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PhD Dissertation Defense

Entitled

ACTIVATED CARBON NANOFIBERS FROM RENEWABLE (LIGNIN) AND WASTE RESOURCES (RECYCLED PET) AND THEIR ADSORPTION CAPACITY OF REFRACTORY SULFUR COMPOUNDS FROM FOSSIL FUELS

by

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Abstract

The development of advanced engineering materials such as carbon nanofibers from low-cost, renewable and/or waste resources is a key aspect of sustainability. In addition, escalating concerns related to the presence of noxious sulfur compounds in commercial fuels are driving the need to develop more efficient desulfurization technologies. In this PhD thesis research, activated carbon nanofibers were produced from a blend of lignin with recycled poly(ethylene terephthalate) (r-PET) and they were successfully tested for the adsorption of refractory sulfur compounds from a model diesel fuel. Starting from different lignin/r-PET mass ratios, precursor nanofibers of different morphologies were initially prepared using the electrospinning technique. With the aid of a Design-of-Experiments statistical methodology, electrospun nanofibrous mats with a minimum average diameter of 80 nm were produced. The electrospun nanofibers were characterized with Differential Scanning Calorimetry, Attenuated Total Reflection – Fourier Transform Infrared Spectroscopy, Thermogravimetry and Scanning Electron Microscopy. Subsequently, electrospun precursor nanofibers consisting of different lignin/r-PET mass ratios and of varying average diameters were carbonized into carbon nanofibers (CNFs). It was discovered that the morphology of the CNFs depends on a synergy between the average fiber diameter and the lignin/r-PET mass ratio of the precursor electrospun nanofibers. These conditions were mapped and CNFs with average fiber diameter close to 100 nm were prepared. The CNFs were characterized using N_2 physisorption, Transmission Electron Microscopy, Raman spectroscopy, X-Ray Diffraction and Energy-Dispersive X-Ray Spectroscopy. Their structure consists mostly of disordered carbon, while the CNFs derived from 50/50 lignin/r-PET with ~400 nm average fiber diameter present the highest BET surface area (353 m^2/g). Their chemical activation with KOH boosted their BET surface area to 1413 m^2/g, while a further treatment with HNO3 anchored oxygen functional groups on their surface. These activated CNFs (ACNFs) were tested for the adsorption of 4,6-dimethyldibenzothiophene (DMDBT) and of dibenzothiophene (DBT) from a model diesel fuel (n-dodecane). It was found that they exhibit a very high adsorption capacity (120.3 mg_{DMDBT}/g_C and 77.82 mg_{DBT}/g_C respectively), combined with remarkably fast adsorption kinetics. Therefore, the ACNFs have a great potential to be used as desulfurization adsorbents.

Keywords: carbon nanofibers, lignin, recycled PET, electrospinning, adsorption, refractory sulfur compounds, desulfurization.