

Polymer Nanocomposite Materials reinforced with amyloid fibrils

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Fibers have fascinated mankind since the very beginning. Most of textile products are made of fibers, which for centuries have been obtained from natural sources. Many biological materials use nano fibers as building block. One of the best examples is spider webs. The incredible properties of spider silk fibers, with their exceptional toughness, have prompted scientist to investigate their structure in the hope of creating light weight but highly resistant materials. Given the difficulty in working with silk proteins, we used instead amyloid fibrils, which are less known but have similar structure to silk and are much easier to prepare, to create an entire new class of reinforced rubber materials.

In this work, a novel type of composite polymeric materials reinforced by protein fibrils has been prepared. Protein fibrils are self-assembled structures resulting from partial denaturation of certain proteins, and the resulting aggregation mediated by beta-sheets interactions. These structures are characterized by an extremely large aspect ratio, with a diameter that changes depending on the age of the fibrils, and on the degree of association of the different strands. For the fibrils used in our experiments, which are prepared by partial denaturation of beta-lacto globulin at pH 2.0 and 80°C for 24 hours, and at a concentration of 10mg/ml, typical diameters are about 25nm with a length of several micrometers. For the first time high concentrations of fibrils have been incorporated into a polymer. The process used to incorporate fibrils is unique. We started from a suspension of polymer particles in water, which are mixed with the fibrils in the aqueous phase. It has been observed that not only the elastic modulus of composite materials with fibrils is increased, but also the ductility of the materials is enormously improved. Further improvement of the properties of the materials have been obtained by combining amyloid fibrils with silica nanoparticles, resulting in the formation of composite materials with mechanical properties even more enhanced, as a result of augmented elastic modulus provided by silica, and ductility increase provided by amyloid fibrils. This procedure to reinforce materials could provide a new alternative to reinforcement of a broad variety of elastomers.