Marek Zieliński, Ph.D.

SUMMARY OF PROFESSIONAL ACCOMPLISHMENTS

(Appendix No 4)

The new technology for obtaining selected metallic and non-metallic (building) materials in constant magnetic field.

Department of Inorganic and Analytical Chemistry
Faculty of Chemistry
University of Lodz

Lodz 2015

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SCIENTIFIC ACTIVITIES

DIDACTIC ACTIVITY

ORGANIZATIONAL ACTIVITY

1. Personal information.

- First and family name: **Marek Zieliński**
- Date and place of birth: September 16th, 1956, Włocławek.
- Address of residence: 93-355 Łódź, Białostocka 11 apt. 22.
- Secondary education: XVIII Liceum Ogólnokształcącego im. Jędrzeja Śniadeckiego (Jędrzej Śniadecki Memorial General Education High School No XVIII (graduation in 1976).
- Academic education: Technical University of Lodz (now Lodz University of Technology), Faculty of Food Chemistry (now Faculty of Biotechnology and Food Sciences) – Specialization: food chemistry and technology. Master thesis entitled "Chemical analysis of the selected components of smoke of Polish cigarettes" written in the Institute of Fundamentals of Food Chemistry under the supervision of Wiesława Olejniczak, Ph.D. (Eng.). The title of Master of Sciences in Chemical Engineering obtained on June 12th, 1981.
- Position and workplace: Assistant Professor in the Department of Inorganic and Analytical Chemistry, Faculty of Chemistry, University of Lodz, 12, Tamka St., 91-403 Lodz, Poland, tel. (4842) 6355788, e-mail: zielmark@chemia.uni.lodz.pl

2. Professional and scientific development.

2.1. Professional development before conferral of Doctor (Ph.D.) degree.

In September 1981, I started to work in industry, according to the studied specialization. As the topic of my master thesis had been ordered by the Tobacco Industry, my first employment contract was with the Cigarette Manufacturer in Lodz. Then, in 1982, I was employed in administration of the University of Lodz (UL), in the Planning Section. Since 1985, I have been working in the Faculty of Mathematics, Physics and Chemistry, in the Chair of General and Inorganic Chemistry (now: Department of Inorganic and Analytical Chemistry of the UL Faculty of Chemistry). Because of the engineering profile of my education, I prepared, together with other authors, a few **patent applications**, which resulted at a later stage in granted patents.

My scientific interests were associated with a field of electrochemistry involving the research on electrochemical redox reactions of inorganic and organic compounds investigated using the cyclic voltamperometry (CV). The doctoral dissertation entitled „Effect of constant magnetic field on the kinetics and mechanisms of redox reactions of the selected inorganic and organic compounds in various solutions" was prepared under the supervision of Prof. Henryk Scholl, D.Sc., in the w Department of Electrochemistry, Chair of General and Inorganic Chemistry. The public defense of the doctoral dissertation took place in 2001. It was awarded a distinction by both reviewers: Prof. Leszek Wojtczak, D.Sc., University of Lodz, and Jerzy Bieliński, D.Sc. (Eng.), Warsaw University of Technology.

2.2. Professional development after conferral of Doctor degree.

After conferral of the Doctor degree, I extended my scientific interests in the area of constant magnetic field and started the research on structure, the physical and chemical properties as well as the parameters of formation of metallic and non-metallic materials. At the first stage, my studies focused on metals and alloys obtained electrochemically. The novelty was that they were obtained under **constant magnetic field (CMF)** conditions, which affects their structure, composition and properties. To date, no universal model of the effect of CMF on chemical and electrochemical processes, or materials, has been developed, although scientists all over the world have been presenting empirical equations with a number of hypotheses which explain that effect with certain approximation. Information concerning the effect of CMF has been accumulated and some conclusions have been drawn. My subsequent studies concerning the utilization of constant magnetic field overlap with the area of environment protection in view of the objects obtained on the basis of waste materials, especially generated by industry such as phosphogypsum and fly ashes. The new materials were produced also with the use of CMF, which allowed to obtain different structure, mechanical strength, and other physical and chemical properties. Such materials can be widely applicable in building industry, construction of roads, or as fillers in plastic industry. Detailed research on the effect of CMF on the selected materials was an important element of the dissertation. The area that I deal with is a niche one, which is evident on the basis of a low number of papers concerning this topic published worldwide. This is due to the difficulties associated with the interpretation of phenomena and processes taking place under the influence of CMF. I think that the research on problems which are difficult or not investigated extensively is worthwhile, because their elucidation is of greater value.

SCIENTIFIC ACTIVITIES

3. Presentation of achievements on which the application for conferral of habilitation degree (D.Sc.) is based.

On 27.10.2015, at the University of Lodz Faculty of Chemistry, within the framework of a seminar of the Lodz Division of the Polish Chemical Society, the **main theses** of my research work were presented. My research is technological in character, with particular consideration of its potential applications in industry. I demonstrate the method of obtaining, under constant magnetic field conditions, new products characterized by better physical and chemical parameters. Cobalt alloys with new properties, presented in my papers, were obtained electrochemically under constant magnetic field conditions for the first time. Some non-metallic materials, obtained with the use of constant magnetic field, have already been presented also in patent applications. I supported experimental studies with theoretical considerations, equations and schematics published in renowned foreign journals.

My publications include: patents, patent applications and research papers. I have divided them into three groups:

H 1 – H 8. Papers constituting the basis for habilitation proceedings.
A 1 – A 11. Papers published before conferral of Doctor degree.
B 1 – B 31. Papers published after conferral of Doctor degree.

3.1. List of the series of publications constituting the basis for habilitation proceedings.

As the accomplishment pursuant to Art. 16 section 2 of the law dated 14 March 2003 concerning the academic degrees and titles in sciences as well as degrees and titles in the field of art (Legal Gazette No 65, item 595 with amendments), I indicate the series of eight papers, constituting the basis for habilitation proceedings [**H 1 – H 8**] entitled: **The new technology for obtaining selected metallic and non-metallic (building) materials in constant magnetic field.**

H 1. **M. Zieliński*,** *International Journal of Electrochemical Science*, "Influence of Constant Magnetic Field on the Electrodeposition of Cobalt and Cobalt Alloys", Volume 8, Issues 11, pp. 12192-12204 **(2013).** [IF = 3,729] [IF$_5$ = 2,209] [30 p.]

** corresponding author*

*My contribution involved: obtaining cobalt, Co-Mo, Co-W, and Co-Mo-W alloys electrochemically in different CMF, doing research by the XRD, SEM, EDX, STM methods, analysis of test results, creation of drawings and diagrams and edition of the article. I define its proportionate share as **100%.***

H 2. M. Zieliński*, *Materials Chemistry and Physics*, "Effects of constant magnetic field on the electrodeposition reactions and cobalt-tungsten alloy structure", Volume 141, Issues 1, pp. 370-377 **(2013).** [IF = 2,129] [IF$_5$ = 2,503] [35 p.]

** corresponding author*

*My contribution involved: electrochemical production of Co-W alloy in various CMF and different orientations of the magnetic induction vector B, study of the structure using XRD method, SEM morphology, determination of composition by EDX, interpretation of research results, edition of the paper. I define its proportionate share as **100%.***

H 3. **M. Zieliński***, E. Miękoś, D. Szczukocki, R. Dałkowski, A. Leniart, B. Krawczyk, R. Juszczak, *International Journal of Electrochemical Science*, "Effects of constant magnetic field on electrodeposition of Co-W-Cu alloy", Volume 10, Issue 5, pp. 4146-4154, (**2015**). [IF=1,956] [IF$_5$ = 2,209] [25 p.]

** corresponding author*

*My contribution involved: obtaining Co-W-Cu alloys electrochemically in different CMF, analysis of test results, creation diagrams and edition of the article. I define its proportionate share as **70 %.***

H 4. M. Zieliński*, E. Miękoś, *Journal of Applied Electrochemistry*, „Influence of constant magnetic field on the electrodeposition of Co-Mo-W alloys", Vol.38, No12, 1771-1778 **(2008).** [IF = 1,745] [IF$_5$ = 2,254] [20 p.]

** corresponding author*

My contribution involved: CVC studies in various CMF, coulometric studies in various CMF, analysis of results obtained with CVC, SEM, EDX, creation of drawings and co-

edition of the paper. I define its proportionate share as ***80%.***

H 5. W. Szmaja, W. Kozłowski, K. Polański, J. Balcerski, M. Cichomski, J. Grobelny, **M. Zieliński,** E. Miękoś, *Materials Chemistry and Physics,* "Study of the morphological and magnetic structures of nanocrystalline cobalt films obtained by electrodeposition", Volume 132, Issues 2-3, 1060-1064 **(2012).** [IF = 2,072] [IF$_5$ = 2,503] [35 p.]
My contribution involved: electrochemical deposition of cobalt layers on polycrystalline gold substrate, SEM measurements of the morphological structure of the cobalt films, elaboration and analysis of the results. I define its proportionate share as ***20%.***

H 6. M. Zieliński*, Patent No 186189 of **22.12.2003**, Patent Office of the Republic of Poland, entitled *„Method of phosphogypsum waste processing".*
* *corresponding author*
My contribution involved: preparation of the experimental part, conditioning of phosphogypsum, adjustment of the time and temperature parameters, chemical investigations of the sulfate groups, interpretation of the results, preparation of the patent application. I define its proportionate share as ***100 %.***

H 7. M. Zieliński*, *Chemical Industry*, „The use of industrial waste, aided by constant magnetic field, for stabilization of the road surface subsoil", Warsaw, No 8, Vol. 92, p. 1453, **(2013).** [IF = 0,367] [IF$_5$ = 0,332] [15 p.]
* *corresponding author*
My contribution involved: testing physical and chemical properties of raw and conditioned phosphogypsum, fly ash, phosphogypsum and fly ash radioactivity studies of fly ash, SEM studies of both waste materials, creating mixes applicable in building industry, mechanical strength tests, frost resistance, water absorption of the obtained samples, analysis of results and comparison with standards, creation of drawings, edition of the paper. I define its proportionate share as ***100%.***

H 8. M. Zieliński*, *Construction and Building Materials,* "Influence of constant magnetic field on the properties of waste phosphogypsum and fly ash composites", Volume 89, 13-24 ,(**2015**). [IF = 2,296] [IF$_5$ = 2,710] [40 pkt.]
* *corresponding author*
My contribution involved: conditioning of phosphogypsum, creating mixes applicable in

building industry, mechanical strength tests, frost resistance, water absorption of the obtained samples, analysis of test results and edition of the article. I define its proportionate share as ***100 %.***

3.2. Introduction and objective of the habilitation dissertation.

My studies are a part of a global trend in research, which has flourished worldwide during the last 10 years. Research on the effect of magnetic field in chemistry or materials science is a new and not very popular area. In 2015, in Japan, the sixth conference devoted exclusively to the effect of magnetic field on various chemical and biological media or materials (International Conference on Magneto – Science (ICMS) was held. The motto of that conference, which took place in Matsumoto (Japan) in 2015 was: *„Magnetism is the key for research on physical properties of materials. It is our dream to manipulate the chemical, physical and biological phenomena with the use of magnetic field"*

The term „magnetic field" was first used by Faraday in w 1845. He defined it then as a space in which magnetic forces, originating from permanent magnets or mobile electric charges, act. The flourishing of magnetism dates back to 1820, when H. Ch. Oersted observed the impact of electric current on a magnetic needle and A. M. Ampére demonstrated the equivalence of magnetic fields generated by magnets and electric current circuits (beginnings of electromagnetism). The physical essence of the natural magnetic field, as currently believed, is the exertion of mechanical forces on moving charged particles (electrons or ions) that are a specific form of the convection current or conduction. Owing to the existence of materials with special magnetic properties (e.g. ferromagnetic), the interest in the phenomena accompanying magnetic fields is increasing. Understanding and explanation of magnetic phenomena provides the basis for development of various magnetic materials, with physicochemical properties required for their practical applications in engineering or technology. Experimental testing methods allow characterization of new magnetic materials. Magnetochemistry focuses on the study of correlations between the chemical structure and magnetic properties of a substance that already exists. In my research, I concentrated on the effects of constant magnetic field during formation of the material.

3.3. Objective of scientific research.

The research goals were dictated by the state of contemporary knowledge in this field. It was, and still is, a niche area, not because it is not worth dealing with, but because it is difficult to interpret. **The main objectives of the research** are as follows:

1. Identification of changes in the structure, composition and physicochemical properties of selected metallic materials obtained electrochemically and non-metallic waste created in a constant magnetic field environment.
2. Creation under constant magnetic field conditions of materials characterized by new, modified and more favorable properties.
3. Presentation of dependences and conclusions clarifying the effect of constant magnetic field on the formation and magnetic properties of materials.
4. Application of the possibility to use waste materials in the research by developing appropriate technologies.
5. Obtaining with the use of constant magnetic field metallic and non-metallic materials applicable in practice.

The aim of habilitation (D.Sc.) dissertation was to investigate the effect of constant magnetic field (CMF) on electrochemical processes conducted to obtain metals and alloys, as well as their structure and properties (**part I**) and the effect of CMF on the production of new materials based on waste phosphogypsum and fly ash (**part II**).

The concept of the study included two variants of research. Their aim was to determine the changes in structure, composition, physical and chemical properties of the selected materials obtained under constant magnetic field (CMF) conditions (B – magnetic induction of specific value) – **variant 1**, and those obtained outside CMF ($B = 0$) – **variant 2**. The materials were presumed to be extremely varied to confirm the effect of CMF irrespectively of the material type. The previous experience and earlier interests in the fields of electrochemistry, magnetochemistry, environment protection and chemistry of building materials were also addressed. The research was intended to lead to creation of materials characterized by new, modified and often more favorable properties. As there was no CMF impact model, I wanted to present some correlations, observations and conclusions elucidating the effect of magnetic field on the obtained materials and their properties. As it can be observed, the research was interdisciplinary in character. Its scope combined electrochemistry, physics, materials science, civil engineering and environment protection.

The diagram (**Fig.1**) presents the most important elements of research constituting a scientific achievement on which the application for conferral of the habilitation degree was based.

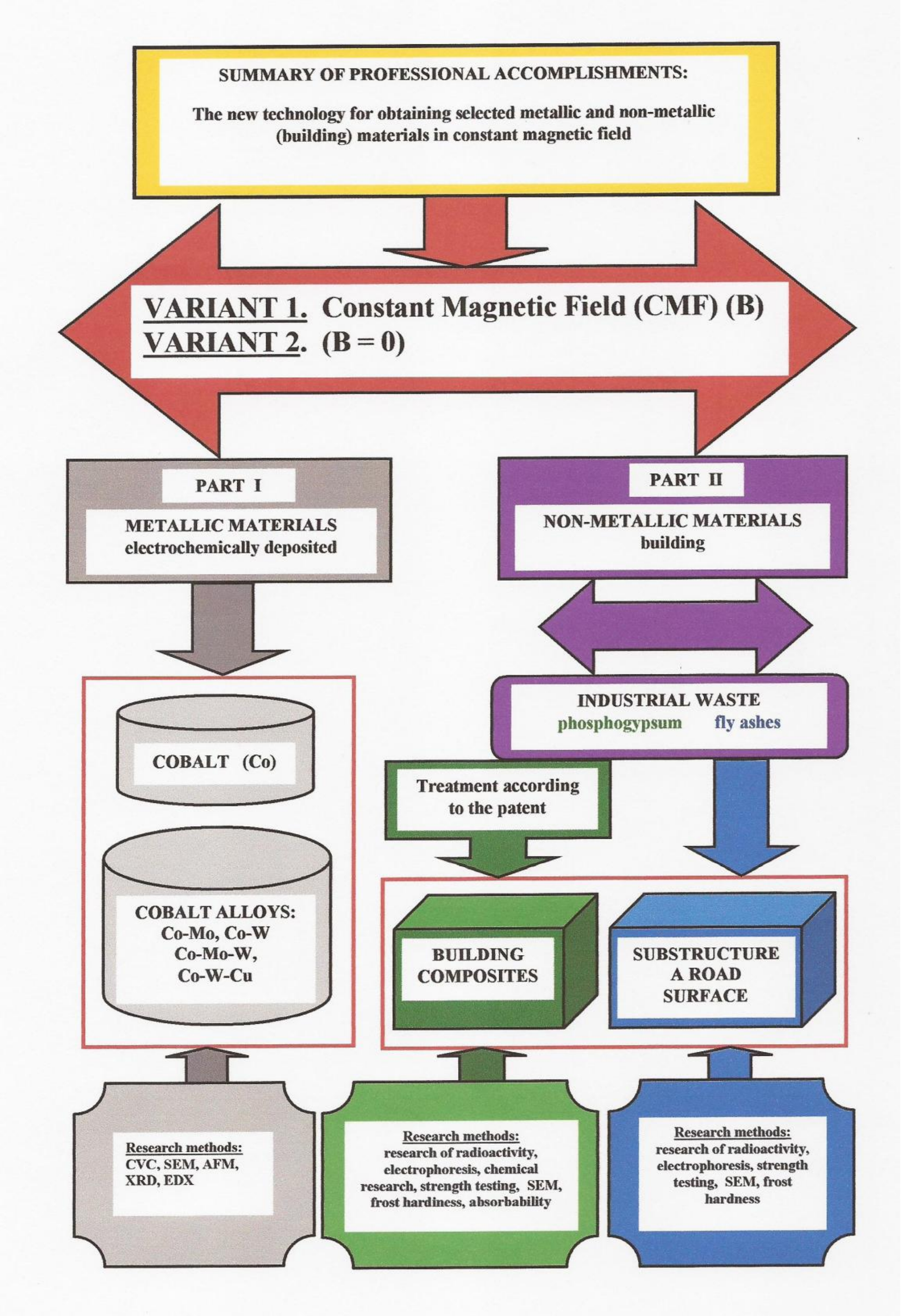


Fig. 1. Diagram presenting the concept of the study constituting a professional accomplishment providing the basis for application to initiate the habilitation proceedings.

The research was interdisciplinary in character. Its scope comprised chemistry (electrochemistry), physics, mathematics, engineering and material science (**Fig. 2**).

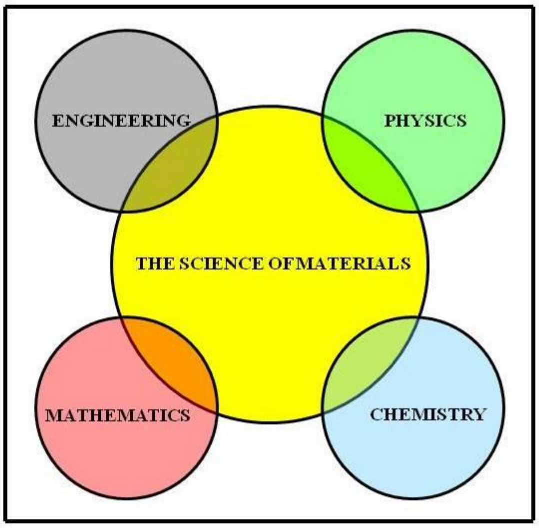


Fig. 2. Interdisciplinary character of material science.

3.4. Discussion of research results obtained within the framework of the habilitation dissertation.

3.4.1. Metallic materials.

3.4.1.1. Cobalt.

The basic material used in the presented research concerning metallic materials was cobalt. It was used both because of its ferromagnetic properties favorable in investigation of the effect of magnetic field and because of its universal applicability. Magnetic films demonstrate various magnetic properties dependent on their thickness, chemical composition, morphological and crystalline structure, as well as methods of deposition. This is important from the point of view of both technology and applicability. We investigated the morphology and magnetic structures of thick ferromagnetic cobalt crystals, deposited electrochemically (with 20 mA/cm^2 current density) on gold, polycrystalline, diamagnetic substrates. The thickness of the cobalt layers amounted to 14, 18 and 55 μm (Scanning Electron Microscopy – SEM). As the layer thickness increased, the metal structure became more and more inhomogeneous. The morphological structure of the electrodeposited cobalt consisted of rounded nanocrystalline grains ca. 100 nm in diameter (Atomic Force Microscopy – AFM)

[1]. No significant internal stresses were observed in the metal. The magnetic domains of the electrodeposited cobalt films were ca. 500 nm in size and demonstrated sufficiently strong perpendicular anisotropy. The mean size of the magnetic domains increased with a decrease of average size of the grains [2, 3]. We obtained cobalt layers with hexagonal crystalline structure and strong, favorable orientation [0001]. Another study [4] [**publication H 5**] concerned electrochemical deposition of 14 i 23 μm thick cobalt layers on polycrystalline gold. We observed the cross-sections of these layers using SEM (**Fig. 3**). The metal structure was made up of round nanocrystalline grains ca. 100 nm in diameter (for the 14 μm layer) and ca. 130 nm in diameter (for the 23 μm layer) (AFM) [5]. Studies using Magnetic Force Microscopy (MFM) demonstrated the presence of magnetic domains with magnetization perpendicular to the deposited metal plane. The domains measured ca. 360 nm in size (for the 14 μm layer) and ca. 480 nm (for the 23 μm layer) [6,7] (**Fig. 4)**. The knowledge of the morphological and magnetic structure of ferromagnetics is not only of cognitive, but also of practical importance. A few methods of cobalt layers deposition are known; however, obtaining them by the electrochemical method seems the simplest and the most inexpensive way.

