History of the beginnings of the plastics industry in Portugal

Maria Elvira Callapez

Received: 5 September 2020 / Accepted: 6 February 2021 / Published online: 23 April 2021
© The Author(s), under exclusive licence to Springer Nature Switzerland AG 2021

Abstract
This paper aims to present a history of plastics in Portugal. In the context of this paper, the ‘history of plastics’ means a historical approach to the evolution over time of a broad field of relationships involving plastics after their arrival in Portugal at the beginning of the twentieth century. This will include the technological and scientific developments involved in the production and adaptation of plastics in Portugal, the objects produced from plastic and the influence they had on social and cultural habits, the history of companies that started working with plastics from an early date, and the production and use of plastics. How and when did plastics, materials with such innovative features, appear in Portugal and what was their impact on society at the time, in the 1930s? How did the Portuguese plastics industry evolve from its origins and what was the path of the appropriation and adoption of techniques, and processes for plastics manufacture? These research questions will be analysed in this paper. In addition, the global historical narrative about the origins, evolution and impact of the plastics industry and their products will be briefly described.

Keywords Plastics · History · Portuguese industry · SIPE · Nobre & Silva

Introduction

Plastics were introduced in Portugal in the 1930s, when the plastics industry was still a developing industry, despite having already been established in the most industrially advanced countries. At this point in time Portugal was a country with very little chemical and technological research, where agriculture was the dominant area of production. The national industry had neither skilled labourers nor technicians, nor adequate machinery and equipment, which could have supported the improvement or development of manufacturing techniques.

Also revealing of this serious problem are the figures presented in Table 1, on illiteracy rates for people over 6–7 years old, between 1890 and 1970. These figures leave no room for doubt and justify the so-called Portuguese cultural backwardness. However, over the period shown in Table 1, there is a decrease in illiteracy rates. This is due, on the one hand, to the decrease in school requirements, which translates into a reduction in compulsory education and a simplification of programmes; on the other hand, industrialization and economic growth in the post-World War II period, which required the Estado Novo, a government regime, to start considering school as an “instrument for training human resources” [2]. However, despite this evolution, in the early 1950s, Portugal ranked last among European countries [3]. The State itself recognized this situation of cultural backwardness. Leite Pinto [4], Minister of National Education between 1955 and 1961, denounces, during his mandate, Portugal’s deplorable backwardness concerning Western countries that have already built a world of abundance, referring to it being “evident that from the dams to the switches of the electric lamps it is necessary to have a range of specialized and competent technicians. Training the diversified workforce that the technique requires, training specialists qualified to design, guide, and maintain the machines, and training researchers prepared to activate the School, through research, are urgent tasks” [5]. The Portuguese plastics industry began in the mid-1930s, with two factories, the Sociedade Industrial de Produtos Eléctricos (SIPE) and Nobre & Silva, and has not only emerged as one of the main areas of national economic development today
but also acted as an agent of social, cultural, artistic and urban change.

Well-known to North Americans and film buffs, the phrase “Just one word: plastics”, from the film *The Graduate*, 1968, shows the importance of plastics, when Dustin Hoffman, newly graduated, shy and inexperienced, receives the advice of a business friend for his future career: “I just want to say one word to you. Just one word... Plastics... There’s a great future in plastics” (Fig. 1).

For our purposes, plastic is considered an organic material capable of deforming under the action of temperature and an external force and of conserving that deformation after these agents cease to act. Plastics are polymers, macromolecules, made up of smaller molecules, called monomers that establish chemical bonds with each other, usually through condensation reactions or additional polymerization [6]. Plastics, synthetic polymers, considered by historians as important agents of cultural change, are undeniably part of our modern lives, being present in society, in the global economy and in the evolution of the planet. It appears that throughout history and according to different contexts, “plastics” have assumed various meanings, from an initial definition connected with philosophical/religious aspects in ancient Greece—as the ability of a material like the human soul to be shaped[7]—to the current concept of “new materials”, associated with “high-tech”. Although plastics are associated with modernity, high technology and mark an increasingly visible presence in the current material world, before the existence of these materials, which today we call “plastics”, the word “plastic” was already known, being attributed to the Greek word, plastikós. The word acquired several meanings over time, starting to represent something that could be shaped, regardless of its nature. As its properties and physical–chemical character were further understood, the meaning was modified until it reached the definition currently accepted in academic and industrial circles. In 1951, the word “plastics” was formally adopted by the British Plastics Federation and the British Standards Institute [8].

“Plastics”, responsible for profound changes in our lives, represent not only scientific, technological innovation but also social, cultural, and economic influences, and awaken the most varied feelings, enjoying great popularity as well as antipathy in some quarters [9]. Since the 1950s, the production of plastics has increased exponentially (Fig. 1).

### Table 1
Illiteracy rates (%) (over 7 years old) [1]

| Year | Illiteracy Rate (%) |
|------|---------------------|
| 1890 | 75.9                |
| 1900 | 74.5                |
| 1911 | 70.3                |
| 1920 | 66.2                |
| 1930 | 61.8                |
| 1940 | 49                  |
| 1950 | 40.4                |
| 1960 | 32.1                |
| 1970 | 26.6                |

Fig. 1 Historical evolution of plastics production. Reproduced by kind permission of Statista © 2019 Statista

© Springer
Plastics have recently gained a poor reputation, particularly with regard to packaging waste and environmental pollution. Their mass production has resulted in growing environmental concerns due to inadequate waste disposal, ubiquitous distribution and slow degradation rates (centuries). According to Tony Steels, the CEO of packaging machinery and automation solution provider Mpac Group, “When you really start to analyse where the problem lies with plastics, you find that it is the way we use them. Too often we do not recycle and reuse plastics, we let these materials fall out of the supply chain and that is where the issues begin. So, the solution is not for us all to stop using plastic—but for us all to start using plastics properly” [10].

