Early plastics : perspectives 1850-1950

SUSAN MOSSMAN

Early plastics: perspectives 1850–1950

Plastics had their origins in the mid-nineteenth century and underwent extraordinary growth and proliferation over the next 150 years. The reliance on natural and then semi-synthetic "plastics" gave way to the development of the first truly synthetic plastic, Bakelite, in 1907. From then on the range and uses of plastics developed in a multiplicity of ways. Over time, plastics have proved to be the eminently transmutable and almost magical material envisaged in the dreams of the early plastic pioneers. The next fifty years heralded a range of exciting new plastics and what has been referred to as the "Plastics Age".

Plastics have been defined as "[...] any material that by its nature or in its process of manufacture is at some stage, either through heat or by the presence of a solvent, sufficiently pliable and flowable, in other words plastic, so that it can be given its final shape by the operation of molding or pressing".[1]

Early plastics

Plastics can be defined as natural, semi-synthetic and synthetic. Natural plastics include amber, horn, tortoiseshell, bitumen, natural rubber, papier mâché, gutta percha, shellac, and bois durci. The use of amber, horn, tortoiseshell and bitumen go back to antiquity, at least 4000 years. Amber jewellery is found in Late Bronze Age graves; horn was used for a range of items including drinking horns and lanterns, combs and later snuff boxes. Bitumen was used in ancient Egypt for mummification. Rubber was used extensively by the earlier indigenous populations of South America, notably the Maya and the Inca in infamous ball games using decapitated heads encased in rubber, and for waterproof cloaks. The conquistadors used rubber to make waterproof boots. Rubber reached France in 1736 and Britain in 1791, first used as erasers. It became very popular in early nineteenth century Britain when it was touted as a marvellous material that could be applied to a multiplicity of uses.

Charles Macintosh adopted latex rubber to make his waterproof "mackintoshes", laminating it between two fabric layers, and patented this process in 1823.[2] However latex rubber had some dismal failings – it grew hot and sticky in the heat and went solid in the cold. The material needed to be improved. The next key development was what became known as Vulcanite or Ebonite in Britain and hard rubber in the United States.

Thomas Hancock gained the idea of vulcanised rubber via his friend, William Brockeden, who showed him samples of treated rubber obtained from Charles Goodyear. Hancock was the first to patent the vulcanisation of rubber in 1843, making a new semi-synthetic plastics material with a range of advantageous properties. Hancock eventually wrote his memoirs: "The History of Caoutchouc".[3] A copy now in the Science Museum's archives was owned by his contemporary, Alexander Parkes, who annotated the margins with various uncomplimentary remarks about Hancock, notably that it was Goodyear who really invented vulcanised rubber. However, Hancock combined inventiveness with entrepreneurship and excellent self-promotion so died a well-respected and wealthy man, unlike Goodyear who died in poverty.

THE CHRONOLOGY OF PLASTICS: c. 2000 B.C.–c. 2017

Type of Plastics	Name	Main Period of Use
Natural	Amber	c. 2000 B.C.–now
	Horn	c. 2000 B.C.–now
	Tortoiseshell	c. 2000 B.C.–now
	Bitumen	c. 2000 B.C.–now
	Rubber	1736–now (in the Old World)
	Papier mâché	1772–now
	Gutta percha	1843–c. 1945
	Shellac	1850–1950
	Bois durci	1855–1880s
Semi-Synthetic	Vulcanite	1839–1970
	Cellulose nitrate (celluloid, Parkesine)	1862–1880
	Viscose rayon	1892–now
	Casein-formaldehyde	1899–c. 1970
	Cellulose acetate	1928–now
Synthetic	Phenol-formaldehyde (Bakelite)	1910–now
	Cast phenol-formaldehyde	1928–1960
	Thiourea-urea-formaldehyde	1924–1940
	PVC	c. 1930–now
	Polystyrene	c. 1930–now
	Urea-formaldehyde	c. 1931–1940
	Melamine-formaldehyde (laminates)	1935–now
	Polymethylmethacrylate (Acrylic/Perspex)	1935–now
	Ethyl cellulose	1935–now
	Polyamide (Nylon)	1938–now
	Polyethylene	c. 1938–now
	Polyurethane	c. 1939–now
	Polyester fibres (Polyethylene erephthalate, Terylene)	1941–now
	Glass-fibre reinforced plastics (fibreglass)	1942–now

