseph W. Swan. However, various intrinsic properties of carbohydrates have so far prevented large-scale production and commercial success. At present, carbon fibers are almost exclusively made from PAN- or pitch-based precursor fibers. In search for sustainable and renewable alternatives, the use of cellulose as precursor substrate has experienced a renaissance.

The importance of thermostabilization prior to the actual carbonization is well known. Direct carbonization favors pathways that involve the formation of volatile carbonaceous compound and leads to char yields far below the theoretical maximum of 44.4%. Thermostabilization at moderate temperatures of 150 – 250 °C gives rise to an intermediate structure sometimes referred to as “thermostable condensed phase”. The exact structure of this intermediate or the mechanism leading to its formation are still not fully understood. In this study we shed light on the evolution of the thermostable condensed phase. Surprisingly, the depolymerization of cellulose prior to carbonization plays a central role. Electron beam irradiation of the precursor filaments was found to accelerates thermostabilization which reduces costs and supports the development of better mechanical properties.