Legal measures came into being and the European Union legislation limiting plastics started in the late 1960s and has never stopped. Recently, the European Strategy on Plastics was announced and a new directive is being prepared to ban single-use plastic products, such as disposable tableware, cutlery, etc. Strategies for plastics, such as that adopted by The Ellen MacArthur Foundation, have been applied to help European businesses and consumers to use resources in a more sustainable way. The Ellen MacArthur Foundation has published a series of reports on the environmental implications of plastics and how to profit economically from them, such as The New Plastics Economy: Rethinking the Future of Plastics and Catalysing Action, issued in December 2017 [11].

Plastics are unique materials, with unusual properties and characteristics that penetrate our daily lives in the most diverse forms and functions (Fig. 2). Plastics are now present everywhere and their volume of global production in 1979 surpassed that of steel, the symbol of the industrial revolution [12].

Hence the adoption of plastics, following in the steps of stone, bronze, iron and steel, gradually achieved the appellations of the “Plastics Era”, “Plastics Age” and “Plastics Revolution”. These are repeated in numerous publications and contexts, and we can safely say that we live in the era of polymeric synthetic materials, often just called “plastics”. We only need to look at ourselves, at what we wear, at what we eat, at the objects we use in our daily lives, at home or at work, to understand that these titles are justified.

Although relatively young, the plastics industry has reached such a degree of maturity that it has already largely emancipated itself from the chemical industry and reached a respectable stature of its own. Plastics demonstrate the magic of polymer chemistry and engineering that makes it possible to transform substances into products with tailor-made properties for different and specific uses. There will be many new paths for these new materials with great potential for more discoveries and innovations [14].

Why and how did plastics come about? What were the motivations behind their production?

Since ancient times man has been moulding natural organic polymers. However, many of the end products were too fragile for certain intended applications [15]. To obtain stronger materials, people used metals, ceramics, wood, stone and glass. Until the mid-nineteenth century, the most common everyday items (combs, buttons, containers, decorative objects and jewellery) were often made from natural products, such as horn, ivory hair, shells,

Fig. 2 Popular plastic items [13]. Photo by Anna Laganà. © 2020 J. Paul Getty Trust
tortoiseshell and amber [16]. Over the centuries, man has taken advantage of the natural plasticity of certain products such as natural rubber. These natural polymers could not be obtained industrially by chemical synthesis, so they had very limited applications, since they existed in relatively small quantities and were often too expensive. This situation encouraged the development of new materials at lower costs, more generally available than traditional ones and in larger quantities. Sometimes there were also problems with their uses and attempts were made to improve their properties. Thus, semi-synthetic plastics, such as vulcanite, Parkesine, Celluloid, casein and cellulose acetate, appeared. Many techniques traditionally used to manufacture horn objects, such as heat moulding simple objects, were later adapted to semi-synthetic plastics.

The need to find new and cheaper materials led Alexander Parkes, a British chemist, metallurgist and inventor to carry out experiments in the 1850s, producing a material based on cellulose nitrate, a semi-synthetic plastic, which he trade named Parkesine [17]. This product would be commercially successful only 20 years after its discovery. However, it is considered that the birth of the modern plastics industry dates back to 1862, the year in which, at the International Exhibition in London, Alexander Parkes exhibited some objects made of Parkesine, namely medallions, combs, buttons, trays, knife handles, pens, boxes and bindings (Fig. 3).

However, in the field of semi-synthetics, the most famous example is that of the North American John Wesley Hyatt who “developed”, in 1870, Celluloid, a semi-synthetic, resulting from a chemical modification of cellulose (Fig. 4) [19].

This semi-synthetic plastic “replaced” the increasingly rare and expensive ivory used in the manufacture of billiard balls and quickly Celluloid articles began to be appreciated and used by a wide range of people during the Victorian era (Fig. 5).

Celluloid, despite having found numerous applications, was flammable. An unforgettable memory for many is the sad image of the ferocious flames of a fire, resulting from the Celluloid film bursting into flames, and shown in the 1988 film, Cinema Paradiso, produced by Giuseppe Tornatore. Celluloid, according to American historian Robert Friedel, became successful through its links with the emerging film industry, as well as through its application in products like billiard balls and use in novelty goods such as hatpins and letter openers. Such consumer items became available to a large audience for the first time [21]. After Celluloid, the great plastics discovery was Bakelite, patented in 1909.

**Bakelite: the first synthetic plastic**

The synthetic plastics industry started on June 19, 1907, when Leo Hendrik Baekeland (1863–1944) (Fig. 6), a North American chemist of Belgian origin (who resigned from a university career in Ghent, to dedicate himself to industry in the USA) synthesized Bakelite, the first plastic produced entirely from synthetic materials, made by man, through a condensation reaction between phenol and formaldehyde [22] (Figs. 7, 8, 9). Like many others, Baekeland was looking for a replacement for shellac, an expensive and highly sought-after material used for lacquer on quality goods.

Even before Baekeland, other chemists had tried this reaction but obtained hard substances, difficult to mould and therefore of little use [23]. However, unlike his predecessors, Baekeland realised that by imposing specific temperature and pressure conditions, he was able to control the hardness of these phenolic resins and therefore mould them. It was as a result of his long systematic research work that he obtained a mouldable, insoluble and infusible resin—Bakelite, with good electrical, thermal and insulating properties, and with commercial potential, immediately finding numerous applications, particularly in the electrical, telecommunications, automobile and radio industries. Baekeland is considered to be key in the foundation of the synthetic plastics industry and the first successful entrepreneur in this industry [24].

