Fiber dielectric elastomer actuators (DEAs) are potential candidates for the realization of artificial muscles due to their close resemblance with human muscles. In this work, a polydimethylsiloxane (PDMS) hollow fiber is prepared by means of a wet spinning method using a photocurable thiol-ene reaction between silicones with sulfhydryl (R-SH) group and alkene groups, respectively. The optimized PDMS fiber has an external diameter of 463 µm and uniform wall thickness of 78 µm and shows excellent tensile properties (596 % strain at break and 0.62 MPa tensile strength) compared to these of a planar film with identical composition (86 % strain at break and 0.14 MPa tensile strength). Fiber DEAs are assembled by injecting ionic liquid as the core electrode and dip-coating iono-gel as the outer electrical sheath. Due to the combination of highly transparent PDMS elastomer layer and ionic electrodes, the fiber DEA presents a transparency of ~91 % in a visible light spectrum. The fiber DEA exhibits a sizeable linear strain of 9 %, and repeatable and stable linear actuation strain over 1000 cyclic actuation tests. Furthermore, the fiber DEA can be assembled into bundles for increased forces. The work presented herein provides a pathway for creating active soft matter with complex architectures to enable fast programmable actuation for soft robotics or for the replacement of human muscles in the future.