INTRODUCTION

General description of the work. The dissertation is devoted to the preparation of nanostructured fibers based on polyacrylonitrile polymer with the addition of technogenic waste in the form of coal tar obtained from the coking of fossil coal, with further modification of the obtained fibers by adding functional additives in the form of nickel oxide nanoparticles, nanoporous coals and silicon dioxide nanoparticles, and their experimental study. physical and chemical properties to use nanostructured fibers as gas sensitive and sorption materials.

The relevance of the thesis topic. Electrospinning is a widely used process for producing fibers with diameters in the nanometer to micrometer range. In this process, an electric field is applied to a polymer solution or melt, resulting in a charged jet that is drawn out and deposited on a collector. One of the critical factors in electrospinning is the choice of polymer, which can affect the morphology, structure, and properties of the resulting fibers. While polyacrylonitrile (PAN) is the most commonly used electrospinning polymer, coal tar pitch (CTP) has gained attention as an alternative due to its unique properties.

Coal tar pitch is a by-product 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 suitable for the production of carbon fibers with high mechanical strength and electrical conductivity. In addition, CTP is low cost and widely available in our region. CTP is usually disposed of by incineration or landfill, which can lead to environmental pollution. However, by using CTP to produce valuable carbon materials such as carbon fiber, the environmental impact is reduced by recycling this product.

Therefore, the use of CTP instead of PAN in electrospinning is of great importance to produce 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 have a significant impact on various industries.

However, CTP also poses some problems in electrospinning, such as its high viscosity, which can affect the formation of a stable jet, and the need for high processing temperatures. However, this paper presents the results of optimizing the electrospinning process using CTP, which can be used as a prerequisite for producing fibers with controlled morphology and properties. For example, in this work a solution of PAN and CTP was prepared to reduce the viscosity and improve the mouldability of the solution. PAN is a widely used electrospinning polymer and has a low viscosity, making it a suitable additive for CTP-based fibers.

In order to prepare the obtained fibers for practical applications, they were modified with various additives in the form of nickel oxide nanoparticles, nanoporous carbons and silica nanoparticles. As a result, the nanostructured fibers can be effectively used as gas-sensitive and sorption materials. The creation of novel gas sensing and sorption materials with low cost and improved properties is an important direction in materials science and sensing.

Goal of the work. The aim of this thesis is to obtain carbon and nanostructured fibers based on materials from man-made or plant waste and various functional additives to give the modified fibers the desired physical and chemical properties, and to use the obtained nanostructured fibers for sorption of metal ions and as gas sensitive materials.

Work tasks. In order to achieve this goal, the following tasks were solved:

– to determine the optimum conditions for the synthesis of carbon pitch from coal tar and to work out the process of obtaining carbon fibers based on the physical and chemical properties and morphology of carbon pitch;

– to determine the optimum conditions for the processes of electrospinning, stabilization, carbonization for the synthesis of carbon and nanostructured fibers;

– to synthesize nanostructured fibers with the addition of carbon pitch and nickel oxide nanoparticles for use as a gas sensing material;

– to synthesize nanostructured fibers with the addition of materials from vegetable waste raw materials - activated carbon and silica and to determine their sorption characteristics with respect to metal ions.

Research methods. Modern and meaningful methods of physical and chemical research have been used to solve the problems required to achieve the objective: X-ray phase analysis, scanning electron microscopy, transmission electron microscopy, optical microscopy, Raman spectroscopy, infrared spectroscopy.

The main provisions for defense:

– the formation of carbon pitch with the removal of volatile components is achieved by heat treatment of coal tar at 400 °C for an hour in argon, which is due to the destruction of chemical bonds between the molecules of the resin and the formation of a highly ordered form of carbon;

– carbon fibers (C content ≥ 92%) are synthesized by electrospinning at a ratio of polyacrylonitrile and carbon pitch of 70:30 by weight, which is due to the use of coal tar pitch due to its high carbon content in the composition;

– sensitivity to acetone equal to 73% is achieved by doping carbon fibers with nickel oxide nanoparticles with an average size of 48 nm, due to which the surface area for gas adsorption increases and the detected gas enters into a chemical reaction with nickel oxide nanoparticles, leading to a change in the electrical conductivity of the fibers;

– based on nanoporous carbons and silicon dioxide nanoparticles synthesized from vegetable raw materials waste, nanostructured fibers are obtained with a sorption degree of at least 88% relative to manganese II ions, which is achieved due to the large specific surface of the additives used.

The object of research is carbon and nanostructured fibers obtained on the basis of materials from industrial or plant waste and functional additives in the form of metal oxides.

The subject of research is the physical and structural properties of carbon and composite fibers based on technogenic or plant wastes and functional additives, as well as their sorption and gas-sensitive characteristics.

Novelty and importance of the obtained results. The following results were obtained in the work:

– conditions for the synthesis of carbon pitch from coal tar and conditions for the production of carbon and composite fibers have been improved;

– for the first time synthesized nanostructured fibers with the addition of carbon pitch and nickel oxide nanoparticles obtained by liquid-phase combustion for their use as a gas-sensitive material;

– nanostructured fibers were synthesized for the first time with the addition of products obtained from plant waste (activated carbon or silicon dioxide) for use as sorbent materials.

