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## **DEVELOPMENT OF PAINTS AND VARNISHES IN THE FACE OF DYNAMIC CHANGES OF END USERS' NEEDS – CHALLENGES FOR RAW MATERIAL PRODUCERS**

*Paint and varnishes market is one of the fastest growing globally, mainly due to the huge demand in the construction industry. Based on the purpose of using paints, varnishes and other coatings industry can be categorized in architectural decorative, industrial and special purpose coatings. The largest segment, with highest number of producers is the decorative one. The development of raw materials for decorative market segment must satisfy the needs of today's and future end users as well as regulatory challenges and economical challenges. This will not happen without influence on currently used raw materials and future development. Aim of the article is present short history of coating industry on the world and in Poland, drivers of changes that are currently ongoing as well as future trends and developments.*

**Keywords:** paints, varnishes, market, raw materials, users needs, ecological impact.

### **Introduction**

Paint and varnishes are liquids, powders and pastes, which are applied to surface by several methods and equipment in layers of specified film thickness, depending on application. It is one of the fastest growing industry globally mainly due to the huge demand in the construction industry. In 2014 global sales of paint,

varnishes and other coating increased by 3,9% comprising about USD 132,3 billion (43.38 million tons). Europe is second largest consumer taking 24% of volume and 29% of value in 2013 of global production [6].

Based on the purpose of using paints, varnishes and other coatings industry can be categorized in architectural/decorative, industrial and special purpose coatings. Each market segment has its specific requirements, drives and restraints. Decorative is the largest segment, accounting 48% in of total sales 2014. It is also the segment with highest number of producers.

Because paint manufactures in decorative segment range from very small producers, acting locally and producing few tones of paints annually up to large multinational players producing several thousand tons annually. Diversify of the market and revised upper limit of volatile organic compound (VOC) are and will be strong drivers in future development. Eighty five percent of decorative (architectural) coatings are waterborne systems, the rest are solvent borne systems. The waterborne systems' segment is continuously gaining market share and will increase in the future. All materials in architectural coating are subject to environmental legislation. These laws promote the new development of environmentally friendly raw materials.

The development of raw materials for decorative market segment must satisfy the needs of today's and future regulatory challenges and economical challenges. This will not happen without influence on currently used raw materials and future development. Aim of the article is present short history of coating industry on the world and in Poland, drivers of changes that are currently ongoing as well as future trends and developments. Those aspects seem to be crucial for introducing effective strategies in the area of product development as well as supply chain optimization and will be further analyzed by authors in their future research.

## **2. History of paint techniques in the world**

Paint and coating manufacturing has a long history, going back several thousand years. Paintings discovered in caves in southern France and Spain are considered the oldest monuments of paint and coating manufacturing. Research has shown that paints used there date back several thousand years. Similar paintings were found in Egypt, Assyria, Babylon from the time of Minoan culture, not to forget the monuments of art on the territory of China and Far East [1]. A lot of pieces of art from different ancient cultures which we can admire in various museums, all over the world, are covered with paint and coating of different nature. Colour fastness and durability of these coatings arouses the admiration of professionals up to this day.

Following Z. Klonowski's classification formulated in the fifties of the last century, we can divide history of paint techniques into three periods [1]:

- natural pigments period and water based paints,
- oil paints and pigments period, modified and also synthetic,
- synthetic paint period and coatings based on synthetic binders.

The first period covers the most ancient past and ends by the end of 10<sup>th</sup> century. In ancient times, the manufacture of paints and coating was based only on natural raw materials available locally and mainly used for the decorative purposes. As centuries passed, formulators of paints experimented and developed different binders: casein, proteins, acacia gum and waxes. In the Far East, formulators were developing paint techniques like aquarelle, tempera and gouache using Shellac and other natural resins available.

Natural pigments and coloured earths like terra di Sienna, ocher and umber were commonly used. It is also reported that first cases using pigments were coming from the chemical processing. Pliny the Elder in his Natural History mentions lead white, produced in ancient Greece. He also described in the quoted book a possibility of achieving different shades of red lead.

