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FORMATION OF CHEMICAL TECHNOLOGY EDUCATION AND SCIENCE IN LVIV POLYTECHNIC NATIONAL UNIVERSITY

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ã Yavorskyi V., Blazhivskyi K., 2011

Abstract. On the occasion of the 140th anniversary of the foundation of the Department of Chemical Technology of the Technical Academy in Lviv (now Lviv Polytechnic National University) the origin and development of educational and scientific activities in the field of organic and inorganic chemical technology in this institution is described. The information about the first professors-chemists, their scientific, educational and other activities, as well as their contribution to the development of the region is presented.

Keywords: history, technical academy, department, chemical technology, Friedrich Rochleder, Gustaw Wolf, Rudolf Günsberg, August Freund, Julian Medvedskyi.

On June 18, 2011 140 years pass since the Department of Chemical Technology of the Technical Academy in Lviv – a fundamental basis of the modern Lviv Polytechnic National University – was established by the royal decree [1]. This significant event in the history of the institution crowned the efforts of the teaching staff and the Galician Seym, contributed to the Academy rising to the level of the leading European Polytechnic Institutes and gave the possibility to provide industry of Galicia and other regions with qualified chemical engineers. The department creation stipulated a transition from prevailing at that time chemical education to chemical technology, grounded the future organization of specialized departments, at that time Chemical Technology Department, now the Institute of Chemistry and Chemical Technology. The events of those times and the personalities behind them are little known to modern chemists and undeservedly forgotten. By this publication we try to analyze the occurrence of chemicotechnological education at Lviv Polytechnics and pay tribute to the first professors-chemists.

In the first half of the XIX century the chemical technology as applied science existed as a separate unsystematic knowledge called technical chemistry that distinguished it from the proper chemistry (*i.e.*, theoretical chemistry). At that time theoretical chemistry was already formed as a science and from the end of the XVIII century has held a worthy place among the natural sciences at the departments of philosophy. However, the universities

generally provided a humanitarian and natural education without sufficient practical skills necessary for the production of chemical products. Such state of affairs did not satisfy the increasing demands of the chemical industry, which originated during the first decades of the XIX century and required technical specialists. Solving the problem was the creation of a new type of higher education institutions – Polytechnic schools, *i.e.* Polytechnics in Europe, whose structural units were Departments of Technical Chemistry and later Departments of Chemical Technology. Their task was to prepare qualified specialists in the field of chemical technology.

In the middle of the XIX century there was a sharp need in chemical engineers in Galicia. Though it was a backward province of the Austrian Empire, from ancient times there were traditional industries here, such as: textile, leather, salt, iron ore, tobacco, wood, *etc.* The production of building materials (bricks, lime, stone), ceramic products, soda products was widespread, less common was the manufacture of glass, porcelain and matches. Among organic productions there were obtaining of fuel and lubricants from crude oil, processing of agricultural products, and production of sugar, vodka, beer, *etc.* Unfortunately, most of these enterprises were technically outdated and unproductive. They did not receive proper support from the government and therefore could not compete with factories and plants of the empire's western provinces. However, unreclaimed deposits of oil and mineral wax, potash ore, *etc.* in the province attracted a keen interest to Galicia.

To assure the development of the existing and new chemical industries skilled specialists were needed, and so the Galician Seym repeatedly appealed to the Vienna government to open a higher technical school in Lviv. Earlier there were unsuccessful attempts to organize a technical department in Lviv real school, which would train technicians, specialized in chemistry and chemical technology. With time there were attempts to organize technical departments of chemistry and mechanics at the Department of Philosophy of Lviv University in order to teach, among other subjects, general and applied chemistry. However, these plans were not realized. Finally, on November 4, 1844 the imperial-royal Technical Academy was opened in Lviv. It had six departments including the

Department of Chemistry. Since then chemical education began to develop in Lviv Polytechnic. The Academy was located in the left side of Darovsky's house on the corner of Virmenska and Teatralna streets (now house number 2 on Virmenska street).