1 Table of early plastics.

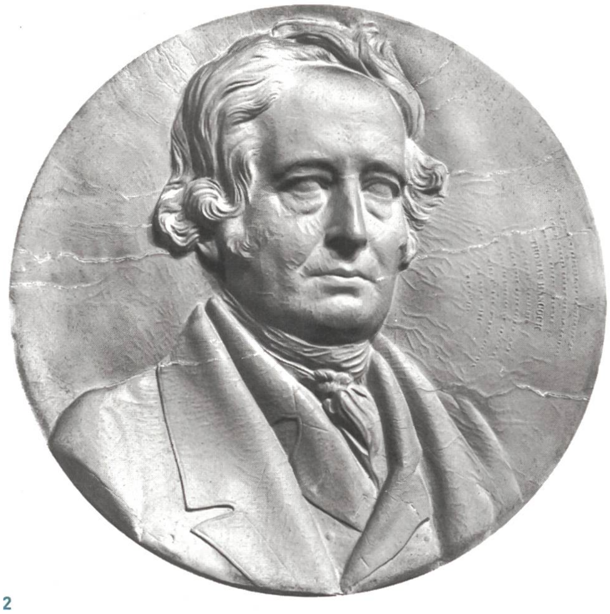
Parkesine

Parkesine is a semi-synthetic mixture of natural cellulosic fibres such as cotton flock and nitric acid. It is a close relative of gun cotton. Alexander Parkes obtained the idea for Parkesine from the correspondence of Swiss-German chemist, Christian Schönbein with Michael Faraday, to whom he wrote on 27 February 1846: "I have […] made a little chemical discovery which enables me to change very suddenly and very easily common paper in such a way as to render that substance exceedingly strong and entirely waterproof."[4] Schönbein sent a specimen of this transparent substance to Faraday later that year on March 18, noting that, "This matter is capable of being shaped into all sorts of things and forms […]."[5] Parkes learned of this discovery from his agent, John Taylor.

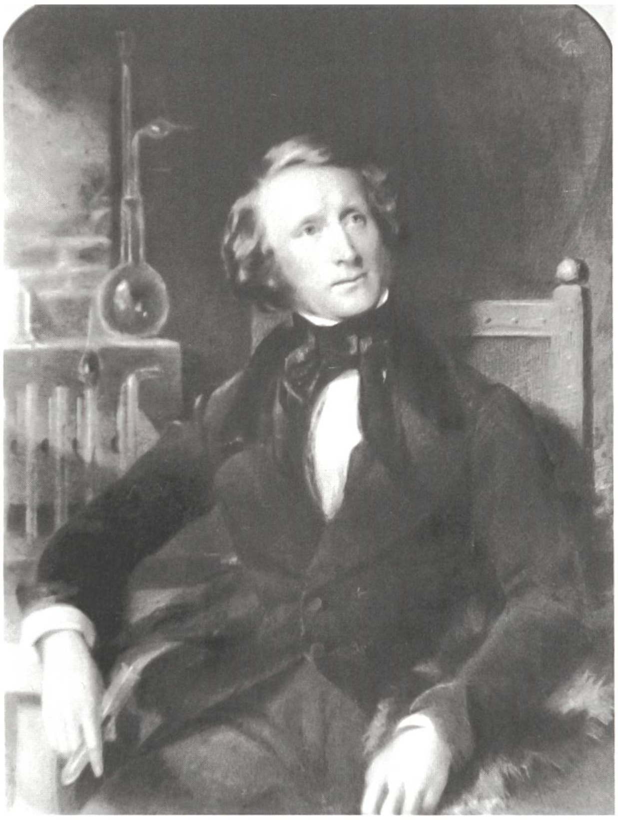
To nitrate his "coton", Parkes used a mixture of nitric and sulphuric acid. He mixed these constituents with vegetable oils and small proportions of organic solvents producing a mouldable dough, which he christened Parkesine. Objects were produced from the dough, which was heat-softened and then pressed into moulds; alternatively they were hand carved and then inlaid with mother of pearl or metal wire. Parkesine was first exhibited in Britain at the International Exhibition in 1862. It became better known in the later form of celluloid. This was a material that could be made to imitate ivory or tortoiseshell or even mother of pearl.

