



REVIEW

of Assoc. Prof. Dr. Yordanka Tsankova Tasheva

Department of Industrial Technology and Management

University "Prof. Dr. Assen Zlatarov" - Burgas

of dissertation work of **Mag. Eng. Dimitar Vassilev Georgiev**

on the topic: "**Research on the production of electrodes and dielectrics for supercapacitors using high-porosity silicate and carbon materials**"

presented for obtaining the educational and scientific degree "DOCTOR"

in the field of higher education 5. **Technical sciences**

professional field 5.10 **Chemical technologies**

scientific specialty 02.10.12 "**Technology of silicates, binders and refractory non-metallic materials**"

scientific supervisors of the doctoral student: **Prof. Dr. Irena Markovska** and **Assoc. Prof. Dr. Dimitar Rusev**

Based on Order № UD-54 / 15.03.22 of the Rector of the University "Prof. Dr. Assen Zlatarov" - Burgas I have been appointed reviewer and Chairman of the Scientific Jury for the procedure for obtaining an educational and scientific degree of dissertation on the topic: " Research on the production of electrodes and dielectrics for supercapacitors using high-porosity silicate and carbon materials ", presented for obtaining the educational and scientific degree "Doctor" in the field of higher education 5. Technical sciences, scientific field 5.10 Chemical technologies, scientific specialty 02.10.12 " Technology of silicates, binders and refractory non-metallic materials ".

1. **Autobiographical notes for the PhD student**

The author of the dissertation, M.Sc. Dimitar Vassilev Georgiev graduated from the University "Prof. Dr. Assen Zlatarov", specialty " Materials Technology and

Materials Science ", Bachelor's degree and Master's degree, and in 2010 he completed a second master's degree, specialty " Oil and Gas Technology ".

From 2019 to the present he is a PhD student in the Department of Chemical Technology, Faculty of Technical Sciences with supervisors: Prof. Dr. Irena Markovska and Assoc. Prof. Dr. Dimitar Rusev.

I must note that the presented by Mag. Eng. Dimitar Vassilev Georgiev materials / on paper and electronic media / are in full compliance with Art. 42 of the Regulations for acquiring scientific degrees and holding academic positions at the University "Prof. Dr. Asen Zlatarov "- Burgas.

2. Content of the dissertation

The presented dissertation has a volume of 144 pages, bibliography - 218 literature sources, 69 figures and 15 tables.

The dissertation contains the following: Introduction, Theoretical part, Experimental part, Conclusions, Scientific and scientific-applied contributions, Publications and patents and Applications.

The literature review is in-depth and shows the stable educational preparation of the dissertation. I must also emphasize that the literature review meets the requirement to use contemporary literature.

3. Topic and relevance of the dissertation

The chosen topic of the dissertation is contemporary and very relevant. Given the presented literature review, it should be noted that the theme and purpose of the dissertation are very timely, not only for Bulgaria but also worldwide.

The aim of the present dissertation is to obtain efficient and innovative coatings for electrodes by using silicate and carbon materials, which will be used to make an experimental supercapacitor.

To achieve the goal of this dissertation the following tasks are set: obtaining graphene and proposing appropriate ways to apply it on the surface of the electrodes; obtaining electrically conductive paint, through which to attach the

graphene to the electrode of the supercapacitor; synthesis of barium titanate and its introduction into the composition of the electrode coatings; construction of an experimental capacitor based on all developed components and measurement of its capacity.

It is noteworthy that in fulfilling the tasks set in the dissertation, the doctoral student has performed numerous experimental experiments and studies related in series in sections 2 and 3 of the Experimental part, where graphene was obtained by various methods, which is experimentally proven by modern physical methods in analytical chemistry. Section 4 of the Experimental Part demonstrates the possibility of applying a graphene coating in the form of a layer on an aluminum substrate. SEM's show homogeneity of the obtained graphene coating.

Section 5 of the Experimental Part considers the possibility of obtaining electrically conductive graphite paint for electrode coatings. It has been proven that the obtained electrically conductive paint can be applied to improve the electrical and capacitive characteristics of capacitor electrodes.

Section 6 of the Experimental Part deals with the preparation of a dielectric from barium titanate by solid phase synthesis and by the sol-gel method.

Section 7 of the Experimental Part considers the possibility of developing and constructing experimental models of supercapacitors, as well as measuring their capacitive characteristics.

As a result of the reviewed experimental part, I am convinced that the latter fully corresponds to the goal and objectives of the dissertation, in addition, it makes an excellent impression that modern methods and analysis devices are used, which speaks of their excellent knowledge of PhD student Dimitar Georgiev .

4. Contributions to the dissertation

The main contributions of the dissertation presented to me for review are reflected in Chapter 4 and are of scientific and scientific-applied nature. The following scientific and applied scientific contributions have been presented:

1. Cheap and environmentally friendly technology for graphene production is proposed, through a combined effect of electrolysis and ultrasound;

2. A technology has been developed for coating graphene on a metal aluminum base using a high voltage generator;

3. An innovative electrically conductive solder is obtained, necessary for laying and attaching the active ingredients on the surface of the electrodes;

4. On the basis of the developed innovative coatings and the used electrolytes a construction is proposed and experimental capacitor cells are made on which the specific capacity is determined;

5. A software product has been developed for processing the experimental data obtained from the research and for optimizing the design of the capacitor plates.

After getting acquainted in detail with the contributions presented in the dissertation, I must note that I completely agree and confirm them.

