Coal tar pitches / PAN based electrospun fibers

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The investigation work focuses on the obtaining of nanostructured fibers using polyacrylonitrile and technogenic waste, specifically coal tar produced from fossil coal coking. The resulting fibers are further modified with functional additives, including nickel oxide nanoparticles, nanoporous coals, and silicon dioxide nanoparticles. The physical and chemical properties of the modified fibers are experimentally investigated to evaluate their potential use as gas-sensitive and sorption materials.

Electrospinning is a well-established technique for producing fibers ranging in diameter from nanometers to micrometers. The process involves applying an electric field to a polymer solution or melt, resulting in a charged jet that is deposited onto a collector. The choice of polymer is a crucial factor in electrospinning as it can affect the morphology, structure, and properties of the resulting fibers. While polyacrylonitrile (PAN) is the most commonly used polymer for electrospinning, coal tar pitch (CTP) has emerged as a promising alternative due to its unique properties.

Coal tar pitch is a byproduct of the coal carbonization process and contains high molecular weight polycyclic aromatic hydrocarbons. CTP has a complex chemical structure and high carbon content, making it a suitable material for producing carbon fibers with high mechanical strength and electrical conductivity. Moreover, CTP is a low-cost and readily available material in our region. Usually, CTP is disposed of by incineration or landfill, which leads to environmental pollution. However, by recycling CTP to produce valuable carbon materials like carbon fibers, we can reduce the burden on the environment. In summary, electrospinning is an established technique for producing fibers, and CTP has emerged as a promising alternative to PAN due to its unique properties. By using CTP to produce carbon fibers, we can not only obtain materials with desirable mechanical and electrical properties but also recycle a waste product, reducing the environmental impact.

The use of CTP as an alternative to PAN in electrospinning is crucial for producing fibers with improved properties such as higher thermal stability, mechanical strength, electrical conductivity, and chemical resistance. With further research and development, CTP-based fibers have the potential to revolutionize materials science and significantly impact various industries. However, CTP presents some challenges in electrospinning, such as its high viscosity, which can affect the formation of a stable jet, and the requirement for high processing temperatures. Nevertheless, this paper presents optimized electrospinning parameters for CTP, which can serve as prerequisites for the production of fibers with controlled morphology and properties. For instance, we prepared a solution by combining PAN and CTP to reduce viscosity and enhance solution moldability. PAN is a widely used electrospinning polymer with low viscosity, making it a suitable additive for CTP-based fibers.

Based on our experimental work, we have established that the optimal weight ratio of PAN to CTP for producing carbon fibers is 70:30. Using this ratio, we were able to produce one-dimensional fibers with an average diameter of 248 nm and a carbon content of at least 92% through a one-stage electrospinning process. Carbon fibers doped with nickel oxide nanoparticles, with an average crystallite size of 48 nm obtained through solution-combustion synthesis, demonstrated a sensitivity of 73% towards acetone. The gas sensitivity analysis of the material yielded positive results, indicating excellent chemical stability and high sensitivity of the sample towards gaseous acetone.

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