The second period of development according to Z. Klonowski is the period from the end of the 10<sup>th</sup> century until mid-19<sup>th</sup>-century. While still dominated by simple manufacturing processes, the clear difference compared to earlier times is the development of processing of natural binders. Taking advantage of international trade, Europe and Far East are using commonly available fossil and natural resins in combination with drying oils (e.g. hempseed oil, linseed oil). East European manufacturing followed the process of Byzantine oil technologies, mainly poppy seed oil, hempseed oil and linseed oil. China wood oil (tung oil) was already used in Far East. Common in use were natural resins from the Chinese lacquer tree: products coated with this lacquer are recognizable by an extremely durable and glossy finish.

The 18<sup>th</sup> century is very important for the fact that first paint producers, in today's sense of the word, were founded and a significant development of technical thought in the field of synthetic inorganic pigments began. In 1775 Leithner invented cobalt blue, in 1780 Riemann invented cobalt green and Vauguelin invented chrome green in 1809. Synthetic ultramarine was invented by Guimeta in 1824 and synthetic lead white by Dietela in 1839 [8]. This practically marks the end of the second period of Klonowski's historical division. It has to be mentioned that the entire production has a character of industrial production, although with a complete lack of mechanization and a lot of manual work.

The end of the 19<sup>th</sup> century and the beginning of the 20<sup>th</sup> century is a period of epochal inventions of many synthetic chemical products used in different industries, but the paints and coatings industry still used traditional binders. It is also the beginning of polymer chemistry, which is a base for synthetic binders production. This is considered as the beginning of the third period in the development of paints

and coatings, which continues to this day. After the Second World War we see significant changes in coating technology. Natural raw materials became too valuable to be used in the mass production of paints. They were also not able to meet the technical requirements of final users, who began to expect shorter drying times, often in elevated temperatures, and also coating with improved physicochemical properties. General development of many industries e.g. engineering, shipbuilding, automotive and electrical production, forced the coating industry to make significant changes in terms of raw materials and product assortment.

In the mid-20<sup>th</sup>-century the measure of modern paint industry was the ability to use raw materials of synthetic origin rather than natural origin. Further development of paint technology was possible due to introduction of synthetic polymers as binders and synthetic pigments. Return to water-based paints in the form of Latex was a significant and important step in development.

Progress in coating chemistry was made possible and supported by advances in coating techniques. Various application modes like brushing or spraying were now supplemented by electrodeposit coating or powder coatings. Ambient air drying was joined by infrared and radiation drying methods (UV, electron beam), and the automation of coating processes continued to advance. Precondition for selective product development is the reproducible quantifiability of coating properties.

The 21<sup>st</sup>-century does not appear to have any clear-cut revolutionary innovations in the coating chemistry and coating technology. At the same time awareness that human activity have ecological impact and responsibility for the future, makes environmental regulations and sustainability will have an important role and will drive product development across different coating applications.

To sum up, production and use of paints and coatings has developed from a prehistoric art form into the multi-disciplinary, highly complex coating technology of today.

### **3. Short history of paint production in Poland**

The tradition of paint production in Poland goes back to 1820. At that time, a producer of horse-drawn vehicles and carriages named Steinkeller, started to produce oil and asphalt varnishes for his own purposes. A second factory was set up by Krause in 1840 producing similar products, but this factory operated for a very short time. A company by Leppert-Karpiński in Helenówek, close to Warsaw, manufacturer of oil-based, natural resin based and asphalt paints since 1870 played a very important role in the coating industry. In 1896 Jozef Kochanowicz founded a factory in Włocławek “Nobiles”. Kujawska Fabryka Farb i Lakierów “Nobiels” was in an operation under its name until 2008, when it was taken over-by Akzo Nobel [1].

Since 1945, after the Second World War, paint production was rapidly growing; significant amount of Polish production was exported to the former USSR. Production reached its peak in 1975 with a volume of around 450 000 tons [1]. At that time, numerous new factories were founded. The biggest and most modern in planning was OLIVA, a producer of marine coatings for the entire “Soviet block”, however the investment was never finalized and Oliva never attained its nominal capacity. In the 80’s of the last century, all paint companies were state owned and most of them operated under Polifarb, a union of paint and varnish producers.

