Modification of the Kevlar-29 fibers tensile properties after a brine (NaCl) treatment

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The performance of any composite is highly dependent upon the properties of the reinforcement, which make important the study of its mechanical behavior. Kevlar is an organic aramid fiber with a typical yellowish or golden look due to the presence of aromatic groups [1]. This fiber is an innovative technology that combines high strength with light weight to help dramatically improve the performance of a variety of consumer and industrial products (e.g. ballistic protection armor, helicopter blades and sporting goods) [2]. The mechanical properties of aramid fibers are related to their peculiar microstructure characterized by several features such as fibrils, radial pleated sheets and skin-core differentiation. The surface fibrils are uniformly oriented in the axial direction, while the fibrils in the inner core are imperfectly packed. The slippage between the fibrils under load and the step-wise fibrillar breaks produce uneven and jagged morphology in which the fibers are fibrillated and split at the breaks. The origin of the splitting may be as a result of stress concentrations at flaws or inside the fibers [1].

It is well known that when a material is exposed to different degrading environments, such as UV light and chemical reagents, its mechanical properties decrease. In this work the tensile mechanical behavior of single Kevlar-29 fibers of ~12 µm in diameter were investigated, after a treatment in brine. To perform this, the fibers were immersed in a 30 wt.% NaCl solution for 10 minutes at 323 K; after this the samples were immediately tested. The diameter measurements of the monofilaments and the tensile tests were carried out at room temperature under the same conditions reported in our previous paper [3]. Field emission scanning electron microscopy (FESEM) characterization was achieved using a JEOL JSM-7401F microscope operated at 2 kV; secondary electron emissions were used to obtain the images.

The tensile stress-strain curves of the brine-treated single Kevlar-29 fibers were acquired. The results indicate that these curves remain practically linear until failure, as can be seen in figure 1; for comparison, a representative curve of the as-received Kevlar-29 fibers was include [3]. The inset of figure 1 displays clearly that the curve slope for the brine-treated fiber is higher than that of the as- received one. The mechanical properties were calculated from these curves, whose values are shown in table 1 and compared with those obtained in our previous work [3]. A decrement in tensile strength and breaking strain, as well as an increment in Young’s module for the brine-treated fibers are evident. The tensile fracture morphology was similar for all the brine-treated fibers tested (Figs. 2 and 3). Even though this morphology is typical for the tensile rupture of Kevlar fibers [1,3], a more complex form was obtained after the fibers were subjected to a brine treatment. Figure 2 show a general view of a fiber under this condition and tested in tension; the severe splitting is evident. Details of break zones are displayed in figure 3. All these results point out that the fibers were damaged when they were exposed to a degrading environment.