Since there was a lack of highly qualified professionals with a degree of Doctor of Philosophy in Chemistry in Austria, Doctor of Medicine Friedrich Rochleder (1819–1874) became the first professor of chemistry. With time this Austrian scientist became famous as one of the founders of phytochemistry and structural chemistry [2]. He was born in the pharmacist's family in Vienna. From 1836 he studied medicine at Vienna University, where he worked after graduation. At the age of 23 he received his doctoral degree. Later he worked on probation in Gießen under supervision of Justus von Liebig, developing his ideas of the chemistry application in physiology and agriculture. At that time F. Rochleder took a great interest in biology. In 1845 the governor of Galicia count F. Stadion invited him to head the Department of Chemistry in Lviv. Besides F. Rochleder, the Department was staffed by an assistant for laboratory studies and a technician. Gradually, Prof. Rochleder together with professor of mathematics Aleksander Reisinger, the Deputy Director of the Academy, equipped a chemical laboratory and gathered a large collection of minerals. Thus the Academy started to train professional chemists. What was the chemical education at those times anyway?

Professor Rochleder taught general chemistry and chemistry application in those areas of chemical industry which were developed in Galicia. This course took 5 hours per week, which was insufficient for those students who have not studied the subject earlier. The courses of technical chemistry, *i.e.* chemical technology, and mineralogy were also insufficient. Therefore, first Prof. Reisinger and later other professors of chemistry began to teach mineralogy while professors of physics and mechanics supplemented their courses with technological parts. However, even this was not enough, so graduates-chemists were forced to continue their studies at other institutions – Warsaw Polytechnic Institute, Krakow Technical Institute, and others.

Unfortunately, we could not find information about scientific activities of Prof. Rochleder in Technical Academy, only the fact that during this period he investigated the properties of plant substances and in 1847 published the article “Phytochemistry Questions” (Beiträge zur Phytochemie) in Vienna. The next year at the age of 29 he became a member of the Vienna Academy of Sciences. Later, working as a professor at the University of Vienna and Prague, F. Rochleder discovered natural dyes known to all chemists (alizarin, purpurin, litmus, and quercitrin) and became one of the founders of the of homology and unsaturated compounds conception.

In 1848 a surge of national liberation revolutions, known as the “Spring of Nations”, swept over Europe. The students of Technical Academy entered into the People's Guard and took part in the revolutionary events in Lviv. 29-

year-old Prof. Rochleder was chosen as their commander [3]. Since guardsmen lacked for rifle shells, they mounted a machine for their production in the chemical laboratory and provided with ammunition not only themselves but other divisions too. Prof. F. Rochleder quartered the main guard in the academic building, which had dramatic consequences for the Academy. On November 2, 1848 the General Commander of Austria, General Hammerstein ordered to bombard the city controlled by the National Guard. This caused numerous victims, fires and destruction of homes. City Hall, as well as the buildings of the Technical Academy and the University were destroyed. The archives and documents of the Academy and University, University Library with invaluable books were burned. In the Academy the fire destroyed equipment of chemical and physical laboratories, a rich collection of minerals and a plenty of other valuable artifacts. The loss of these documents does not allow to reproduce in detail educational and scientific achievements of the Academy's chemists during that period.

Because of the fire and destructions there were no studies in 1848/49 academic years. At the end of next year the Academy's building was restored and the training for all departments was resumed. Only chemistry was not taught, because no students signed up and the chemical laboratory was not ready. Prof. Rochleder left the Academy and joined the Department of Chemistry at Prague University.

In 1851/1852 academic years the Academy's work was fully restored. Prof. Reisinger became the director. Doctor of Medicine Gustaw Adolf Wolf from Lviv University was invited to fill the position of professor of chemistry. He restored the teaching of general chemistry and partially the mineralogy and petrography and rebuilt the chemical laboratory. Later, in the late fifties he prepared and taught a full course of mineralogy, geology and paleontology. Prof. Wolf did not sever ties with the University – during 1855-1857 he was combining the work at the academy with heading of the Department of Chemistry.

In the fifties 80–100 students per course studied in the Technical Academy. The study was concentrated and encyclopedic; the students developed their independence and ability to solve non-typical problems. Duration of training at the technical department was two years at first, but then increased to three years. To raise the erudition level of the students who have not completed Real school or gymnasias the preliminary courses were organized. The students were able to extend their knowledge using the private coaches, but for those who could not learn a subject the repeated training was introduced. Trying to raise the level of the academy, A. Reisinger developed a plan of reorganization which implied the creation of new departments, changes in curricula, *etc.* He wanted to introduce the course of chemical technology of organic and inorganic substances. The Ministry did not object to the innovations, but did not give funds for their implementation.