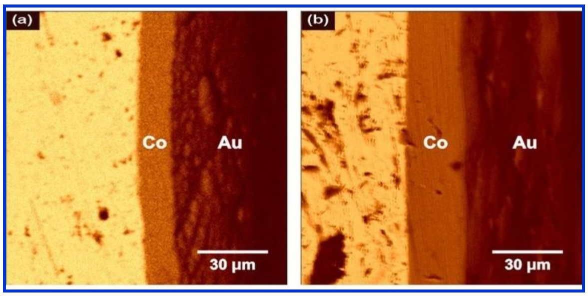


Fig. 3. Cross-sections of electrodeposited ferromagnetic Co layers of 14 μm (a) and 23 μm (b) thickness [**H 5**].

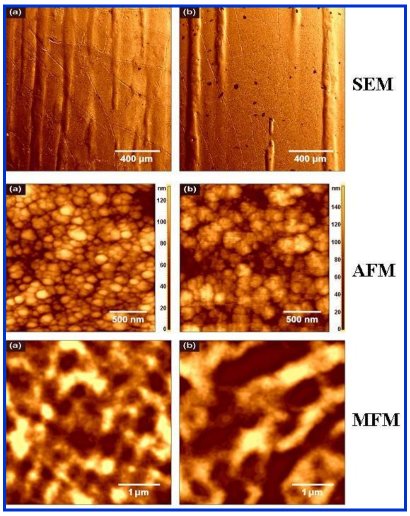


Fig. 4. Morphological and magnetic structures of electrochemically deposited ferromagnetic cobalt of 14 μm (a) and 23 μm (b) thickness **[H 5**].

3.4.1.2. Cobalt alloys.

One of the most important problems in „applied electrochemistry” is the production of working electrodes, the surface of which would have a specific chemical and phasic composition. It can be accomplished by deposition of transition metal alloy films on the electrodes. The studies of alloys focus on obtaining so-called functional metallic films with special physical and chemical properties such as mechanical, electric, magnetic, or optic ones. The demand for alloy films possessing specific properties has increased in the recent years. They demonstrate much better resistance to corrosion than single metal ones. The alloy properties associated with chemical composition and structure, such as microhardness, residual stresses, ductility, electric conductivity, can be adjusted with appropriate composition of the galvanic bath as well as by appropriate selection of the technological parameters [**H 1**]. Obtaining binary, ternary alloys and those with higher numbers of components, among which cobalt is the basic one must involve introduction of other metals with physical properties superior to cobalt. Such properties characterize, among others, molybdenum and tungsten. Molybdenum and tungsten are metals incapable of isolated deposition from aqueous salt solutions. However, they can be codeposited by induction method with metals of the ferrous triad: Fe, Co, Ni. This phenomenon has not been fully elucidated yet. The currently prevailing view is that codeposition of tungsten and molybdenum with the metals belonging to the ferrous group occurs as a result of reduction of heteropolytungstates or heteropolymolybdates [**H 2**]. In line with that hypothesis, research has been conducted to elucidate the mechanism of this phenomenon and to apply it in industry. The alloy obtained according to this mechanism is Co-W. It is characterized by high hardness and resistance to corrosion. The higher the content of tungsten in the alloy, the less ductile it is and the higher electrical resistance it has. Also the obtained and investigated binary Co-Mo and ternary Co-Mo-W alloys demonstrated better properties than cobalt alone. Because of high content of ferromagnetic cobalt, the studied alloys could be classified as so-called magnetics. Those obtained additionally in constant magnetic field (CMF) had modified, also more favorable physical and chemical properties. Magnetics are materials whose thermodynamic system properties could be described exclusively by thermodynamic equations – without taking into account their microscopic structure. The processes taking place in CMF are of considerable practical importance in the thermodynamics of magnetics. Owing to Maxwell’s thermodynamic equations we can calculate the functional correlations of the variables whose values cannot be modified in the experiment. In the presence of CMF (at V, T, P = const.) the internal energy of a diamagnetic decreases parabolically with the increase of CMF, whereas the internal energy of a paramagnetic is not affected by CMF. Diamagnetic enthalpy increases parabolically with the increase of CMF, whereas paramagnetic enthalpy demonstrates a linear decrease with the increase of CMF. An increase of CMF does not cause any heat exchange with the environment in a diamagnetic (heat is transmitted into the environment – the magnetic entropy decreases). In contrast, in paramagnetics and ferromagnetics an increase of CMF induces the release of heat. This is a so-called magnetothermodynamic magnetocaloric effect. As written by M. Pękała in his book "Experimental methods of magnetochemistry" (Published by University of Warsaw, Warsaw, 2013) it has been confirmed that each magnetic material demonstrates magnetocaloric properties. This is a change of magnetic energy of the material when the arrangement of magnetic moments in a magnetic field changes. The measure of the magnetocaloric effect is a change of the material temperature with an adiabatic change of the magnetic field, or a change in entropy if the field is applied isothermally.

The main objective of the study [8] [**publication H 2**] was to answer the question what is the effect of CMF on the fundamental processes involved in electrodeposition of Co-W alloys, transport of the mass towards the cathode and kinetics of electrode reactions. The use of CMF to control the rate of Co-W alloy crystals growth and their texture was also intended. The methods utilized in the research included SEM (Scanning Electron Microscopy), EDX (Energy Dispersive X-ray), EDS (energy-dispersive X-ray spectroscopy) and XRD (X-ray Diffraction). During electrodeposition of Co-W alloys, as a result of exposure to CMF, Lorentz force F was generated [9]. It caused magnetohydrodynamic (MHD) effects in the solution, resulting in movement of the electrolyte. Consequently, the Nernst diffusion layer (δ_D), was reduced, which could be described by equation (1):

$$\delta_D \approx 1.59\left(\rho R v^{2/3} D^{1/3}\right)^{1/3}\left(nFCB\right)^{-1/3} \qquad (1)$$

where: ρ – electrolyte density [kg· m^{-3}], R – radius of the working electrode [m], υ – kinematic viscosity of the electrolyte [m^{2}· s^{-1}], D – electrolyte diffusion [m^{2}· s^{-1}],], n – number of electrons involved in the electrochemical process, F – Faraday’s constant [96487 C· mol^{-1}], C – concentration of electroactive ions in the solution [mol·dm^{-3}], B – magnetic induction [T].

A new hydrodynamic Navier-Stokes layer (δ_H) appeared, which determined the flow velocity of electroactive molecules to the working electrode according to the following equation (2):

$$U \approx \left(nFCDB\,\mathrm{Pr}^{1/3}\eta^{-1}\delta_H\right)/\,0.62 \approx \left(nFCD^{4/3}B\rho^{1/3}\delta_H\right)/\left(0.62\eta^{4/3}\right) \qquad (2)$$

where η was dynamic viscosity of the liquid phase and $\mathrm{Pr} = D/\nu = (D\rho)/\eta$, with Pr standing for Prandtl number. As it follows from the equation, the molecular velocity (U) increased with the increase of magnetic induction (B). The increase of B correlates also with the increase of hydrodynamic Navier-Stokes layer (δ_H) thickness, determining the flow of the liquid phase during exposure to CMF.

My experiments demonstrated numerous cracks of the electrochemically deposited Co-W alloy samples, formed as a result of residual stress. Under exposure to CMF, the cracks were reduced or disappeared completely [11] (**Fig. 5**). The effect of CMF involved also an increase of cobalt content with a simultaneous decrease of tungsten content.

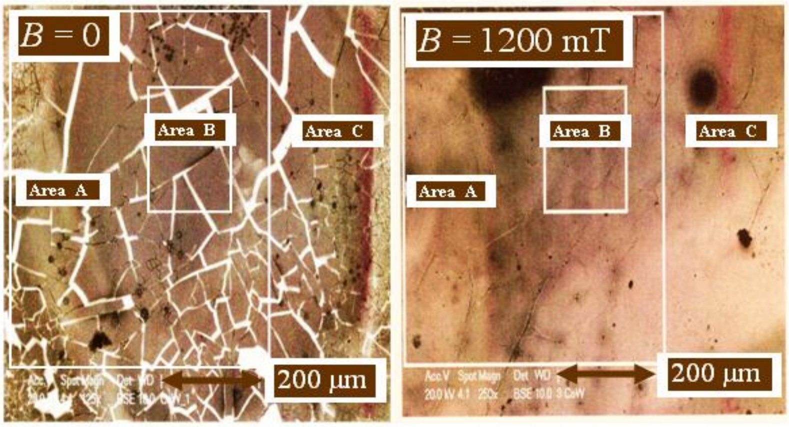


Fig. 5. SEM images of Co-W alloys samples obtained with no magnetic field and in CMF with magnetic induction B = 1200 mT ($B \parallel P_E$), mag. x 250, BSE type images **[H 2]**.

The Co:W weight ratio changed from 2:1 (with no exposure to magnetic field) to 3:1 or 4:1 (under CMF conditions). Using the XRD method, I identified in the alloys phase (Co_3W) in a hexagonal system, phase (Co_7W_6) in a trigonal one, as well as phases (α-Co) and (W) , both in regular configurations. The predominant phase in the investigated alloys was Co_3W (**Fig. 6**). The films constituted {0 0 0 1} type (basal) lattice planes. Under exposure to CMF, some planes of the crystals were deflected at a certain angle (ranging from 10 to 20^0, depending on the value of magnetic induction B) in the process of alloy formation. Thus, the orientation of crystallites should be described as the plane family of {0 -1 1 3} type, and some planes as {3 2 -5 1} type. Exposure to CMF changed also the volume fraction of the dominant phase in the alloy as well. The (Co_3W i Co_7W_6) phase volume increased by ca. 9% in CMF, in parallel with simultaneous decrease of cobalt and tungsten proportions.

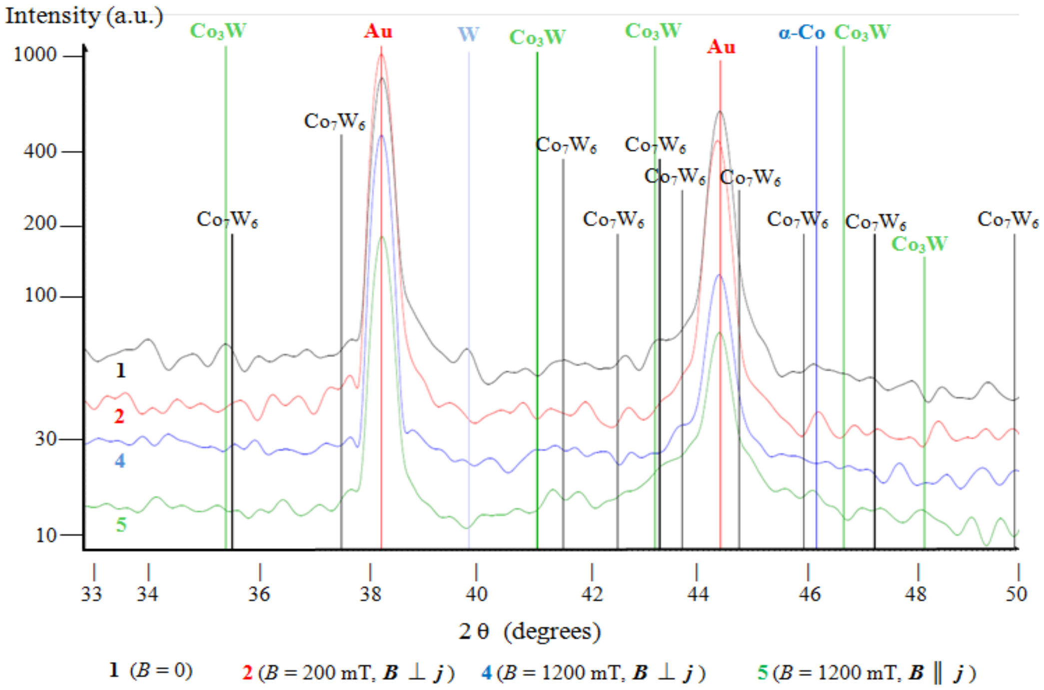


Fig. 6. X-ray diffractograms obtained for four samples of cobalt-tungsten alloys
1 – black (B = 0), 2 – red (B = 200 mT, $B \perp$ j), 4 – blue (B = 1200 mT, $B \perp$ j), 5 – green (B = 1200 mT, $B \parallel$ j).
The positions of diffractive reflections for the particular phases marked with vertical lines: green – Co_3W, black – Co_7W_6, blue – α-Co, light blue – W, red – Au (substrate) [**H 2**].

The changes in the course of electroreduction reaction of the ternary Co-Mo-W alloy due to exposure to CMF are discussed in another paper [10] [**publication H 4**]. We observed changes in the topography of the alloy surface, as well as changes in the chemical composition of the alloy. The methods applied in the study included CV (Cyclic Voltammetry), coulometry, SEM (Scanning Electron Microscopy) and EDX (Energy Dispersive X-ray). During crystallization of Co-Mo-W alloy, cracks due to residual stresses of the alloy were formed on the surface of the gold electrode. Like in the case of Co-W alloy, the use of CMF reduced the width of the formed fissures (**Fig. 7**) as a consequence of increased concentration of electroactive molecules in the vicinity of the working electrode and reduced stress values in the alloy [12].

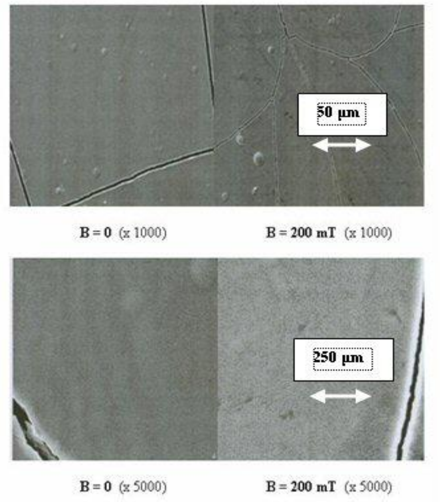


Fig. 7. Reduction of fissure width on the surface of Co-Mo-W alloy under the influence of CMF (magnification x 1000 and x 5000) [**H 4**].

Movement of the electrolyte in CMF caused an increase in percentage content of the main ferromagnetic component (Co) in the alloy. It was also observed that with increasing complexity of the metallic film structure: Co, Co-Mo, Co-Mo-W, higher magnetic induction (*B*) values were required to obtain the maximal effect of CMF on the charge value (Q) (**Fig. 8**).

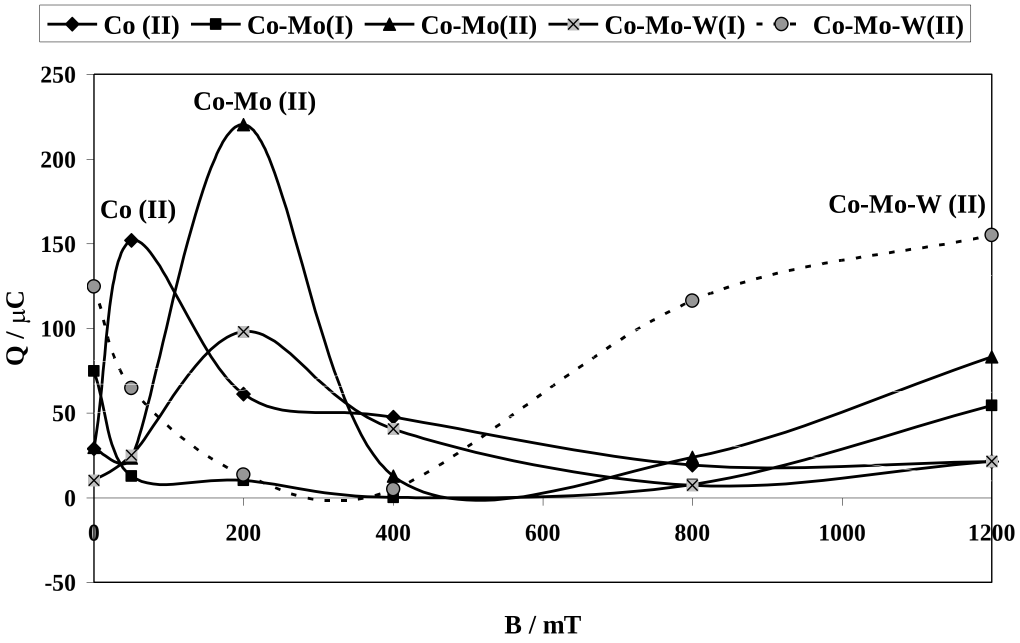


Fig. 8. Correlation of charge (Q) with magnetic induction (*B*) in Co electroreduction reaction of Co-Mo and Co-Mo-W alloys [**H 4**].

The effects of CMF on the processes of electrolytic deposition of cobalt, binary cobalt alloys such as: Co-Mo and Co-W and ternary ones: Co-Mo-W were also compared. The results obtained in the study [13] [**publication H 1**] indicated that the use of CMF resulted in changes of cobalt and alloy deposition kinetics, chemical composition and surface morphology, as well as changes of crystallographic parameters. It is currently presumed that the effects of magnetic fields in electrochemical processes are associated with the electrolyte mass transport. In the processes of electrolytic deposition of cobalt and cobalt alloys, so-called Lorentz force, generated as a result of exposure to CMF, was involved. That force induced magnetohydrodynamic (MHD) effects in solutions, which caused electrolyte movement. Consequently, the Nernst diffusion layer (δ_D) was reduced and a new Navier-Stokes hydrodynamic layer (δ_H), determining the velocity of electroactive ions flow towards the working electrode, appeared, as shown in (**Fig. 9**) [14]. In the CMF, some planes of cobalt and cobalt alloy crystals were deflected at a certain angle (up to 20^0, depending on the value of magnetic induction *B*) during their formation.

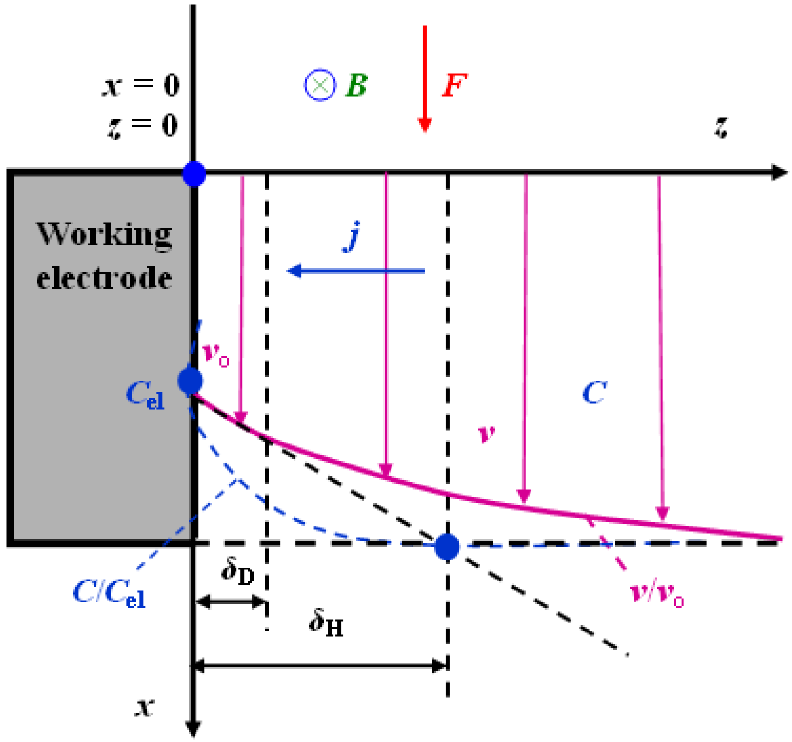


Fig. 9. Reduction of Nernst diffusion layer (δ_D) thickness at the surface of the working electrode and development of Navier–Stokes hydrodynamic layer (δ_H) in the CMF [**H 1**].

I also observed a significant effect of CMF on the morphology of metallic films, e.g. Co-Mo-W (**Fig. 10**) [15].

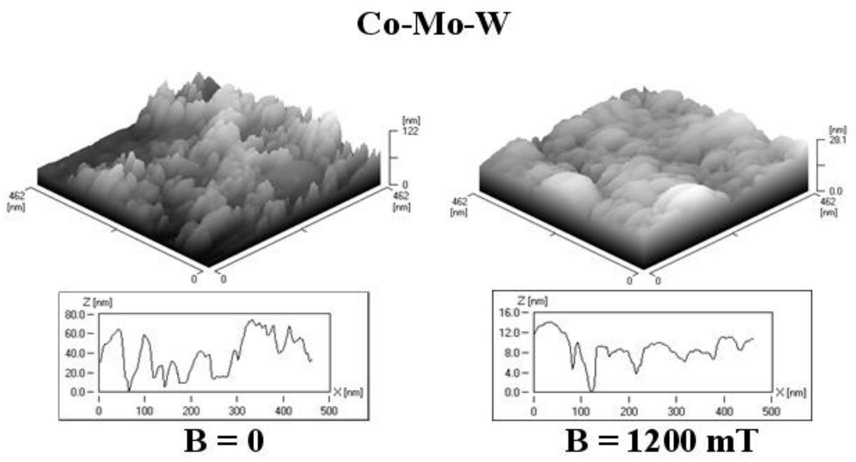


Fig. 10. STM (Scanning Tunneling Microscope). Topography of Co-Mo-W alloy surface electrodeposited on a plate-shaped gold electrode in CMF with magnetic induction *B* = 0 and *B* = 1200 mT, scanning area 462 x 462 nm [**H 1**].

The metals electrodeposited in the presence of CMF were more homogeneous and smooth than those obtained without CMF. In the research of Co-W-Cu alloy deposited electrochemically in CMF and without magnetic field [16] [**publication H 3**] X-ray spectra (**Fig. 11)** confirming the alloy composition were obtained.

