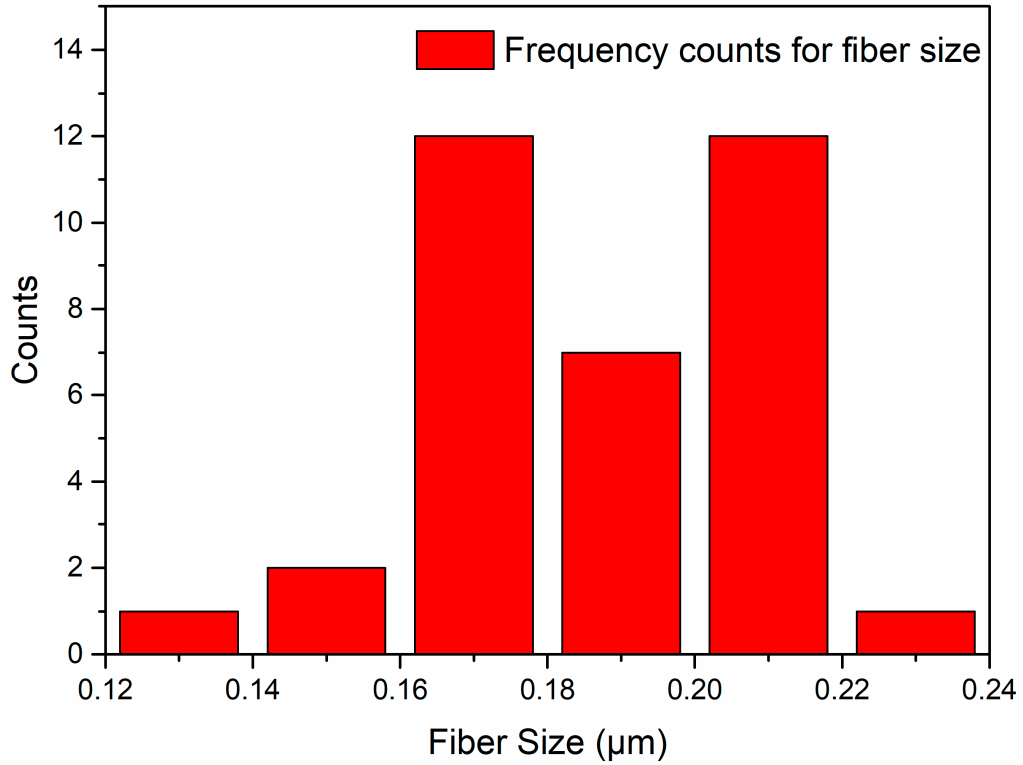


**Supplementary Materials:**

The temperature is maintained at 30 °C and the humidity is between 40% and 50% during electrospinning. The thickness of the PAN and composite separator used is 45 $\mu$ m in the test. The average diameter of the fibers in the membrane is 180 nm.



**Figure S1.** The size distribution of membrane fiber.