OXIDATIVE STABILIZATION STUDIES IN THE FORMATION OF ELECTROSPUN CARBON NANOFIBERS FROM A PURIFIED SOFTWOOD KRAFT LIGNIN

*Omid Hosseinaei, Darren A. Baker**
University of Tennessee
2506 Jacob Dr.
Knoxville, TN, USA
*dbaker20@utk.edu

Lignin, as the second most abundant natural polymer, has gained attention for the production of carbon fibers. Lignin-based carbon fibers will be inexpensive compared to petroleum-based carbon fibers and will therefore increase the application of carbon fibers. Electrospinning is a simple and relatively inexpensive way to produce continuous nano-scale carbon fibers. Electrospun fibers have broad applications in filtration media, nanocomposites, pharmaceutical compositions and protective clothing. The high surface area to volume ratios of electrospun carbon nanofibers, which can be increased by activation, make them a good choice for use in energy applications.

Oxidative stabilization can be considered as the most important step in the process of making carbon fiber. Lignin is a thermoplastic material and oxidative stabilization is needed to prevent the fusion of fibers during carbonization. Stabilization is achieved by oxidatively heating the fibers (historically at a rate of 0.01 to 0.2°C/min to between 200 and 250°C) to cause the cross-linking and condensation of lignin. The heating rate used during stabilization is such that the treatment temperature always remains below glass transition temperature (T_g) of lignin which gradually increases during stabilization. Therefore, in contrast to technical lignins used in the past, the lignins used for this study were optimized to have a high T_g, so that oxidative stabilization of the lignin would proceed at a much faster rate.

A commercial kraft softwood lignin was used for making electrospun carbon nanofibers. The lignin was first purified to remove any residual ash, carbohydrates and low molecular weight (MW) components. The purified lignin was then sequentially solvent extracted to obtain two lignins of differing Tg, and therefore MW. The high molecular weight lignin after extraction had a high T_g as measured by differential scanning calorimetry. Electrospinning solutions were prepared by dissolving this lignin in a mixture of two solvents optimized for lignin dissolution.The solutions were electrospun using a syringe pump, rotating target and a potential difference between the two. The electrospun lignin fibers were oxidatively thermostabilized at differing heating rates and were then anaerobically carbonized to 950°C. The stabilization and carbonization yields were calculated for each sample. The chemical and thermal properties of the stabilized fibers were studied by infrared spectroscopy and thermogravimetric analysis, while the morphology of the carbon fiber webs was examined by scanning electron microscopy.