Isotropic Polymer reinforcement using Cellulose Aerogels

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Cellulose has an impressively strong polymeric backbone that makes it outstandingly suitable for utilization as fiber-reinforcement in polymers. It therefore increasingly appears in projects and publications that address sustainable reinforcement strategies using biopolymers.[i]
Nonetheless, it is often hampered due to sedimentation of the Cellulose fibers or for incompatibility reasons with respect to the resin matrix which is often addressed by functionalization of the cellulosic backbone.

These obstacles can be overcome using Cellulose aerogels instead of adding loose Cellulose fibers aiming for the reinforcement of a desired thermoset.

Cellulose Aerogels consist of the strong cellulosic backbone building up an accessible and highly porous (>85%) structure resulting in a light yet stiff monolithic material. Numerous routes can yield Cellulose Aerogels, but all of them involve the dissolution of the original Cellulose (e.g. in aqueous salt hydrate melts such as $ZnCl_2$) followed by regeneration and drying in supercritical CO_2.

As a result a randomly arranged nano-fibrous felt of Cellulose (7-25 nm in diameter)[ii] is obtained. In substituting the air in the obtained system with a thermoset matrix yields strong Cellulose nanocomposites.

While conventional fiber matrix composites most often use fiber fractions far beyond 30 vol.% the nanoscale fibrils in the Cellulose aerogel significantly influence the mechanical properties while only minimally adding to the composites' density with less than 20 vol.% fiber fraction (Fig. 1).

As a result, Cellulose aerogels are clearly suited to reinforce polymer matrices providing their open-porous network for a mechanical interlocking of the matrix resin to give performance-competitive composites.

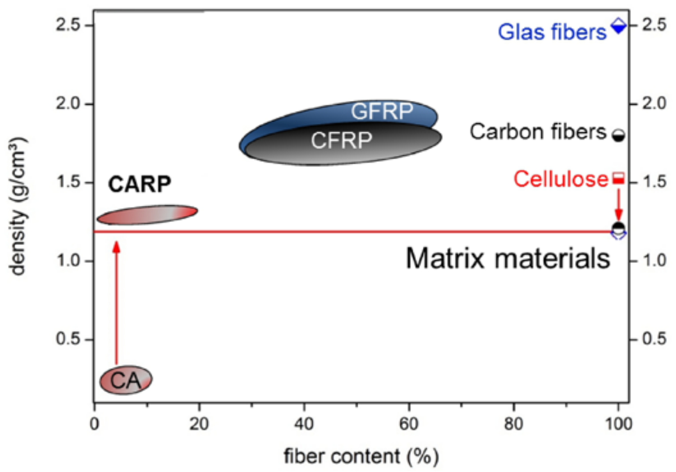

Figure 1. Densities of conventional fiber reinforced polymers compared with densities of Cellulose Aerogels and composites thereof.

[i] K. Oksman, Y. Aitomäki, A. P. Mathew, G. Siqueira, Q. Zhou, S. Butylina, S. Tanpichai, X. Zhou, *S.* Hooshmand, *Compos Part A Appl Sci Manuf* **2016**, 83, 2-18

[ii] A. Rege, M. Schestakow, I. Karadagli, L. Ratke, M. Itskov, *Soft Matter* **2016**, 12, 7079-7088