This easily mouldable and economical material has become widely used in the electrical and radio industries. In fact, Bakelite has become synonymous with the modern style because the products to which it was linked (radios, for example) have themselves become icons of modern design (Fig. 10).

In the 1930s, plastics began to be seen by designers and consumers as modern materials par excellence, imbued with something that could not, in the final analysis, be described, but were tacitly seen as representative of modern life (Fig. 11).

Following the appearance of Bakelite and other thermosets in the 1920s, the 1930s and post-World War II period the widespread growth and development of new plastics, namely thermoplastics such as nylon, polystyrene, polyvinyl chloride, polyethylene, acrylics and polyesters, were witnessed. After 1945, these materials gradually replaced the thermosetting materials which had been dominant from 1910 onwards [25]. These materials thus acquired maturity and independence and are no longer seen as ersatz, trivial, second-rate, inferior, replacement, imitation materials and have often proven to be the best for specific purposes, superseding traditional materials such as glass, wood, metals, stone and ceramics in many applications for reasons of both ease of manufacture and competitive costs.
Fig. 3  Diploma accompanying the medal awarded to Alexander Parkes for the discovery of Parkesine, presented at the International Exhibition in 1862, London, reproduced in Imperial Chemical Industries Limited—Plastics Division (1962) Landmarks of the Plastics Industry. The Kynoch Press, England, Birmingham, back of first cover [18].
Fig. 4  John Wesley Hyatt’s Celluloid billiard ball [20]. National Museum of American History, Smithsonian Institution. Photo by NMAH, Smithsonian Institution

Fig. 5  Advertisement card for Celluloid collars, cuffs and shirt bosoms. National Museum of American History collection, Smithsonian Institution
Paradoxically or not, plastics can hardly be easily discounted because more and more scientific and technological innovations allow the development of new plastics, new processes and new applications with the desired characteristics and at an extraordinary rate. Plastics are now indispensable in our modern daily lives and manufactured in abundance since the middle of the twentieth century. They are diversifying and massifying, having replaced a series of traditional materials, with evident advantages. Their usefulness and versatility mark their place in the history of the technological and material revolution.

**Emergence of Portuguese plastics**

The plastics industry in Portugal was born and developed during the Oliveira Salazar regime, a dictatorship under which the State was responsible for directing and regulating the country’s economic and social activity. António de Oliveira Salazar was the prime minister of Portugal for 36 years (1933–1968) of a dictatorial government called Estado Novo. Salazar’s dictatorship was continued by his successor, Marcelo Caetano, until the Carnation Revolution of 1974 [26].

One of the measures of the industrial policy of the Estado Novo consisted of the regime of industrial constraint, formally installed in 1931. As was the case with all industries, the plastics processing industry was also subject to that stringent measure, until 1947 [27]. According to the regime of industrial constraint, informally implemented in 1926, the establishment of any new industry and its location, the enlargement of industrial premises, the acquisition or replacement of equipment and machinery, and the trade

---

**Fig. 6** Leo Hendrik Baekeland (1863–1944). Source: Hugh Karraker’s Archive, New York. Reproduced by kind permission of Hugh Karraker

**Fig. 7** Leo H. Baekeland at his laboratory. Bakelite Temporary Exhibition, Kunsthall Museum, Rotterdam, Feb. 2017 (Photo ME Callapez). Reproduced by permission of Kunsthall Museum, Director Eva van Diggelen
of industrial goods had to be sanctioned by the central government. This policy, which allegedly aimed at protecting Portuguese industry, had perverse consequences, because only well-established industrialists with good connections were protected from competitors. Those who intended to start their business had to battle through a harsh bureaucracy, often with no success [28].

The Portuguese plastics industry was developed in this environment, and its emergence is associated with two direct causes: on the one hand plastics were increasingly required by the electrical industry, and on the other, it was necessary to respond to the basic needs of the population arising from a political measure that forbade people to enter towns and villages barefoot. Two companies closely associated with the response to these needs pioneered the transformation and manufacture of plastics in Portugal: The Industrial Society of Electrical Products, SIPE (Sociedade Industrial de Produtos Eléctricos) and the firm Nobre & Silva [29]. Hence it was in the mid-1930s, with this background, that these two companies ushered in the era of plastic products to Portugal.

The Industrial Society of Electrical Products (Sociedade Industrial de Produtos Eléctricos, SIPE)

The Industrial Society of Electrical Products (SIPE) pioneered plastics in Portugal. This plant was founded in 1935, in Dafundo, by João Cândido Barbosa Corsino (J. B. Corsino), an engineer and professor at the Instituto Superior Técnico [30, 31]. It started its activity in the production of...
plastic materials, specifically Bakelite (phenolic plastics), for the manufacture of electrical articles. For the production of its plastics goods, the factory synthesized the polymer itself, and imported, from England, the raw material used in the synthesis of Bakelite, in particular phenolic acid, urea and urotropin. SIPE also imported anilines from abroad to give various colours to Bakelite. Other colours were extracted from metal oxides, which were already available in Portugal [32]. SIPE’s manufacturing programme included, in addition to the synthesis of Bakelite, the preparation of moulding powders and the manufacture of moulded low voltage electrical equipment and other items.

