Dr. Jerzy POLACZEK*, Dr. Tomasz ZIELIŃSKI**

DOI: 10.15199/180.2019.1.2

* „Przemysł Chemiczny" Monthly, Ratuszowa 11, 09-950 Warsaw, po box 1004
e-mail: przemyslchemiczny@sigma-not.pl
** Warsaw Technical University; President of Polish Chamber of Chemical Industry

DEVELOPMENT OF CHEMICAL INDUSTRY IN POLAND. ACHIEVEMENTS AND CONSTRAINTS

ROZWÓJ PRZEMYSŁU CHEMICZNEGO W POLSCE. OSIĄGNIĘCIA I OGRANICZENIA

Summary: *History of chemical industry in Poland was comprehensively outlined. A special attention was paid to the transformation of national economy in Poland early nineties of XX century and them accompanied changes of the chemical industry. Current state of the industry was characterized in detail. Availability of raw materials and innovativeness of the industry were particularly discussed. Some recommendations for the future were given.*

Keywords: *chemical indystry, historical outlook, transformatoin, national economy, innovativeness*

Streszczenie: *Zwięźle naszkicowano historię przemysłu chemicznego w Polsce. Szczególną uwagę zwrócono na transformację gospodarki narodowej na początku lat dziewięćdziesiątych XX w. i towarzyszące jej zmiany w przemyśle chemicznym. Scharakteryzowano dokładnie obecny stan przemysłu chemicznego w Polsce. W szczególności przedyskutowano sprawę dostępności surowców dla przemysłu chemicznego oraz innowacyjności tego przemysłu. Dano też pewne zalecenia na przyszłość.*

Słowa kluczowe: *przemysł chemiczny, spojrzenie historyczne, transformacja, gospodarka narodowa, innowacje*

Chemicals and polymers are key products for the national economy in the country. They are indispensable everywhere: in transportation (both fuels and construction materials), agriculture (fertilizers, preservatives and pesticides), electrical engineering, electronics and telecommunication (conductors and insulators), energy technology (fuel cells, batteries) and construction as well as in medicine and household. The old motto „Chemistry feeds, heals and dresses"[1] remains still valid up-to-date.

Historical outlook

The history of industrial chemistry in Poland was comprehensively outlined in a reference work[2]. Distilleries, sugar refineries, salt plants, paper mills, glassworks and zinc smelters were operated on Polish land already in the ninetheenth century. Gunpowder was also the Polish specialty that time[3]. Just before the World War I, the occupied Poland was a serious deliverer of petroleum-derived products to the European countries from the Galicia-located crude oil refineries. At the beginning of XX century, output of petroleum was 1–2 million tons a year.

During the World War I, the chemical factories were mostly destroyed and had to be rebuilt after the Poland became independent[4]. The most important was the production of sulfuric acid (by conversion of zinc and iron sulfides), nitrogen and phosphor-containing chemical fertilizers, soda, rubber goods (tires, hoses, gaskets, conveyor belts) and pharmaceuticals. The chemical factories in Chorzow (nitric acid, fertilizers and calcium carbide), Mościce (nitric acid and nitrate fertilizers) and Jaworzno (electrolysis of salt) were the greatest industrial achievements after the World War I in Poland. Moreover, the operation of many small pharmaceuticals-producing factories was also of a crucial importance. The new processes were based either on licences granted by foreign companies or developed at the domestic Chemical Research Institute in Warsaw (synthetic rubber, coal tar-derived products).

The World War II stopped the rapid growth of the chemical industry in Poland[4]. The chemical factories were totally destroyed or robbed by the German and Soviet occupants. It was necessary to start from the zero level after the war. According to the communistic ideology, the Polish industry has been nationalized. Maybe, it was a right solution because of shortage of private capital resources necessary for the reconstruction. The American Marshal Plan was rejected by Polish administration according to recommendations of the Soviet occupant. Hence, all chemical enterprises became practically also state-owned ones.

The restoration of the chemical industry was carried out in very hard circumstances. There were neither modern processes nor skilled personal available. But the production was the goal. The whole population of Poland was involved in the execution of the first Three-Year Plan (1947-1949) and it was completed successfully in the area of basic (mostly inorganic) chemicals (Table 1).