Formation of Chemical Technology Education and Science in Lviv Polytechnic National University

At that time the chemical specialty (or technical chemistry) was not popular due to insufficient development of chemical industry in Galicia. The only educational and scientific center was Lviv University, where the Philosophy Department prepared chemistry teachers for gymnasias and real schools. Students were taught a course of general and technical chemistry. In a small chemical laboratory assistants and professors carried out some experiments in the area of organic and inorganic chemistry, mineralogy, *etc.* Students were not involved in the research work. After the fire in 1848 the teaching of chemistry stopped. It was only in 1851, when the University moved to new premises on St. Nicholas str. (now Grushevskiy str.), that a separate Department of Chemistry was opened, from which the modern chemists start their history. The first two decades the Department consisted of one professor, one assistant and one technician. Franz Pless (1819-1905) became the first professor of chemistry. He created a chemical laboratory which started to work in 1853. Only that year laboratory classes were introduced.

Technical Academy from the moment it was created was somewhat lagging behind the University in the level of teaching and scientific researches. The curriculum of the students-chemists in the academy was reduced to study of theoretical foundations of general and applied chemistry without enough practical training. In addition, they studied some parts of mineralogy. Due to low funding there were not adequately equipped laboratories and corresponding staff. Chemical technology was practically not taught; there was no practical trainings at enterprises. There were little researches in chemistry and for a brief period of 1845-1848 Prof. Rochleder was involved in biochemical researches. As a result, graduated students-chemists did not have sufficient theoretical and practical training and were forced to extend their professional knowledge in other educational institutions. Thus, Technical Academy did not fulfill its task – providing of Galicia enterprises by qualified chemical engineers.

A new stage in the formation of chemical education and science in Technical Academy began with the arrival of R. Günsberg in 1857. Rudolf Herman Günsberg (1823–1879) was a founder of teaching and scientific research in the field of chemical technology at our university. He came from a Jewish family from the town of Pidkamin near Brody [4-6], graduated from the Vienna Polytechnic Institute in 1852, then worked for two years in the chemical laboratory at the University of Breslau (now Wrocław). From 1854 to 1856 he worked as a Master of Hamburg Gymnasium, where at the same time headed the Chemical technology laboratory. In Lviv R. Günsberg filled a position of assistant-professor in chemistry. He was the first who prepared and taught a chemical technology of organic and inorganic substances as an optional course. He made many efforts to equip existing chemical laboratory with new equipment and instruments as well as to implement the methods of analysis in educational and scientific process.

Later, in 1864 he organized a new chemical technology laboratory. A special merit of Rudolf Günsberg was initiating scientific researches in the technology of vodka and alcohol, salt processing (methods of salt solutions purification from magnesium salts) and others. For a short time he published several scientific papers in the “Wiener Akademische Sitzungsberichte”: about the chemical composition of water from Bronislava spring in Truskavets (1861), gluten production from grains (1861), and the interaction between caoutchouc and albumen (1862). Moreover, he published a few articles on the teaching of chemical technology in higher technical schools.

Taking into account the works of R. Günsberg and the growing need in specialists in chemical technology, in 1863 the Ministry gave consent to create technical chemistry adjunct courses at the Department of Chemistry. Rudolf Günsberg accepted the post of adjunct and in 1867/68 academic year the name of the department was changed to General and Technical Chemistry Department. The above-mentioned facts prepared the ground for the establishment of chemical- technology education in Technical Academy and in 1872 the Department of Chemical technology was created. The Head of the Department was Prof. R. Günsberg.

Of special interest is the activity of Prof. R. Günsberg in the seventies when he showed himself not only as a talented teacher, researcher and organizer of the department, but also as propagandist of scientific achievements and publisher as well as a patriot of his land. Intending to raise the technical level of alcohol-vodka production in Galicia, he founded (together with like-minded persons) a society and school of experts in alcohol-vodka industry. He began publishing a newspaper devoted to the matter. Being incurably sick during his last years he wrote and published at his own expense a substantial two-volume work “Handbook in Alcohol Production”. At the same time Prof. Günsberg initiated the research of ammonia-soda process, acetone structure, properties of hydrocarbons, *etc.* Many ideas and practical advices on the application of chemicals, especially fertilizers in agriculture, he stated in the articles in the journal “Rolnik”, which was published in Lviv. His works were also published in Central European, British, American and Scandinavian journals. Prof. Günsberg was a member of Galician economic society, and in 1874–1876 was the Dean of School of Technical Chemistry.