From 1936 onward, large electric presses were used for the moulding of Bakelite, in articles with different shapes and applications, and using various dyes [33]. The installation of this factory was an initiative which had great

Fig. 11 Modern Bakelite materials. The rods are phenolic resinoid, about 4-foot long, in the workshop of NYC jeweller, Jorge Caicedo. The rods are sliced like cookies to make buttons or parts of larger pieces. Source: Testimony of Hugh Karraker (great-grandson of Baekeland) and https://allthingsbakelite.com/. Reproduced by kind permission of Hugh Karraker

Fig. 12 Announcement of SIPE, in 1958 [36]. Reproduced by permission of the Associação Industrial Portuguesa (AIP), CEO Rui Madaleno
economic repercussions in the electricity sector, as Bakelite had advantages over porcelain, which until then had been the material used in those factories. This new raw material and the manufacturing process not only allowed the production of high-quality articles but also the possibility of obtaining greater production at a lower cost. SIPE acquired a prominent position in Portuguese industry, moving from a small workshop installed “on the ground floor of a building that was neither owned nor suitable for an industry” [34] to a large enterprise which became the leader in the production of small electrical apparatus, the first unit of its kind then assembled, not only in Portugal but in the Iberian peninsula itself [35] (Fig. 12).

Only 3 years after SIPE was set up it was considered that Portugal, owing to this company, could already be proud to produce articles of Bakelite that were identical in price and quality to those produced by foreign competitors [37].

The firm ‘Nobre & Silva’

At the origin of the plastics processing industry in Portugal, in addition to meeting the needs of the electrical industry, there was also a legal requirement that forced the population to wear shoes. It all started, in the 1930s, in Leiria, a coastal region “with large sandy areas and pine groves in the sand” [38] where the population “maintained the beach habitats in the countryside, and there were no arguments to convince them to put on shoes” [39]. The rural populations, poor, without land, without money and fleeing the poverty of the fields, went to the city councils to ask for work and bread (Fig. 13). Then, the city council issued an edict prohibiting people entering villages barefoot.

The population, who were mostly rural, poor, without resources and on low wages, had no choice but to buy
cheaper shoes. A pair of grey cloth espadrilles appeared to be an ideal option [40]. This is the background to the beginning of the firm Nobre & Silva, which is now defunct. At present, part of the premises of Nobre & Silva, is a Chinese store (Fig. 14).

José Nobre Marques and José Lúcio da Silva, two Banco Nacional Ultramarino bank employees, spent their spare time manufacturing espadrilles, destined for the less prosperous classes, while having only one store and one machine [41]. In 1927, they formed a commercial company called Nobre & Silva to manufacture and market espadrilles and slippers [42]. Information on the type of material used by the company to manufacture the espadrille soles appears in 1929, in an advertisement and again in the newspaper O Mensageiro, with the following text: “Factory of espadrilles and slippers with rubber soles—sewn inside” (Fig. 15) [43].

When Nobre & Silva began their production, the soles of the espadrilles were made of jute. In 1928, these entrepreneurs moved to Spain, where the industry was also new. In a factory in Mahon (Balears) they collected the information necessary to start the manufacture of espadrilles with rubber soles in Portugal. They then changed the technique for making espadrilles by replacing jute with rubber [45]. This was obtained by using waste, specifically rubber from crushed tyres [46]. The use of these as the main raw material used in the manufacture of these articles brought an advantage, namely the lower price at which espadrilles were offered for sale. In the early 1930s, the poor classes started to rely on this new type of footwear, cloth espadrilles with rubber soles and later canvas with rubber soles. The espadrilles industry, created for consumers with lower incomes, was therefore seen as “a friendly industry and well worthy of protection from the public and government” [47].

José Hermano Saraiva adds that an espadrille manufacturer, whom he calls the founder of plastics from Leiria, visiting Lisbon, saw a new system for closing bottles: the black Bakelite stopper. He went to Barcelona, obtained equipment and, in an addition to manufacturing espadrilles, the first plastics factory appeared in Leiria to produce stoppers and other goods. According to Fernando Costa, it was José Lúcio da Silva who, during a visit to Lisbon, found a Catalan who spoke to him about Bakelite [48]. Hence Nobre & Silva, around 1936, diversified its range of products and started its activities in the plastics industry. This company, whose first plastic items were stoppers, lids and ashtrays, was particularly dedicated to manufacturing a series of products such as household and industrial articles, packaging for medicinal products, various containers, plastics for agriculture, tubes and profiles, articles for the electronics and telecommunications industries, civil construction and polyethylene laminating on paper and canvas for the final consumer. As in the case of espadrilles, we found for the first time, in early 1942, the articles of Bakelite, produced by that company, announced in the newspaper O Mensageiro: “Nobre & Silva, Lda—Fábrica de Espadrilles and Articles of Bakelite” [49].

Unlike SIPE, Bakelite was not synthesized by Nobre & Silva who bought it from representatives of foreign manufacturers or imported it directly from Spain and the USA [50].

The firm Nobre & Silva continued to develop the production of Bakelite articles and plastic materials derived from casein, milk or other cellulosic, of national origin. Before the end of World War II, in addition to the moulding and finishing workshops for plastic materials, the company also had a moulding section for its own use, which gave the team the opportunity to learn about and perfect various technologies needed to develop this emerging industry. The first technique for processing plastic materials that Nobre & Silva employed was compression moulding. Their first equipment was simple machinery, the operation of which depended almost entirely on manual labour. This factory unit owned the first license to install, in Portugal, extrusion, one of the main techniques of the plastics processing industry [51]. It is also possible that Nobre & Silva were responsible for introducing injection moulding into Portugal in 1946 [52].

As a result of disagreements with the City Council of Leiria, the firm Nobre & Silva moved, in 1945, with its sections for producing espadrilles, plastic materials and its
moulding and finishing workshops, to Venda Nova—Amar- dor, as in Leiria they had not been given the necessary conditions for their work [53]. According to José Hermano Saraiva, the firm “thought that, since it was intended for industry, they should sell the kilowatt of energy at a reduced rate; in the Chamber it was understood… whoever wants luxuries, pays for them, and being an industrialist was… something that should only exist in the Americas” [54]. This quotation reveals the fear that existed in 1945, about the development of this new industry, because at this time in Portugal being an industrialist was considered a luxury, and it was thought necessary to put a brake on the industrial growth of those who had become aware that industry was a necessary factor for the economic development of any country.