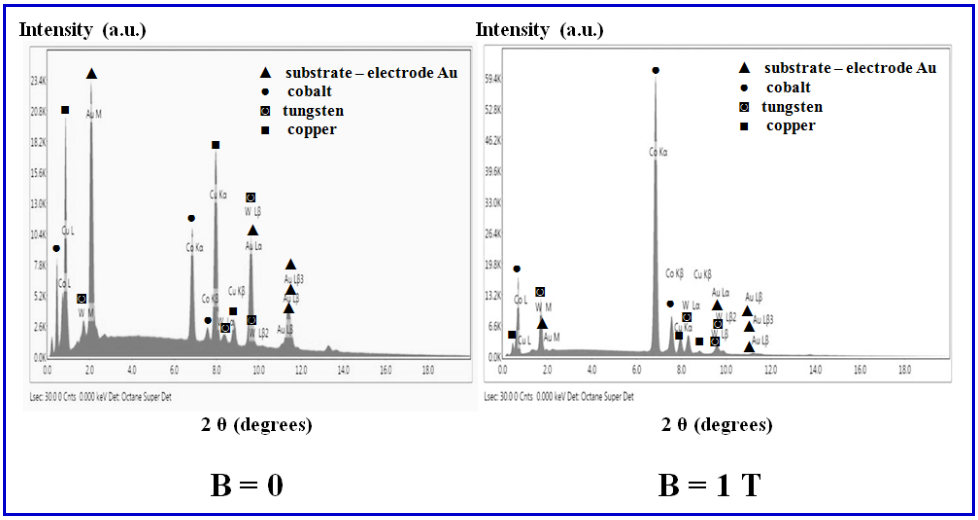


Fig. 11. Qualitative analysis. X-ray spectra of Co-W-Cu alloy obtained in magnetic field with magnetic induction B = 1 T and without magnetic field. The (Au) peak represents the substrate made of gold (gold disc working electrode) [**H 3**].

The EDS method was used to determine the quantitative composition of the elements present in the alloy (**Table 1**). Exposure to CMF during the alloy deposition process resulted in a significant increase in the percentage of the ferromagnetic component, an increase in the quantity of the paramagnetic component as well as in a significant decrease in the quantity of the diamagnetic component [17].

Table 1. EDS method. Quantitative analysis of chemical elements present in the obtained Co-W-Cu alloys [**H 3**].

Metal	**Constant magnetic field**	
	B = 0	**B = 1 T**
Co	18,47 % wag.	69,55 % wag.
Cu	70,33 % wag.	12,53 % wag.
W	11,20 % wag.	17,92 % wag.

Fig. 12. presents the surfaces of Co-W-Cu alloys obtained in CMF and without magnetic field, visualized using the AFM method. The alloys electrodeposited in CMF were smoother, and their atoms, or groups of atoms, more densely packed.

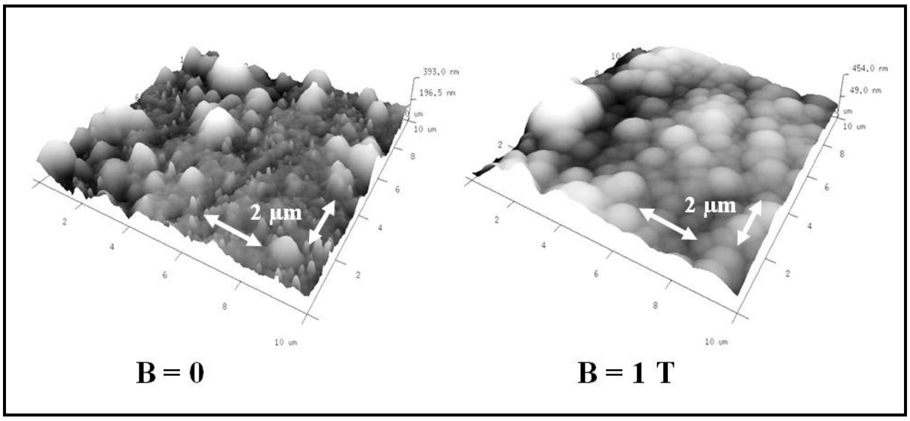


Fig. 12. AFM method. The surface topography of Co-W-Cu alloy obtained electrochemically in the presence of magnetic induction B = 0 and B = 1T [**H 3**].

Reduced roughness of Co-W-Cu alloy obtained in CMF (**Table 2**) makes its surface less developed and less susceptible to chemical reactions (e.g. oxidation). The access of reagents (e.g. oxygen) to active sites is reduced, which makes the alloy more resistant to corrosion.

Table 2. Roughness of Co-W-Cu alloy surface (scan area 1 x 1 µm) [**H 3**].

Magnetic induction	**WRP**	**RMS (nm)**	**h_{max} (nm)**
B = 0	1,06	15,3	117
B = 1 T	1,02	10,1	95,4

The surface topography has been confirmed by investigation of the roughness of the electrodeposited CoWCu alloy. The AFM method was used. The roughness was expressed as surface development index (WRP/SDI), root mean square deviation of the roughness profile (RMS) and maximum height of the electrodeposited alloy layer (h_{max}). SDI and RMS are described by the following equations:

$$WRP = P_R / P_G \tag{3}$$

$$RMS = \left[\sum_i (Z_i - Z_{śr})^2 / N \right]^{1/2} \tag{4}$$

gdzie:
WRP – surface development index (SDI)
P_R – actual surface area
P_G – geometrical surface area (projection of the area onto a plane)
RMS - root mean square deviation of the roughness profile
Z_i – the distance of point i from the average $Z_{śr}$ level
N – number of measurement points

3.4.2. Non metallic and waste materials.

Pursuing the objectives of my research at its next stage, I focused on were non-metallic materials, such as waste phosphogypsum and fly ash.

3.4.2.1. Phosphogypsum waste.

Phosphogypsum is a waste material obtained in the process of phosphoric acid production. It contains mainly calcium phosphate dihydrate and residual amounts of phosphoric and sulfuric acids. Production of 1 t of phosphoric acid yields 5.5 t of phosphogypsum waste. The annual amount of such waste generated all over the world, mainly in the US, Arab countries – Morocco, Jordan, as well as in Europe, among othes in the Netherlands, France and Germany, amounts to 100 mln t. Poland produces ca. 4 mln t of phosphogypsum waste every year: in Police, Wizów and up to recent times also in Gdańsk (**Fig. 13**). Therefore, phosphogypsum is becoming a more and more serious environmental problem, especially in view of the fact that the production of phosphoric acid, applicable in many industrial sectors, is increasing steadily. In the experts' opinion, the best direction of phosphogypsum utilization is production of gypsum binders and construction elements for the building industry, which enables to save the natural gypsum resources.

Fig. 13. Heaps of waste phosphogypsum in Police.

Besides the problem of natural resources, there is also a problem of energy expenditure. Replacing the natural raw materials with waste materials in technological processes allows to save significant amounts of energy that would have to be expended for mining, recovery and processing of natural raw materials. However, the methods of utilization of phosphogypsum on industrial scale have not been sufficiently effective to date. Apart from the economic significance, the problem is also becoming a prestigious issue. **The report of 2010-2012** entitled „*The problem of inorganic waste and the development of chemical industry in Poland”*, presented by the Institute of Environmental Protection in Warsaw and Fertilizers Research Institute in Gliwice indicated that the storage of waste accounts for 33% of the environment protection costs incurred by industrial companies. According to the report, new technologies, even those which are unprofitable at present, are an appropriate direction of development.

In my patent [18] [**publication H 6**] I presented a solution which involves processing phosphogypsum waste to the form applicable especially as a substrate for production of materials used in the building industry, as well as fillers for paints, enamels and plastics. Treated phosphogypsum can also be used in production of cement-gypsum composites for building industry with properties improved by the use of CMF. My solution involved conduction of the process in a waste-free way by heating, with simultaneous mixing, starting from ambient temperature and maintaining the temperature gradient within the 0.05 – 0.33 deg/s range until the sulfate (SO_4^{-2}) groups content reached less than 0.23 % by weight, determined at ambient temperature by any quantitative method. The heating process was conducted in a fluidized bed (**Fig. 14**). After reaching the consecutive temperature intervals: 380-390 K, then 550-560 K and 600-610 K, isothermal heating within these intervals was conducted for 5-12 minutes. The above invention allows effective utilization of considerable amounts of phosphogypsum waste, which constitutes a more and more serious environmental problem in its untreated form.

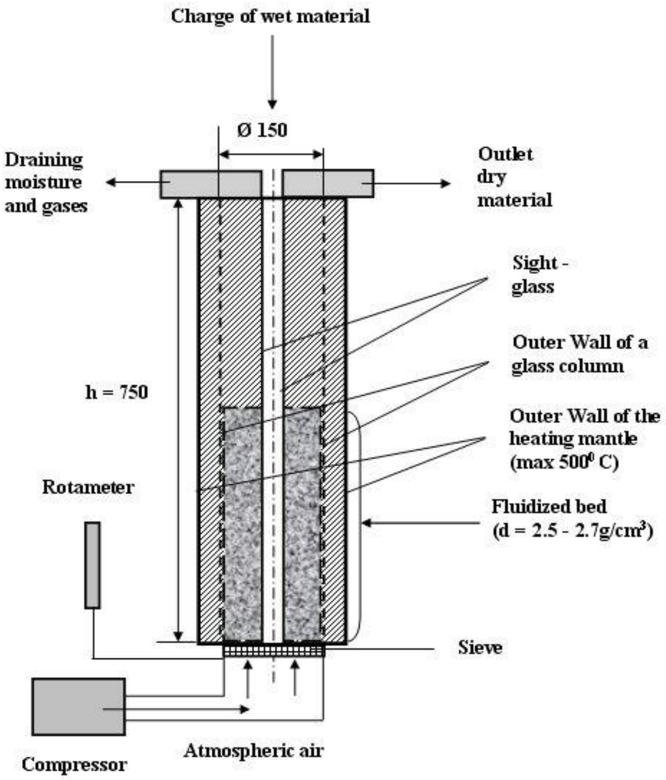


Fig. 14. Glass fluidized bed column of diameter Ø = 150, height h = 750 mm, for waste phosphogypsum processing [**19**].

The parameters of phosphogypsum processing in a fluidized bed column of own design were as follows [19]:

- energy consumption: 520 kJ / 1 kg phosphogypsum to final heating ca. 673 K,
- air compression: 1 – 1,5 atm. per column,
- amount of air introduced to the column (containing ca. 50 kg phosphogypsum): 0.3 m^3/s,
- amount of energy required to heat 0.3 m^3 of air: 59.1 kJ (for 288 – 453 K), 87.8 kJ (for 288 – 533 K), 138.0 kJ (for 288 – 673 K),
- heating device power: 13.8 kW,
- heating time for 0.3 m^3 of air - 10 s.

As a question arise whether processing of waste phosphogypsum would not be too costly, I conducted cost calculations for such a process. I took into account the parameters of the designed device for phosphogypsum processing, as well as the parameters of the process itself. The calculation is presented below. It demonstrates that 50 kg of crude phosphogypsum can be processed in a fluidized bed column in 15 min. incurring the cost of PLN 1.0775. That sum was obtained from the following calculations of phosphogypsum processing parameters:

1. Heating of crude waste phosphogypsum.

(assuming energy consumption of 520 kJ / 1 kg phosphogypsum for final heating to ca. 400^0C).

- expenditure : 6 gr for electric energy / 1 kg phosphogypsum.
- with transmission-related losses : 9 gr for electric energy / 1 kg phosphogypsum.

2. Air compression.

From 1 atm (atmosphere) to 1.5 atm per column.

3. Compressor.

A compressor with a continuous change of compression from 1 atm to 2 atm, capable of 0.5 m^3/ s output, is needed.

4. Amount of air introduced to the column (initial air volume).

(containing ca. 50 kg of crude phosphogypsum) .
assumption 1 : air is compressed first, and then heating conducted.
assumption 2 : 0.2 m^3/ s output .

$P_1 \cdot V_1 = P_2 \cdot V_2 \qquad 1\ \text{atm} \cdot V_1 = 1{,}5\ \text{atm} \cdot 0.2\ m^3 \qquad V_1 = 0.3\ m^3$

5. Amount of energy required to heat 0.3 m^3 of air.

(from temp. 15 ^{0}C to 180 ^{o}C as well as to 260 ^{o}C and 400 ^{o}C).

1 cal = 4.186 J
$M_{mol} = 28.96$ g/mol - air molar mass
$d = 1.185\ kg/m^3$ - air density
$c_w = 29200$ J/ kmol · K - specific heat of air

$Q = m \cdot c_w \cdot \Delta T \qquad d = m / V$

$Q = d \cdot V \cdot c_w \cdot \Delta T = 1.185\ kg/m^3 \cdot 0.3\ m^3 \cdot 29200\ (J/\ kmol \cdot K) \cdot 165\ K =$
$= 1712799\ kg \cdot J / kmol = 1712799\ g \cdot J / mol =$
$= 1712799\ g \cdot J / 28.96\ g = 59143.612\ J =$
$=$ **59.1 kJ** (for 15 – 180 ^{o}C) .
87.8 kJ (for 15 – 260 ^{o}C) .
138.0 kJ (for 15 – 400 ^{o}C) .

6. Calculation of heating device power.

assumption : heating time for 0.2 m^3 of air = 10 s.

$P = W/ t = Q/ t \qquad P = 138000\ J / 10\ s = 13800\ W =$ **13.8 kW** .

S. I. system P [1 W = 1 J / s], 1 KM = 736 W, 1 kWh = 1 kW · 1 h
The final calculations were as follows:
0.2539 PLN – 1 kW – 1 h
x = 3.5038 PLN - 13.8 Kw - 1 h
x = 0.8760 PLN - 13.8 Kw - 0,25 h
x = 1.0775 PLN (including 23 % VAT)

For a single process with **50 kg phosphogypsum** treated in a fluidized bed column in time **t = 0.25 h** the cost amounts to **PLN 1.0775.**

3.4.2.2. Phosphogypsum and fly ashes in building materials.

The science of building materials should be interesting to a lesser or greater extent for almost everyone, as they certainly have had, or will have, some contact with it. The progress in the building sector is very rapid, which requires extensive knowledge of technologies, materials, or control methods. The development of civilization has resulted in considerable depletion of natural resources available in the environment. Therefore, it is necessary to increase utilization of the available waste materials. The progress in civil engineering is also based on development of novel building materials, inexpensive and at the same time characterized by good parameters [20-26]. One of the waste materials used in the research was the aforementioned phosphogypsum. To date, the phosphoric acid production plants have generated ca. 5 bn T if this waste, 70 - 90% of which has been deposited in landfills. One of the largest users of phosphogypsum waste can be building industry, which can utilize large amounts of this material for production of e.g. mortars, or concrete elements. It was mentioned in the report issued by the Institute of Environment Protection in Warsaw in 2009, entitled „The problem if inorganic waste and the development of chemical industry in Poland", co-financed within the framework of a project supported by the European Regional Development Fund of the European Union. The second type of waste investigated in the research was fly ash. It is a by-product of incineration of pulverized coal or lignite in power plants, yielded in the amount of ca. 20 mln ton a year in Poland. The most important areas in which fly ash is used in building materials industry include currently the production of: clinker, Portland cement, cements, concretes, lightweight aggregates and ceramic elements [27]. My studies indicated that the use of so-called mixing water that had undergone magnetic treatment in CMF with magnetic induction B = 1 T [28] [**publication H 8**], improved some parameters of appropriately selected building composites. There were four variants of the research (**Fig. 15**). Variant I included no exposure either of water, or of the components making up the composite, or of the curing process, to CMF. In variant II only water was treated magnetically, without exposure to CMF of either the remaining components, or the curing process. In variant III, water was not treated magnetically, but the composite was exposed to CMF while curing. Variant IV involved both magnetic treatment of water and exposure of the composite to CMF during the curing process.

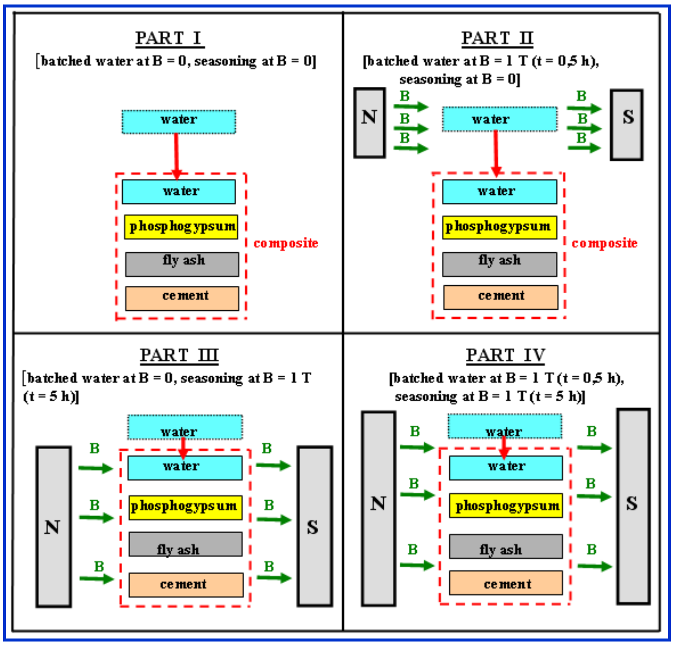


Fig. 15. Variants of the research of building materials and composites [**H8**].

In magnetically treated water, a change in concentrations of gases contained in water takes place [an increase of oxygen concentration, with a decrease in CO_2, ozone and chlorine concentrations] [29]. The content of selected anions in mixing water exposed to CMF of B = 1 T induction for 30 minutes, investigated by electrophoresis, decreased (**Fig. 16**).

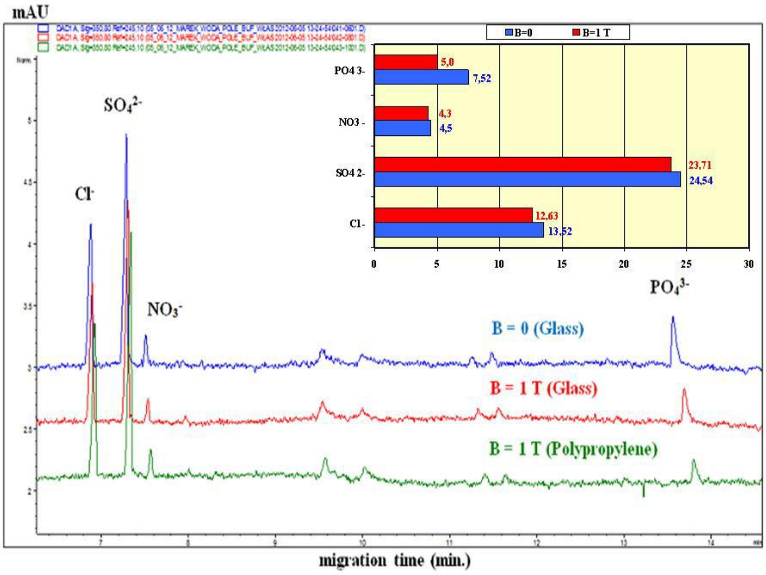


Fig. 16. Electrophorogram of waters, treated and not treated with CM in glass and polypropylene containers, for selected anions. The content of selected anions in mixing water exposed to CMF of B = 1 T induction for 30 minutes and not exposed to CMF [**H 8**].

According to my studies, the use of tap CMF (B = 1 T, t = 30 min.) resulted in:

- reduced absorbability of Portland cement samples by [16 % wt.] (containing, depending on the brand, from 6 to 20 % fly ash),
- reduced absorbability of building composite samples with fly ash content by [7.4 % wt.],
- increased frost resistance of Portland cement samples by [2.6 % wt.],
- increased frost resistance of building composite samples with fly ash content by up to [6.9 % wt.],
- increased chemical resistance to H_2SO_4, CH_3COOH, NaOH, $(NH_4)_2SO_4$, of Portland cement samples by [1.4 – 65.6 % wt.],
- increased chemical resistance to CH_3COOH, NaOH, $(NH_4)_2SO_4$, $MgCl_2$, $(NH_4)_2SO_4$ of building composite samples with fly ash content by [9.5 – 82.1 % wt.],
- increased mechanical flexural strength of Portland cement samples by 11.8 %, building gypsum by 38.9 %, building composite (CP : PL) by 7 %, building composite (GB : FU) by 30.6 % and composite (CP :PL : FU) by 155.6 %,

- increased mechanical compressive strength of Portland cement samples by 59.8 %, building gypsum by 70.0 %, building composite (CP : PL) by 37.3 %, building composite (GB : FU) by 82.4 % and composite (CP : PL : FU) by 156.9 %.

The effect of CMF on building materials can be also confirmed by statistical evidence. I obtained it for the mechanical compressive strength parameter tested on standardized bar samples of 40 x 40 x 160 mm dimensions of four building materials, six identical samples for each material, obtained using mixing water treated magnetically (B = 1 T) versus untreated. I calculated the arithmetic mean $\bar{x}$, variance σ^2 (characterizing the scatter, deviation of the particular results from the actual value), standard deviation (mean squared error) σ, mean error of the mean (mean squared error of the arithmetic mean) $S_{\bar{x}}$ and the width of confidence interval ε (the range of values of the random variable) around the obtained mean value, including the actual value). The other values indispensable for statistical calculations, were calculated or read from the tables:

n - number of measurements equal = 6
k - number of degrees of freedom = 5
α - level of significance = 0.05
P - probability = 95%
t - value read from the Student distribution tables = 2,776

I presented the statistical results in **Table 3** and **Table 4**.

Table 3. Statistics of the measurement results for (B = 0).