In his portrait Parkes has chosen to represent himself as a chemist although he was not formally trained. He rather modestly called himself "a modeller, manufacturer, and chemist".[6] He might equally have described himself as a metallurgist. He worked closely with his younger brother, Henry, who had been a student of the highly influential German professor August Wilhelm von Hofmann (1813–1920) at the Royal College of Chemistry in London. It is highly likely that Alexander Parkes paid for his brother to be trained in chemistry and writes of his dependence on his brother in his later correspondence: "In […] 1852 […] I gave nearly 5 years of my Extra time to Chemical Experiments assessed by my brother Henry Parkes whose Chemical Knoledg [knowledge] was allwas [always] of great value to me Espethr [especially] in Preparing the Nitro Selose [nitrocellulose]."[7]

The Parkesine Company Limited was set up in 1862 with shares totalling £100 000. It is worth noting that the company pamphlet lists the first investor as Sir Henry Bessemer of steel fame and a notable inventor in his own right.



2



3

2 Vulcanite plaque of Thomas Hancock, c. 1840.

3 Alexander Parkes, 1848; Portrait by A Wivell Junior.

4 Decorative Parkesine items, c. 1862.

Parkes came from a brass working and artisan background with a specialist interest in the decorative arts. His notebooks include occasional drawings. It is likely that he designed his Parkesine items and adapted some of his artistic and metal working skills to the new medium, notably in the form of brass, silver and mother of pearl decorative inlays.

Parkes, although a keen and varied inventor, was no businessman. He had perhaps too many interests. Later in 1881 he wrote: "The aims of the Company [were] to Produce the Cheapest Possibl [possible] NitroSelulus for Parkesine [and] i[t] was quite unnecessary to use the fine Colour or Papers I used at first and only the Cheapest and commercial – materials [...] some so low in Price as 1/-? lbs."[8] He became obsessed with producing Parkesine for a shilling a pound, and it is probable that he substituted inferior materials for those of high value such as camphor which he had later noted as a material in his diaries.[9] There were complaints that his "combs sent out in a few weeks became so wrinkled and contorted as to be useless."[10] Insufficient seasoning of the Parkesine, a process necessary to allow for any shrinkage before the material was turned into commercial goods, may well have been a contributory factor. The use of inferior cotton-flock also resulted in dirty-looking products.

This lack of attention to detail and quality are likely contributory factors to the failure and liquidation of his Parkesine Company in 1868. Parkes assigned his patents to the liquidators in 1869 with Daniel Spill as manager.[11] Spill was himself assigned the patents in 1873 to Parkes' displeasure. Indeed Parkes testified against Spill on behalf of the Hyatts in a long drawn out patent battle in the United States courts on the origins of celluloid – a battle that only finally ended with Spill's death in 1887.

Parkes had returned to Parkesine, which he now referred to as celluloid in 1881 when he set up the London Celluloid Company with his brother, Henry. This was not a success either, and the company quickly folded. Until he found his own invention was being claimed by others, Parkes did not think it necessary to labour the point – perhaps he was too busy making a living for his ever increasing family. Towards the end of his life a somewhat pained letter from Parkes indicates that he felt his own contribution to the invention of celluloid was unrecognised. On March 7, 1881 Parkes signed a letter to a journalist, Mr G Lindsey of Birmingham which stated: "In answer to the American Inquiry 'Who Invented Celluloid' I have put together a brief history of my various patents for the invention of Parkesine, Xylonite, or Celluloid for they are all the same. I do wish the World to know who the inventor really was, for it is a poor reward after all I have done to be denied the merit of the invention [...]."[12]

John Wesley Hyatt later recognised Parkes' contribution to the invention of celluloid in his speech of acceptance for the Perkin medal in 1914 in the United States, but Parkes' contribution is not generally recognised even today.[13]

Under Spill, Parkesine was renamed Xylonite and Ivoride (imitation ivory). The trade literature of the Xylonite Company refers to this as "an excellent substitute for ivory,

4

bone, tortoiseshell, Horn, Hard Woods, Vulcanite etc. – it is not at all affected by chemicals or atmospheric changes, and therefore valuable for shipment to hot climates".[14] Spill's main contribution was to produce high quality decorative goods, for which he made his own drawings[15] and used heavy fillers to make more robust goods such as his own death's head walking stick handle. Apart from imitation ivory he was also to produce a range of goods in imitation coral.

Spill set up the Xylonite works at Hackney Wick in 1869 but once again the business did not thrive. He later entered into extended patent litigation with the Hyatt brothers in the United States for infringement of his patents with their new material, celluloid. However although the judgment went originally in his favour – on appeal he lost his case and returned to Britain a broken man, to die in 1887.

Celluloid

John Wesley Hyatt, and his brother Isaiah, set up the Albany Billiard Ball Company in the United States in 1868. This was the response to the need for a new material to replace the increasingly rare ivory used for billiard balls. In 1870 they set up the Albany Dental Plate Company which they renamed the Celluloid Manufacturing Company in 1872.