In 1945, Nobre & Silva arrived in Venda Nova—Amar dor, a region that had a concentration of many industries in the 1940s [55]. This company was one of the first generation of factories in this industrial park [56], and started with the production of domestic articles and toys, and later on producing articles mostly for industrial use, predominantly for packaging. The company specialized in injection, blow moulding, extrusion, compression and rolling processes. Its production range became quite varied, including articles for domestic and industrial use, technical parts, packaging for medicinal products, various containers, plastics for agriculture, tubes and profiles, articles for the electronics and telecommunications industries, civil construction and lamination of polyethylene onto paper and canvas.

**Growth of the Portuguese plastics industry**

When looking at the history of Portuguese plastics in the 1930s, it is worth noting the novelty and the phased introduction to the market of new goods. In addition to SIPE and Nobre & Silva, the first plastics factories were predominantly run by families. They functioned as small workshops and produced plastic objects such as toys, flowers, corks, slippers and covers. Artificial flowers and toys were the first objects to be manufactured in the country for popular consumption. Toys made of traditional materials such as wood, tin and tinplate gave way to plastic toys, initially made of Celluloid. In the 1940s, new industrial units were built exclusively for the production of plastics. These were dedicated to the manufacture of a variety of articles in Bakelite, Galalith [57], Celestilite [58] and in synthetic thermoplastic materials [59] (Mipolam, Astralon and Trolitul). Among the articles produced, there were belts for women and objects for domestic, personal, travel, cosmetic, decorative and toiletry use.

The nearby town of Marinha Grande (located on the coast of central Portugal, in the district of Leiria) became linked to this new industry owing to its existing glass industry, with a centuries-old tradition. In 1929, Aires Roque founded a glass-moulding industry [60] and expanded it, together with his brother Aníbal H. Abrantes. In 1936, inspired by the success of the moulding industry and the appearance of Bakelite in Portugal, Aníbal H. Abrantes manufactured moulds...
for plastics in Marinha Grande [61]. The transformational plastics industry grew in Leiria under the influence of the glass industry whose earlier moulding technology would also be used for plastics. In summary, the techniques used in glass moulding naturally evolved into those used for plastic moulds.

The geographical location of Leiria also contributed to the development and concentration of the plastics industry in the region [62], being “historically a crossing region that connects the North to the South, where the population and the industries are concentrated, dividing the country in two distinct theoretical sets: the coast and the interior” [63]. Most of the country’s industrial activity is located on the coastal strip that stretches from Braga to Setúbal, the region where Leiria is located (Fig. 16) [64].

During World War II, attempts were made to set up new firms for the manufacture of plastics. Probably, aware of the possibilities that plastic materials could provide an increase in economy in the future, companies that produced articles in traditional materials also opted for the manufacture of plastics instead. Examples of such firms were J. B. Corsino, Empresa Electro Cerâmica, and Standard Eléctrica, which produced electrical material for low and high voltage, telephone, telegraphic, radiotelephonic, radiotelegraphic material, transformers and rectifiers in Bakelite [65].

The company Baquelite Liz was also founded in 1946, in Gândara dos Olivais, Leiria (Fig. 17) [66].

Baquelite Liz is still located in the same place. From its beginning until 1949 it was a small company, with three to four employees and two manual machines. The company used phenolic resins as raw materials and compression moulding as a manufacturing technique. Its production range was extended to toys, combs, and office supplies, also in Bakelite. Today, it produces hoses, tubes, boxes for agriculture and for transporting glass and packaging for beverages from PVC.

The company Matérias Plásticas was also founded in the region of Leiria in the 1940s [67] and would come to occupy a prominent position in the Portuguese plastics market, although with less publicity than the firms Nobre & Silva and Baquelite Liz. At the end of the 1960s, a study [68] carried out by the French National Foreign Trade Centre on the Portuguese plastics industry highlighted four companies, namely Nobre & Silva, Baquelite Liz, Matérias Plásticas and Plásticos de Santo António (Figs. 18, 19) [69], the last of which is still established in Leiria, and the factories Fábrica Hércules and Luso Celuloide de Henriques & Irmão based in Espinho, classifying
them as belonging to the group of large Portuguese companies, owing to the diversity of manufactured products, good equipment and dynamism. Other companies such as Ruanos Lda, Plasgal, Faplana, Plastidom, Sival and Edmar were established in the district of Leiria around the same time.

Although the Portuguese plastics industry had developed since the mid-1930s, it made the most significant progress after World War II. The end of the war coincided with a greater development of this industry worldwide. It was also at that time that the first injection machines for moulding plastic materials were introduced into Portugal [70].

As was the case in the rest of the world, an environment more favourable to the development of the plastics industry was created, so that it was able to develop more rapidly with the installation of several specialized production centres. The arrival in Portugal of imported plastic goods, with varied characteristics and applications, contributed to this growth, as did the increased acceptance of these articles by consumers. Thanks to the relatively low prices at which they were sold to the public, plastic products became popular among the poorer classes, fulfilling some of their needs.

The plastic articles produced in Portugal were presented to the general public for the first time in 1949, when the Portuguese Industrial Association (PIA) organized the first Industry Fair. The presence of this new industry had now gained the appreciation of the PIA, which took the opportunity to show and value Portuguese industrial progress in the production of plastics [71]. The exhibitors included some of the companies already described and are shown in Table 2.