The Polifarb union consisted of following companies [1]:

- Polifarb Pilawa (nitrocellulose paints),
- Polifarb Wrocław (decorative paints),
- Polifarb Oliva (marine paints),
- Polifarb Cieszyn (industries coating and car OEM),
- Polifarb Łódź (industrial coating),
- Polifarb Kalisz (ultramarine & dry paints),
- Polifarb Dębica (industrial coating),
- Polifarb Bliżyn (pigment production),
- Polifarb Gliwice (trading).

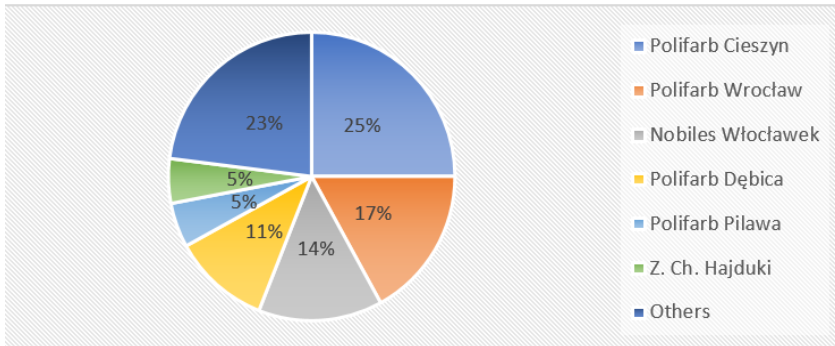
Other producers did not belong to any group but were state owned:

- Radomska Fabryka Farb i Lakierów “RAFFIL” (industrial coating and car coating),
- Kujawska Fabryka Farb “Nobiles” decorative coating and car coating),
- Zakłady Chemiczne “Baltkolor” (marine and industrial coating),
- Zakłady Chemiczne “Hajduki” (producing white paints and siccatives),
- Zakład Tworzyw i Farb “Złoty Stok” (industrial coating).

There were also three companies producing printing inks:

- Warszawska Fabryka Farb Graficznych,
- Gdańska Fabryka Farb Graficznych,
- ATRA in Toruń.

There were no private companies of major importance at that time.



**Fig. 1.** Polish paint production late 80's

*Source: Author's estimations based on historical knowledge.*

In the late 80's and beginning of 90's when the "Soviet block" began to fall apart, the first big change in Polish Paint Sector was observed. The production of paints dropped to the level of 200 000 tons in 1990 [9]. Paint producers were looking for new possibilities and new markets. The Polifarb union disintegrated and the former members of the alliance started to compete with each other. Considering the economic situation, each company entered new areas of application and started to produce a full range of products, from emulsion decorative paint to industrial coatings. Competition was especially high in the low price DIY markets, where volumes are the highest but margins are low. Companies began to have financial problems and had to dismiss many employees.

This was the time when many small paint companies were founded mainly by experts from the industry and very often located close to big state owned companies. Some information sources give a number of 600 paint companies at that time [8].

Just to mention a few of many companies that were founded in the beginning of 90's: Altax Poznań, Akwa Łódź, Anser Wiskitki, Cedar Poznań, Chemal Dębica (Śnieżka); Chemal Zgierz, Chemstal Dębica, Dorex Dorotowo, Hadrokor Włocławek, Hirsch-Pol Osielsko, Kolor Poznań (ink), Lakma Cieszyn, Malchem Chynów, Malfarb Ostrów Wielkopolski, Poly Color Szczecin, Starko Częstochowa, Topkolor Gdańsk, Wega Nieszawa. Some of them developed extremely well like Śnieżka and others like Akwa are no longer in operation.

Internal competition helped foreign competition enter the Polish market. Some of them took over existing companies and some of them decided to build their own facilities.