L.p.	Building material	x [MPa]	$\bar{x}$	σ^2	σ	$S_{\bar{x}}$	ε	$(\bar{x} \pm \varepsilon)$
1	PC	16,00 19,59 15,13 20,49 19,84 16,41	17,91	5,37	2,32	0,95	2,64	17,91 ± 2,64
2	G	4,69 3,80 3,92 3,76 3,85 4,12	4,02	0,12	0,35	0,14	0,39	4,02 ± 0,39
3	PC : G	4,61 4,31 4,50 6,05 6,12 4,74	5,06	0,65	0,81	0,33	0,92	5,06 ± 0,92
4	PC: P: FA	4,31 8,20 8,77 5,95 5,60 6,20	6,51	2,81	1,68	0,69	1,91	6,51 ± 1,91

PC – Portland cement, G – Gypsum, P – Phosphogypsum, FA – Fly ash.

Table 4. Statistics of the measurement results for (B = 1 T).

L.p.	Building material	x [MPa]	$\bar{x}$	σ^2	σ	$s_{\bar{x}}$	ε	$(\bar{x} \pm \varepsilon)$
1	PC	33,24 30,37 26,48 32,29 21,61 27,80	28,63	18,45	4,29	1,75	4,86	28,63 ± 4,86
2	G	6,29 5,75 6,56 6,11 9,03 6,92	6,78	1,38	1,17	0,48	1,33	6,78 ± 1,33
3	PC : G	9,09 9,13 8,56 10,92 8,71 9,22	9,27	0,72	0,85	0,35	0,97	9,27 ± 0,97
4	PC: P :FA	18,27 17,37 14,39 17,33 18,11 14,52	16,67	3,08	1,75	0,71	1,97	16,67 ± 1,97

To compare the samples produced in CMF and without magnetic field, I have compiled a comparative table (**Table 5**).

Table 5. Statistics of the measurement results (comparison).

L.p.	Building material	$(\bar{x} \pm \varepsilon)$ [MPa]				Δx [%]
		B = 0	ε [%]	**B = 1T**	ε [%]	
1	PC	17,91 ± 2,64	**14,7**	28,63 ± 4,86	**16,9**	**59,9**
2	G	4,02 ± 0,39	**9,7**	6,78 ± 1,33	**19,6**	**68,7**
3	PC : G	5,06 ± 0,92	**18,2**	9,27 ± 0,97	**10,5**	**83,2**
4	PC: P : FA	6,51 ± 1,91	**29,3**	16,67 ± 1,97	**11,8**	**156,1**

As it follows from that table, the increase of mechanical compressive strength $\Delta \bar{x}$ of the particular building materials obtained using magnetically treated mixing water is definitely higher than the confidence interval ε of this method for the particular materials. This is the evidence for the effect of CMF on mechanical compressive strength of building materials.

3.4.2.3. Phosphogypsum and fly ashes for stabilization of road surfaces.

Knowing the properties of materials to be used for road construction and their designation for the particular road surface layers is very important. Such materials should be resistant to repeated loads and various climatic conditions. Interesting ideas and technologies associated with waste materials are currently preferable in order to make road construction more environment-friendly. The use of alternative materials, available at the construction sites, has been attempted [30-33]. The bottom layer of the road surface is the subbase, protecting the surface against water, frost and permeation of the underlying soil particles. This layer is most suitable for utilization of waste-based materials – composites containing industrial waste, meeting requirements established for such materials. Generally, the materials used in road construction are divided into three groups:

- comminuted materials,
- materials based on hydraulic binders,
- materials based on bituminous binders..

New materials for road surface stabilization, discussed as one of the investigated elements, could be classified as belonging to the second group. They are materials obtained by mixing the aggregate with a binder. The chemical reaction involving the binder and water results in hardening of the binder and binding the aggregate grains together. The binder used to prepare the mixture can include cement, lime, as well as waste materials such as fly ashes or treated phosphogypsum. The properties of such binders are dependent on their chemical and mineral composition, which in turn depend on the raw materials used and the manufacturing technology. An additional element reinforcing the material was the use of magnetically treated water as so-called mixing water. The materials could withstand both compressive and tensile stresses.

Recycling has been the fundamental idea in development of new technologies during the recent years. Solutions taking into consideration, in addition to technological and economic criteria, also the environmental and social ones, have been created. They make it also possible to receive financial support within the framework of environment protection programs. Waste materials, especially industrial waste, including fly ashes or phosphogypsum as the components of appropriate mixtures and in compliance with the relevant stabdards, can be used e.g. to make improved road subsoil or construction layers. The development of new technologies is based on utilization of waste materials, including those of industrial origin. Economic and environment-related aspects are important here. The mixtures obtained as a result of research [34] [**publication H 7**] can be used in various material and technological solutions. They make it possible to improve the soil quality using fly ash (with the mixture added), which after 42 days of hardening reached the mechanical strength of 0.5–2.5 MPa, in compliance with the standard. The subsoil improved with the developed mixture and stabilized with cement (one or two layers of concentrated mixture) reached after 42 days of hardening the mechanical strength of 2.5–5.0 MPa, consistent with the standard, and could be topped with the surface layer of asphalt concrete (**Fig. 17**).

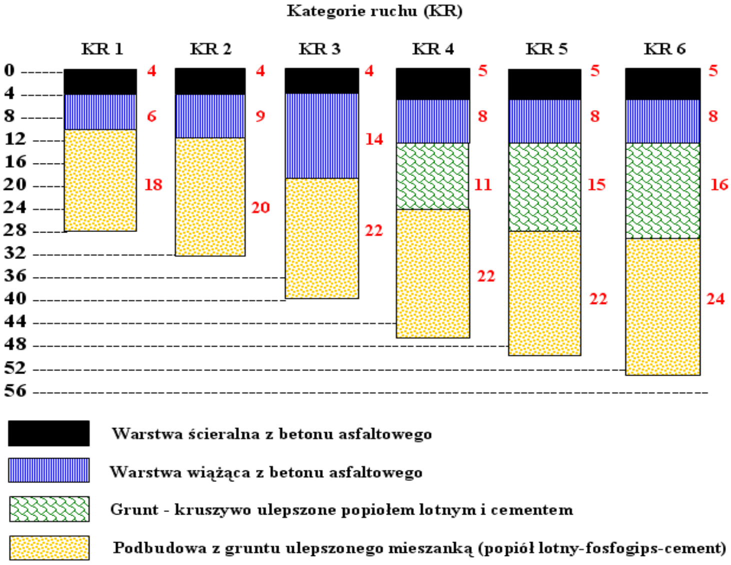


Fig. 17. Cross-section of a road surface obtained using asphalt concrete and subsoil improved with the mixture (compressive strength 2.5-5.0 MPa according to the PN-S-96012-1997 standard) [**H 7**].

The subsoil made of ash concrete (one or two layers of concentrated mixture) became after 42 days of hardening the load-bearing part of the road surface of 5.0–8.0 MPa strength, in compliance with the relevant standard, and could be topped with the surface layer of asphalt concrete and lean cement-ash-phosphogypsum concrete (**Fig. 18**).

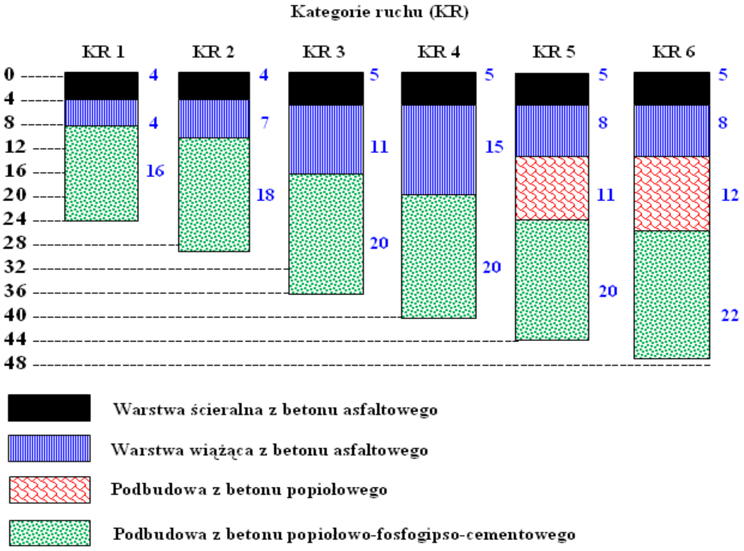


Fig. 18. Cross-section of a road surface obtained using asphalt concrete and subsoil of ash-phosphogypsum-cement concrete, constituting the load-bearing part of the road surface (compressive strength 5.0-8.0 MPa according to the PN-S-06103 standard) [**H 7**].

The treatment process of phosphogypsum waste with calcium sulfate as the main component was conducted by heating the material in a fluidized column at 210–230°C (483–503 K) for 0.25 h. Fly ash was generated as waste in power plants where pulverized coal or lignite is used as fuel. I adjusted the optimal composition of mixtures containing these waste materials on the basis of determinations of compressive strength and frost resistance. The frost resistance parameters of sand-ash mixtures enhanced with phosphogypsum-cement binder complied with the requirement set for the lower road subsoil layers ($n \geq 0.5$). The mixing water used to combine the components was additionally **treated in an electromagnet**, at magnetic induction $B = 1$ T for 30 min. The experiments demonstrated that CMF exerted a favorable effect on improvement of compressive strength parameters of some composites even by 65% and of their frost resistance by 22%. The best composite contained 15% phosphogypsum, 20% fly ash, 5% cement and 60% sand. CMF increased the potency of hydrogen bonds. The dipoles of mixing water were arranged along the lines of the magnetic field. Changes occurring under the influence of CMF modified the course of hydration of the composites. CMF exerted its influence mediated by water both on the electrons and on the ionized atoms, causing dynamic effects.

To investigate the **cost-effectiveness of the magnetic water treatment process** conducted in an electromagnet (e.g. ER – 2505) I performed an approximate calculation. I took into account the cost of energy, the working time of the electromagnet and its parameters. All these aspects are analyzed below. As it follows from the calculation, the cost of treatment of water, or another material, in the ER – 2505 electromagnet for a period of 30 min. will amount to PLN 0.2915. I conducted the calculation as follows:

electric energy: PLN 0.2539 /kWh + 23 % VAT,

electromagnet (ER-2505): Max power P = 2,8 KW, Max current per a single coil I = 12.5 A (there are 6 coils), Number of loops in a coil n = 710, Resistance of a single coil R = 2.85 Ω, Max magnetic induction B= 1.5 T.

Power supply unit for the electromagnet - PZP – 80: Power U = 3 x 380 V, Load resistance R = 0,5 Ω, Three-phase socket I = 16 A, Power $P = U \cdot I = I^2 \cdot R$, Heat $dQ = (U^2/R)\,dt = (I^2 \cdot R)\,dt$,

Final calculations:

0.2539 PLN – 1 kW – 1 h
x = 0.7109 PLN - 2.8 KW - 1 h
x = 0.3555 PLN - 2.8 KW - 0,5 h
x = 0.4373 PLN (including 23 % VAT) for $B_{max} = 1{,}5$ T

x = 0.2915 PLN (including 23 % VAT) **for B = 1 T**

For a single magnetic treatment process in an electromagnet, for water or a material sample in time **t = 0.5 h** the cost will amount to **PLN 0.29.**

3.5. Explanation of effect of constant magnetic field on materials [H 2, H 3, H 8].

Magnetic materials have the ability to store energy. The energy of the magnetic field is located both in the volume of a magnetic (80% of energy) and in the surrounding space (20% of energy), since the magnetic field exists both inside and outside the magnetic. As presented by the magnetic field theory [35] the energy of each particle (*ε*) and its velocity (*v*) in the magnetic field is constant. A charged particle moves in constant magnetic field (CMF) along the helical line, the axis of which is parallel to the direction of magnetic field strength vector (*H*) or magnetic induction vector (*B*). According to this theory, the particle movement in CMF can be described with equation (5) as follows:

$$\frac{\varepsilon}{c^2}\frac{dv}{dt} = \frac{e}{c} v \times H \qquad (5)$$

where: *e* – charge value, c – light velocity, *t* – time.

When a charged particle is exposed at the same time to a constant magnetic and electric field, the direction of its movement is perpendicular to the plane of the magnetic field strength vector (*H*) electric field strength vector (*E*). The particle will be moving along the line referred to as trochoid or cycloid. Its mean velocity can be expressed in the form of the following equation (6):

$$\bar{v} = \frac{cE \times H}{H^2} \qquad (6)$$

If vectors (*H*) and (*E*) are parallel to each other, the magnetic field will have no effect on the movement of the particle.

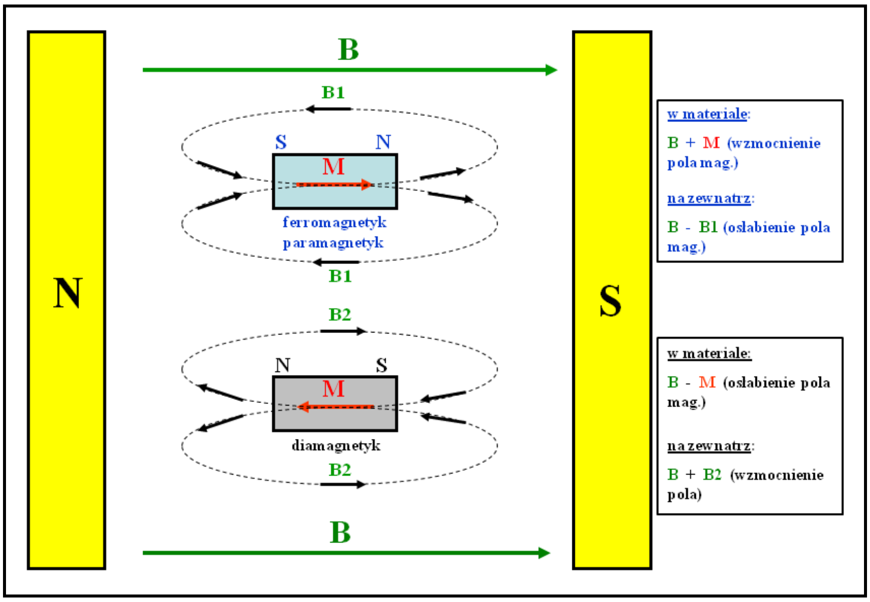
Each material particle exposed to CMF is subject to mechanical forces. The results of their action vary according to the type of materials - dia-, para-, or ferromagnetics. An important property of atoms of diamagnetic substances is that with no exposure to external CMF their magnetic moments equal zero. In external CMF with magnetic induction (*B*) , the diamagnetic atoms become dipoles with induced magnetic moment (m) following equation (7):

$$m = -\frac{e^2 r^2}{4m_e} B \qquad (7)$$

where: e – electron charge, r – radius of its orbit, m_e – electron mass.

The vector **(m)** is in opposite direction to vector (***B***). The magnetism of paramagnetic and ferromagnetic atoms is completely different from that of diamagnetic atoms. The existence of permanent magnetic moments, induced by the electrons moving on their orbits around the nuclei, spinning around their own axes, and the correlation of the magnetic moment with the temperature is essential. The dipoles of para- and ferromagnetics tend to be arranged along the magnetic field lines according to the direction of the magnetic induction vector (***B***).

Until the 1990's, the influence of magnetic field on chemical reactions was negated. In ferromagnetic materials in the ground state electron spins are arranged in parallel by the energy of exchange interactions. In a magnetic field, the electron spins and the corresponding magnetic moments take on the direction of the magnetic field. In diamagnetic materials, the electron spins are set antiparallel by the energy of exchange interactions (the magnetic moments compensate each other). The impact of exchange interactions is very strong and the magnetic field is too weak to reverse any of the spins, and it would be a proof of the influence of magnetic field on chemical reactions [36, 37]. The magnetic field cannot reverse the spin in a thermodynamically stable molecule with paired spins, but in a chemical reaction, when the molecule falls apart and its components have not created new diamagnetic molecules yet, there are energetic conditions to reverse the spin of the magnetic field (during 10^{-10} s time) . The molecule is in an excited state, the exchange energy weakens to zero and at a certain distance between the emerging molecule fragments in the solution (it must be within the spherical space sphere with a 10Å diameter), the magnetic field reverses the spin. The energy if magnetic field interaction with the magnetic moment of one of the two fragments of the molecule becomes greater than the exchange energy. **Fig. 19** shows the formation of constant magnetic field lines and their possible impact on the investigations either of the inside of the material, to determine its properties such as structure, composition (an increase or decrease in magnetics content), internal stress, or of the outside of the material, e.g. surface (shape, roughness, packing of atoms etc.).



B – magnetic induction vector, **M** – magnetic moment vector.

Fig. 19. Distribution of constant magnetic field lines in a diamagnetic as well as in a para- and ferromagnetic.

Considering the effect of CMF, two classes of phenomena can be distinguished. The first one includes the direct interaction of magnetic field with the permanent or inductive magnetic moments of atoms or molecules, in which the quantum effects are manifested (in the crystalline structure it is demonstrated by the occurrence of stresses). The second class includes the phenomena taking place in the liquid due to the so-called **Lorentz force F** according to the following formula (8):

$$F = Q \bullet (v \text{ x } B) \qquad (8)$$

where Q is the charge of the molecule, **v** – the molecule velocity vector, and **B** – the magnetic induction vector.

In this case, magnetic fields act both on the electrons and on the ionized atoms, causing dynamic effects. They include volumetric motion of the medium, which in turn causes modification of the electromagnetic fields. **Magnetohydrodynamics** considers the effects of magnetic field from a different point of view [38]. It is based on correlations forming a set of equations, consisting of: the **fluid continuity equation** (9),

$$\frac{\partial \rho}{\partial t} + \nabla \cdot (\rho v) = 0 \qquad (9)$$

where: ρ – mass density, v – velocity vector, t – time, $\nabla \cdot (\rho v)$ - divergence of the vector function v (divergence of the vector field in the vicinity of the point – scalar value),

the **fluid motion equation** (10),

$$\rho\frac{dv}{dt} = -\nabla p + \frac{1}{c}\left(J \times B\right) + \eta\nabla^2 v + \rho g \tag{10}$$

where: $-\nabla p$ - p (pressure function gradient) [pressure force], $\frac{1}{c}\left(J \times B\right)$ [magnetic field force], $\nabla^2 v$ - divergence of the velocity gradient ∇v, c – light velocity (under vacuum conditions 2,998 · 10^8 m/s), ***J*** – current density vector, ***B*** – magnetic induction vector, E (11) B (12) **function rotation equations:**

$$\nabla \times E + \frac{1}{c}\frac{\partial B}{\partial t} = 0 \tag{11}$$

$$\nabla \times B = \frac{4\pi}{c} J \tag{12}$$

where: $\nabla \times E$ - rotation of vector function *E*, $\nabla \times B$ - rotation of vector function *B*,

E – electric field strength vector,

Ohm's law (for a single-component, conductive liquid) (13),

$$J = \sigma\left(E + \frac{v}{c} \times B\right) \tag{13}$$

where: σ - electrolytic conductivity,

fluid state equation (14),

$$\frac{\partial B}{\partial t} = \nabla \times \left(v \times B\right) + \frac{c^2}{4\pi\sigma}\nabla^2 B \tag{14}$$

where: $\nabla \times \left(v \times B\right)$ - rotation of vector function ($v \times B$), $\nabla^2 B$ - divergence of magnetic induction gradient ∇B.

I used CMF to modify the physical and chemical parameters of the materials developed within the framework of the research. The CMF-related changes were dependent on the magnitude of magnetic induction, the direction of magnetic field force lines, or the time of exposure to CMF. CMF affected not only chemical and electrochemical reactions, but also the crystalline structure, physical and chemical properties of the final products. The effect of CMF on atoms was demonstrated in the form of stresses in the crystal lattice. In the liquid, magnetic fields acting both on electrons and on ionized atoms caused dynamic effects, including volumetric motion of the medium. The movement of masses caused in turn modification of the magnetic fields. Thus, we were dealing with a complex coupled system of matter and fields. Hardening of the composites involved an interaction between the solid and liquid phase. As I established, the interactions between the grains included capillary (attractive) forces, Van der Waals (attractive) forces, Coulomb electrostatic ones in the double force layer (repulsive forces), repulsive pressure (repulsive forces) and hydrodynamic forces. In the case of small particles (10^{-6} – 10^{-2} mm) (colloidal particles), Coulomb electrostatic forces and Van der Waals forces predominated, whereas in the case of larger ones (0,1 – 1 mm), capillary forces became predominant. The role of hydrodynamic forces increased in the presence of CMF. CMF induced in the molecules, in most cases diamagnetic, specific magnetic dipole moments whose value was in proportion to the magnetic field intensity H, and therefore also to magnetic induction B. Magnetic dipole moments were induced in the diamagnetic substance molecules in the direction antiparallel (counter) to that of the CMF induction. The atoms or molecules present in the CMF were affected by mechanical forces. The generation and results of such forces depended on the magnetic properties of the substance exposed to CMF. The important property of diamagnetic atoms and molecules was the zero value of their magnetic moments under no exposure to CMF. It was due to mutual compensation of magnetic moments generated by pairs of electrons moving along their orbits in the opposite directions. The magnetic induction $\boldsymbol{B}$ vector lines in a diamagnetic were sparse, whereas outside they were more concentrated. It means that CMF caused reduction of the distances between the diamagnetic molecules. Diamagnetic dipoles influenced by CMF were both oriented (opposite to the direction of vector $\boldsymbol{B}$), and arranged in a system. On the surface of the forming crystals of materials there were unbalanced charges, which came from unbound valence electrons of surface atoms and were the result of isomorphic substitutions. Unsaturated charges on the surface of the solid phase attracted the ions from the solution, and at the interface of both phases, an electric double layer was formed. One of the layers was a layer composed of ions bound tightly to the surface with opposite charge. It was the Stern layer, constituting a stabilizing charge of colloidal particles. The second layer consisted of scattered ions. It was the diffusion layer (Gouy layer), where ions were weakly bound and tended to diffuse into the solution. The diffusion layer was the layer determining the thickness of the double layer as a whole. The application of the classic double layer model to cement pastes or composites might arouse some doubts, as the surface was not in thermodynamic equilibrium, but it presented an approximate solution. Reduced thickness of the diffusion layer facilitated coagulation. It also caused the change of the surface charge and the electrolyte concentration. It was CMF that caused a reduction of Nernst diffusion layer thickness (δ_D) next to the surface of the solid phase. The decrease of Nernst diffusion layer thickness (δ_D) consequently increased the concentration of molecules (C) near the solid phase and resulted in deposition of a higher number of molecules according to the following equation (15):

$$m \approx 0.63(\rho R)^{-1/3} v^{-2/9} D^{8/9} (nFCB)^{1/3} \qquad (15)$$

in which m denotes the mass of the molecules.