In the 1950s, when polyethylene bowls and buckets appeared, housewives began to display coloured plastic bowls in their kitchens instead of the old, grey, zinc mugs.

The washerwomen’s wooden sinks gradually disappeared from the backyards, and were replaced by light, pleasant-looking plastic basins. From then on, utilitarian plastic objects became commonplace in the daily life of the Portuguese. Among these articles were highlights such as crockery, cutlery, combs, hairpins, toiletries, buttons, boxes and containers (Fig. 20).

Plastic materials gradually had more and more applications in the industrial field, benefitting the Portuguese national economy in several ways. They began to be used as raw materials in the manufacture of products that were in common use, advantageously replacing the use of natural raw materials that generally came from abroad and at a higher cost. Plastics contributed to the improvement and cost-effectiveness of certain products when they were used instead of traditional materials in paints and varnishes, canvas synthetic textile, paper or cork supports; films for making waterproof clothing; tubes and profiles and laminates; electrical materials and various coatings. Plastics, in the form of resin or glue, also served as auxiliary elements in the manufacture of various products, namely as binders for cork and wood agglomerates, and in the bonding of plywood.

Table 2 Exhibitors of plastic articles at the first Industry Fair, in 1949 [72]

| Companies                          | Items                                                      |
|------------------------------------|------------------------------------------------------------|
| Empresa Electro Cerâmica           | Insulators, tube rods of different size                     |
| J.B.Corsino                        | Switches, sockets, telephone plugs etc.                     |
| Nobre & Silva, Lda                 | Various articles: tubes, toys, beach and camping items [73] |
| SIPE                               | Stoppers, electrical and office supplies etc.               |
| Sociedade União de Indústrias de Lacticínios, Lda | Milk-derived plastics such as buttons, combs, office supplies etc. |
| Standard Eléctrica                 | Rectifiers, telephone switches, radio gramophones etc.     |
Final remarks

Leo Hendrik Baekeland carried out the heat and pressure reaction that would revolutionize the industrial world [74]. Plastics have historically been seen as a miraculous material [75] and considered an exceptional example of engineering, even reaching the unique status of a material perceived as indispensable to the modern lifestyle. However, latterly there has been strong negative reaction with regard to plastic waste contaminating the oceans, as David Attenborough highlighted in the Blue Planet II series [76]. The diversity of plastics and other polymers and the versatility of their properties have facilitated the production of a wide range of products with numerous social benefits. Plastics are everywhere, we take them for granted, and they have helped to improve living standards, hygiene and nutrition worldwide, especially in developing countries. Their presence in sectors as important as medicine (human tissues, organ transplants), transport (ultralight cars and aircraft), construction (insulation) and food preservation (smart packaging that monitors food content for signs of deterioration) indicates that plastic will play an increasingly significant role in our lives in the future. The European Commission proposed on May 2018 new EU-wide rules to target the 10 single-use plastic products [77] most often found on Europe’s beaches and seas, as well as lost and abandoned fishing gear. Together these “constitute 70% of all marine litter items” [78]. Portugal will ban them by 2021 and more prohibitions will follow. The transformative plastics industry in Portugal reached a considerable degree of development during the Estado Novo (Second Republic), particularly after World War II, as was also the case in the more industrialized countries. After a period of initial resistance, these new materials were completely adopted by Portuguese society, as had also happened elsewhere as plastics began to be used to make affordable products for mass consumption. In response to the success achieved and widespread consumption, there was a significant increase in the number of industrial establishments, from 2 in 1937 to 34 in 1947, reaching 45 in 1956. It should be noted that when Portuguese companies started their businesses, the first steps of the country’s industrialization were taking place which may explain why their technological strategies were merely adaptive and imitative rather than innovative.

Acknowledgements I would like to thank the anonymous referees and the editors for their helpful, meticulous, and accurate comments and suggestions.

Declarations

Conflict of interest The author declares no conflict of interest.