Kujawska Fabryka Farb i Lakierów "Nobiles" was the first one to be acquired by Akzo Nobel. It was clear that the biggest local producers were not big enough to stand up to multinational players. There was a plan to rebuild Polifarb Union: the two biggest companies, Polifarb Cieszyn and Polifarb Wrocław merged but the

merger did not serve its purpose. Subsequently they were acquired by the Sigma-Kalon group.

The following purchases took place later on: ICI purchased Polifarb Pilawa, Beckers purchased Polifarb Dębica and Tikkurila purchased Baltkolor.

Companies which could not find foreign investors were forced to restructure.

The companies that decided to set up their own organizations in Poland were Aquatic Color in Szczecin, Ashland in Miszewo, Dyrup in Łódź, Farby Kabe in Bielsko Biała, Farby Maestria in Płońsk, Feidal in Częstochowa, Jobi-Düfa in Częstochowa, and Sicpa in Warszawa (ink).

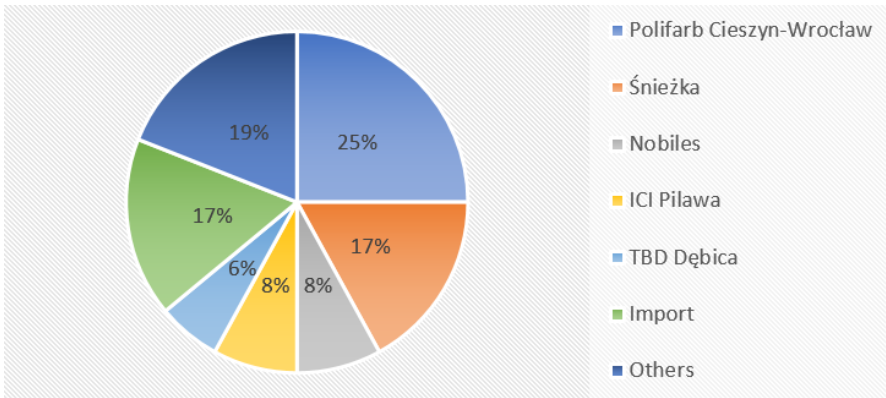
A number of specialized industrial coating and car refinish producers started to gain market share: Alma Kolor Gniew, Champion Warszawa, Haya Gorzów Wielkopolski, Multichem Luboń, Novol Komorniki, Polexpo Łódź, Pollak Siedlce, Unilack Olsztyn, Ranal Częstochowa, Troton Ząbrowo.

Next to traditional paint producers, some start-ups appeared producing facade plasters and paint and selling them locally: Atlas Łódź, Bolix Żywiec, Chemstal Borne Sulinowo, Euromix Żory, Kreisel Zgierz, Matres Revko Morzeszczyn, Sto Warsaw, Terranova Gdynia, Toraed Chemicals Jaśkowice, WEGA Żory.

It appeared that by 1999 the Polish paint market had stabilized and that it would stay that way for a longer time. Very small companies closed down operation and all foreign investments were rather clear. At that time, there were around 150 paint companies in Poland [8].

The only constant in life is change, and this is also true for coating industry. Because of new trends gaining ground at the beginning of 21<sup>st</sup> century, Polish coating industry is now undergoing further restructuring and segmentation. Expansion of the European Union back in 2004 also contributed to faster dynamics in general industrial growth in Poland and in Eastern Europe. It also created a new business environment, which contributed to further development. Polish producers gained new markets and at the same time Poland was opened up for foreign investment. The structure of paint market in Poland in 2005 is presented on figure 2.