Table 1. Production of chemicals [3, 4], Gg/year

PRODUCT	Year			
	1938	1949	1970	1980
Sulfuric acid	196	276	1716	2890
Ammonia	38.5	48.8	1445	1803
Chlorine	4.3	5.0	188	309
Soaps*	53	52	114	244
Fertilizers**	96	669	1629	2095
Soda	87	120	657	762
Sodium hydroxide	30	56	310	416
Sodium chloride	417	450	2900	4510
Plastics and resins	0.7	1.8	267	546
Dyestuffs	2.0	3.8	20.8	25

** various types including washing powders;*
*** both N and P fertilizers*

The consumption needs grew however much faster than the productivity. Therefore, the former German chemical factories on the "regained grounds" (Kędzierzyn, Blachownia Śląska, Brzeg Dolny, Gliwice, Wrocław, Racibórz, Gorzów, Toruń) were set in operation in the fifties to produce some organic intermediates, monomers, carbon black, carbon electrodes, synthetic fibers and plastics. But it was still not enough to meet the demand for chemicals, liquid fuels and polymers. Therefore, a big program for "chemicalization" of the national economy started in the sixties.

A petroleum refinery was the first step in this program. The refinery has been built at Płock. It was really a great deal. According to the assumptions of the Soviet occupants, the refinery was fed with the Romashkino crude oil transported with the "Friendship" pipeline and should deliver gasoline and gas oil for the Soviet occupation troops being stationed on the Polish territory. However, the Polish managers transformed the refinery into a main domestic deliverer of petrochemical raw materials (phenol, aromatics, ethylene, propylene, ethylene oxide, butadiene, polyethylene) for the domestic chemical industry[5-7]. In the next step, the second petroleum refinery has been built in Gdańsk. It was based on licences granted by Western companies and constructed according to the Western specifications and equipment. The refinery processed Arabian crude oil and produced liquid fuels and lubricating oils. This way, the coal-derived chemical raw materials were successfully replaced with petrochemical ones.

That time, modern plants for production of poly(vinyl chloride) at Włocławek, dimethyl terephthalate and poly(ethylene terephthalate) at Toruń, caprolactam in Tarnów and Puławy, polyamide-6 in Gorzów and epoxy resins in Pustków have been also built[3]. The investments contributed to substantial increase in production of plastics (Table 1).

At the beginning of the eighties, the development of the chemical industry has been stopped because of political reasons. The Ministry of Chemical Industry was dissolved and changed to Ministry of Chemical and Light Industries, where chemistry was no more prominent. An economic slump in the chemical industry has been dawned and all investments were suspended.

Transformation of national economy

The transformation of Polish planned national economy to the free-market one started 1989 and was accompanied with formation of joint-stock companies with private shareholders. This way, many companies (also chemical ones) became politically (at least partly) independent and were concentrated on profits. The independence resulted in an investment boom. After 10 years long calm, the companies started with investment to build new production plants and revamp the old ones. It was very well visible on example of the Petrochemia Płock SA refinery (converted then into Polish Oil Company PKN Orlen SA). The investment boom in the Company was shown in Table 2. Unfortunately, privatization was soon stopped and many companies remained state-owned ones.

The privatization was necessary but was carried out very inefficiently and not transparently in many cases. The foreign capital had priority in the process. A friendly takeover of a state-owned factory by the company staff took place only in one case in the chemical industry. The company's facilities for production of dressings in Toruń passed along to employees with a great success. To-day, this company (TZMO) is a global player on the world market of dressings.

Many chemical companies went bankrupt because of lack of financing and know-how, wrong administration and animosity towards privatization. Zachem at Bydgoszcz, Carbochem at Gliwice, Blachownia at Kędzierzyn-Koźle, Hajduki at Chorzów, Zakłady Chemiczne at Tarnowskie Góry and Opol-Rapp at Lewin Brzeski are only few examples of crashed state-owned chemical companies. There were not any real causes for closing the factories in most cases. Only the problems of environmental pollution on the sites have remained unsolved up to now.

Many new chemical companies with Polish capital were advantageously formed that time. Atlas at Łódź (building materials), Impuls at Pruszcz Gdański (surfactants and disinfectants), Viwax at Plock (polyolefin waxes), Inwex at Kielce (brighteners for electroplating, fuel additives, cosmetics) and Kikgel at Ujazd (dressings) are only few examples of the new prospective companies.