In 1850-1860 the economics of Europe revived – heavy, chemical and other industries gained in strength; railways and towns developed; mechanization and chemicalization were gradually applied in agriculture. In Germany a commercial-scale production of potassium salts developed for use in agriculture. In 1852 the construction of railways started in Galicia. Extraction of kerosene from crude oil by Lviv pharmacists Jan Zeh and Ignacy Łukasiewicz and the invention of kerosene lamp by Lviv tinsmith Adam Bratkowski in 1853 caused the rapid

development of oil and petroleum refining industries in Eastern Galicia. Paper and cloth manufactories, iron and ceramic enterprises were founded. In 1867 in Kalush the commercial production of potassium salts began. All this activity required the technology, which caused the growing role of Polytechnic.

At the same time, in the sixties the reform of technical schools in Karlsruhe, Prague, Graz, and Vienna took place. Lviv Technical Academy also prepared a project of its reorganization into Polytechnic Institute, which would consist of five faculties, including chemical-technology one. It would include two divisions – for training of chemical engineers (5 years) and chemists-technicians (3 years). Two departments: General and Analytical Chemistry Department and Chemical Technology Department as well as two adjunct courses were planned to be open. A museum and laboratory of general chemistry and chemical technology had to be opened. The project was submitted to the Ministry in 1867, but it was realized much later.

In view of European Polytechnic reforming and changes in the economic development of Galicia, Viennese Government decided to reorganize Technical Academy. Thus seventies were a turning point in its activity. The emperor gave permission to build special buildings for the Academy and to create six new departments including the Department of Chemical Technology.

Finally, on June 18, 1871 Department of Chemical Technology was founded at Technical Academy, which played a major role in training of chemical engineers. With its formation the existing chemical (theoretical) education was supplemented by chemical technology (applied chemistry) and the Academy gained the opportunity to prepare qualified specialists in chemical technology by itself. The first Head of Department was Rudolph Günsberg, who made a decisive contribution to its creation. Due to the large teaching load the additional position of assistant was introduced and decision to extend the Department's facilities was made. The Ministry allowed to rent the office for chemical technology laboratory in a nearby Hauenschild's building No. 18, Teatralna str. (later Natural History Museum was situated there). To develop this laboratory and purchase the needed tools, devices and chemicals special funds were appropriated. Full-scale work of the Department began from 1872.

According to the changes, the Department of General and Technical Chemistry was transformed into the Department of General and Analytical Chemistry. The annual subsidy for the maintenance of chemical laboratory was increased. It was equipped with the gas network, a place for professor and assistant and special tables for students. The famous Austrian organic chemists and cyclopropane discoverer A. Freund (PhD) took over the post of the Department after Prof. G. Wolf, who retired in May 1872.

August Freund (1835–1892) was born in Kęty in Krakow region [7, 8]. He studied pharmacy in Lviv, then in

Leipzig. From 1858 he worked as an assistant at Lviv University, where he received his doctorate. Then from 1861 he worked as a gymnasium teacher in Ternopil, and since 1869 – as a professor of real school in Lviv. In 1872 as an experienced teacher and scientist in the field of organic chemistry he was invited for the post of Professor of Chemistry in Lviv Technical Academy. Scientific interests of Prof. Freund included fermentation processes, structure and properties of oil, synthesis and structure of ketones, and others. His works concerning the obtaining of trimethylcarbinol and trimethylenalkohol from glycerine, the nature of ketones, phenylsulphureted and phenylsulphuric acids and others were published in contemporary Austrian and German newspapers. However, his major achievements were the discovery of cyclopropane synthesis *via* interaction between 1,3-dibrominepropane and sodium (this reaction in 1881 was named after him) and establishing its structure, as well as the development of ketones and acid chlorides obtaining methods using organochlorine compounds. Prof. Freund was a respected teacher and researcher, five times he was elected as the Dean of the school, then of the Faculty of Technical Chemistry, and three times – as the Rector of Polytechnic (1876/77, 1882/83, 1889/90 academic years).

In 1872 the structure of Technical Academy was changed. Separate departments, whose number almost doubled, were combined into three professional schools (later they were given the name Faculty) – technology, technical chemistry and architecture. The number of students (at that time they were called listeners) increased by one third compared with the previous year (291 against 204). Although there were only few chemists (12 students) among them, their number gradually increased. Already in 1874/75 academic years there were 28 chemists, and in 1875/76 – 47.