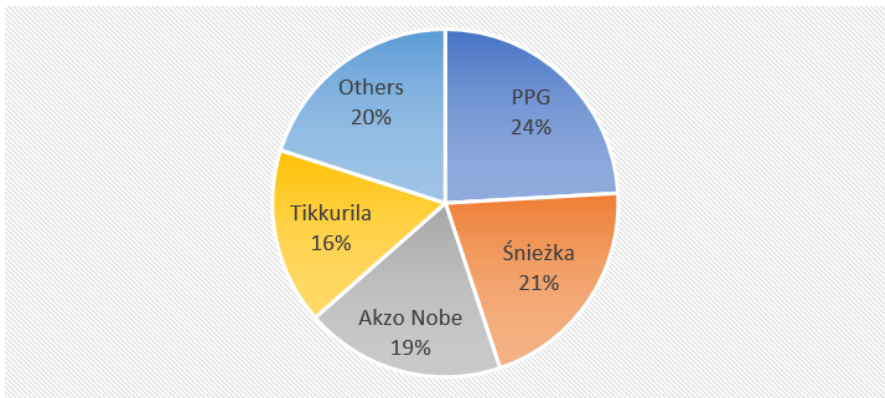




**Fig. 2.** Structure of paint market in Poland in 2006 (in terms of quantity)

Source: <http://tworzywa.com.pl/Wiadomo%C5%9Bci/Rynek-farb-i-lakier%C3%B3w-w-Polsce-2006-21623.html> (assessed 22.02.2019).

From one day to another, the competitive environment changed. Consolidation in paint and costing industry is a long-term trend, and slowly and surely this trend is materializing in the Polish paint market. In some market segments 80% is controlled by less than 8 players. This trend results in the Polish paint market being dominated by only four players – figure 3.



**Fig. 3.** Polish decorative coating market in 2015

Source: *Paint and Coating Industry Overview, HIS Chemical, April 2017 p. 117.*

In 2002 three out of five market leaders were Polish local companies and in 2015 the key four market players are multinational ones. Śnieżka operates across the region with production sites in Poland, the Ukraine, Belorussia and Hungary.

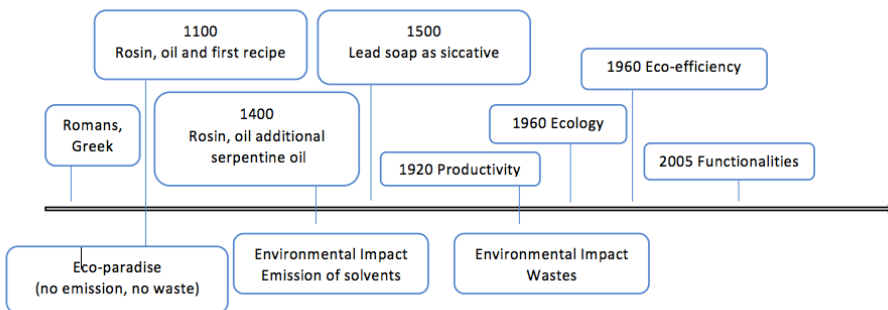


The consolidations process is a lengthy one, and it is actually preferred not only by paint producers but also by raw material suppliers and customers. It all comes down to the benefits of purchasing scale, power and production efficiencies.

#### 4. Coating technology and coating chemistry today

If professor Klonowski were alive today, he would probably have to change his periodification or rather add another period in paint techniques. He likely would also change the terminology, as coating chemistry and coating technology are more appropriate today. Current knowledge of chemistry and technological advancement are promising for further development, where limits of needs are difficult to see.

Coatings are virtually everywhere, regardless if we see them or not in our daily life, and they are following trends of new industries. Some of them are obvious, but others are hardly recognizable. The role, importance and application of coatings has changed significantly over time – figure 4. Not only are they offering aesthetic effect but also provide important functions and functionalities. This development goes hand in hand with industrial and application development.



**Fig. 4.** Paint techniques over the time

*Source: own preparation.*

In addition to market expectations and final user's needs in different segments, environmental legislations have strong influence on coating technology. The impact on paint technology is diverse. Traditional material used in paint production can be harmful for the environment and an obvious example is lead. The measures to reduce impact on the environment are driving change in coating technology. Paints with lower waste production are preferred, also high solid and water based coating are contributing to safe environment. There are a number of legislation acts that force paint producers to manufacture environmentally friendly coatings.

The subject of ecology in paint production is vast, so two current standards that are driving development of architectural coating EcoLable and Blue Engel will be mentioned here. They strongly influence and force reduction of volatile organic compounds.

A volatile organic compound (VOC) is defined by the US Environmental Protection Agency (EPA) as ‘any compound of carbon, excluding carbon monoxide, carbon dioxide, carbonic acid, metallic carbides or carbonates, and ammonium carbonate, which participates in atmospheric photochemical reactions’ [9].