5. Publications and patents

The PhD student Dimitar Vassilev Georgiev has published his results from his experimental research in the following journals and scientific forums:

- D. Rusev, I. Markovska, P. Milusheva, Y. Hristov, M. Mitkova, **D. Georgiev**, High voltage deposition of graphene coating onto metal substrate to prepare super capacitor electrodes, *Journal of the Balkan Tribological Association*, 2020, vol. 26, No 3, p. 86– 94 (SCOPUS cited, IF 0, 737, Q3);
- Irena Markovska, **Dimitar Georgiev**, Fila Yovkova, Obtaining of BaTiO₃ powder as dielectric material for capacitor's elements, *Journal of Chemical Technology and Metallurgy*, 2021, book 1, p.161-166 (SCOPUS cited, SJR 0.220);
- Irena Markovska, **Dimitar Georgiev**, Dimitar Rusev, Fila Yovkova, Obtaining of electrically conductive graphite paste from cheap and harmless materials for capacitor's electrode coatings, *Journal of the Balkan Tribological Association*, 2022, (SCOPUS cited, IF. 0, 544, Q3);
- Fila Yovkova, Irena Markovska, **Dimitar Georgiev**, Dimitar Rusev, Magdalena Mitkova, Synthesis of highly porous dielectric materials with

- rice husk as pore-former, Annual of Assen Zlatarov University, 2019, volume XLVIII, book 1, p. 27-31 (Open Access);
- Fila Yovkova, Irena Markovska, Magdalena Mitkova, **Dimitar Georgiev**, Dimitar Rusev, Yancho Hristov, Synthesis of highly porous dielectric mullite ceramics with wood sawdust as pore-former, Proceedings of University of Ruse "Angel Kanchev", vol. 58, book 10.1, 2019, p. 69 – 76 (Open Access);
 - Fila Yovkova, Irena Markovska, Dimitar Rusev, **Dimitar Georgiev**, Investigation of electrical characteristics of barium titanate (BaTiO₃), Proceedings of University of Ruse "Angel Kanchev", vol. 59, book 10.1, 2020, p. 59-63 (Open Access);
 - **Dimitar Georgiev**, Irena Markovska, Dimitar Rusev, Possibility to obtain electrodes for supercapacitors using graphene coating, Scientific session for students, PhD students and young researchers "Natural and Technical Sciences", 2019, p. 15;
 - **Dimitar Georgiev**, Fila Yovkova, Obtaining an electrically conductive graphene film for application on electrodes for supercapacitors, Scientific session for students, PhD students and young researchers "Natural and Technical Sciences", 2020, p. 14;
 - Member of the working team of the issued patent № 112894 / 18.03.2019 "High-voltage technology for graphene production and its application as a surface coating on a metal substrate" with inventors Irena Georgieva Markovska - Minova, Dimitar Rusev Rusev, Yancho Hristov, Magdalena Sabeva Mitkova , Polina Ilieva Milusheva - Mandadjieva, Dimitar Vassilev Georgiev, 2019.

I was very impressed and I must emphasize the personal participation of the PhD student in the development of the dissertation - in 2 of the presented scientific publications that reflect the results, the latter is the first author.

Another objective proof of the personal participation of the PhD student in the research and experimental part of the dissertation is his participation in the following projects:

1. National Scientific Program "Low Carbon Energy for Transport and Life (E +)", approved by Decree of the Council of Ministers № 577 / 17.08.2018, DOI-214 / 28.11.2018;

2. NIH 445/2020 "Research on the synthesis of zircon and garnet pigments, in view of their possible application in ceramic production", head: Chief Assistant. Dr. Fila Yovkova;

3. NIH 415/2018 "Synthesis, properties and application of new materials - graphene and ceramic pigments", head: Prof. Dr. I. Markovska.

From the above evidence I am convinced that the dissertation and the presented results are a personal contribution of the doctoral student.

6. Abstract

The dissertation is summarized and presented in an abstract with a volume of 50 printed pages. The abstract accurately, correctly and correctly reflects the main results, conclusions, scientific, scientific and applied contributions, publications and patents of the dissertation, as well as fully meets the generally accepted requirements.

7. Critical remarks

During the review and evaluation of the dissertation I noticed some technical errors in writing some formulas, dimensions and inaccuracies in the used literature sources, but I must emphasize that these remarks do not relate to the topic, relevance, and rich experimental part and in no way do they change my excellent opinion of the dissertation, namely its perspective, scientific and scientific-applied value.

8. Conclusion

In conclusion of this review I confidently give my positive assessment of the dissertation. The candidate for educational and scientific degree "Doctor" - mag. Dimitar Vassilev Georgiev fully meets the requirements of the Law on the Development of Academic Staff in the Republic of Bulgaria, the Regulations for its implementation, as well as the regulatory requirements of the University "Prof. Dr. Assen Zlatarov" - Burgas.

From the dissertation it can be concluded that the doctoral student has acquired professional qualities of an established researcher in his field, with proven scientific and scientific - applied contributions for the award of the educational-scientific degree "Doctor".

In conclusion, I strongly recommend to the Honorable Scientific Jury to award Mag. Eng. Dimitar Vassilev Georgiev educational and scientific degree "Doctor" in the field of higher education 5. Technical sciences, professional field 5.10. Chemical technologies, scientific specialty 02.10.12 "Technology of silicates, binders and refractory non-metallic materials".

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16.05.2022 г.

Reviewer:...

/Assoc. Prof. Dr Yordanka Tasheva/