3.6. Summary of research results.

The research goals formulated in the five objectives have been realized.

The effects of scientific innovations are as follows:

1.

a. Observation of the changes in crystalline structures of the studied cobalt alloys, obtained in constant magnetic field **[H2, H3]**.

b. Examination of the growth and decline trends affecting the diamagnetic component in cobalt alloys in the process of their electrochemical formation under constant magnetic field conditions **[H1].**

2.

a. Cobalt alloys obtained in constant magnetic field with a smoother surface, denser packed, better oriented material grains, reduced roughness **[H3, H4].**

b. Observation of an effect of constant magnetic involving reduction of fissures on the alloy surface due to decreased internal stresses in the materials **[H1, H2].**

c. Creation of building composites characterized by lower water absorption, increased frost and chemical resistance as well as increased mechanical compressive and flexural strength **[H6, H8].**

3.

a. Formulation of the thesis concerning the existence of impact of the direction of magnetic induction B in relation to the direction of electric field E on the kinetics of the metals and alloys electrodeposition processes **[H2, H5]**

b. Development of variants of the impact of constant magnetic field on electrochemical processes depending on the ion charge, magnetic properties of ions and the type of reaction **[H3].**

c. Indication of changes in electrochemical parameters (cathodic potential, cathodic current density, constant reaction rate) due to the value of magnetic induction B **[H4].**

d. Derivation of the equation for the speed of electroactive particles in the electrochemical process under the influence of the applied magnetic induction B **[H1, H4].**

4.

a. Preparation of treatment technology for phosphogypsum waste with the possibility of its use in the production of building materials involving constant magnetic field **[H6, H7, H8].**

5.

a. The applicability of cobalt alloys obtained under constant magnetic field conditions for anti-corrosion coatings, for the production of new solid electrodes **[H1, H2]**.

b. Stabilization of the ground under road surfaces with processed phosphogypsum, as a component of an appropriate composite **[H7].**

where: [**H1 – H8**] - the series of eight publications constituting the basis for habilitation proceedings.

3.7. Literature.

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[28] **M. Zieliński**, *Construction and Building Materials,* Vol. 89, 13-24 (**2015**).

[29] L.G.M. Petterson, A. Nilsson, *Journal of Non-Crystalline Solids* 407, 399–417 (**2015**).

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4. Presentation of the achievements on which not being the basis for applying for habilitated doctor degree, indicating the possibility of a constant magnetic field application.

4.1. Concealed insulating layer as warming alternative.

In the patent application I proposed a new way of creating a concealed insulating layer consisting of : treated waste phosphogypsum in an amount of 15% wt., fly ash in an amount of 20% wt., Portland cement in an amount of 35% wt. and 30% wt. if magnetically treated water **[35] [publication B2]**. The patent application utilized the element of action of the magnetic field as well as the use of waste phosphogypsum and fly ash. An insulating layer underlying the plaster as a warming alternative is shown in **Fig. 19**.

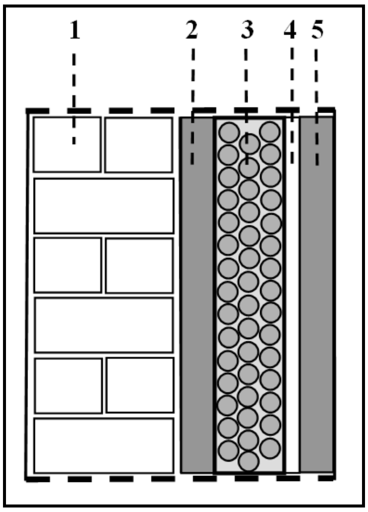
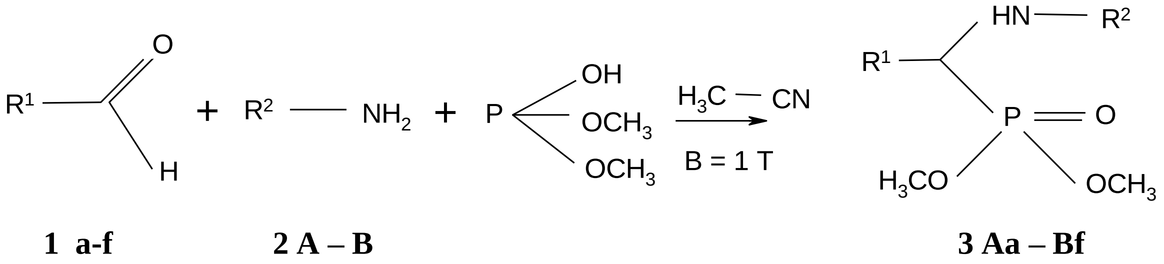


Fig. 20 . Location of concealed insulating layer, where:
1 – solid wall, 2 – previously existing plaster, 3 – impermeable, rigid insulation mounted mechanically, 4 – concealed insulating, humidity-controlling layer, 5 – new layer of plaster.

One version of the masses designed for the concealed layers was cast into the marked three molds for standard samples in the form of 4 x 4 x 16cm prisms. After 28 days of aging at 323 K under conditions consistent with PN-EN 13279-1: 2005 and PN-EN 13279-2: 2006 the samples were subjected to tests. Mixing water had previously been treated magnetically in a constant magnetic field with induction B = 0.4 T. The average absorption of water by the standard trabecular samples was 25.6% after seasoning (a decrease of 5.2%), frost resistance was 4.4% (an increase of 15,4%), flexural strength - 3.12 MPa (an increase of 74.3%) and compressive strength - 9.35 MPa (an increase of 72.2%).

4.2. Organic synthesis.

The patent application and the paper describe the impact of constant magnetic field on organic syntheses [39, 40] **[publication B1 and B 8]**. The reactions conducted were Kabachnik-Fields reactions to produce N-substituted amino acid (aryl or alkyl) methylphosphonic methyl esters by a reaction coupling an aldehyde, an amine and dimethyl phosphite. They took place in constant magnetic field environment with induction B = 1T, as well as without the magnetic field. The reactions proceeded as follows:



gdzie:
R^1 – **a:** grupa fenylowa, **b:** grupa ferrocenylowa, **c:** grupa 2-furylowa, **d:** grupa 2-tienylowa,
e: grupa 2-fenyloetenylowa, **f:** grupa cykloheksylowa
R^2 – **A**: grupa benzylowa, **B**: grupa 4-metylofenylowa.

The results of the Kabachnik-Fields reactions in an external magnetic field with magnetic induction B = 1 T and without the magnetic field (B = 0 T) are shown in **Table 7**, where: α meant the percentage conversion rate.

Table. 7. Results of Kabachnik-Fields reaction in constant magnetic field with B = 1 T and without magnetic field (B = 0 T).

R^1	R^2	Czas reakcji [h]	**B** = 1 T α [%] (masa [g])	**B** = 0 T α [%] (masa [g])
Ph (**a**)	CH_2Ph (**A**)	52	70 (1.07)	30 (0.46)
Fc (**b**)	CH_2Ph (**A**)	28	75 (1.55)	64 (1.32)
2-furyl (**c**)	CH_2Ph (**A**)	55	71 (1.05)	55 (0.81)
2-thien (**d**)	CH_2Ph (**A**)	79	59 (0.92)	22 (0.34)
PhCH=CH (**e**)	CH_2Ph (**A**)	73	68 (1.13)	53 (0.88)
c-Hex (**f**)	CH_2Ph (**A**)	28	73 (1.14)	58 (0.91)
Ph (**a**)	*p*-CH_3-C_6H_4 (**B**)	52	74 (1.13)	68 (1.04)
Fc (**b**)	*p*-CH_3-C_6H_4 (**B**)	28	69 (1.42)	64 (1.32)
2-furyl (**c**)	*p*-CH_3-C_6H_4 (**B**)	105	64 (0.95)	39 (0.58)
2-thien (**d**)	*p*-CH_3-C_6H_4 (**B**)	76	73 (1.14)	63 (0.98)
PhCH=CH (**e**)	*p*-CH_3-C_6H_4 (**B**)	100	69 (1.15)	56 (0.93)
c-Hex (**f**)	*p*-CH_3-C_6H_4 (**B**)	25	71 (1.10)	63 (0.95)

As can be seen from each of the syntheses magnetic field resulted in an increased degree of conversion of substrates. Here in **Fig. 22** and **23** illustrated the effect of the static magnetic field at the two selected organic synthesis.

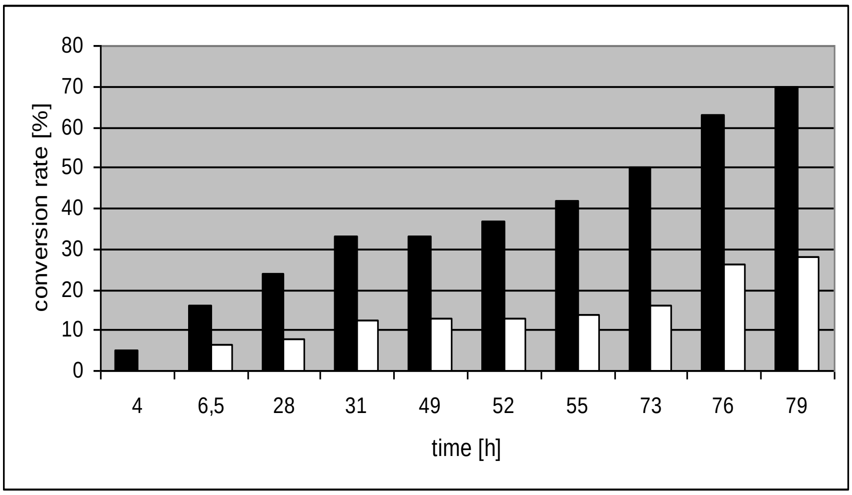


Fig. 21. Conversion rate α (in %) estimated at fixed time intervals for the reaction of benzyl amine 2A with 2-thiophenocarboaldehyde 1d and dimethyl phosphite, under the influence of magnetic induction B = 1 T (■) i B = 0 T (☐)

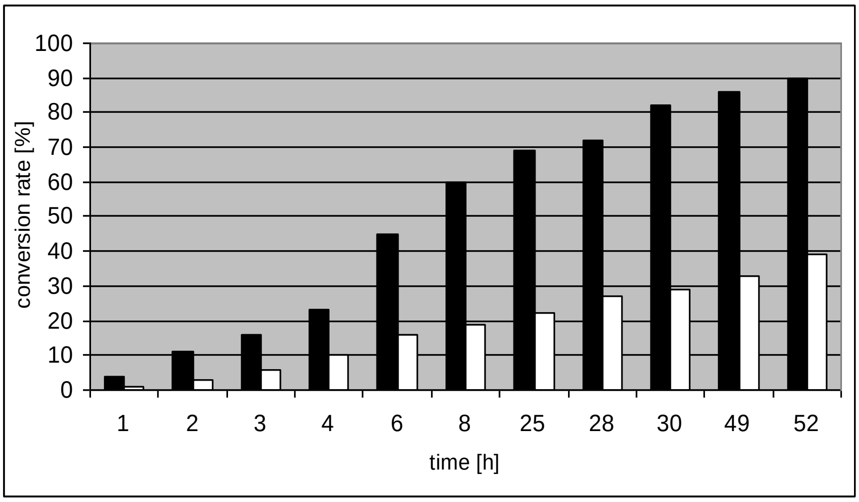


Fig. 22. Conversion rate α (in %) estimated at fixed time intervals for the reaction of benzyl amine 2A with benzyl aldehyde 1a and dimethyl phosphite, under the influence of magnetic induction B = 1 T (■) i B = 0 T (☐)

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5. Papers published before conferral of Doctor degree.

My publications include: patents, patent applications and research papers.

A 1 – A 11. Papers published before conferral of Doctor degree.

Patents, patent applications.

A 1. **M. Zieliński***, Patent No 24576 of **31.12.1998**, Patent Office of Morocco, entitled *„Procede pour transformer les dechets de phosphogypse"*.

** corresponding author*

*My contribution involved: testing physical and chemical properties of raw and treated phosphogypsum, phosphogypsum radioactivity, frost resistance, absorptivity, analysis of the results, edition of the patent application. I define its proportionate share as **100 %.***

A 2. **M. Zieliński***, M. Cyrkiewicz, Patent No 163643 of **9.09.1994**, Patent Office of the Republic of Poland, entitled „*Method of plaster production from waste phosphogypsum*.

** corresponding author*

*My contribution involved: research of raw and treated phosphogypsum, testing phosphogypsum radioactivity, tests of the obtained samples, analysis of the results, edition of the patent application. I define its proportionate share as **90 %.***

A 3. W. Radke, M. Cyrkiewicz, T. Błaszczyk, M. Bieniecki, B. Maciejewski, H. Scholl, **M. Zieliński**, Patent No 150648 of **21.02.1991**, Patent Office of the Republic of Poland, entitled „*Consul 253- Odra 1305 type system for obtaining data"*.

*My contribution involved: drawing the diagrams, analysis of the research results, edition of the patent application. I define its proportionate share as **20 %.***

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*My contribution involved: analysis of the research results, edition of the patent application. I define its proportionate share as **30%.***

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*My contribution involved: preparation of solutions, studies of surface tension, analysis of the research results, edition of the patent application. I define its proportionate share as **40 %.***

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*My contribution involved: electrochemical investigations yielding oxide surfaces, analysis of the research results, edition of the patent application. I define its proportionate share as **30 %.***

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*My contribution involved: research of film stock preparation, analysis of results, edition of the patent application. I define its proportionate share as **30 %.***

Papers.

A 8. M. Cyrkiewicz, **M. Zieliński**, „*Polish Journal of Applied Chemistry*”, “Viscosimetric Studies on Water-Glass Solutions in Stable Magnetic Fields”, No 1-2, p. 89-94, **(1993).** [6 p.]
*My contribution involved: conducting viscosimetric studies in magnetic field, analysis of results, edition of the paper. I define its proportionate share as **50 %.***

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My contribution involved: obtaining the new material, chemical studies and mechanical

*strength tests, analysis of results, edition of the paper. I define its proportionate share as **50 %.***

A 10. M. Cyrkiewicz, **M. Zieliński**, *„Cement-Wapno-Gips"[Cement-Lime-Gypsum],* „Effect of mixing water treated in magnetic field on cement mortars and the chemistry of their setting], No 1, p.21-23, (**1993**). Title change to „*Cement-wapno-beton"* [*Cement-lime-concrete*], current [IF = 0,385] [20 p.]

*My contribution involved: water treatment in magnetic field, tests of frost resistance and absorptivity of the obtained samples, analysis of results, edition of the paper. I define its proportionate share as **50 %.***

A 11. M. Cyrkiewicz, **M. Zieliński**, *„Cement-Wapno-Gips"[Cement-Lime-Gypsum]* „The properties of pastes of hemihydrate gypsum obtained with the new method and the effect of magnetic field on these properties", No 9, p. 252-254, **(1991).** Title change to „Cement, wapno, beton [Cement, lime, concrete] ", current [IF = 0,385] [20 p.]

*My contribution involved: obtaining plaster with the new method, tests of the samples in constant magnetic field , tests of frost resistance and absorptivity of the obtained samples, analysis of results, edition of the paper. I define its proportionate share as **50 %.***

6. Papers published after conferral of Doctor degree.

My publications include: patents, patent applications and research papers.

B 1 – B 31: Papers published before conferral of Doctor degree.

Patents, patent applications.

B 1. R. Karpowicz, J. Lewkowski*, E. Miękoś, **M. Zieliński***, Patent application No **P.403857** of 13.05.2013, entitled „*New methyl esters of N-substituted amino(aryl- or alkyl)methylphosphonic acids"*, Patent Office of the Republic of Poland, **2013**.

** corresponding author*

My contribution involved: conducting syntheses samples in constant magnetic field, *analysis of the research results, edition of the paper. I define its proportionate share as* ***30 %.***

B 2. **M. Zieliński*,** E. Miękoś, D. Szczukocki, R. Dałkowski, B. Krawczyk, R. Juszczak, Zgłoszenie patentowe nr **P.410037**, **data zgłoszenia: 03.11.2014**., p.t. „Method of producing layers of insulationflush-mounted as warming alternative", Patent Office of the Republic of Poland, **2014**.

** corresponding author*

My contribution involved: conducting syntheses samples in constant magnetic field, analysis of the research results, edition of the paper. I define its proportionate share as ***75 %.***

Papers.

B 3. W. Szmaja, W. Kozłowski, K. Polański, J. Balcerski, M. Cichomski, J. Grobelny, **M. Zieliński**, E. Miękoś, *Chemical Physics Letters*, "Investigation of thick cobalt films electrodeposited on gold substrates", Volume 542, 117 - 122 **(2012).** [IF = 2,145] [IF_5 = 2,150] [30 p.]

My contribution involved: electrochemical deposition of cobalt layers on polycrystalline gold substrate, SEM measurements of the morphological structure of the cobalt films, elaboration and analysis of the results. I define its proportionate share as ***20%.***

B 4. **M. Zieliński***,*Przemysł Chemiczny [Chemical Industry],* „The use of phosphogypsum in the aspect of natural environment protection", Warsaw, No 7, Vol. 85, p. 478-483, **(2006).** [IF = 0,414] [IF_5 = 0,332] [15 p]

** corresponding author*

My contribution involved: testing physical and chemical properties of raw and conditioned phosphogypsum, structural studies using the XRD method, SEM studies, analysis of the results, creation of drawings and tables, edition of the paper. I define its proportionate share as ***100 %.***

B 5. **M. Zieliński***, E. Miękoś, D. Szczukocki, K. Polański, R. Dałkowski, B. Krawczyk, R. Juszczak, *Wulfenia***,** "Waste fly ashes in composites enhanced by constant magnetic field”, Volume 22, No 8, 285-297,(**2015**) [IF= 1,312] [15 pkt.]

* *corresponding author*

My contribution involved: creating mixes applicable in building industry, mechanical strength tests, frost resistance, water absorption of the obtained samples, analysis of test results and edition of the article. I define its proportionate share as ***70 %.***

B 6. M. Zieliński*, E. Miękoś, D. Szczukocki, R. Dałkowski, B. Krawczyk, R. Juszczak, *Wulfenia***,** “Technology of phosphogypsum waste treatment and influence of constant magnetic field on new materials”, Volume 22, No 5, 383-399,(**2015**) [IF= 1,312] [15pkt.]

* *corresponding author*

My contribution involved: testing physical and chemical properties of raw and conditioned phosphogypsum, and radioactivity studies, creating mixes applicable in building industry, mechanical strength tests, frost resistance, water absorption of the obtained samples, analysis of results and comparison with standards, creation of drawings, edition of the paper. I define its proportionate share as ***75%.***

B 7. W. Kozłowski, I. Piwoński, **M. Zieliński**, E. Miękoś, K. Polański , W. Szmaja, M. Cichomski, *Applied Physics A, Materials Science and Processing*, „Investigation of nanocrystalline cobalt films electrodeposited at different current densities”, Volume 120, Issue 1, pp. 155-160, (**2015**). [IF=1,704] [30 pkt.]

My contribution involved: electrochemical deposition of cobalt layers on polycrystalline gold substrate, elaboration and analysis of the results. I define its proportionate share as ***20%.***

B 8. R. Karpowicz, J. Lewkowski*, E. Miękoś, **M. Zieliński*,** *Heteroatom Chemistry,* „Kabachnik-Fields Reaction Accelerated in Constant Magnetic Field. The First Example of Its Influence on a Non-radical Conversion”, Vol.25, Issue 3, pages 163-170, **(2014).** [IF = 1,257] [25 pkt.]

* *corresponding author*

My contribution involved: the study of organic synthesis (Kabachnik-Fields reaction) in constant magnetic field, elaboration and analysis of the results. I define its proportionate share as ***30%.***

B 9. **M. Zieliński,** co-author of two chapters of the book (monograph) (p. 135-143 i 362-

373), R. Cieśliński, K. Jareczek-Korzeniewska, *The problems of water research in the twentieth and twenty-first century)*, Wydawnictwo Uniwersytetu Gdańskiego, Gdańsk, **2014**.

My contribution involved: write and compose two chapters of monographs.
*I define its proportionate share as **5 %.***

B 10. Barbara Krawczyk, Dominik Szczukocki, Justyna Stachniuk, Radosław Dałkowski, **Marek Zieliński**, Renata Juszczak, Ewa Miękoś and Robert Zakrzewski, *Mediterranean Journal of Chemistry*, „The determination of the folic acid and its selected derivatives", Vol.3, No 4, 1003-1012, (**2014**). [7 pkt.]