Table 2. Investments in Polish Oil Company Orlen in 1980–2010[8]

Year of commissioning	Plant	Capacity, Gg/year	Remarks
1983	ethylene oxide and glycols	60	licenced by Shell and Uhde, intensified in 2009
1984	sulfur (Claus)	30	domestic licence
1991	methyl-tert-butylether	120	domestic licence
1993	sulfur (Claus)	60	licenced by Elf and Lurgi
1994	reforming	700	licenced by UOP
1994	hydrorefining gas oil	900	licenced by Mannesmann
1996	bitumen	960	licenced by Poerner
1996	polypropylene film	10	licenced by Brueckner
1997	hydrocracking	2600	licenced by Unocal and UOP
1997	hydrogen	144	licenced by SNAM and KTI
1999	bitumen	1800	licenced by Axens
1999	crude oil distillation	3700	licenced by SNAM
2000	reforming	873	licenced by UOP
2000	hydrorefining gas oil	1600	licenced by ABB Lummus
2000	C5 isomerization	600	licenced by UOP
2000	gas desulfurization	318	domestic licence
2002	crude oil distillation	up to 6700	licenced by Fluor Daniel
2005	olefins	700 (ethylene)	licenced by Lummus Global
2005	aromatics	500	licenced by Krupp and Uhde
2006	gasoline desulfurization	no data	licenced by Axens
2010	hydrorefining gas oil	2200	licenced by Technip
2010	p-xylene	400	licenced by UOP
2010	terephthalic acid	600	licensed by Mitsubishi

The Polish chemical industry was, however, still very late and remained far away behind the developed countries at the turn of the twentieth and twentieth first centuries[9]. Production of sulfuric acid was then not a bench mark for the chemical industry any more. This role played production of ethylene which was on the very low level in Poland (Table 3). First in 2005, it was increased to 0.7 Tg/year.

Current state

The economic transformation in Poland resulted in an enormous increase in demand on chemicals and related products (polymers, pharmaceuticals, agrochemicals, fuels). The domestic chemical industry was not strong enough to meet the demand. It was done by imports of respective chemicals and chemical products. Therefore, the foreign trade balance became negative. A dramatic situation was observed in pharmaceuticals: in 1991 the balance was a surplus 63 mil $ and in 1966 was a deficit 758 mil $! The foreign trade balance in chemical products has been remaining negative up to day (Fig. 1) although the production value grew permanently (Fig. 2).

Table 3. Production of ethylene[9], Tg/year

Country	1983	1996
USA	13.0	25.5
Japan	3.7	7.5
Germany	3.2	4.6
[...]		
Turkey	0.1	0.4
Bulgaria	0.2	0.4
Poland	0.2	0.4
Portugal	0.1	0.3

Fig. 1. Polish foreign trade balance in chemicals and chemical products in 2006–2017[10], million €

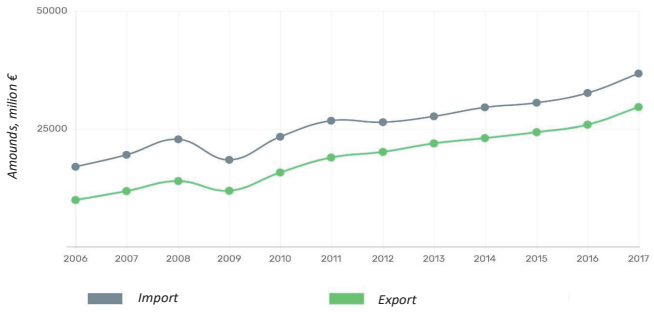
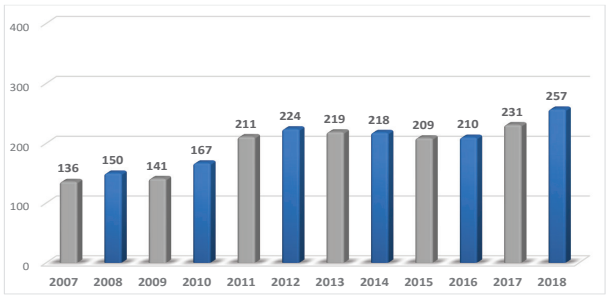