The Hyatts' main contribution was to patent in 1872 the fact that camphor made a good solvent for cellulose nitrate[16]. They also employed an ingenious engineer, Charles Burroughs who devised a series of machines to make the production process reliable. The Hyatts combined this reliability with business acumen. They worked out what the market for this material was. Celluloid was never going to replace the real thing for those who had the money, but it did allow those from poorer levels of society to purchase decorative and even beautiful items rather than merely mundane and serviceable goods. A notable application was the use of celluloid for collars and cuffs for the working man or woman who needed to make a clean and respectable appearance in the office when laundering linen was an expensive business. Celluloid was also used for decorative combs and hair combs in a time when women's hair was worn long.

Celluloid, film and legacy

Parkes took out a provisional patent in 1856 to replace the contemporary heavy glass negative plates with Parkesine.[17] Samples of transparent Parkesine films are found in the Science Museum's collections.[18] In 1870, Spill lectured to the London Photographic Society and mentioned that he hoped that he would one day be able to produce from Xylonite "a flexible and structureless substitute for the glass negative supports".[19] British, French and American photographers then studied celluloid. The British efforts were unsuccessful as the British Xylonite Company could not produce a material which was thin and transparent enough. The Hyatt brothers did manage to make a sufficiently thin material and produced celluloid in different forms, selling licenses to other companies to turn their material into marketable goods, including film.[20]

John Carbutt left Britain for America where from c. 1884 he experimented with materials from the Celluloid

5

5 Objects made of Ivoride and Xylonite, c. 1869.

6 Cellulose nitrate (Celluloid) 1870–c. 1920.

7 Celluloid collars & cuffs advertising card.

Manufacturing Company. In 1888 he announced to the Franklin Institute that it was only now that "it has been produced uniform in thickness and finish and I am now using at my factory large quantities of sheet celluloid 100th of an inch in thickness, coated with the same emulsion as on glass, forming flexible negative films". Carbutt marketed this product and advertised it as Carbutt's Celluloid film – the first commercial photographic use of celluloid as a substitute for glass.[21] Thin flexible transparent celluloid was the next development by John H Stevens, George Eastman and Hannibal Goodwin.[22]

Celluloid film remained vital to the film industry until the 1940s although its successor, cellulose acetate safety film was available from 1910 and used by amateurs from the 1930s.[23] The true legacy of celluloid and its precursor, Parkesine, today is the movie industry, frequently alluded to as the celluloid industry.

Other semi-synthetic plastics

Other early semi-synthetics were developed in the nineteenth century, notably milk-based casein, patented by W. Krische and Adolph Spitteler in Germany in 1899 and called Galalith. This was made in a range of extraordinary colours and also enjoyed a range of names. In Britain it was known as Erinoid and was beautiful but not durable as casein is hydroscopic and warps and crazes in the presence of moisture.

The first synthetic plastic: Bakelite

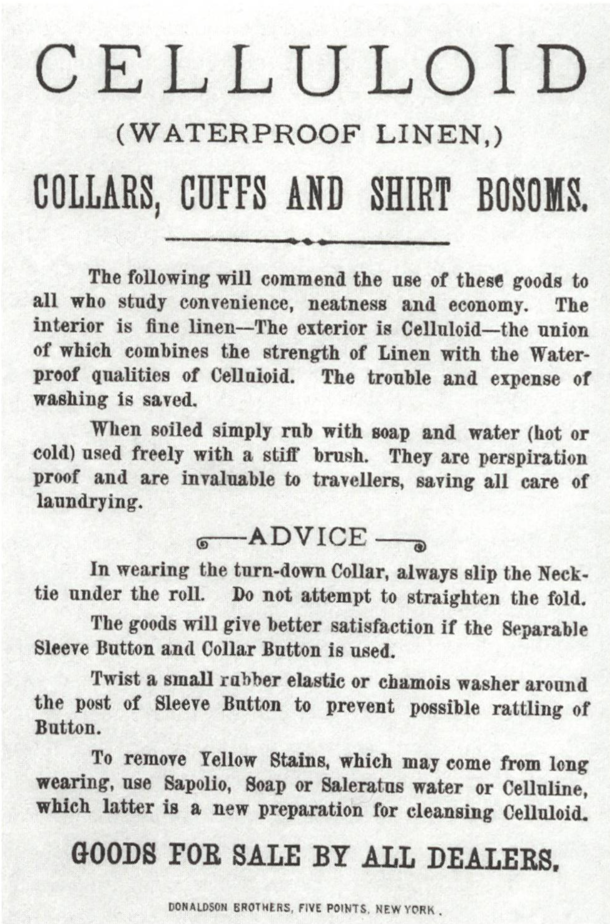
With the advent of Bakelite, the brain child of the eponymous Dr Leo Baekeland, came a new synthetic plastic that was truly suited to the new industries developing in the early twentieth century.