References

1. Rosas F, Brito JMB (1996) Dicionário de História do Estado Novo, vol 1. Círculo de Leitores, Lisboa, p 303
2. Rosas F, Brito JMB, reference no. 1, p 47
3. UNESCO statistics (World Survey of Education), 1950, cited in reference no. 1, p 304
4. Francisco de Paula Leite Pinto was Minister of National Education between July 1955 and May 1961. About his biography, cf. Rosas F. Brito JMB, reference no. 1, vol. 2, p 730 and Agudo FRD (1998) «Ciência», in Vitor Wladimiro Ferreira (coord.), Portugal 45–95 nas Artes nas Letras e nas Ideias, Centro Nacional de Cultura, Lisboa, pp 231–32
5. Carvalho R (1986) História do Ensino em Portugal - Desde a Fundação da Nacionalidade até ao Fim do Regime de Salazar-Caetano. Fundação Calouste Gulbenkian, Lisboa, p 794
6. Callapez ME (2000) Plásticos em Portugal—A Origem da Indústria Transformadora. Ed. Estampa, Lisboa, p 20
7. Mossman STI, Morris PTF (1994) The development of plastics. The Royal Society of Chemistry, Cambridge, pp 2–3
8. Mossman STI, Morris PTF, reference no. 7, p 3
9. Freinkel S (2011) Plastic: a toxic love story. Houghton Mifflin Harcourt, Boston
10. Plastics in packaging here to stay, says packaging solution provider. https://www.plasticsneweurope.com/news/plastics-packaging-here-stay-says-packaging-solution-provider#adunit_path=opinion/view-point. Accessed 12 July 2019
11. The Ellen MacArthur Foundation was launched in 2010 to accelerate the transition to a circular economy: www.newplasticseconomy.org. Accessed 20 Dec 2019
12. Mossman STI, Morris PTF, reference no. 7, p 3
13. Plastic makes perfect: exploring a modern material. http://blogs.getty.edu/tris/plastic-makes-perfect-exploring-a-modern-material/. https://creativecommons.org/licenses/by/4.0/. Accessed 4 June 2020
14. Newman TR (1965) Plastics: an infant in art. Art Educ 18:24
15. Newman TR (1965) Plastics: an infant in art. Art Educ 18:24
16. These products contain the fibrous protein keratin, a polymer with a high sulfur content, insoluble and relatively inert to chemical solvents. They could thus be moulded into various shapes, after being heated in hot water and cooled to room temperature. Seymour R, Kauffman G (1992) The rise and fall of celluloid. Journal Chem Educ 69:311
17. Friedel R (1983) Pioneer Plastic: The Making and Selling of Celluloid. University of Wisconsin Press, London (Melkde JL 1995) American plastic: a cultural history. Rutgers University Press, Nova Brunswick/Nova Jersey and Mossman STI, Morris PTF, reference no. 7.
18. Imperial Chemical Industries Limited - Plastics Division (1962) Landmarks of the plastics industry. The Kynoch Press, Birmingham, Back of first cover
19. As early as 1862, the Englishman Alexander Parkes had synthesized Parkesine, also a semi-synthetic one, derived from cellulose, but with less reliable properties than Celluloid. Callapez ME, reference no. 6
20. Madden AECCO, Cobb PT, DePriest KC et al (2017) The age of plastic: ingenuity and responsibility. Smithsonian Institution Scholarly Press, Washington, p 7
21. Friedel R, reference no. 17
22. Bakelite is a thermoset or thermostable. Thermosets are polymers that harden during their manufacturing process and hot moulding. They solidify forming a solid and stable body, which prevents their subsequent reuse. Therefore, they cannot be transformed again, i.e. softened and moulded. In use, they are hard and rigid and decompose when heated above a certain temperature. Examples: urea-formaldehyde resin, epoxy resins and some polyesters
23. Before the discovery of Baekeland, chemists, such as Sir James Swinburne, Adolf von Baeyer, Werner Kleeberg and Adolf Luft, among others, produced hard, viscous masses through the reaction of phenol with formaldehyde, but they never realised the potential of these products. Mossman STI, Morris PTF, reference no. 7, p 26
24. Mossman STI, Morris PTF, reference no. 7, pp. 8, 26
25. These materials belong to the category of thermoplastics—polymers hard at room temperature, but soft and flexible at high temperatures. Thus, they can be moulded plastically as many times as necessary, returning to the solid state after being cooled. Examples: polyethylene, polystyrene, polypropene, polyvinyl chloride (PVC), acrylics and nylon (polyamides)
26. Rosas F (1994) In: Matosso J (ed): O Estado Novo (1926–1974). Ed. Estampa, Lisboa
27. Callapez ME (2002) In: Braun, JJ, Herlea, A (eds) Materials: research, development and applications, Brepols, Liège
28. Callapez ME (2002), reference no. 27, p 139
29. Callapez ME (2002), reference no. 27
30. Anonymous (1967) A SIPE e a Sua Fábrica na Vanguarda Europeia - Dos mais Acreditados Produtores da Pequena Aparelhamagem Elétrica. Indústria Portuguesa 40:312
31. João Barbosa Corsino (1895–1963), engineer and professor at the Instituto Superior Técnico, was considered a prominent figure in Portuguese industry having been the pioneer and driver of the electrical equipment industry in Portugal. Custódio J (1996) Recenseamento e Estudo Sumário do Parque Industrial da Venda Nova. Câmara Municipal da Amadora: Amadora, p 165
32. Anonymous (1939) O Fabrico da Baquelite em Portugal. O Jornal do Comércio e das Colónias, 7 January, pp 4, 8
33. Anonymous (1939) O Fabrico da Baquelite em Portugal. O Jornal do Comércio e das Colónias, 7 January, reference no. 32
34. Anonymous (1967) A SIPE e a Sua Fábrica na Vanguarda Europeia..., reference no. 30, p 312
35. Anonymous (1967) J. B. Corsino, Lda. - A Fábrica montada pelo Pioneiro em Portugal da Pequena Aparelhamagem em Matéria Plástica. Indústria Portuguesa, 40: 301. In 1955, the administration of SIPE acquired land in Carcavelos where the factory, offices and warehouses were installed. A SIPE e a Sua Fábrica na Vanguarda Europeia..., reference no. 30, p 312
36. Anonymous (1958) Indústria Portuguesa, 370:XXI
37. O Fabrico da Baquelite em Portugal, reference no. 32, p 4