Fig. 2. Growth of the chemical production value in Poland in 2007–2018[11], million zlotys



The situation changed, however, significantly last years. The export of Polish cosmetics reached 1.3 billion euro in 2017 and was by 50% higher than their import. The cosmetics exported are not only products of Beiersdorf, Avon and l'Oreal but also of Polish Ziaja, Dr. Irene Eris and Inglot[10]. The export of Polish pharmaceuticals was substantially increased and reached 3 billion euro in 2017. The exported pharmaceuticals are not only produced in Poland by famous Western companies (Novartis, Sanofi, GlaxoSmithKline) but also by Polish companies (Polpharma, Adamed). Unfortunately, the import of pharmaceuticals remained still higher by 1 billion euro.

The situation in plastics can be hardly evaluated. The balance in foreign trade in plastics is highly negative according to the official data. But the imported plastics are mostly processed in Poland to plastic parts of machines, cars and household equipment or to packages and then exported as goods (not as plastics!). The plastics processing became even a Polish specialty. There are more than 10 Thousand companies active in this branch. Many private enterprises are equipped with modern machines and are competitive on the European market. Plast-Box and Gamrat are only 2 examples of the companies.

All the exported value-added chemical products (pharmaceuticals, cosmetics, plastic goods) came from enterprises with a private capital.

The main players in the chemical industry in Poland are shown on Fig. 3. Some of them are still state-owned companies. Liquid fuels, fertilizers, plastics (including rubbers) and basic chemicals are the main chemical products manufactured in Poland. The most important constructions in Polish chemical industry are shown in Table 4. Unfortunately, they fall short to meet the demand on chemical products by the national economy.

Fig. 3. Basic data on Polish chemical industry in 2017[13]

Table 4. The most important capital constructions in Polish chemical industry in 2015–2019[13]

Year	Company	Subject	Capacity, Gg/year	Expenditures, million zloty
2015	Synthos, Oświęcim	SBBR rubber	90	568
2015	Grupa Azoty, Puławy	urea/ammonium sulfate fertilizer	160	138
2015	Grupa Azoty, Kędzierzyn-Koźle	Oxoviflex plasticizer	50	40
2016	Ciech, Inowrocław	soda	200	318
2017	Grupa Azoty, Tarnów	polyamide	80	320
2018	PCC Rokita, Brzeg Dolny	monochloroacetic acid	42	293
2018	Grupa Lotos, Gdańsk	efficient refining EFRA	900*	2300
2019*	PKN Orlen, Płock	propylene	100	400
2019**	Grupa Azoty, Puławy	ammonium nitrate granules	360	365

The development of particular branches of the Polish chemical industry in XXI century was very accurately forecasted by A. Szyprowski[20]. Many of his forecasts were well-aimed (methanol, synthetic fibers) but some of them were to pessimistic (fertilizers, plant protection agents, pharmaceuticals, rubber). Bankruptcy of the company producing epichlorohydrin, isocyanates and polyurethanes (Zachem) was indeed hard to forecast!

Vision of the development of Polish chemical industry given by J. Kijeński[21] was also remarkable. Shortage of investment capital, low production capacities, false political decisions and unsatisfying innovativeness are the basic constraints in the development.

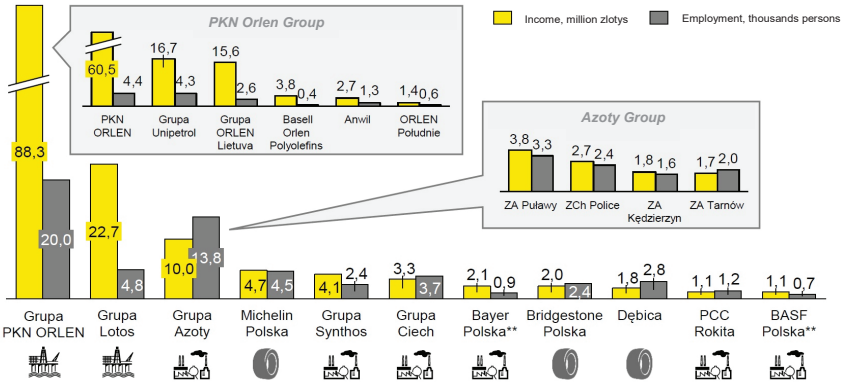
The chemical industry has no economic priority in to-day Poland. Nevertheless, the share of the value of sold chemical products (without fuels) in permanently growing value of total industrial production in Poland was increased from 10.4% in 2005 to 12.2% in 2016[13].