At the beginning of the academic year the School of Technical Chemistry consisted of two Departments (General and Analytical Chemistry and Chemical Technology), but soon the third Department (of Mineralogy and Geology) was opened in accordance with the decree of October 29, 1872. The Department provided knowledge about mineral raw materials for chemical industry, their deposits and properties. It was headed by Yulian Medvedskyi – the first Ukrainian professor in Lviv Polytechnic University, known geologist and petrographer in the future, researcher of salts, oil and other mineral deposits in Galicia, and a known public man [9, 10].

Yulian Medvedskyi (1845–1918) was born in a family of a clerk in Przemysl. After graduation from gymnasium he studied at the Faculty of Natural Sciences, University of Vienna (1864–1869), then worked as a geologist in the state geological administration. Since 1873 he filled a post of professor of Lviv Technical Academy, where he worked for 39 years. In the Academy Prof. Medvedskyi organized a geological laboratory and mineralogical museum, began regular geological expeditions, and

gathered a large collection of rocks and minerals consisted of tens of thousands of samples. His museum was one of the best in Europe by systematization standards and number of specimens. The scientist paid great attention to the study of oil and salt deposits of the Carpathian region, being of great importance for the industrial development in Galicia. On the basis of investigation results he published about 100 scientific papers, a number of textbooks on mineralogy, petrography, and geology. A part of the papers were published at his own expense. Prof. Medvedskyi was a founder and active member of Scientific Society named after Shevchenko, a founding member of the Polish Society of Naturalists named after Copernicus, a member of the Krakow Akademia Umiejętności, a honorary member of the Geological Society in St. Petersburg, a corresponding member of the Vienna geological institution, a member of the Provincial Council of Mining, and more. For many years he edited the magazine "Kosmos". He was elected as Dean of the School and Faculty of Technical Chemistry and Rector of the Polytechnic School three times (1879/80, 1884/85, 1887/88 acad. years). During his term Rector Yu. Medvedskyi organized mining and metallurgical courses and petroleum division – the first in Europe, which gave higher education in petroleum mining and initiated the formation of three research stations: oil, ceramic and mechanical. In gratitude and recognition of Prof. Medvedskyi Lviv Polytechnic for the first time in its history awarded to him the title of Honorary professor. Shortly after this award Prof. Medvedskyi received the title of Doctor *Honoris causa*, along with five other worthy persons among whom was Marie Skłodowska-Curie. In the evening of his life Yu. Medvedskyi presented to Scientific Society named after Shevchenko the scientific library of over 2000 volumes. His savings in the amount of 50 000 Austrian crowns he bequeathed to the development of Ukrainian education, dormitories building, and scholarships to poorer students.

Beside newly opened departments, professors' staff solicited for the formation of zoology and botany Department in the School of Technical Chemistry, since at that time crop and livestock products were the main raw material for chemical industry. However, the Ministry only agreed to allocate the position of Associate professor, where Dr. Emil Godlewski (1847–1930) was appointed.

Thus, starting from 1872/73 acad. years School of Technical Chemistry, consisting of three departments started to train qualified chemical engineers. The first Dean of the school was Prof. Freund, then Prof. Günsberg followed by Prof. Medvedskyi (two years each). According to the curriculum (3 years), students-chemists were taught the following subjects, in addition to the general ones (mathematics, physics, descriptive geometry, and elementary mechanics) [11]:

- General chemistry (Prof. Freund):
 - Introduction to modern chemistry
 - Mineral chemistry

- Organic chemistry
- Detailed chemistry (Prof. Freund)
- Analytical chemistry (Prof. Freund)
- Chemical technology (Prof. Günsberg):
 - part I: Air and water. Fuels. Clarification materials and methods. Chemistry of building materials.
 - part II:
 - a) Production of salt. Production of sulfuric acid and soda. Products from clay. Production of glass. Processing of agricultural products (fermentation production). Skin handling. Painting
 - b) Analysis and chemical- technology production (laboratory course)
 - Mineralogy (Prof. Medvedskyi);
 - Geology (Prof. Medvedskyi);
 - Botany (Associate Professor E. Godlewski).

Investigation of chemical disciplines involved a substantial amount of laboratory and project works in the third year (12 hours / week on the first and second year of training and 24 hours / week on the third year). In addition, chemists studied mechanical technology, description of vehicles, building on land. For the students of the schools of technology and architecture professors-chemists lectured mineral chemistry (Prof. Freund), mineralogy, geology and geognosy (Prof. Medvedskyi) and later – chemical technology of building materials (Prof. Günsberg).