Leo Baekeland was that rare person who combined academic brilliance and inventiveness with business acumen and entrepreneurship. He was born in Ghent in

6

Belgium in 1863. His father was a cobbler and an alcoholic but his mother, a domestic servant, inspired him to success. His early experience as his father's apprentice made him redouble his academic efforts and he graduated from the University of Ghent in chemistry, cum laude. He went on to obtain his doctorate of which he remained proud for the rest of his life, commemorating the day of the award of his doctorate, July 23, in his diaries. While an associate professor in Ghent, he set up a business but this failed. Awarded a travel scholarship, he left for America in 1889, and never returned to his academic position. He returned once in later life to Belgium – only to be disappointed by the lack of interest in his work. He did not visit his homeland again.

After an almost fatal illness, peritonitis, and heavily in debt, Baekeland decided to focus his attention as he had too many interests. The result was the development of Velox Photographic paper which he sold to Eastman Kodak for $75 000 dollars in 1899. This established him as a wealthy and independent man – free to pursue his own lines of research. He then focused on developing a new mouldable material which could replace traditional shellac. He turned his attention to phenolic resins, building on the work of others such as Werner Kleeburg, Adolf von Baeyer and Adolf Luft. He was also in direct competition with a Scotsman, Sir James Swinburne. Baekeland was successful where others had failed in making this material commercially viable by controlling the heat, temperature and pressure of the reaction.



7

Bakelite was the product of five years of dedicated research in Baekeland's own laboratory, built next to his home in Yonkers, New York. He had a faithful assistant, Nathanial Thurlow, but his 1907 diary shows that he felt it needed his own special touch to make the breakthrough in developing this material. He commented that he had managed to do in a few days what his assistant Thurlow had been working on for a year. He was determined to be first – and so he was – beating his competitor, Swinburne, by one day in submitting his so-called "heat and pressure patent" on July 13, 1907.[24] So – what could have been called Swinburnite became the world-wide success story, Bakelite.

Baekeland had immediately recognised the value of what he had discovered and written in his diary on July 11, 1907: "Unless I am very much mistaken, this invention will prove important in the future." He first mentions "Bakalite" in his diary on June 21, 1907.[25] This he swiftly renamed Bakelite. Bakelite is made from a resin of phenol plus formaldehyde, to which various fillers are added, depending on the application. Phenol formaldehyde resin is a solidified amber liquid. It is a thermoset, which means that once set it cannot be melted.

Baekeland developed a special contraption to produce his new material using heat and pressure. He called this device – reminiscent of a giant pressure cooker – the Bakeliser.[26] His original device is now at the Smithsonian Museum of American History. The Bakeliser was originally set up in a laboratory adjacent to Baekeland's Yonkers home. Seeing the Bakeliser undergoing high pressure reactions became a family event. This could be a dangerous experience. On one occasion his assistant opened the hatch into the high pressure vessel and there was an explosion – luckily the assistant only singed his brows – although he lost his job.

Baekeland was an enthusiastic advocate for his new invention and gave a barnstorming presentation to the American Chemical Society in New York on February 5, 1909. This received headline coverage in the Tribune, the New York Herald and the Sun and led to a barrage of orders. He was highly energetic in both launching his new material – showing it to a range of his contacts including John Wesley Hyatt – and developing and marketing it both in the USA and internationally.

Baekeland had already learned a lesson from his work on Velox that often knowledgeable people did not read the instructions and would go about a process in the way they knew best. This made things difficult for his new Bakelite material as those manufacturers he dealt with were very familiar with manufacturing celluloid, which could be heated and pressed into moulds, and they found making the new thermosetting Bakelite resin difficult. In the early days Baekeland had to spend an inordinate time showing people how to make his new material. Finally in 1910 he decided to set up his own company, the General Bakelite Company, to manufacture his invention, Bakelite. This became the Bakelite Corporation in 1922 – the result of a merger of three companies following patent litigation, from which Baekeland successfully emerged.