The non-governmental Polish Chamber of Chemical Industry plays a very important role in consolidation of the whole branch, stimulation of its activity, protection of its economic interests and assistance in implementation of EU regulations in the area of process safety, environmental policy and quality issues (both chemical raw materials and products).

Raw materials

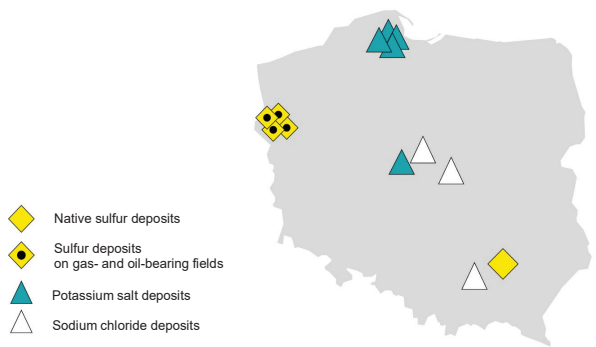
Unfortunately, the country of Poland is rather resourceless and chemical industry has to import most of the raw materials needed. The location of domestic mineral resources in Poland is shown on Fig. 4. There are admittedly big reserves of coal in Poland but its applicability for chemical processing decreased substantially last time. Additionally, the undercapitalization of coal mines and overexploitation of coal deposits resulted in their exhaustion and the coal yield decreased dramatically in last years. A lot of low-quality coal is now even imported to meet the energy production needs. Therefore, the coal gasification to synthesis gas can be hardly considered as the efficient way to replace natural gas in the chemical industry. Coal can be however coked to clean solid fuels ("blue coal") according an original Polish technology (Zabrze). The Polish society has a great liking for coal, called as a "black gold" in the past, and is hopeful about its comeback to the list of chemical feedstocks in the not too distant future.

Fig. 4. Main players on Polish chemical market[13]



Prospecting the oil and gas-bearing fields is a great challenge for the future but the Polish chemical industry is now import-dependent in this respect. Resources of native sulfur and halite are quite large but they do not play any crucial role for chemical industry (except for potassium and magnesium-containing halites) (Fig. 5). The availability of metallic raw materials is much better. There are big copper, zinc, lead and silver ore deposits under exploitation in Poland. Biomass is also easily available in Polish agriculture and forestry.

Fig. 5. Location of some Polish mineral resources[13]



Among raw materials, the special role was played by hydrogen, a crucial feedstock for many productions (ammonia, fuels, organic intermediates). Nowadays, the hydrogen is also taken into consideration as a clean fuel for automotive purposes[22]. The hydrogen is not available in free form on the Earth, but can be produced by conversion of water and/or hydrocarbons (gasification of coal or biomass, reforming of natural gas or other hydrocarbons, as well as electrolysis or thermolysis of water). The emission-free production of hydrogen is still waiting for an economic decision.

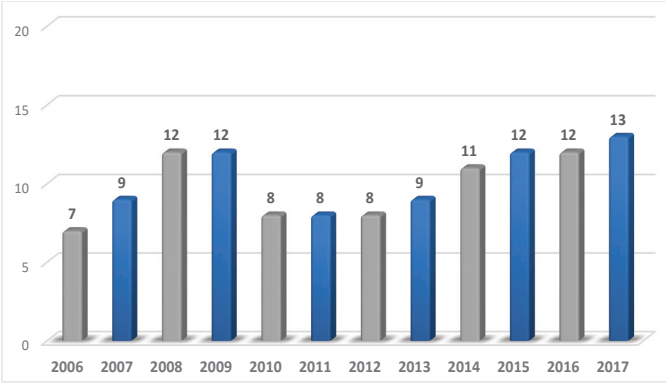
The raw materials can be therefore treated as the key factor limiting the development of the chemical industry in Poland. It has to strive for a high degree of raw material utilization and to bring only value-added products on the market. This principle is applied in Switzerland where the mineral resources are much poorer then in Poland but imported raw materials are converted to expensive pharmaceuticals, dyestuffs and plant protection agents[9].

