Al-Farabi Kazakh National University

PhD specialty "8D07113 - Nanomaterials and Nanotechnologies in Chemistry"

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General Overview and Relevance. The presented dissertation is devoted to a comprehensive study of the processes involved in converting plant-based waste (mowed grass, rice husks, and walnut shells) into cellulose and carbon materials, subsequently used to create nano-paper with enhanced mechanical and electrochemical properties. The topic is highly relevant from the standpoint of modern sustainable development strategies and "green" technologies aimed at the rational use of renewable resources, minimizing waste, and reducing negative environmental impacts.

Scientific Novelty and Significance of the Results. The author has developed a scientifically grounded approach to obtaining nanostructured materials from plant-based raw materials. In the course of the research, optimal conditions were determined for the chemical-thermal treatment of plant waste and its subsequent enrichment with mineral fillers (wollastonite, diatomite, barium sulfate) to improve the mechanical properties of paper and cardboard products. Crystalline and fibrillar nanocellulose was obtained by means of acid hydrolysis and TEMPO oxidation, with controllable fiber diameters (down to 20–40 nm). The possibility of regulating the porosity and degree of graphitization of carbon materials derived from rice husks and walnut shells was investigated using various activation methods (KOH and CO_2). Nano-paper was created based on nanocellulose, activated carbon, and carbon nanotubes, which is used in "binder-free" supercapacitor electrodes, enabling high specific capacitance (up to 145 F/g) and improved

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electrochemical performance (energy density up to 9.9 kWh). This work makes a significant contribution to the development of materials science and nanotechnology, as well as to the practice of biomass processing for obtaining competitive functional products.

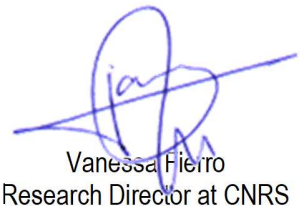
Contribution of the Overseas Internship and Collaboration with the International Scientific Advisor. A crucial component of this dissertation involved the research conducted during the candidate's overseas scientific internship at the Jean Lamour Institute (Epinal, France) under the guidance of the international scientific advisor. During this internship, the structural and morphological characteristics of nanocellulose and carbon materials were studied using scanning and transmission electron microscopy. X-ray phase analysis and spectroscopic (Raman spectroscopy) studies of the samples were carried out, enabling accurate interpretation of the degree of graphitization and structural defects. Methods of electrochemical impedance spectroscopy and cyclic voltammetry were tested for assessing the specific capacitance and conductivity of new composite materials. The internship demonstrated the candidate's high level of independence and motivation, as well as his ability to integrate into international scientific teams.

Degree of Substantiation and Reliability of the Results. The reliability of the presented results is confirmed by the comprehensive use of modern physical and chemical analytical methods, as well as by the reproducibility of data when varying parameters for activation and modification of materials. The author's approach to processing and interpreting experimental data is characterized by systematic rigor and scientific depth. The scientific results, reflected in a number of publications in peer-reviewed international journals (Web of Science, Scopus), confirm the high scholarly level of the work.

Practical Significance and Potential for Implementation. The practical significance of this research lies in the possibility of scaling up the technologies for obtaining cellulose and nanocellulose from biomass for paper and cardboard production, as well as in the application of the developed nanocomposite materials (nanocellulose, activated carbon, carbon nanotubes) as electrodes in energy storage systems (supercapacitors) without the use of polymer binders. This approach contributes to improved performance characteristics while reducing the environmental impact through the utilization of plant waste. The obtained results can have a broad range of applications in the pulp and paper industry, the production of electrochemical power sources, flexible electronics, and other related fields.

Conclusion. The dissertation work of Azamat Taurbekov “Obtaining nanopaper based on waste plant materials and wollastonite” represents a substantial scientific study that successfully addresses the relevant interdisciplinary problem of developing new functional nanomaterials from renewable feedstocks. The scientific novelty, detailed experimental elaboration, and proven practical applicability lead to the conclusion that the candidate has demonstrated a high level of competence, independence, and scientific maturity.

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