Baekeland became managing director of the company – a position he was to hold until his company merged with Union Carbide in 1939. He swiftly became successful and company profits boomed. His was a material that was developed at exactly the right time – a thermosetting plastic with superior insulating properties and high temperature resistance, emerging at the same time as the burgeoning automobile and electrical industries.

The running of the General Bakelite Company and related matters, including defending his phenolic resin patents, was to occupy most of Baekeland's energies and scientific endeavours for the remainder of his career, and he produced 119 related patents. He was not always happy in this role and sometimes complained about the time he had to spend in business. However, following the commercial success of his invention, Bakelite, he was awarded a range of international honours. His correspondence archived in the Smithsonian shows that he was revered internationally until the end of his life.

Bakelite, marketing and transformation

Although Bakelite was a synthetic substitute for natural shellac, its superior properties gave it excellent heat resistance and insulating properties. Initially Baekeland concentrated on the technical rather that the consumer goods market. However the 1920s saw a huge growth in new consumer goods and in the ownership of iconic items such as Bakelite radios and, later, the iconic Bakelite phone.

Contemporary 1920s advertising material depicted Bakelite with the chemical formula: "oxybenzylmethylenglycolanhydride" and called it "modern magic".[27] Baekeland did not really know what the chemical formulation of his material was. Hermann Staudinger had yet to posit the idea of giant molecules (in 1923), and this was not an idea that was readily accepted until much later so that we now understand the structure of Baekeland's Bakelite as having the chemical formula: "polyoxybenzylmethylenglycolanhydride".[28]

By 1924 The Bakelite Corporation advertised Bakelite as "the Material of 1000 uses". In the same year Bakelite was profiled in *Time* Magazine with the same tag line. Baekeland himself appeared on the front cover – a huge tribute to his success and status. The company literature called their product "modern magic".[29] We begin to see at this point the transformation of Bakelite, a plastic, into a "magical material" and the beginning of the mythologising of both the material and its inventor. Baekeland himself was to be referred to as "Grand Duke, Genius and Wizard".[30] Baekeland also contributed to this mythologising with his accounts of his discovery and with what Bijker believes was a rewriting of the sequence of events surrounding the invention of Bakelite.[31]

However perhaps the greatest influence was Baekeland's marketing director, Allan Brown. He became a leading player in constructing the Bakelite legend when

8 Ekco AD36 radio, 1935, designed by Wells Coates.

he commissioned John Mumford to write *The Story of Bakelite.*[32] Published in 1924, this used grandiose terms such as the story of creation to set Bakelite in context and called Bakelite "wonder stuff". Baekeland was not quite comfortable with this eulogising, writing that there was "something not quite right about it".[33]

Brown employed the best designers of the time, including Norman Bel Geddes. This was particularly important after the First World War when plastics were gaining a poor reputation due to poor examples being produced, especially in Europe. The Americans were generally more positive towards plastics and Bakelite. Brown perceived that there was a new market for Bakelite in decorative goods that might be attractive to women and so The Bakelite Corporation produced a range of advertising literature and goods designed to appeal to this new market, including jewellery, decorative boxes and other items, including the 1924 classic: *A Romance of Industry* aimed at the female consumer. This booklet used imagery such as the genie lamp, and once again referenced the magical theme. These allusions were later picked up by Roland Barthes who refers to plastics as being a "magical substance" capable of "infinite transformation".[34] Bakelite has now become synonymous with all early twentieth century plastic. In fact as a term, Bakelite is often loosely used by collectors to describe an artefact's material rather than the term "plastic".

In Britain, the Ekco radio company also decided to employ some of the best designers of the time such as Misha Black, Serge Chermaeyeff, and Wells Coates to produce a stunning range of Bakelite cabinet designs for their radios. These are almost architectural in form and have survived the test of time to become most desirable to plastics collectors.

Baekeland was to defend his invention zealously – he fought and won patent battles against those he thought had infringed his patents. This did not stop him railing against the state of American patent law. By 1928 his patents had run out and he was forced to do business or merge with those who had been his fiercest competitors, and even issue them licenses. However, the hyperbolic marketing continued with the 1937 The Bakelite Corporation film, *The Fourth Kingdom*. This referred to Bakelite as equal to the existing kingdoms of animal, vegetable, mineral, emphasised how this wonderful new material was indispensable in a wide range of fields and showed the company symbol, infinity. Baekeland continued to run the company until it was merged with Union Carbide in 1939.