The beneficial characteristics of such paints include low odor, clean air, and safer technology, as well as excellent durability and a washable finish”.

## **5. Challenges and trends for the future**

Well, what needs to be emphasized is that paint is not just decoration anymore. In the old-style understanding one will simply classify paint as a color carrier on a surface, which is missing the point. Development of different industries drive and force new properties the paints need to have. One example of recent development are conductive coating, they need to have ability of discharging all charges generated directly to ground. Especially important it is in electronic production, where in purely financial terms, electrostatic discharge causes the greatest damage to production processes for electronic equipment – meltdown or scorching of sensitive components constitutes a major problem [11].

Good example is a smart phone. 20 years ago, would you have expected it to be able to respond to your screen touch or fingerprints? Definitely not. Screen of smart phones are covered with coatings, which need to fulfill user needs. In the past it was good enough to have high gloss, stretch resistance and now we need conductivity to operate it. This would not be possible with recent development of coating technology and additives.

Paints can also be used for air purification, just need to use special additives responsible for absorbing of formaldehyde and hence clean up the air. There are much more recently developed new features, functionalities of decorative coatings.

Significant contribution for future development of raw materials for paint and varnishes production will have the achievements in materials science. The good example is Graphene. It represents a conceptually new class of materials that are only one atom thick, and, on this basis, offers new inroads into low-dimensional physics that has never ceased to surprise and continues to provide a fertile ground for applications [12]. In coating industry Graphene can improve corrosion resistance or tribological wear reduction [13].

These are only few examples of recent developments, and there are much more to come in the future. Regardless of functionalities developers will have to challenge governmental regulations and market demands:

- Low-VOC (Volatile Organic Compounds) waterborne coatings,
- High-solids solvent borne coatings,
- UV (Ultraviolet Cure)-cured coatings,
- Coatings that will save energy once applied to a surface.

Economy is also challenging and driving the development:

- Fluctuating and volatile prices of key raw materials and crude oil,
- Supply shortages/finite amount of natural resources/growing population,
- Increasingly stringent regulatory environment,
- Developing water-based coatings that have the same performance properties [6].

Depending on light intensity, walls' colour may change. You could get back home tired after a long workday and the walls could read your mood, soothing your mind with a calm, green atmosphere. But here comes the weekend and you have just impressed your guests who paid you a visit with the bright, vivid colors of your living room reflecting beats of rock music being played in the background. This is, of course, a bit of science fiction but who knows what direction all developments will take?

There is so much being discussed these days on sustainability. This is also not ignored when it comes to painting industry. Functional coatings are the future of development regardless of market segment and will be main drive of development.

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## ROZWÓJ FARB I LAKIERÓW W OBLICZU DYNAMICZNYCH ZMIAN KOŃCA POTRZEBY UŻYTKOWNIKÓW – WYZWANIA DLA PRODUCENTÓW SUROWCÓW

### Streszczenie

Rynek farb i lakierów jest jednym z najszybciej rozwijających się na świecie, głównie ze względu na ogromne zapotrzebowanie w branży budowlanej. Biorąc pod uwagę zastosowanie końcowe farb i lakierów rynek ten można podzielić na architektoniczne powłoki dekoracyjne, przemysłowe i specjalne. Największy segment z największą liczbą producentów stanowi segment dekoracyjny. Rozwój surowców do segmentu farb i lakierów dekoracyjnych musi spełniać potrzeby dzisiejszych i przyszłych użytkowników jak i wyzwań regulacyjnych oraz wyzwań ekonomicznych. Nie stanie się to bez wpływu na obecnie stosowane surowce i przyszły rozwój. Celem artykułu jest przedstawienie krótkiej historii przemysłu lakierniczego na świecie i w Polsce, wskazanie czynników napędzających obecnie ten rynek jak również wskazanie trendów istotnych w przyszłości.

**Słowa kluczowe:** farby, lakiery, rynek, surowce, potrzeby użytkowników, wpływ środowiskowy.