*My contribution involved: chemical research, the analysis of the results of research, editing an article. I define its proportionate share as **15 %.***

B 11. **M. Zieliński***, *Journal of Advanced Chemical Engineering*, "Positive and Negative Aspects of Electrode Reactions of Hydrogen Evolution and the Influence of Constant Magnetic Field ,Vol. 4, Issue 2, (**2014**).

** corresponding author*

*My contribution involved: all experimental studies, the analysis of the results of research, editing an article. I define its proportionate share as **100 %.***

B 12. **M. Zieliński*,** E. Miękoś, R. Dałkowski, R. Juszczak, *Current Topics in Biophysics,* Vol. 36 (B), 27-28, **(2013).** [6 p.]

** corresponding author*

*My contribution involved: conducting research with the use of CVC method in various magnetic fields, analysis of the results of CVC, and co-edition of the paper. I define its proportionate share as **70%.***

B 13. E. Miękoś, **M. Zieliński,** D. Szczukocki, B. Krawczyk, *Current Topics in Biophysics,* Vol. 36 (B), 22-23, **(2013).** [6 p.]

*My contribution involved: conducting research with the use of CVC method in various magnetic fields with different magnetic induction, analysis of the results of CVC, and co-edition of the paper. I define its proportionate share as **40%.***

B 14. **M. Zieliński*,** „*CHEMIK – Nauka, Technika, Rynek [CHEMIST – Science, Technology,Market]*", „The effect of constant magnetic field on aniline electropolymerizaton", Katowice, No 6, **(2008).** [8 p.]

** corresponding author*

My contribution involved: conducting electrochemical studies of aniline electropolymerizaton in constant magnetic field, analysis of CVC results, edition of the paper. I define its proportionate share as ***100%.***

B 15. **M. Zieliński*,** E. Miękoś, D. Szczukocki, *„LAB – Laboratoria, Aparatura, Badania",* "Cobalt superalloys obtained electrochemically in constant magnetic field", Warsaw, No 5, (**2011).**

** corresponding author*

My contribution involved: conducting electrochemical studies of cobalt superalloys in constant magnetic field, analysis of CVC results, edition of the paper. I define its proportionate share as ***70%.***

B 16. M. Zieliński*, *„LAB – Laboratoria, Aparatura, Badania",* "Effect of constant magnetic field on the kinetics of electrochemical processes and material properties. Cobalt-palladium alloy materials", Warsaw, No 2, **(2010).**

** corresponding author*

My contribution involved: conducting electrochemical studies of cobalt-palladium alloys in constant magnetic field, analysis of CVC results, edition of the paper. I define its proportionate share as ***100%.***

B 17. **M. Zieliński*,** *„LAB – Laboratoria, Aparatura, Badania",* "Effect of constant magnetic field on the kinetics of electrochemical processes and material properties. Electrochemical reduction of cobalt-palladium alloys], Warsaw, No 1, **(2010).**

** corresponding author*

My contribution involved: conducting electrochemical studies of cobalt-palladium alloys in constant magnetic field, analysis of results, edition of the paper. I define its proportionate share as ***100%.***

B 18. **M. Zieliński*,** *„LAB – Laboratoria, Aparatura, Badania",* „Effect of constant magnetic field on the kinetics of electrochemical processes. Electrodeposition of cobalt-nickel alloys from solutions with various concentrations of cobalt], Warsaw, No 2, **(2009).**

** corresponding author*

*My contribution involved: conducting electrochemical studies of cobalt-nickel alloys in constant magnetic field, analysis of results, edition of the paper. I define its proportionate share as **100%.***

B 19. **M. Zieliński*,** *„LAB – Laboratoria, Aparatura, Badania”,*”Effect of constant magnetic field on the kinetics of electrochemical processes. Kinetics of electrodeposition and dissolution of cobalt-based ferromagnetic alloys”, Warsaw, No 1, **(2009).**

** corresponding author*

*My contribution involved: : conducting electrochemical studies of ferromagnetic alloys in constant magnetic field, analysis of results, edition of the paper. I define its proportionate share as **100%.***

B 20. **M. Zieliński*,** *„LAB – Laboratoria, Aparatura, Badania”,* ”Electrochemical processes of alloys deposition in constant magnetic field. Experimental studies of Co-Mo-W alloy”, Warsaw, No 4, **(2008).**

** corresponding author*

*My contribution involved: conducting electrochemical studies of Co-Mo-W alloys in constant magnetic field, analysis of results, edition of the paper. I define its proportionate share as **100%.***

B 21. **M. Zieliński*,** *„LAB – Laboratoria, Aparatura, Badania”,* „Electrochemical processes of alloys deposition in constant magnetic field. Theoretical considerations based on the example of Co-Mo-W alloy”, Warsaw, No 3, **(2008).**

** corresponding author*

*My contribution involved: conducting electrochemical studies of Co-Mo-W alloys in constant magnetic field, analysis of results, edition of the paper. I define its proportionate share as **100%.***

B 22. **M. Zieliński***, E. Miękoś, *“Annals of the Polish Chemical Society”,* “ The Course of Electrocrystallisation and Electrooxidation Processes of a Binary Cobalt-Molybdenum Alloy in Constant Magnetic Field”, Annals of the Polish Chemical

Society, Gdańsk, (**2007).**

** corresponding author*

*My contribution involved conducting electrochemical studies of Co-Mo alloys in constant magnetic field, analysis of results, co-edition of the paper. I define its proportionate share as **80%***

B 23. **M. Zieliński*,** E. Miękoś, *„LAB – Laboratoria, Aparatura, Badania”,* „Effect of constant magnetic field on the kinetics of processes. A comparison of electrocrystallization and electrooxidation of ternary Co-Mo-W with binary Co-Mo alloy”, Warsaw, No 3, **(2007).**

** corresponding author*

*My contribution involved: conducting electrochemical studies of Co-Mo-W and Co-Mo alloys in constant magnetic field, analysis of results, co-edition of the paper. I define its proportionate share as **80%.***

B 24. **M. Zieliński*,** E. Miękoś, A. Leniart, *„LAB – Laboratoria, Aparatura, Badania”,* ”Effect of constant magnetic field on the kinetics of processes. Electrocrystallization and electrooxidation of binary Co-Mo alloy], Warsaw, No 6, **(2006).**

** corresponding author*

*My contribution involved: conducting electrochemical studies of Co-Mo alloys in constant magnetic field, analysis of results, co-edition of the paper. I define its proportionate share as **70%.***

B 25. M. Zieliński*, *„LAB – Laboratoria, Aparatura, Badania”,* „Kinetics and mechanisms of electrochemical redox reactions of nitroxyl radicals in constant magnetic field, part.2”, Warsaw, No 5, **(2006).**

** corresponding author*

*My contribution involved: conducting electrochemical redox reaction studies of nitroxyl radicals in constant magnetic field, analysis of results, edition of the paper. I define its proportionate share as **100%.***

B 26. **M. Zieliński*,** *„LAB – Laboratoria, Aparatura, Badania”,* „Kinetics and mechanisms of electrochemical redox reactions of nitroxyl radicals in constant magnetic field, part.1”, Warsaw, No 4, **(2006).**

** corresponding author*

My contribution involved: conducting electrochemical redox reaction studies of nitroxyl radicals in constant magnetic field, analysis of results, edition of the paper. I define its proportionate share as ***100%.***

B 27. **M. Zieliński***, E. Miękoś, J. Kupis, *„LAB – Laboratoria, Aparatura, Badania",* „Studies of homogeneity of constant magnetic field used in electrochemical measurements", Warsaw, Nro2**, (2006).**

** corresponding author*

My contribution involved: conducting studies of homogeneity of magnetic field in electrochemical measurements , analysis of results, co-edition of the paper. I define its proportionate share as ***80%.***

B 28. **M. Zieliński***, E. Miękoś, J. Kupis, *„LAB – Laboratoria, Aparatura, Badania",* „Electrochemical reactions of ferrocene in constant magnetic field", Warsaw, No 1**, (2006).**

** corresponding author*

My contribution involved: conducting electrochemical studies of ferrocene reduction in constant magnetic field, analysis of results, co-edition of the paper. I define its proportionate share as ***80%.***

B 29. **M. Zieliński***, J. Kupis, E. Miękoś, *„LAB – Laboratoria, Aparatura, Badania",* „Reduction of diamagnetics on a paramagnetic platinum electrode in constant magnetic field", Warsaw, No 6,(**2005)**.

** corresponding author*

My contribution involved: conducting electrochemical studies of diamagnetics reduction in constant magnetic field, analysis of results, co-edition of the paper. I define its proportionate share as ***80%.***

B 30. M. Zieliński*, J. Kupis, E. Miękoś, *„LAB – Laboratoria, Aparatura, Badania",* „Effect of constant magnetic field on the kinetics and mechanisms of redox reactions", Warsaw, No 5, (**2005).**

** corresponding author*

My contribution involved: conducting electrochemical redox studies in constant *magnetic field, analysis of results, co-edition of the paper. I define its proportionate share as **80%.***

B 31. M. Zieliński*, E. Miękoś, J. Kupis, *„Annals of the Polish Chemical Society*", "Electrochemical reactions in constant magnetic field", Wrocław, **(2004).**

** corresponding author*

*My contribution involved: conducting electrochemical studies in constant magnetic field, analysis of results, co-edition of the paper. I define its proportionate share as **80%.***

7. Participation in international and national scientific conferences.

International scientific conferences (oral presentations and posters)

1. **M. Zieliński (as an oral presentation)**, E. Miękoś, *6th Meeting on Chemistry and Life 2015*, "Research on chemical and electrochemical reactions in constant magnetic field. Modification of metallic and waste materials", Faculty of Chemistry, Institute of Chemistry and Technology of Environmental Protection, Brno University of Technology, 2-4.09.2015., Brno, Czech Republic (**2015**).

2. R. Karpowicz, J. Lewkowski, E. Miękoś, **M. Zieliński**, *17th International Symposium*, „Advances in the Chemistry of Heteroorganic Compounds", "Aza-Pudovik Reaction Is Accelerated by the Action of Constant Magnetic Field", 21.11.2014, PAN, Łódź (**2014**).

3. K. Czarny, D. Szczukocki, B. Krawczyk, R. Dałkowski, **M. Zieliński**, E. Miękoś, R. Juszczak, *16 International Symposium*, JCF Fruhjahrssymposium, "Toxicological Threats To Birds In The Natura 2000 Area– Jeziorsko Water Reservoir", 26-29.03.2014, Jena (Niemcy) (**2014**).

4. **M. Zieliński,** E. Miękoś, R. Dałkowski, R. Juszczak, *II International Symposium*, Electromagnetic Fields and Quantum Phenomena in the Biological Systems, University of Medical Sciences, 3-4.10.2013, Poznań (**2013)**.

5. E. Miękoś, **M. Zieliński,** D. Szczukocki, B. Krawczyk, *II International Symposium,* Electromagnetic Fields and Quantum Phenomena in the Biological Systems, University of Medical Sciences, 3-4.10.2013, Poznań (**2013)**.

6. B. Krawczyk, **M. Zieliński**, E. Miękoś, D. Szczukocki, R. Dałkowski, R. Juszczak, *International Conference,* Protection of soil functions – challenges for the future, "The radiological soil contamination of zone around phosphogypsum waste heap", 15-18.10.2013, Puławy **(2013)**.

7. R. Karpowicz, E. Miękoś, **M. Zieliński**, J. Lewkowski, „The Kabachnik-Fields Reaction Accelerated in External Magnetic Field", *Łódź-Giessen Chemistry Workshop*, Łódź **(2012).**

8. **M. Zieliński**, E. Miękoś, "Waste phosphogypsum treatment technology – studies of new materials and composites]", *6th International Festival Lodz Design 2012,* Lodz **(2012).**

9. **M. Zieliński**, E. Miękoś, *International Conference,"Protection of agricultural soils against joint stress of natural and anthropogenic factors",* Puławy, Poland **(2011).**

10. **M. Zieliński**, E. Miękoś, „Technology of phosphogypsum waste processing", „Studies of the effect of constant magnetic field on electrochemical and bioelectrichemical processes", *Central European Forum of Biotechnology & Innovative BioEconomy, Bioforum Łódź* **(2011).**

11. **M. Zieliński (as an oral presentation)**, „The technology of transformation of phosphogypsum waste", *Central European Forum of Biotechnology & Innovative BioEconomy, Bioforum Łódź* **(2010).**

12. **M. Zieliński**, E. Miękoś, „The technology of transformation of phosphogypsum waste", *Central European Forum of Biotechnology & Innovative BioEconomy, Bioforum Łódź* **(2010).**

13. **M. Zieliński**, E. Miękoś (S8-PS1-24), „Studies of ternary cobalt-molybdenum-tungsten alloys obtained electrochemically in constant magnetic field], *11th International Environmental Chemistry Conference, Toruń,* **(2007).**

14. **M. Zieliński (as an oral presentation),** M. Cyrkiewicz, *EXPO-93 World Exhibition in Taejon (South Korea),* **07.08.- 07.11.1993** (Polish Day 27.09.1993), an invention – environment-friendly solution for utilization of chemical waste, after qualification by the Research Review Board (KBN) (10.02.1993).

15. **M. Zieliński (as an oral presentation),** M. Cyrkiewicz, *„Brussels Eureka-92 World Exhibition, Brussels (Belgium),* Silver Medal in the „Chemical Industry" category, **11.11.1992 r**.

Scientific conferences held in Poland.

1. D. Szczukocki, B. Krawczyk, K. Czarny, R. Dałkowski, **M. Zieliński**, E. Miękoś, *IX Conference – Analytical Applications of Liquid Chromatography*, "Quantitative assessment of phytoplankton by determination of dyes with HPLC", 22-23.10.2015., Warsaw (**2015**).
2. B. Krawczyk, D. Szczukocki, R. Dałkowski, R. Juszczak, E. Miękoś, **M. Zieliński**, *IX Conference – Analytical Applications of Liquid Chromatography*, "Application of HPLC in monitoring of the quality of waters in water reservoirs", 22-23.10.2015., Warsaw (**2015**).

3. K. Czarny, K. Szadkowska, D. Szczukocki, R. Dałkowski, B. Krawczyk, **M. Zieliński,** E. Miękoś, R. Juszczak, XLII Polish School of Chemistry, „The use of EC for determination of total antioxidative potential", 30.04.-04.05.2015., Lubenia **(2015)**.

4. M. Podrażka, D. Szczukocki, B. Krawczyk, R. Dałkowski, **M. Zieliński,** E. Miękoś, R. Juszczak, K. Czarny, XLII Polish School of Chemistry, „Monitoring the environment using modern analytical techniques and chemometry – CHEMONIT. Training module for students", 30.04.- 04.05.2015., Lubenia **(2015)**.

5. A. Składowski, B. Krawczyk, M. Szczepańska, D. Szczukocki, R. Dałkowski,

M. Zieliński, PTChem Spring Congress entitled „Analysis of hydrochemical data withnthe use of chemometric methods on the example of Jeziorsko water reservoir", 22-24.04.2015., Dobieszków near Lodz **(2015).**

6. K. Czarny, D. Szczukocki, B. Krawczyk, R. Dalkowski, **M. Zieliński**, E. Miękoś, R. Juszczak, V Copernican Symposium of Natural Science Students, I Toruń Symposium of Natural Science Doctoral Candidates, „Monitoring of storage reservoir waters]", 20-22.03.2015, Nicolas Copernicus University in Toruń, Toruń (**2015**).

7. **M. Zieliński,** E. Miękoś, D. Szczukocki, R. Dałkowski, B. Krawczyk, R. Juszczak, *Scientific Conference* „Assessment of agricultural soils", Acidification of soils by chemical industry wastes, 26-27.06.2014., Puławy (**2014**).

8. K. Czarny, D. Szczukocki, B. Krawczyk, R. Dałkowski, **M. Zieliński**, E. Miękoś, R. Juszczak, *Zjazd Zimowy PTChem*, Wpływ wybranych terpenów na zielenicę *Chlorella vulgaris*, 13.12.2014, Wrocław (**2014**).

9. D. Szczukocki, B. Krawczyk, R. Dałkowski, **M. Zieliński,** E. Miękoś, R. Juszczak, *X Chromatography Conference*, Effect of terpenes on the composition of photosynthetic pigments in algae], 23-26.09.2014, Lublin (Poland) **(2014)**.

10. K. Czarny, D. Szczukocki, B. Krawczyk, R. Dałkowski, **M. Zieliński**, E. Miękoś, R. Juszczak, 31 PTChem Spring Congress, *Determination of fatty acids and their derivatives in algae and blue algae]*, 9-13.04.2014, Zawoja (Poland) **(2014).**

11. R. Dałkowski, D. Szczukocki, B. Krawczyk, J. Stachniuk, **M. Zieliński,** R. Zakrzewski, *VI Chromatography Conference,* Faculty of Chemistry, University of Lodz15-17.05.2013., Lodz **(2013).**

12. R. Dałkowski, D. Szczukocki, M. Walisch, B. Krawczyk, **M. Zieliński**, *Scientific conference – Aspects of water studies in the 20th and 21st century, Gdańsk,* 18.10.2013. Report entitled „Characterization of water quality variations in the years 2001-2011 based on the example of the rivers of the Lodz Hills Landscape Park], Gdańsk **(2013).**

13. W. Kozłowski, W. Szmaja, M. Cichomski, **M. Zieliński**, E. Miękoś, „Studies of nanocrystalline cobalt lazers electrodeposited on the gold substrate”, [poster], *VII STM/AFM Seminar* 2012 (28.11-2.12.), Zakopane **(2012).**

14. R. Dałkowski, B. Krawczyk, L. Kubisiak-Banaszkiewicz, **M. Zieliński,** D.Szczukocki, *V Sympozjum chromatograficzne,* „Characterization of waters of the retention reservoirs of the Greater Poland region with the use of electromigration techniques against the background of toxic algae blooms in season 2011], Faculty of Chemistry, Technical University of Lodz**,** Lodz, 14-16 May **(2012).**

15. D. Szczukocki, **M. Zieliński,** G. Andrijewski, R. Juszczak, R. Dałkowski, B. Krawczyk, IX *Chromatography Conference*, "Chromatography? It is everyday practice!], 26-29.06.2011**,** Poznań, **(2011).**

16. **M. Zieliński**, E. Miękoś [poster] (PC-08-12), „The kinetics of electrochemical reduction of cobalt-palladium alloys under constant magnetic field conditions”, *52nd PTChem and SITPChem Congress, Lodz,* **(2009).**

17. **M. Zieliński**, E. Miękoś [poster] (PC-08-13), „Effect of electrolyte concentration on the physical and chemical properties of cobalt-palladium alloys], *52nd PTChem and SITPChem Congress, Lodz* **(2009).**

18. **M. Zieliński**, E. Miękoś [poster] (S02-PS-49), „The kinetics of electrochemical deposition and dissolution of binary and ternary alloys in constant magnetic field], *51st PTChem and SITPChem Congress, Opole,* **(2008).**

19. **M. Zieliński**, E. Miękoś [poster] (S02-PS-50), „Effect of constant magnetic field on electrochemical deposition of cobalt-nickel alloys from solutions with various cobalt concentrations”, *51st PTChem and SITPChem Congress, Opole,* **(2008).**

20. **M. Zieliński**, E. Miękoś [poster] (S8-PS1-24), „Studies of ternary cobalt-molybdenum-tungsten alloys obtained electrochemically in constant magnetic field], *50th PTChem and SITPChem Congress, Toruń,* **(2007).**

21. E. Miękoś, **M. Zieliński**, [poster] (S10-P-16), „Effect of constant magnetic field on binary cobalt-molybdenum alloy electrocrystallization and electrooxidation processes on a disc-shaped polycrystalline gold electrode], *XLIX PTChem and SITPChem Congress, Gdańsk,* **(2006).**

22. **M. Zieliński**, [communication] (K006), „Electrochemical redox reactions in constant magnetic field], *XLVII PTChem and SITPChem Congress, Wrocław*, **(2004).**

23. **M. Zieliński**, E. Miękoś, J. Kupis [poster] (P017), „Effect of constant magnetic field on the kinetics and mechanisms of redox reactions], *XLVII PTChem and SITPChem Congress, Wrocław,* **(2004).**

8. Research projects.

1. Project No RID-I/3 of. **04.04.2015.,** problem entitled: „*The use of recycled materials*", within the framework of the **I RID** (Road Innovations Development) **Contest**, A joint venture of **NCBiR** (Narodowe Centrum Badań i Rozwoju / National Research and Development Centre) and **GDDKiA** (Generalna Dyrekcja Dróg Krajowych i Autostrad / General Directorate of Polish Roads and Highways), applicant: University of Lodz, **M. Zieliński** [project coordinator] – qualified for Stage II.

2. Project No FSS/2014/HEI/W/0108 [supported from Norwegian and EOG 2009-2014 funds], entitled „Training developing the competences of students and graduates: Monitoring the environment using modern analytic techniques and chemometry", applicant: University of Lodz, project coordinator: D. Szczukocki,, Ph.D., project value: **343 730,60 PLN**, (approved for financing: **26.11.2014**) – project contractor: **M. Zieliński.**

3. Research project within the scope of fundamental research [**NCN Contest No 13 (OPUS 7)]** No 260750, p.t. „Phosphogypsum waste processing technology and research of new materials and composites",**(2014.06.17) –M. Zieliński** [project coordinator] - qualified for Stage II.