Developing plastics

From the development of Bakelite in 1907 the plastics industry continued to grow. The 1930s saw a wide range of new plastics, in particularly polyethylene, polyamides (nylons), polystyrenes and polyurethanes. By the 1940s polyesters and also glass fibre reinforced plastics were developed. The 1950s saw the advent of plastics packaging in a big way including the birth of the plastic bag as well as the development of polypropylene. By the 1960s plastics were synonymous with the space age and modern living. They were also vital in putting man on the Moon – providing light-weight materials such as Teflon that were also durable and could be used in the multiple layers that made up the fabric of the Apollo landing astronauts' space suits.

Developed in the 1960s, aramids came on the market in the 1970s, from DuPont's laboratories. A relation of the nylon family of polymers, aramids (trade named as Kevlar® or Twaron®) have been used in bullet proof vests, a use their inventor, Stephanie Kwolek was most proud of due to the lives they have saved. Other plastics have been adapted or combined for new applications, notably acrylonitrile butadiene styrene – indispensable for car bumpers. Polyesters (PET) have been modified into a form suitable to make light weight bottles able to contain fizzy liquids. Polythene continues to be very adaptable – from the early low-density type of the 1930s and 40s used for cable insulation, to high density and even ultra-high molecular weight polythene used for applications where additional toughness is required. A type of polythene is even being developed by NASA in the United States for use in radiation shielding for spacecraft in deep space. There is now a multiplicity of engineered plastics ranging from the high specification polyesters used in sports clothing to the spandex which makes even our everyday clothing more comfortable. Modern high tech composites play their part in applications as diverse as medicine, sport, prosthetics and aerospace.

Increasingly complex plastics are being developed for medical applications such as timed drug release. Plastics are also important in bioengineering as the carbon base of most polymers does not react with the body – which is a hostile and corrosive environment; hence polythene is used as linings for the ball joints of hip replacements and nylons and polyester for replacement veins. Phase-changing plastics have been developed and have had applications in sports clothing and potentially aerospace applications, so-called acrobatic plastics which have triple phase shapes may be used for intelligent stents.[35]

Electronic plastics (light emitting diodes) are another important class of modern plastics. Also, increasingly scientists are manipulating the surfaces of polymers to alter their properties, for example by printing them to make them conductive for use for example in solar cells, making them super hydrophobic for use in goggles, or super hydrophilic to capture water. Others have built-in antibacterial agents. Some are now superoleophobic, or oil-repellent, others also repel water (i.e. superhydrophobic). New omniphobic plastics repel everything – a form of super Teflon – and are self-cleaning without soap and water. They may have a possible use in mobile phone displays.[36]

Sustainability

Increasingly scientists are investigating the long term sustainability of plastics, in efforts to ensure modern plastics complete their necessary service life but then can be reused, recycled or disposed of in environmentally friendly ways. Although there are issues in museum collections with preserving the semi-synthetic early cellulosic plastics such as Parkesine and celluloid, now there are efforts underway to manufacture plastics that do not last forever or blight our landscapes and oceans with their litter. There is increasing interest in the field of biopolymers that can degrade naturally. These include plant-based plastics grown from starch, sugar and corn – although there is some debate as to whether this is an ethical use of food resources. Such plastics have been used to make casings for mobile phones. Other research goes on to develop plastics that can break down safely in sea water without harming sea life, endlessly recyclable plastics and a new family of algae-based plastics.

The future possibilities are many and varied for plastics. Truly their astonishing development over the last 150 years has brought and will continue to bring Baekeland's vision of dreams and realities to fruition.[37] ■

Related article in the Ferrum archives:
«The contribution of Space Technology to materials for the future» von W. Betteridge in Nachrichten aus der Eisen-Bibliothek 39/1972

About the author

Dr Susan Mossman

Susan Mossman is Senior Exhibitions Manager at the Science Museum, London, UK, where she directs exhibition projects related to science and technology. As Senior Curator of Materials Science, she curated the *2007 Plasticity: 100 years of making plastics* exhibition. Her publications include *Fantastic Plastics* (2008) and *Early Plastics: perspectives 1850–1950*. She has a PhD in Archaeometallurgy and an MSc in Advanced Materials Technology. She is a Fellow of the Institute of Materials, Minerals and Mining, vice chair of the Plastics Historical Society and council member of the London Materials Society.

Science Museum, London UK
Susan.mossman@sciencemuseum.ac.uk

Annotations

1 J. Harry Du Bois: Plastics History USA. Boston 1972, p. 1–2.

2 Charles Macintosh: Process and manufacture for rendering the texture of hemp, flax, wool, cotton, and silk, and also leather, paper and other substances impervious to water and air, British patent no. 4804, 17 June 1823.

