POLITÉCNICO DE LEIRIA
CENTRO PARA O DESENVOLVIMENTO RÁPIDO E SUSTENTADO DE PRODUTO

November 8, 2023

REVIEW OF A FOREIGN SCIENTIFIC CONSULTANT
on the doctoral dissertation (PhD) Maltay Anar Burkhatkyzy for the PhD degree in the specialty NANOMATERIALS AND NANOTECHNOLOGIES

To defend her dissertation for the PhD degree, Maltay Anar Burkhatkyzy (Almaty, Kazakhstan), presented a manuscript on the topic "Creation of nanostructured composite materials for energy storage". The manuscript consists of 4 parts and is written in English. The manuscript is well presented using excellent English and Figures. The research topic is central to the current world-wide movement to move away from fossil fuels to renewable energy sources. Systems such as solar energy or wind energy need energy storage to provide energy when those technologies are not active and to balance and maintain the supply when switching between different sources. As with much of the current research on energy supplies, many of the principles are established but the detailed science and technology is lacking. This scientific work reveals the development of new methods for manufacturing electrical energy storage devices such as batteries and supercapacitors with a particular focus on sustainable manufacturing.

In the first chapter, the candidate provides a review of the available literature. This is a comprehensive review covering topics, such as: production of lignin, fibers, activated carbons based on wood waste; use of carbon fibers and activated carbons. From my perspective the review would have been more balanced with attention paid to other energy storage systems such as mechanical storage of energy which has a similar efficiency to batteries and supercapacitors. Another strand overlooked is the degradation of battery and supercapacitor storage with repeated cycling. I also note that there are several disadvantages identified with PAN but no mentioned of the advantage of hybrid capacitance due heterocyclic rings containing nitrogen.

The second chapter is devoted to a description of the experimental part of the dissertation, which includes methods for producing lignin and activated carbons from wood waste; obtaining fibers by electrospinning; process of thermal stabilization and carbonization; production of electrodes for supercapacitors and Li-ion batteries; research methods. This part is well written and provides good information. However, the topic of producing electrospinning was introduced without any perspective of the advantages or other possibilities.

As one of the recurring themes is sustainability and in this chapter little is written about possible green chemistry alternatives, solvent recovery etc. It would have been useful to know what "conductive acetylene black" was (Page 38)

The principle results and discussions are presented in the third chapter of the work, where the author presents the main data obtained as a result of the entire work: the main conditions for the production of lignin and fibers are determined; the physical and chemical characteristics of lignins, carbon nanofibers, and activated carbons are described as well as the electrical characteristics of the electrodes prepared for supercapacitors and the Li-ion batteries fabricated.

The main findings of the study include the analysis and determination of the electrical characteristics of the resulting carbon nanofibers and activated carbon from sawdust. The thesis

also describes the optimal technological parameters for producing continuous lignin-containing fibers using the electrospinning method and the optimal lignin/PAN ratio by weight for producing nano-sized fibers. On page 54, the candidate draws attention to the interesting observations that mechanical and function properties increase with a decreasing fibre diameter, but there is not discussion on this fascinating observation. The experimental work carried out in this thesis by Maltay A.B. allowed her to achieve her goal as defined in 1.8 - obtaining carbon nanofibers and activated carbon from plant waste with specified physical and chemical properties, and determining the features of using the resulting fibers based on them for energy storage. On P64 there is a mechanism given for the activation of the carbonaceous material, and I wondered if it might be more sustainable to add the postassium carbonate directly. T|here is a short section on costs, but I think I was anticipating more of a Life Cycle Assessment.

This thesis lists 181 sources of international scientific literature, which made it possible to conduct a deep and comprehensive study. The main results and conclusions of this research were presented in scientific publications, conferences and seminars. I understand that Maltay Anar Burkhatkyzy published three articles on the topic of her thesis, which were published in international journals, however, these are not listed in the thesis. She also actively participated in the presentation of her results at international conferences and symposiums.

From the thesis I can see that the candidate, Maltay A.B., has gained extensive experience in the production of carbon nanofibres and activated carbon based on plant waste, creating efficient electrodes for supercapacitors and Li-ion batteries. This is important research and very relevant topic for understanding the fundamental mechanisms as well as for technological applications.

Based on this thesis I believe that the candidate Maltay A.B. has developed knowledge and obtained significant scientific results and is therefore worthy of obtaining the qualification of the scientific degree of Doctor of Philosophy (PhD) from the Al-Farabi Kazakh National University (Almaty, Kazakhstan) in the specialty 6D074000 – «Nanomaterials and nanotechnologies».

I have provided some comments on areas where more work could have been included, but their absence does not detract from the quality of the research undertaken and described in this thesis.

Therefore, I support her work and give my permission to present her doctoral dissertation before the Examination Committee, which will be appointed by Al-Farabi Kazakh National University (Almaty, Kazakhstan).

Typographical observations

1. Excellent presentations, high quality English and particularly good figures.
2. In some figures, some of the text embedded in the graphic is written in Russian.
3. In some cases the images do not contain a scale bar (eg Figure 24a) and in some where there is a scale bar is it not readable (eg Figure 24b).
4. For some figures, the caption is separated from the Figure
   See Figures 4,5,6,8
5. P21 H2O2 numerals should be subscripts
6. Figure 15, I could not identify the item described as "c" in the caption
7. Page 43 SEM JEOL ….. FEI USA I think there is some mistake here JEOL and FEI are rival companies
8. Line 7 P53 "Weaves" is probably not the best translation and the term entanglements makes more sense in English and the candidate uses later in this chapter
9. AOC, AOS, and SDO not defined in the list of Notations and Abreviations



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