Although the training process in Technical Academy was quite intense and diverse, actually it did not meet the latest requirements. So in 1874 the professoriate began to develop a new curriculum. The European Polytechnics plans were the basis that could provide the possibility for students to change the place of study according to their needs. In 1874/75 acad. years a new plan was implemented in practice. According to it the duration of training in the School of Technical Chemistry increased from three to four years, the teaching of mineral, organic and analytical chemistry, particularly chemical technology was significantly enhanced [12]. Besides botany, Assoc. Prof. Godlewski started to teach zoology, agricultural chemistry and merchandizing. Prof. Freund introduced to his courses parts of phyto and zoochemistry. The analysis of those curricula shows that the preparation of chemical engineers was a good balance of general and specific disciplines with considerable practical training.

In 1875/76 acad. years the institute of private Associate professors was introduced in the academy. Their task was to expand and extend students' knowledge in those subjects which professors and paid associate professors had no time to lecture. The private associate professors taught the following subjects: general and analytical chemistry – Dr. Julian Grabowski, assistant professor of Lviv University, and chemical technology – Dr. Roman Wawnikiewicz, professor of agricultural school in Dublyany.

An important event in the life of Technical Academy was the construction of a respectable main building and a building for Chemical Department (at that time it was

called chemical laboratory). In 1876 the chemical building was put into operation, and the next year saw the opening of the main building. This not only solved the problem of schools location, but also raised the prestige of the institution and its popularity in the Empire. The chemical building contained classrooms, chemical laboratories,

backrooms and accommodations for two professors and laboratory technicians. Prof. Günsberg as a Dean devoted himself to the development of the building. He equipped the laboratory with advanced devices and instruments and arranged an apartment for his family in the right wing of the building, where he spent his last years.



Chemical building in XIX century

The rise of chemical industries in Eastern Galicia in the 60's and 70's was reflected in the content of the lectures of all professors-chemists in the Academy and in the subjects of laboratory studies. The research work became more intense by both chemical (synthesis and structure of ketones and chloranhydrides, studying the properties and extraction of petroleum products, the analysis of mineral springs and ores) and technological (fermentation processes, petroleum refining, salts processing) directions. The academy chemists obtained more possibilities after moving classrooms and laboratories to the new building. It should be noted that till 1895 there was only one Department of Chemistry in Lviv University and chemical building was situated in Dlugosh street (now St. Cyril and Mephody str., 6/8).

On October 8, 1877 Technical Academy was renamed to Higher Technical School (Technische Hochschule), which legalized its title and rights among academic schools of the monarchy. Professors collegium changed the name to Imperial-Royal Polytechnic School. At the same time professional schools were renamed to faculties.

Thus, in the 70's of the XIX century Lviv Polytechnic School became the leading higher technical educational institution in Galicia, which gave solid and versatile chemical and chemical- technology education, prepared qualified chemical engineers, having the necessary material base, classrooms, laboratories, and

museums. The famous professors R. Günsberg, A. Freund, and Y. Medvedskyi taught the students and performed researches involving students to them. Their achievements were a number of inventions, many books, monographs and papers on chemical technology, organic chemistry, mineralogy, and geology. They were not only outstanding scholars and teachers, but true patriots of their country.

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ABOUT THE BOOK BY AKBAR K. HAGHI AND GENNADY ZAIKOV “ADVANCES IN NANOFIBRE RESEARCH”

In 2011 *i*Smithers – A Smithers Group Company (Shawbury, Shrewsbury, Shropshire, SY4 4NR, UK) published a new book “Advances in Nanofibre Research” by Akbar K. Haghi (University of Guilan, Iran) and Gennady Zaikov (Russian Academy of Sciences, Russia).

This book provides an overview of the polymeric nanofibre fabrication *via* electrospinning process; structure formation of polymeric nanofibres in electrospinning; optimization of the mentioned process; practical

hints on the processing parameters and geometric properties of electrospun nanofibres as well as on the production of electrospun nanofibres from regenerated silk fibroin; characterization and formation of polymeric electrospun nanofibres; experimental study on electrospinning of polymeric nanofibres.

The collection of topics in this book may be useful for scientists as well as for graduate students and engineers.