3 Thomas Hancock: Personal Narrative of the Origin and Progress of the Caoutchouc Or India-Rubber Manufacture in England. London 1857.

4 G.W.A. Kahlbaum & F.V. Darbishire: The Letters of Faraday and Schoenbein. London 1899, p. 152–153.

5 Kahlbaum, Darbishire, The Letters (see n. 4), p. 155.

6 R. Friedel: Men, materials and ideas: A history of Celluloid. Ph.D. thesis, The John Hopkins University, 1976.

7 Alexander Parkes, undated note, Inverness, c. 1881, London, Science Museum Library Archive, Parkesine documents.

8 Parkes (see n. 7).

9 Alexander Parkes, Parkes diaries, F13, Science Museum Library Archive, Parkesine documents. Although this diary dates to 1881.

10 E.C. Worden: 'Nitrocellulose Industry'. New York 1911, p. 570–571, note 2.

11 Alexander Parkes and Another to the Xylonite Company Ltd – Assignment of Letters Patent. 23 June 1869, London, Hackney Archives Department, D/B/XYL/14/1 (patent assignment). Xylonite Company, Xylonite Company Price list, October 1869, London, Hackney Archives, D/B/XYL/2/1. This price list refers to Daniel Spill as manager of the Xylonite Company.

12 Alexander Parkes, Science Museum Library Archive, Parkesine documents: E10.

13 John Wesley Hyatt: "Address of Acceptance" (of the Perkin Medal). In: Journal of Industrial and Engineering Chemistry, vol. 6 (1914), p. 158–161.

14 Xylonite Company: Xylonite Company Price list, October 1869, London, Hackney Archives Department, D/B/XYL/2/1.

15 Science Museum Inventory numbers: 1999-343 to 1999-351.

16 J.W. & I.S. Hyatt, US Patent 133,229, November 19, 1872.

17 Provisional British Patent application 1123. This was never issued. Information courtesy of Deac Rossell.

18 Science Museum Inventory numbers: 1937–30/25; 1937–30/39.

19 Daniel Spill. In: British Journal of Photography, 17 (1870), p. 603.

20 Colin Harding: Celluloid and Photography. In: Plastiquarian, 15 (1995/96), p. 15ff.

21 Ibid., p. 16ff.

22 Colin Harding: Celluloid and Photography Part Two. In: Plastiquarian, 16 (1996), p. 6–8; Colin Harding: Celluloid and Photography Part Three. In: Plastiquarian, 17 (1996), p. 10–12.

23 Thanks to John Ward for this information.

24 Leo H. Baekeland, US patent 942,699. December 7 1909. Method of making insoluble products of phenol and formaldehyde.

25 Leo H. Baekeland, Papers, 1863–1968, Archives Center, National Museum of American History, Smithsonian Institution, series 4, box 18, diary 1907, p. 46.

26 His original device is now at the Smithsonian Museum of American History.

27 J. Harry DuBois Collection on the history of plastics, ca. 1900–1975 #8, Archives Center, National Museum of American History, Smithsonian Institution, Series 1: Bakelite Catalogs, 1910–1944.

28 Staudinger was only to receive the Nobel prize for chemistry for his discoveries in the field of macromolecular chemistry in 1953.

29 DuBois Collection (see n. 27).

30 Carl Kaufmann: Grand duke, wizard and bohemian – a biographical profile of Leo Baekeland. Thesis, unpublished, 1968. In: Baekeland Papers (see n. 25), subseries 1.1.

31 W. E. Bijker: Of bicycles, bakelites, and bulbs: Toward a theory of sociotechnical change. London 1997.

32 John Kimberly Mumford: The story of Bakelite. New York 1924.

33 Baekeland Papers (see n. 25), series 1, box 5: Correspondence Baekeland to Little, 27 October, 1927.

34 Roland Barthes: "Plastic" in Mythologies. New York 1972, p. 97–99 (translation by Annette Lavers).

35 I. Bellin, S. Kelch, et al.: Polymeric triple-shape materials. In: Proceedings of the National Academy of Sciences, Nov 28; 103(48): 18043–18047.

36 Anish Tutejaa, Wonjae Choib, et al.: Robust omniphobic surfaces. In: Proceedings of the National Academy of Sciences, 2008, 105(47) 18200–18205.

37 Leo H. Baekeland: Dreams and realities. In: Journal of Chemical Education, 1932, 9 (6).

Picture credits

1 Susan Mossman
2–8 Science Museum Group Collection
© The Board of Trustees of the Science Museum