The structure of Polish chemical industry does not allow for a rapid transformation from cheap fertilizers, basic chemicals and commodity plastics to value-added specialty chemicals. There are however some projects within easy reach. The crude oil has to be deeply processed to petrochemicals (and not exported as heating oil in any case!) and the biomass waste has to be biotechnologically gasified to biogas. The rate of raw material utilization can be also substantially increased either by circular economy or by using efficient processes for carrying out the chemical reactions (flow chemistry, biotechnology).

Innovativeness

Polish chemical researchers and engineers have made a big contribution to the development of industrial chemistry. The alumina-supported copper-zinc oxide catalyst for low-temperature methanol synthesis developed by E. Błasiak was used for industrial methanol production in Poland (Oświęcim) in 1979 and is still used over the world practically in all new production plants[14]. The ion exchange resins-catalyzed process for synthesis of bisphenol A developed by E. Grzywa was also used in an industrial plant in Poland (Kędzierzyn-Koźle) in 1982 and in many foreign chemical factories[15, 16]. An original remedy for arterial hypertension (todralazine hydrochloride, binazine) developed by S. Biniecki (Warsaw) was produced and used in Poland and in Japan. The process for catalytic oxidation of cyclohexane to cyclohexanone, a key intermediate in production of caprolactam developed by S. Ciborowski (Warsaw) and A. Krzysztoforski (Tarnów) was implemented in Poland (Tarnów and Puławy) in 1979 and sold for many foreign companies[17]. A process for synthesis of methyl (or ethyl)-tert-butyl ether developed by S. Grzeczkowski from the K. Frączek team (Płock) was implemented in Płock refinery in 1991. The process for production of epichlorhydrin by hydrochlorination of glycerol was developed by M. Spadło (Kędzierzyn-Koźle) and sold for abroad. A new phthalate-free plasticizer was developed by B. Tkacz from the A. Krueger team (Kędzierzyn-Koźle) and implemented under commercial scale in Kędzierzyn-Koźle. Finally, a process for production of liquid silicon rubber developed by J. Maciejewski (Warsaw) was implemented in Poland (Kańczuga). There were only some examples of the Polish achievements in industrial chemistry. Fates of the developments were mostly less optimistic. The productions of methanol, bisphenol A, binazine and liquid silicone rubber in Poland were stopped many years ago. Some of the products are imported. The plant for production of epichlorhydrin was constructed (Bydgoszcz) but never started up. Only the plants for manufacturing cyclohexanone, alkyl-tert-butyl ethers and the plasticizer are still under operation in Poland.

Fig. 6. Capital investment in Polish chemical industry in 2006–2017[13], billion zlotys



Many Polish strategic chemical inventions have been never commercialized and were charged off. Graphene, gallium nitride and perovskite are examples of value-added chemical products developed in Poland and thrown away.

Poland occupies only 22nd position (21st in 2018) on the ranking list of Bloomberg Innovation Index 2019. U.K., Australia, Canada and Italy are directly before Poland. Iceland, New Zealand, Czech Republic, Malaysia and Russia are directly after Poland on the ranking list (Table 5). It is far below expectations of the Polish society and Polish chemical industry!

Table 5. Bloomberg 2019 innovation index (an excerpt)[18]

Rank	Economy	Total score
1	South Korea	87.38
2	Germany	87.30
3	Finland	85.57
4	Switzerland	85.49
5	Israel	84.78
[...]		
19	Australia	75.38
20	Canada	73.65
21	Italy	72.85
22	Poland	69.10
23	Iceland	68.41
24	New Zealand	68.12
25	Czech Republic	68.09

Conclusions and recommendations

Polish chemical industry is closely dependent on the global economy. The energy prices, the availability of raw materials, the human resources of highly skilled personal, the process and product safety, the legal regulation (especially in area of environmental policy) and permanent inflow of knowledge are the main factors determining the future of the chemical industry in Poland.