The theoretical significance of the thesis lies in the fact that the scientific results obtained can be useful for understanding the processes of obtaining carbon and composite fibers with the addition of various functional additives for a wide range of applications. The thesis determines the optimum conditions for the heat treatment of coal tar from the Shubarkol deposit for the production of carbon pitches. The conditions for obtaining nanostructured fibers based on materials from technogenic or plant wastes by means of single-stage electrospinning have been studied.

Practical significance. The obtained carbon and composite fibers based on technogenic and plant wastes have shown efficiency as gas-sensitive and sorption material. The obtained composite material based on polyacrylonitrile fibers with the addition of magnetite nanoparticles can be used for protection against microwave radiation. Experimental work on the synthesis of carbon and composite fibers can be included in the educational process when writing laboratory workshops and guidelines.

The main results of the study obtained in and established in the course of the dissertation work:

1. The optimal conditions for processing coal tar to obtain carbon pitches have been established. It has been established that the optimal heat treatment temperature for coal tar is 400 °C for an hour in an argon environment, since at this temperature all volatile components, including sulfur-containing ones, are removed and mesophase centers are formed. Studies have been carried out on the morphological properties of carbon pitches obtained from coal tar; it was found that samples of coal tar pitch obtained by heat treatment at a temperature of 400 °C have relatively better morphological properties;

2. The electrospinning process was organized and the optimal conditions for the synthesis of polymer and carbon fibers were determined. Conditions for the processing of precursor fibers have been worked out, and optimal conditions for the preliminary oxidation of the initial fibers and their further carbonization in the production of carbon fibers have been established. Physicochemical studies have been carried out and the surface morphology of the obtained carbon fibers and composites based on them has been studied. On the basis of the work carried out, it was experimentally established that the best ratio of PAN / CTP in the production of carbon fibers is 70:30 by weight, resulting in the formation of one-dimensional fibers

with an average diameter of 248 nm and a carbon content of at least 92% by means of one-stage electrospinning.

3. It has been established that carbon fibers doped with nickel oxide nanoparticles with an average crystallite size of 48 nm, obtained by liquid-phase combustion, exhibit a sensitivity to acetone equal to 73%. The gas sensitivity analysis of the material showed positive results, during which the chemical stability and high sensitivity of the sample to gaseous acetone are noted.

4. It has been established that on the basis of nanostructured activated carbons and silicon dioxide obtained from vegetable raw materials waste, it is possible to obtain composite fibers that have a sorption degree of at least 88% relative to manganese (II) ions.

Compliance with the directions of development of science or government programs. The work was carried out within the framework of the IRN grant funding project AP09259842 “Obtaining carbon fibers for various functional purposes by processing coal tar and petroleum bitumen” funded by the Science Committee of the Ministry of Education and Science of the Republic of Kazakhstan (2021–2023).

Approbation of work. The materials of the dissertation work were reported and discussed at various international, republican conferences and symposiums:

The main results of the dissertation were reported and discussed at **international and foreign scientific conferences**: The 10th International Conference on Nanomaterials and Advanced Energy Storage Systems, Astana, Kazakhstan, 2022; Carbon-2022, London, United Kingdom, 2022; 7th International conference on agriculture, animal science and rural development, Mus, Turkey, 2021; Combustion and Plasmochemistry. Physics and chemistry of carbon and nano energy materials, Almaty, Kazakhstan, 2021; El Ruha 9th International conference on social sciences, Sanliurfa, Turkey, 2021; Combustion and Plasmochemistry. Physics and chemistry of carbon and nano energy materials, Almaty, Kazakhstan, 2021; International scientific and practical conference, Astana, Kazakhstan 2018.

Personal contribution of the doctoral student to the preparation of each publication. The author's personal contribution consists in setting research objectives, conducting theoretical and experimental studies, discussing and summarizing the results obtained, writing abstracts and articles. Based on the results of the research, 7 abstracts of conferences and symposiums, 5 articles in journals recommended by KOKSNVO, 6 articles in journals indexed by the Scopus database and (or) Web of Science were published. Received a utility model patent No. 6867 of the Republic of Kazakhstan, IPC D01D 5/10, C10C 3/16, D01F 9/22. Method for producing carbon nanofibers / Mansurov Z.A., Kaidar B.B., Smagulova G.T., Imash A.A., Maksumzhanova N.R., Tileuberdi E., Artykbaeva M.T. – Published. 02/18/2022; Bull. No. 7. Received a patent for utility model No. 7580 of the Republic of Kazakhstan, IPC B05D 5/12, B82Y 40/00 Method for producing gas-sensitive composite fibers / Mansurov Z.A., Smagulova G.T., Kaidar B.B., Imash A.A., Taurbekov A.T., Tasmurzaev N.M., Amangeldy B.S. – Published. 11/11/2022; Bull. No. 8. In most articles, Kaidar B. is the first author or corresponding author, thus making the main contribution to the preparation of all these scientific papers.

Scope and structure of the dissertation

The work consists of an introduction, three sections, a conclusion and a list of references containing 161 titles. The total volume of the dissertation is 104 pages of typewritten text, including 57 figures, 11 tables and 2 appendices.