4. Research project within the scope of fundamental research [**NCN Contest No 9 (OPUS**

5)] No 217698, p.t. „Modification of properties of ferromagnetic alloys with constant magnetic field", **(2013.06.17) – M. Zieliński** [project coordinator] – assessed positively, not approved.

5. University of Lodz and Regional Fund for Environment Protection and Water Management (WFOŚiGW) in Lodz Project entitled *„Monitoring of Jeziorsko and Sulejów water reservoirs for eutrophization and toxic algae blooms],* project coordinator: Barbara Krawczyk, Ph.D., project realization: **16.10.2012 – 2013**, budget: 157.800 PLN (including 124.561 PLN subsidy from WFOŚiGW in Lodz), one of the investigators: **M. Zieliński.**

6. Research project within the scope of fundamental research [**NCN Contest No 7 (OPUS 4)]** No 203814, entitled „Electrodeposition of alloys with new physicochemical properties modified by constant magnetic field",**(2012.12.15) – M. Zieliński** [project coordinator] – assessed positively, not approved.

7. General research project [**NCN Contest No 3**] No 169409 [Reg. No. 2011/03/B/ST5/ 01600] entitled „Obtaining ferromagnetics with new physicochemical properties under magnetic field conditions]", (**2011.12.22**) – **M. Zieliński** [project coordinator] – assessed positively, not approved.

8. Research project [**NCN Contest No 2**] entitled „Studies of the impact of constant magnetic field on the course of some organic reactions", (**2011.09.30**) – J. Lewkowski [project coordinator], **M. Zieliński** [prime contractor] – assessed positively, not approved.

9. General research project [**NCN Contest No 1**] No 149671 [Reg. No. 011/01/B/ST5/00798] entitled. „Research of alloys obtained electrochemically in constant magnetic field]", (**2011.06.17**) – **M. Zieliński** [project coordinator] – assessed positively, not approved

10. Project implemented within the framework of Lodz Province Regional Operational Program for the years 2007-2013, No: UDA-RPLD.02.05.00-00-025/09-00, entitled *„Improving the safety of the inhabitants exposed to natural hazards associated with the water reservoirs of the Lodz region by modernization of equipment and implementation of innovative monitoring methods in the Laboratory of Environmental Hazards of the*

University of Lodz], project coordinator: Dominik Szczukocki, Ph.D., project realization **15.02.2010 r. - 30.11.2010 r**., budget: 1 280 508,00 PLN (including: 1 079 931,80 PLN from the EU funds), one of the investigators: **M. Zieliński.**

11. Own research project [**Ministry of Science and Higher Education competition No 40**] no 95911 [Reg. No N N507 221440] **„**Method of electrochemical obtaining of ferro- or paramagnetic alloy materials with unique physicochemical properties under constant magnetic field conditions", (**2010.08.02**) - **M. Zieliński** [project co-ordinator]- assessed positively (10,0; 7,0; 3,5 p.).

12. Own research project [**Ministry of Science and Higher Education competition No 39**] no 82979 [Reg. No N N507 515639] **„**Development of an innovative method of electrochemical obtaining of ferromagnetic alloy materials with special physicochemical properties under constant magnetic field conditions", (**2010.02.01**)- **M. Zieliński** [project co-ordinator]- assessed positively (8,0; 8;0; 7,5 p.).

13. Own research project [**Ministry of Science and Higher Education competition No 37**] no 53501 [Reg. No N N507 482537] „Obtaining electrochemically alloy materials with special physicochemical properties under constant magnetic field conditions", (**2009.02.02**) - **M. Zieliński** [project co-ordinator]- assessed positively (9,5; 7,5; 6,5 p.).

14. Ministry of Science and Higher Education research project No 3T 08C 036 27, entitled *"Research of the effect of NCD layers on electrochemical and corrosive properties of the selected biomedical alloys based on FeCr]*, project coordinator: Prof. Henryk Scholl, D.Sc, project realization: **27.08.2004- 26.08.2007**, one of the investigators: **M. Zieliński.**

9. Reviews of scientific publications in Polish and international journals.

Reviews in international journals.

1. ***Indian Journal of Pure & Applied Physics,*** [IF= 0,854], (IJPAP-2062) **(2014).**

2. ***Indian Journal of Pure & Applied Physics,*** [IF= 0,854], (IJPAP- 1010) **(2014).**

3. ***Industrial & Engineering Chemistry Research,*** [IF= 2,206], (ID: ie-2013-03639z) **(2013).**

4. ***Indian Journal of Pure & Applied Physics,*** [IF= 0,854], (IJPAP –1037) **(2013).**

5. ***Indian Journal of Pure & Applied Physics,*** [IF= 0,854], (IJPAP-906) **(2013).**

6. ***Journal of Hazardous Materials,*** [IF= 4,679], (HAZMAT – D – 09 – 00993) (**2009**).

7. ***Electrochimica Acta,*** [IF= 4,088], (SS09-083) (**2009**).

8. ***Journal of Environmental Management,*** [IF = 3,545], (JEMA-D-08-00913) **(2008).**

9. ***Journal of Environmental Management,*** IF = 3,545], (JEMA-D-07-00989) **(2007).**

Reviews in Polish journals.

1. ***Inżynieria materiałowa”*** [7 pkt.], z 12.03. (**2012**).

10. Research and patent cooperation, foreign and domestic, internships.

Foreign cooperation.

1. **Probably the foreign scientific [by 2015, 1 month] –** Brno University of Technology, Faculty of Chemistry, Institute of Chemistry and Technology of Environmental Protection, Purkyňova 118, Královo Pole, 61200, Brno, Czech Republic.
(Prof. RNDr. Milada Vávrová, CSc; doc. Ing. Josef Čáslavský, CSc.)

2. Leibniz Institute for Solid State and Materials Research Dresden, P.O. Box 270016, D-01171 Dresden, Germany (Institute for Metallic Materials), **Prof. Ludwig Schulz Ph.D., Jakub Adam Koza, Ph.D**., (effect of constant magnetic field on metals and alloys – exchange of opinions and experience).

3. Cooperation with the team of technologists in a company implementing technologies in industry: CHEMICAL WASTE TECHNOLOGIES – Environmental Protection Through Chemistry [Joanis Karageorgis – Greece), 20 East 63rd Street, New York 10021, concerning patents No 163643 and No 186189 (Poland) and No 24576 (Morocco) [**1997-1999]**,

4. Cooperation with the Company "Hercyrkle - Poland" Sp.z o.o., belonging to "Herling Applied Technologies, LTD."[Erwin Herling - USA], Miami Office 5225 Collins Avenue, Miami Beach, Florida 33140, concerning the foreign patent applications: PCT/PL93/00012, PCT/PL93/00013, PCT/PL95/00005 [**1992-1997]**,

Domestic cooperation.

1. **Witold Szmaja, D.Sc, UL Prof**., Faculty of Physics and Applied Informatics, Department of Solid State Physics, University of Lodz, Pomorska 149/153, 90-236 Lodz, Poland, E-mail: witoldszmaja@uni.lodz.pl , Fax: +48 42 6655137, Tel. +48 42 6355687. (electrochemically deposited metals and alloys, methods: AFM, SEM, EDX – co-authorship of papers).

2. **Jarosław Lewkowski, D.Sc, UL Prof**., Faculty of Chemistry, Department of Organic Chemistry, University of Lodz, Narutowicza 68, 90-136 Łódź, jlewkow@uni.lodz.pl (organic syntheses conducted under constant magnetic field conditions – co-authorship of papers and patent application)

3. Cooperation with the Company STEAG Energo Mineral Sp. z o.o., Kolejowa 57, 40-602 Katowice, in the field of utilization of waste phosphogypsum and fly ashes for obtaining novel building materials (**started in 2012,** which resulted in a contract signed on **21.01.2013**).

4. Cooperation with the District Sanitary-Epidemiological Station in Kalisz, with the seat at Kościuszki 6, 62-800 Kalisz (**started in 2011/2012)**.

5. Cooperation with the INNOVATION & IMPLEMANTATION COMPANY „IMPULS”, Jelenia 2, 80-336 Gdańsk, in the field of research projects concerning obtaining disinfectants in constant magnetic field (**21.06.2011)**.

6. Cooperation with the research laboratory of „ C.L.M. Poland S.A.”, Strycharska 2, 26-600 Radom, Production Plant at Kolejowa 99, 26-500 Szydłowiec, concerning manufacturing of a novel flooring material [**1995]**.

11. Statistics of scientific and research output.

#.	**Statistical parameter**	**Value (number)**
1	Total number of publications in scientific journals	**39**
2	Total number of publications in journals listed in Journal Citation Reports (JCR)	**13**
3	Total number of other publications in journals not listed in JCR	**26**
4	Total number of patents	**7**
	- foreign	**1**
	- Polish	**6**
5	Total number of patent applications	**3**
6	Book publications	**2**
7	Summary impact factor according to Journal Citation Reports (JCR) list for publications according to the year of publication	**22,439**
	- current	**19,010**
	- average in 5 years	**20,803**
8	Summary MNiSW (Polish Ministry of Science and Higher Education) score for scientific publications	**330**
9	Total number of cited publications according to Scopus database	**53**
10	Total number of cited publications according to Web of Science database	**51**
11	Number of citations according to Scopus database (autocitations excluded)	**26**
12	Number of citations according to Web of Science database (autocitations excluded)	**24**
13	Hirsch index (h-index) for published papers according to Scopus database	**5**
14	Hirsch index (h-index) for published papers according to Web of Science database	**5**
15	Average IF according to the year of publication based on all publications with IF	**1,726**
16	Total number of research project (grant) applications	**14**
17	Total number of research project (grant) applications accepted for realization	**4**
18	Number of international and national scientific conferences.	**38**
	- international	**15**
	- national	**23**
19	Number of reviews of scientific publications in international and Polish journals	**10**
	- international	**9**
	- Polish	**1**
20	Number of publications (papers and patents) providing the basis for application for the habilitation (D.Sc.) degree	**8**
21	Summary impact factor according to Journal Citation Reports (JCR) list for publications providing the basis for application for the habilitation (D.Sc.) degree, according to the year of publication	**14,294**

	- current	**12,622**
	- average in 5 years	**14,720**
22	Total number of cited publications providing the basis for application for the habilitation (D.Sc.) degree according to Scopus database	**38**
	Total number of cited publications providing the basis for application for the habilitation (D.Sc.) degree according to Web of Science database	**38**
23	Summary MNiSW (Polish Ministry of Science and Higher Education) score for publications (papers) providing the basis for application for the habilitation (D.Sc.) degree, according to the year of publication	**200**
24	Average IF according to the year of publication based on publications with IF for publications providing the basis for application for the habilitation (D.Sc.) degree	**2,042**

The documents presented below show the number of publications and citations for this year (according to Web of Science and Scopus databases, 03.11.2015).

In the presented database of 03.11.2015., the following two publications and citations are not included:

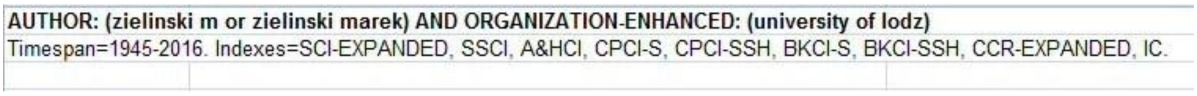
1. M. Zieliński*, E. Miękoś, D. Szczukocki, R. Dałkowski, B. Krawczyk, R. Juszczak, *Wulfenia***,** "Technology of phosphogypsum waste treatment and influence of constant magnetic field on new materials", Volume 22, No 5, 383-399,(**2015**) [IF= 1,312] [15 p.]

2. M. Zieliński*, E. Miękoś, D. Szczukocki, K. Polański, R. Dałkowski, B. Krawczyk, R. Juszczak, *Wulfenia***,** "Waste fly ashes in composites enhanced by constant magnetic field", Volume 22, No 8, 285-297,(**2015**) [IF= 1,312] [15 p.]

NOTE:

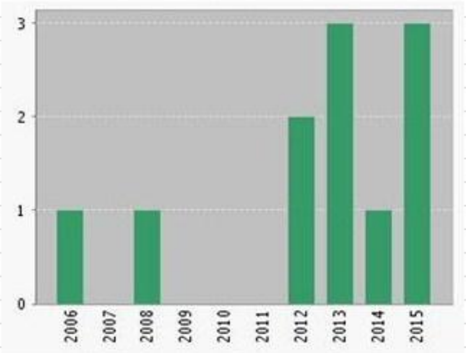
The year of publication of the paper included in Scopus database as item No 3 should be 2015 and not 2014 as recorded: **M. Zieliński***, E. Miękoś, D. Szczukocki, R. Dałkowski, A. Leniart, B. Krawczyk, R. Juszczak, *International Journal of Electrochemical Science,* "Effects of constant magnetic field on electrodeposition of Co-W-Cu alloy", Volume 10, Issue 5, pp. 4146-4154, (**2015**). [IF=1,956] [25 p.]

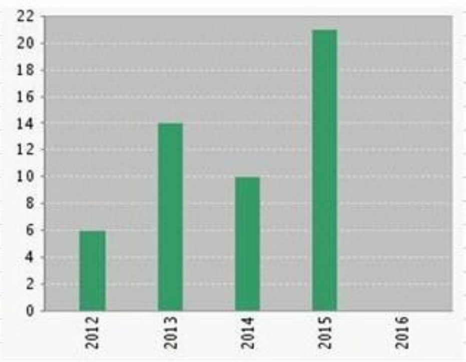
Number of publications and citations for this year (according to Web of Science, 03.11.2015).

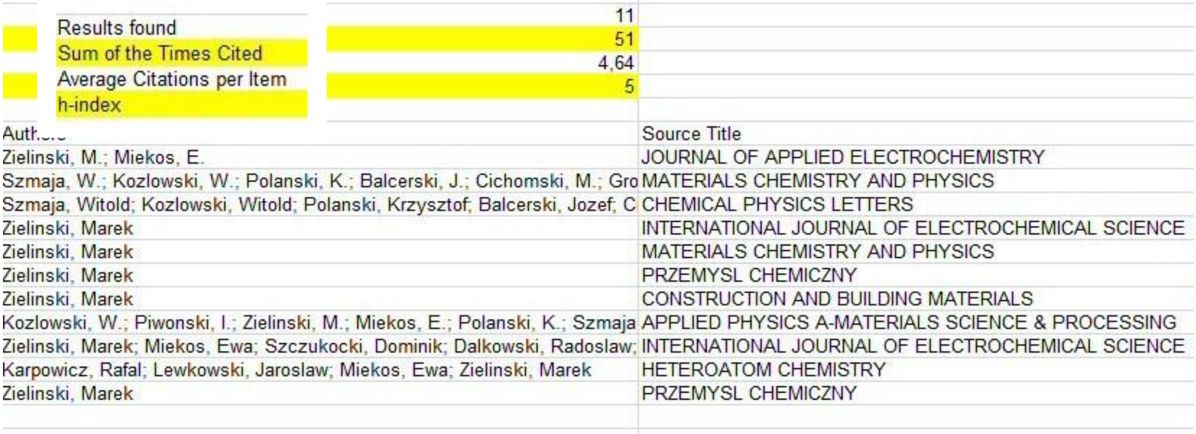


AUTHOR: (zielinski m or zielinski marek) AND ORGANIZATION-ENHANCED: (university of lodz)
Timespan=1945-2016. Indexes=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH, CCR-EXPANDED, IC.

Number of publications **Number of citations**

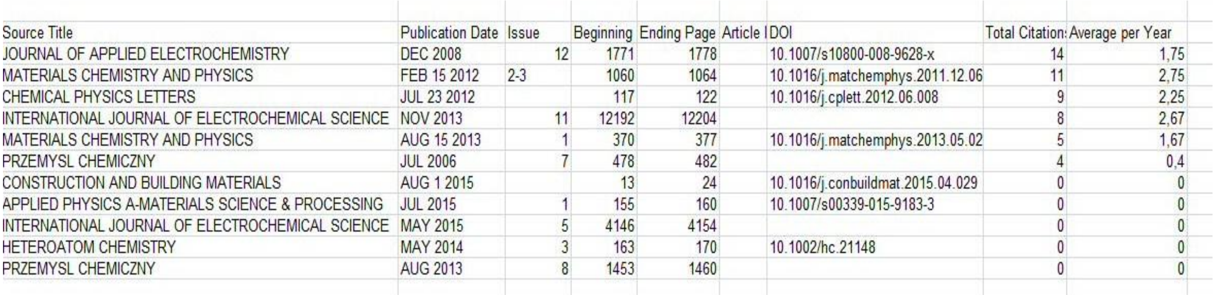






Results found	11
Sum of the Times Cited	51
Average Citations per Item	4,64
h-index	5

Auth	Source Title
Zielinski, M.; Miekos, E.	JOURNAL OF APPLIED ELECTROCHEMISTRY
Szmaja, W.; Kozlowski, W.; Polanski, K.; Balcerski, J.; Cichomski, M.; Gro	MATERIALS CHEMISTRY AND PHYSICS
Szmaja, Witold; Kozlowski, Witold; Polanski, Krzysztof; Balcerski, Jozef; C	CHEMICAL PHYSICS LETTERS
Zielinski, Marek	INTERNATIONAL JOURNAL OF ELECTROCHEMICAL SCIENCE
Zielinski, Marek	MATERIALS CHEMISTRY AND PHYSICS
Zielinski, Marek	PRZEMYSL CHEMICZNY
Zielinski, Marek	CONSTRUCTION AND BUILDING MATERIALS
Kozlowski, W.; Piwonski, I.; Zielinski, M.; Miekos, E.; Polanski, K.; Szmaja	APPLIED PHYSICS A-MATERIALS SCIENCE & PROCESSING
Zielinski, Marek; Miekos, Ewa; Szczukocki, Dominik; Dalkowski, Radoslaw;	INTERNATIONAL JOURNAL OF ELECTROCHEMICAL SCIENCE
Karpowicz, Rafal; Lewkowski, Jaroslaw; Miekos, Ewa; Zielinski, Marek	HETEROATOM CHEMISTRY
Zielinski, Marek	PRZEMYSL CHEMICZNY

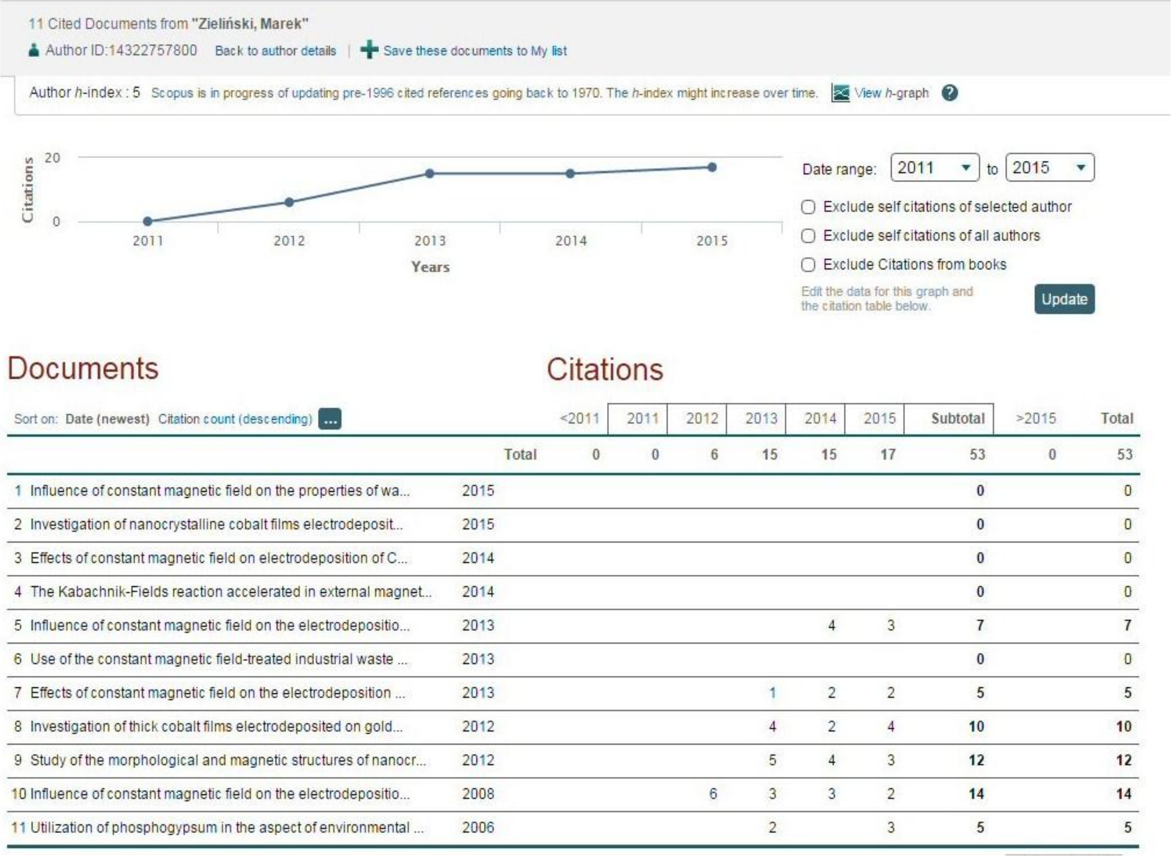


Source Title	Publication Date	Issue	Beginning	Ending Page	Article I	DOI	Total Citation:	Average per Year
JOURNAL OF APPLIED ELECTROCHEMISTRY	DEC 2008	12	1771	1778		10.1007/s10800-008-9628-x	14	1,75
MATERIALS CHEMISTRY AND PHYSICS	FEB 15 2012	2-3	1060	1064		10.1016/j.matchemphys.2011.12.06	11	2,75
CHEMICAL PHYSICS LETTERS	JUL 23 2012		117	122		10.1016/j.cplett.2012.06.008	9	2,25
INTERNATIONAL JOURNAL OF ELECTROCHEMICAL SCIENCE	NOV 2013	11	12192	12204			8	2,67
MATERIALS CHEMISTRY AND PHYSICS	AUG 15 2013	1	370	377		10.1016/j.matchemphys.2013.05.02	5	1,67
PRZEMYSL CHEMICZNY	JUL 2006	7	478	482			4	0,4
CONSTRUCTION AND BUILDING MATERIALS	AUG 1 2015		13	24		10.1016/j.conbuildmat.2015.04.029	0	0
APPLIED PHYSICS A-MATERIALS SCIENCE & PROCESSING	JUL 2015	1	155	160		10.1007/s00339-015-9183-3	0	0
INTERNATIONAL JOURNAL OF ELECTROCHEMICAL SCIENCE	MAY 2015	5	4146	4154			0	0
HETEROATOM CHEMISTRY	MAY 2014	3	163	170		10.1002/hc.21148	0	0
PRZEMYSL CHEMICZNY	AUG 2013	8	1453	1460			0	0

The number of citations for this year according to Web of Science database

2012	2013	2014	2015	2016	Total
6	3	2	3	0	14
0	5	2	4	0	11
0	3	1	5	0	9
0	0	4	4	0	8
0	1	1	3	0	5
0	2	0	2	0	4
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
				Total	51

Number of publications and citations in a specific year (according to Scopus database, 03.11.2015).