To be competitive, the Polish chemical industry has to modernize the existing facilities under operation, to construct new production plants and to commercialize processes for manufacturing value-added chemical products according to the market demand. The implementation both domestic or imported know-how and acquisition of respective foreign companies is strongly recommended. In this respect, a close cooperation between chemical industry, research institutes, academia, governmental administration and non-governmental organizations (like Polish Chamber of Chemical Industry or Association of Chemical Engineers) has a substantial importance[19].

References

[1] E. Zawada, Chemistry in the Six-Year Plan (in Polish), Wiedza Powszechna, Warszawa 1951.
[2] Charts from the history of Polish chemical industry (in Polish), vols. 1-20 (eds. H. Konopacki et al.), SITPChem, Warszawa 1995-2012.
[3] S.B. Książkiewicz, Chemical industry on Polish territories in 1918-1980 [in:] Charts from the history of Polish chemical industry (in Polish), vol. 1, (eds. H. Konopacki et al.), SITPChem, Warszawa 1995
[4] A. Zimowski, Chemical industry in Poland in 1918-1980 [in:] Charts from the history of Polish chemical industry (in Polish), vol. 2 (eds. H. Konopacki et al.), SITPChem, Warszawa 1995.
[5] K. Klęk, Mazovian Petrochemical Company at Płock. A history of a phenomenon (in Polish), Przem. Chem. 2009, 88, No. 11, 1142.
[6] K. Jaskóła, Genesis of success. Dynamic management of industrial corporations (in Polish), Wyd. Nauk. ITE, Radom 2014.
[7] A. Puchowicz, Phenomenon of petrochemistry at Płock and over the world (in Polish) (ed. E. Korsak), Samizdat Zofia Łoś, Płock 2006.
[8] Anonym, Polish Petroleum Concern Orlen SA (1980–2010) [in:] Charts from the history of Polish chemical industry (in Polish) (eds. J. Kijeński et al.), vol. 20, p. 83-111, SITPChem, Warszawa 2012.
[9] E. Grzywa, J. Polaczek, Chemistry and chemical industry at the turn of the centuries (in Polish), Chemik 2000, 53, No. 10, 279.
[10] N. Olszewska, Polish foreign trade. Chemical products (in Polish), www.ikalkulator.pl/blog/produkty-przemyslu-chemicznego.
[11] Anonym, Economic report 2017, Polish Chamber of Chemical Industry, Warsaw 2018.
[12] A. Zimowski, History of heavy synthesis industry [in:] Charts from the history of Polish chemical industry (in Polish), vol. 5 (eds. H. Konopacki et al.), SITPChem, Warszawa 1997.
[13] Anonym, Chemical industry in Poland. Position, challenges, prospects (in Polish), Final Report of EY and PIPC, Warsaw 2017.
[14] J. Skrzypek, J. Słoczyński, S. Ledakowicz, Methanol synthesis. Science and engineering, PWN, Warszawa 1994.
[15] E. Grzywa, J. Molenda, Technology of basic organic syntheses Vol. 2. Syntheses (in Polish), WNT, Warszawa 2008, p. 342.
[16] A. Krueger, Routes for commercialization of research works on example of ICSO Blachownia (in Polish), Chemik 2014, 88, nr 3, 183.
[17] A. Krzysztoforski, In my Nitrogen Works (in Polish), Milenium, Tarnów 2017.
[18] M. Jamrisko, L.J. Miller, W. Lu, These are the world's most innovative countries, https://www.iol.co.za/business-report/international/see-the-worlds-most-innovative-countries-18906132.
[19] T. Zieliński, Polish chemistry in development of the economy. Challenges before the branch [in Polish], Polska Chem. 2019, No. 1, 25.
[20] A.J. Szyprowski, Development forecasts for Polish chemical industry (in Polish), Przem. Chem. 2000, 79, No. 1, 3.
[21] J. Kijeński, Powerfull or powerless. Timeless development dilemmas of polish chemical industry. Controversial and reflective attitudes (in Polish), Przem. Chem. 2016, 95, No. 4, 687.
[22] J. Kijeński, Hydrogen economy. Part 1. To clean energy. Zero emission, zero technology (in Polish), Chem. Przem. 2018, 97, No. 5, 67.
[23] Daily Rzeczpospolita, 27th March 2019, an interview with Tomasz Zieliński

Article reviewed
Received: 20.03.2019/Accepted: 29.03.2019