38. Saraiva JH, Barros J (eds) (1986) In: O Tempo e a Alma: Itinerário Portugalês. Círculo de Leitores, Lisboa, p. 140. Liga Portuguesa de Profilaxia Social (1956) O Pé Descalço – Uma Vergonha Nacional que Urge Extinguir. Imprensa Social, Porto, p 5
39. Saraiva JH, Barros J (eds) (1986), reference no. 38
40. Testimony by Fernando Costa (Head of Manufacturing Services at Sociedade Industrial da Borracha - (BIS), in 1957 and Director Fabril in 1973), granted to Maria Elvira Callapez, in an interview on 5/23/1997
41. Testimony by Romeu Branco (interview). Information provided in a document Breve Descrição da História da Empresa by Romeu Branco to Callapez ME, in an interview on 11/07/1996. Romeu Branco was manager of the company Nobre & Silva from 1960 to 1985
42. The company was formed by Jesuína Neto de Oliveira Nobre and Nour Marques in 1937. Anonymous (1938) Nobre & Silva, Lda. - Uma Sociedade, Matrícula no. 104, Folhas 68 do Livro C1. Conservatória do Registo Predial de Leiria. Livro de Matrícula das Sociedades, 7 January, reference no. 32
43. Anonymous (1929) O Mensageiro, 6 July, p 3
44. Anonymous (1929), reference no. 43
45. Anonymous (1931) Alpergatas. Indústria Portuguesa 4:31
46. Testimony by Fernando Costa, reference no. 40 (interview)
47. Alpergatas. Indústria Portuguesa, reference no. 45
48. Fernando Costa, reference no. 40 (interview)
49. Anonymous (1942) O Mensageiro, 3 January, p 2
50. Testimony by Romeu Branco, reference no. 41 (interview)
51. By order of 6/11/1946. Boletim da Direcção Geral da Indústria, 9º Ano, No. 459, 6/26–1946, p 668
52. Boletim da Direcção Geral da Indústria, 9º Ano, No. 455, 5/29–1946, p 599
53. By order of 15–5–44: “Authorized the firm Nobre & Silva, Ltd.ª to specialize in bottle moulds and various lathe and workbench pieces for the glass industry. Anonymous (1998) O Plástico. Terras da Nossa Terra, May: 17
54. Saraiha JH, Barro J, reference no. 38, p 141
55. On the concentration of industries in Venda Nova and the evolution of its industrial park in Portugal. Custódio J (1996) Recenseamento e Estudo Sumário do Parque Industrial da Venda Nova. Câmara Municipal da Amadora, Amadora, pp 14–26
56. Custódio J (1996), reference no. 55, p 29
57. By José Colares Pinto, municipality of Ovar. Authorized by order of 28–5–40. Boletim da Direcção Geral da Indústria, 3º Ano, No. 145, 6/19/1940, p 521
58. By the companies Manuel C. Pais and Sociedade União de Industriais de Dairínios, Suí, Ltd.ª, in the district of Aveiro. Authorized, respectively, by the orders of 5/28/1940 and 10/15/1943. Boletim da Direcção Geral da Indústria, 3º Ano, No. 144, 6/12/1940, p. 508; Boletim da Direcção Geral da Indústria, 7º Ano, No. 321, 11/03/1943, p 72
59. For the company António Soares de Azevedo, district of Aveiro. Authorized by order of 11/17/1942. Boletim da Direcção Geral da Indústria. 6º Ano, No. 274, 12/9/1942, p 152
60. Aires Roque, a locksmith at the National Fábrica de Vidros, started the mould industry in a shed of an old factory, the Gomes factory. However, Augusto Belchior’s workshop already existed, specializing in bottle moulds and various lathe and workbench pieces for the glass industry. Anonymous (1998) O Plástico. Terras da Nossa Terra, May: 17
61. Anonymous (1981) Marinha Grande: dos Vidros à Indústria de Moldes. Empresas e Projectos Negócios 8:37
62. The region of Leiria is limited to N and NE by the municipality of Pombal; the E and SE by the municipality of Vila Nova de Ourém; the S by the municipality of Batalha; the SW by the municipalities of Porto de Mós and Alcobaca; the N by the municipality of Marinha Grande and the NW by the Atlantic Ocean. Anonymous (1988) Indústria de Plásticos. Terras da Nossa Terra, July: 67
63. Lourenço N (1991) Família Rural e Indústria - Mudança Social na Região de Leiria. Editorial Fragmentos, L.da., Lisboa, pp 22–23
64. In this range, the areas of Braga - Porto - Aveiro, Lisbon - Setúbal, Coimbra - Figueira da Foz and Leiria - Marinha - Grande stand out. Ibidem, p 22
65. Authorized by dispatch of 10/21/1943. Boletim da Direcção Geral da Indústria, 7º Ano, No. 322, 11/10/1943, p 89
66. The information collected on Baquelite Liz was extracted from the interview given to Maria Elvira Callapez by the engineer Jaime Rezola Clemente (Technical Director of Baquelite Liz), on 12/21/1995, as well as from the Book of Companies Registration, Registration No. 185, of the 1st Conservatory of the Land Registration of Leiria and of the Government Gazette, No. 53, III series of March 6, 1946
67. Matérias Plásticas, founded in 1946, in the municipality of Leiria, offered a manufacturing range essentially identical to that of Baquelite Liz, but it was smaller. It used the compression and injection moulding processes for manufacturing
68. Article published in the magazine Profession des Plastiques. “Études et Marchés”, No. 9, 1969, translated in the Revista Plásticos, 1970, IV:25
69. Plásticos de Santo António (Leiria), medium company, specialized in the production of toys and household articles
70. Marinha Grande: dos Vidros à Indústria de Moldes, Empresas e Projectos, reference no. 61
71. Anonymous (1949) Indústria de produtos sintéticos. Indústria Portuguesa 22:839
72. Anonymous (1949) Indústria Portuguesa 22:760–766
73. They included articles for industry, personal and domestic use. Tubes, rods, tapes, screens and cord. Bottle caps, packaging for perfumeries and pharmaceutical products. Toys, beach and camping items. Anonymous (1950) Indústria Portuguesa 23:494
74. As early as 1899, Baekeland had invented Velox, a photo paper, a feat that made him a fortune
75. Barthes R (1957) Mythologies. Éditions du Seuil, Manchecourt
76. As early as 1899, Baekeland had invented Velox, a photo paper, a feat that made him a fortune
77. https://ec.europa.eu/environment/waste/plastic_waste.htm. Accessed 20 Dec 2019
78. https://ec.europa.eu/environment/waste/plastic_waste.htm. Accessed 20 Dec 2019

Publisher’s Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.