11 Cited Documents from **"Zieliński, Marek"**

Author ID:14322757800 Back to author details | Save these documents to My list

Author *h*-index : 5 Scopus is in progress of updating pre-1996 cited references going back to 1970. The *h*-index might increase over time. View *h*-graph

Date range: 2011 to 2015

☐ Exclude self citations of selected author

☐ Exclude self citations of all authors

☐ Exclude Citations from books

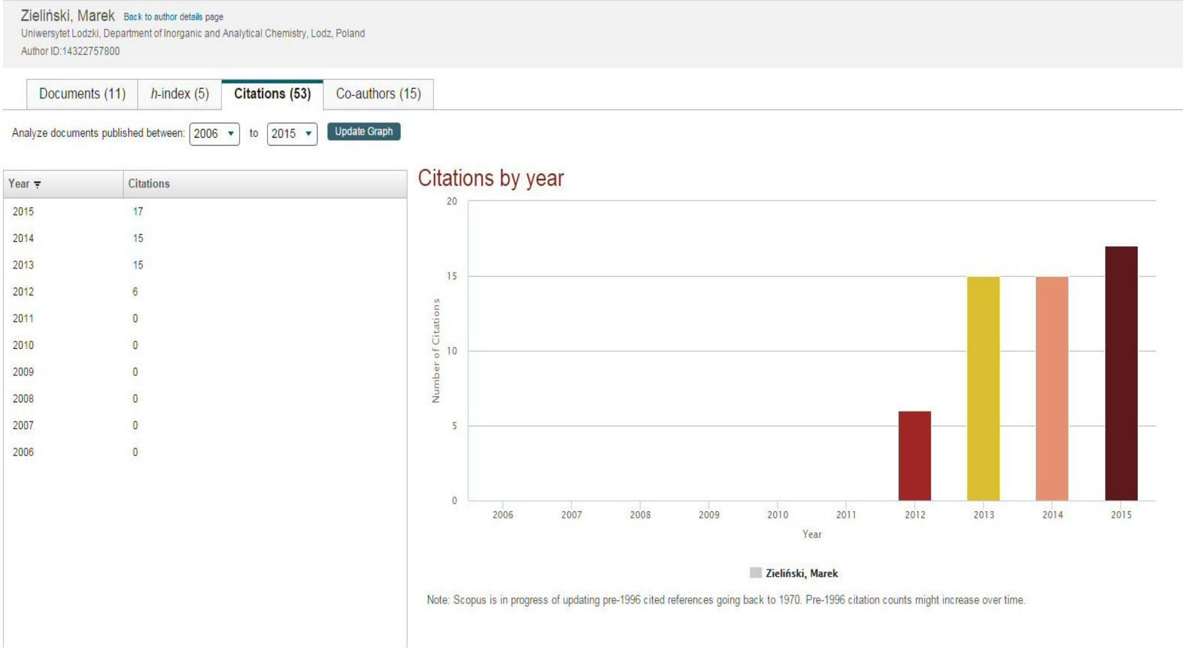
Edit the data for this graph and the citation table below.

Documents **Citations**

Sort on: Date (newest) Citation count (descending)

Documents		<2011	2011	2012	2013	2014	2015	Subtotal	>2015	Total
	Total	0	0	6	15	15	17	53	0	53
1 Influence of constant magnetic field on the properties of wa...	2015							0		0
2 Investigation of nanocrystalline cobalt films electrodeposit...	2015							0		0
3 Effects of constant magnetic field on electrodeposition of C...	2014							0		0
4 The Kabachnik-Fields reaction accelerated in external magnet...	2014							0		0
5 Influence of constant magnetic field on the electrodepositio...	2013					4	3	7		7
6 Use of the constant magnetic field-treated industrial waste ...	2013							0		0
7 Effects of constant magnetic field on the electrodeposition ...	2013				1	2	2	5		5
8 Investigation of thick cobalt films electrodeposited on gold...	2012				4	2	4	10		10
9 Study of the morphological and magnetic structures of nanocr...	2012				5	4	3	12		12
10 Influence of constant magnetic field on the electrodepositio...	2008			6	3	3	2	14		14
11 Utilization of phosphogypsum in the aspect of environmental ...	2006				2		3	5		5

Number of citations in a specific year presented in in graphic form (according to Scopus database, 03.11.2015).



Zieliński, Marek Back to author details page

Uniwersytet Lodzki, Department of Inorganic and Analytical Chemistry, Lodz, Poland

Author ID:14322757800

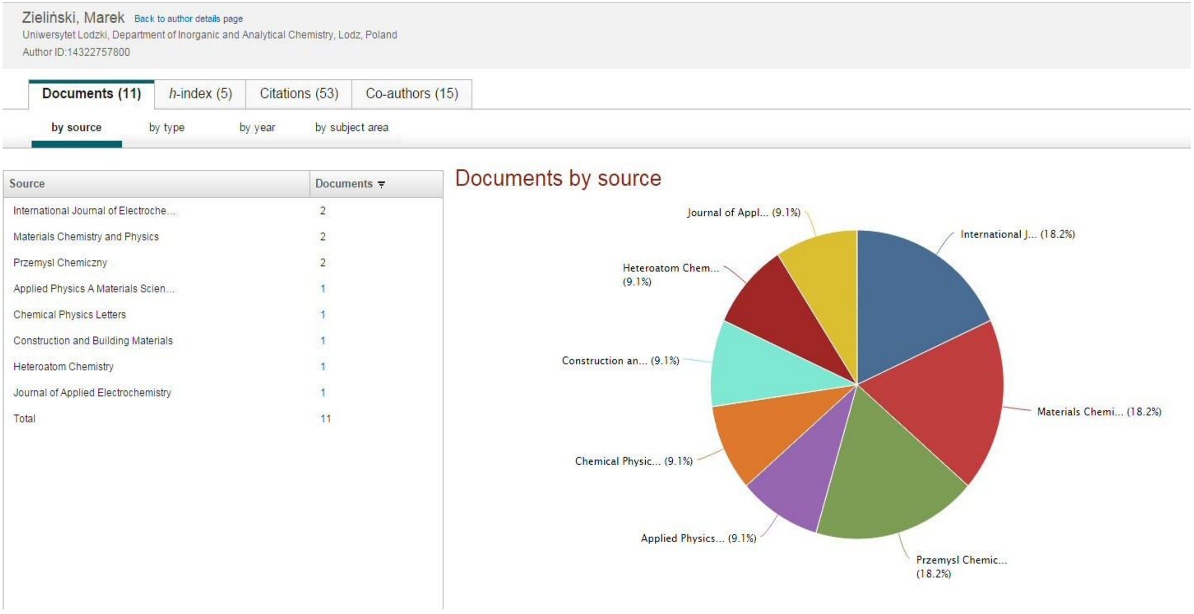
Analyze documents published between: 2006 to 2015

Year	Citations
2015	17
2014	15
2013	15
2012	6
2011	0
2010	0
2009	0
2008	0
2007	0
2006	0

Citations by year

Note: Scopus is in progress of updating pre-1996 cited references going back to 1970. Pre-1996 citation counts might increase over time.

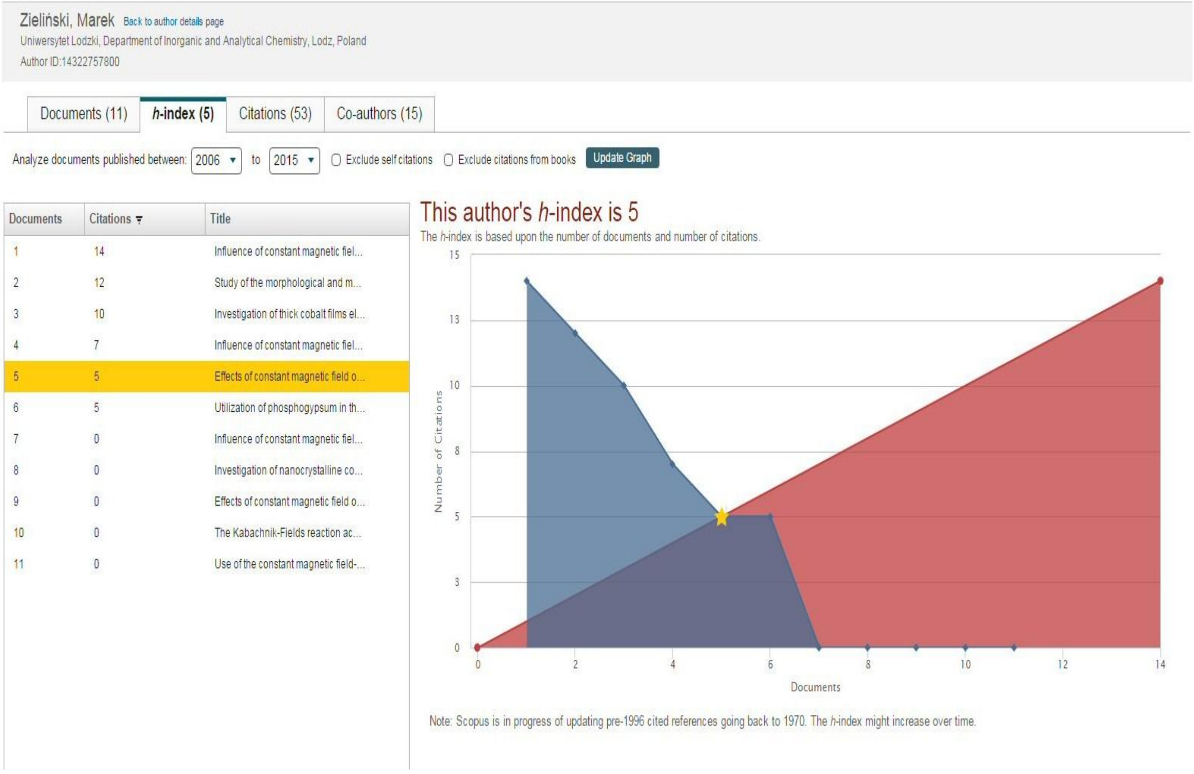
Percentage distribution of publications per journal (according to Scopus database, 03.11.2015).



Zieliński, Marek Back to author details page
Uniwersytet Lodzki, Department of Inorganic and Analytical Chemistry, Lodz, Poland
Author ID:14322757800

Source	Documents
International Journal of Electroche...	2
Materials Chemistry and Physics	2
Przemysl Chemiczny	2
Applied Physics A Materials Scien...	1
Chemical Physics Letters	1
Construction and Building Materials	1
Heteroatom Chemistry	1
Journal of Applied Electrochemistry	1
Total	11

Hirsch index (h-index) presented in in graphic form (according to Scopus database, 03.11.2015).



Zieliński, Marek Back to author details page
Uniwersytet Lodzki, Department of Inorganic and Analytical Chemistry, Lodz, Poland
Author ID:14322757800

Analyze documents published between: 2006 to 2015 ☐ Exclude self citations ☐ Exclude citations from books

Documents	Citations	Title
1	14	Influence of constant magnetic fiel...
2	12	Study of the morphological and m...
3	10	Investigation of thick cobalt films el...
4	7	Influence of constant magnetic fiel...
5	5	Effects of constant magnetic field o...
6	5	Utilization of phosphogypsum in th...
7	0	Influence of constant magnetic fiel...
8	0	Investigation of nanocrystalline co...
9	0	Effects of constant magnetic field o...
10	0	The Kabachnik-Fields reaction ac...
11	0	Use of the constant magnetic field-...

This author's *h*-index is 5

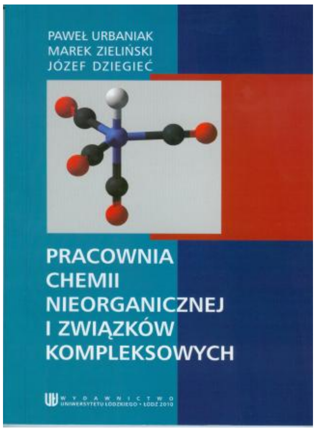
The *h*-index is based upon the number of documents and number of citations.

Note: Scopus is in progress of updating pre-1996 cited references going back to 1970. The *h*-index might increase over time.

DIDACTIC ACTIVITY

12. Books published.

P. Urbaniak, **M. Zieliński**, J. Dziegieć, *Inorganic chemistry and complex compounds laboratory*, script for the chemistry students of the University of Lodz, UL Publishing Office, Lodz, Łódź, **2010.**



PAWEŁ URBANIAK
MAREK ZIELIŃSKI
JÓZEF DZIEGIEĆ

PRACOWNIA
CHEMII
NIEORGANICZNEJ
I ZWIĄZKÓW
KOMPLEKSOWYCH

WYDAWNICTWO
UNIWERSYTETU ŁÓDZKIEGO • ŁÓDŹ 2010

PAWEŁ URBANIAK
MAREK ZIELIŃSKI
JÓZEF DZIEGIEĆ

PRACOWNIA
CHEMII
NIEORGANICZNEJ
I ZWIĄZKÓW
KOMPLEKSOWYCH

WYDAWNICTWO
UNIWERSYTETU ŁÓDZKIEGO • ŁÓDŹ 2010

13. Didactic activities.

- External examinations in chemistry – Laboratory (5th course)
- Specialization laboratory (4th course)
- Inorganic chemistry – Laboratory (extramural study course) (4th course)
- Inorganic chemistry – Laboratory (intramural study course) (2nd course, previously 3rd course)

  Specjalizations: Chemistry and nanotechnology of modern materials, Analytical chemistry, Cosmetic chemistry, Chemistry in science and economy.
- Chemistry of complex compounds – Laboratory (2nd course, previously 3rd course)
- General and analytical chemistry – Laboratory (Chemistry major) (1st course).
- General and analytical chemistry – Laboratory (Environment Protection major) (1st course).
- Waste management and recycling - Lecture (2nd course).
- Teaching foreign students (12 hours) during the intership the foreignscientific (2015) –

Brno University of Technology, Faculty of Chemistry, Institute of Chemistry and Technology of Environmental Protection, Purkyňova 118, Královo Pole, 61200, Brno, Czech Republic.

14. Scientific care.

Supervision or tutorship of Master (M.Sc.) theses :

1. „*Methods of studies of magnetic polymeric composite in constant magnetic field",* **2015/2016.**
2. „*The study of magnetic forces in the magnetic field of neodymium magnets",* **2015/2016.**
3. „*Methods for determining the suitability of magnetically treated water to create concrete Composites",* **2014/2015.**
4. ,,*Magnetoelectrochemical deposition of metallic composites*", **2013/2014.**
5. „*Research of phosphogypsum and fly ashes and ways of their application with the use of a constant magnetic field*", **2011/2012.** – participation in the Best Master Thesis Contest in 2012, Regional Fund for Environment Protection and Water Management in Lodz **(2012).**
6. „*The influence of the direction of magnetic induction on electrochemical and physicochemical properties of ferromagnetic binary alloy materials"*, **2010/2011**.
7. „*Cobalt alloys and superalloys obtained in constant magnetic field"*, **2009/2010**.
8. „*Electrochemical reduction kinetics of alloys in constant magnetic field and investigation of their physico-chemical properties"*, **2008/2009**
9. „*Research into the characteristics of magnetic alloys of binary and ternary ingredients obtained electrochemically in constant magnetic field"*, **2007/2008**.
10. „*Influence of constant magnetic field on electroreduction and electrooxidaion kinetics of Co-Mo-W ternary alloy"*, **2006/2007**.
11. „*Diamagnetic reduction on the paramagnetic electrode in a constant magnetic field"*, **2001/2002**.
12. „*Influence of impact direction of constant magnetic field on the redox reactions of selected inorganic compounds"*, **1999/2000**.
13. „*Effect of constant magnetic field on the kinetics of oxidation and reduction of 4-hydroxy-2,2,4,6,6- pentamethylpiperidine- 1- oxyl"*, **1998/1999.**

Supervision of Bachelor (B.Sc.) theses:

1. *„Magnetocaloric effect in para- and ferromagnetics"*] **2015.**
2. „*Modifications of building materials with polymers*"], **2013**.
3. „*Analysis of chemical composition and physical properties of chemical industrial waste in the production of phosphoric acid "*], **2010**.

Reviews of Bachelor (B.Sc.) theses:

1. „*Biomineralization of materials*", **2015.**
2. „*Magnetorheological fluids",* **2015.**
3. „*Determination of selected herbicides In environment al Samales and drinking water*]", **2014.**
4. „*Determination methods of acid/base equilibria constants of solid surfaces*", **2013.**
5. „*Soft and hard magnetic materials and their application"*, **2013.**
6. „*Some biochemical and bioelectrochemical reactions in constant magnetic field"*, **2012.**

ORGANIZATIONAL ACTIVITY

- Member of the Association of Polish Inventors and Innovators [SPWiR] (**since 04.01.1993** r. , ID No 1011).

- Delegate of the University of Lodz to the General Assembly of University of Lodz Independent Self-Governing Trade Union (NSZZ UŁ) Science Section Delegates, member of the NSZZ UŁ Revision Committee (2014-2018).

- Expert of the National Center of Research and Development [Magnetochemistry, magnetoelectrochemistry, material engineering, utilization of waste – phosphogypsum, fly ash] (**since 2012**).

15. Popularization of chemistry.

1. Participation in the Contest for the best Master, Bachelor of Engineering and Doctor thesis in 2014, paper qualified for Stage II of the ABB Award Contest, entitled „*Magnetoelectrochemical deposition of metallic composites*], **2013/2014** [supervisor and tutor – **M. Zieliński**].
2. VI **International Festival** Lodz Design 2012, presenting an exhibition of projects. The presented project was entitled: "*Waste phosphogypsum treatment technology, research of new materials and composites]"*, Lodz **(2012), M. Zieliński**, E. Miękoś.
3. **Interview for Radio Lodz** (Jume **2012**) **M. Zieliński** „Uzdatnianie odpadów przemysłowych. Tworzenie nowych materiałów. Wpływ stałego pola magnetycznego na reakcje chemiczne, elektrochemiczne i materiały" *[Treatment of industrial waste. Development of new materials. Effects of constant magnetic field on chemical and electrochemical reactions and materials]*.
4. **Participation in the Best Master Thesis Contest in 2012**, Regional Fund for Environment Protection and Water Management in Lodz, „*Research of phosphogypsum and fly ashes and ways of their application with the use of a constant magnetic field*", [supervisor – **M. Zieliński**]
5. Annual presentations and lectures for high school and junior high school students during the **science picnics** concerning: treatment of industrial waste – phosphogypsum, fly ash, development of new materials, effects of constant magnetic field on chemical and electrochemical reactions and materials, [**M. Zieliński**, E. Miękoś].
6. **Report** [**M. Zieliński**], „*The technology of transformation of phosphogypsum waste"*, Central European Forum of Biotechnology & Innovative BioEconomy, Bioforum Lodz **(2010).**

16. International and national awards, distinctions and medals.

1. Silver medal for long-term service (state-awarded) [Lodz, **17.10.2011**]

2. Medal "UL IN THE SERVICE OF SOCIETY AND SCIENCE" [Lodz, **25.05.2009** r.]

3. UL gold badge [Lodz, **23.05.2003** r.]

4. Distinction for the dissertation entitled "Wpływ stałego pola magnetycznego na kinetykę i mechanizmy reakcji redoks wybranych związków nieorganicznych i organicznych w różnych roztworach" [The influence of a constant magnetic field on the kinetics and redox reaction mechanisms of selected inorganic and organic compounds in various solutions], Faculty of Physics and Chemistry, University of Lodz [Lodz, **27.09.2001**].

5. SPWiR (Polish Association of Inventors and Innovators) silver badge of honor [Warsaw, **14.09.2000 r.]**

6. Silver medal for„Merit for the National Defence League", ID No.22682, [Warsaw, **29.03.1994r.]**

7. Silver Medal in the „Chemical Industry" category, „Brussels Eureka - 92 World Exhibition, [Brussels (Belgium), **11.11.1992 r.]**

8. Special Award of the President of the Federation of Engineering Associations for the solution entitled „Novel ceramic-like material", [Warsaw, **24.06.1992** r.]