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Manufacturing of Nanoparticle Reinforced Materials through Electrospinning

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Electrospinning is a process of manufacturing nano-fibrous webs using an electric force to transport threads of a polymer solution. Polyvinyl Alcohol (PVA) was chosen as the base polymer for all testing purposes. PVA is known for having high tensile strength, but the tensile strength is decreased by high humidity. To regulate humidity, all tests were performed inside a sealed box with a dehumidifier.

Two different materials were chosen as additives to the PVA: carbon nanotubes (CNTs) and nanoclay. CNTs have high modulus, elasticity, and strength. CNTs are also effective electrical and thermal conductors. Nanoclay is not easily dispersed throughout polymer mixtures, but once it is evenly dispersed, it has been shown to improve mechanical strength, barrier properties, and flame-resistance.

Three separate experiments were conducted for this study:
1. PVA with no additives (control)
2. PVA with carbon nanotubes
3. PVA with nanoclay

For each experiment, 15 percent by weight (wt%) of PVA was mixed with distilled water and was heated for four hours at 100 °C. For PVA with CNTs, less than 1 wt% CNTs was added to the PVA/water mixture. For PVA with nanoclay, 5 wt% nanoclay was added to the PVA/water mixture. Once the mixture was finished heating, it was cooled and electrospun.

Scanning Electron Microscopy (Sem) was employed to visualize the individual fibers of the electrospun webs. PVA with no additives has fibers that are very sporadic, going in different directions and having varied diameters and connection points. Unlike PVA with no additives, PVA with CNT fibers have a more uniform structure, holding the shape and diameter of each fiber. PVA with nanoclay has the most sporadic fibers, with stacking and changing directions and diameters of the fibers.

Three individual tests/measurements were performed on the samples of the electrospun webs: tensile strength, thickness, and air permeability. From the tests/measurements, it was observed that PVA with no additives has the highest tensile strength and elastic modulus, PVA with CNTs has the best air-permeability, and PVA with nanoclay has the greatest thickness and average force.

Electrospun webs are becoming more popular because of their ability to be used in filtration, textile manufacturing, medical technologies, composite materials, and chemical catalysts. Depending on the application of the electrospun web, PVA with CTNs or nanoclay exhibit improved performance. Future work is needed to explore alternative polymers and additive configurations that were not discussed here.

Statement of Research Advisor:

Kiana has resurrected the research in electrospinning after a disruption due to the move of the Polymer and Fiber department. She obtained good results and presented them in the Fiber Society international conference in Athens, GA in Fall 2017.
—*Sabit Adanur, Polymer and Fiber Engineering*