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## 50 years of Soft Contact Lenses: Life and Impact of Prof. Otto Wichterle

### 50 lat miękkich soczewek kontaktowych. Życie i dorobek profesora Ottona Wichterlego

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#### Summary

Prof. Otto Wichterle was one of the pioneers of modern soft contact lens industry; his work has made a significant impact on the ophthalmic world. 50 years ago, in 1961, Otto Wichterle produced the first soft contact lenses in his own kitchen by spin cast technique using a children's mechanical kit Merkur and dynamo for bicycles. The same year he submitted a patent for HEMA (Hydroxyethylmethacrylate). Today, as a result of his fundamental research millions of people around the world enjoy comfortable vision with soft contact lenses. Even after using modern Refractive Surgery techniques to improve vision, Contact Lenses are still important for people with refractive errors. They are necessary and helpful when dealing with Refractive Surgery complications (e.g. complications with the cut and irregularities of the cornea). In interactive discussions of treating remaining refractive errors after Refractive Surgery contact lenses will be one possible comfortable solution.

Wichterle's invention of the hydrophilic material HEMA (Hydroxyethylmethacrylate) is not only used for manufacturing soft, hydrophilic contact lenses, which he invented too, but can also be used for producing hydrophilic intraocular lenses. Wichterle's inventions have changed the ophthalmic world fundamentally — in only 50 years!

**Keywords:** Contact Lens, History of Chemistry, Soft Contact Lens, Wichterle

#### Streszczenie

Profesor Otto Wichterle był jednym z pionierów nowoczesnego przemysłu miękkich soczewek kontaktowych; jego praca wywarła ogromny wpływ na rozwój okulistyki. 50 lat temu, w 1961 roku, Otto Wichterle wyprodukował pierwsze miękkie soczewki kontaktowe w swojej kuchni, stosując technologię „spin cast” przy pomocy mechanicznych zestawów dla dzieci Merkur i dynamo rowerowego. Tego samego roku złożył wniosek patentowy na HEMA (metakrylan hydroksyetylu). Obecnie w wyniku jego prac badawczych miliony ludzi na całym świecie korzystają z wyższego komfortu życia dzięki miękkim soczewkom kontaktowym. Nawet w czasach gdy dostępne są nowoczesne metody chirurgicznej korekcji wad wzroku, soczewki kontaktowe mają duże znaczenie dla osób z takimi wadami. Są one niezbędne w postępowaniu przy powikłaniach po chirurgicznych zabiegach refrakcyjnych (tj. zabiegach związanych z cięciem rogówki). Ponadto stosowane są w korygowaniu wad wzroku pozostałych po zabiegach refrakcyjnych. Hydrofilny materiał HEMA (metakrylan hydroksyetylu) wynaleziony przez Wichterlego jest używany nie tylko do produkcji miękkich hydrofilnych soczewek kontaktowych, ale również do produkcji hydrofilnych soczewek wewnątrzgałkowych. Wynalazki Wichterlego zmieniły gruntownie świat okulistyki w zaledwie 50 lat.

**Słowa kluczowe:** soczewka kontaktowa, historia chemii, miękka soczewka kontaktowa, Otto Wichterle

## Introduction

Prof. Otto Wichterle (FIG. 1) was one of the pioneers of modern Contact Lens industry and had significant impact on today's ophthalmic world. Due to his work, nowadays millions of people around the world enjoy comfortable vision with soft Contact Lenses. Contact Lenses become more and more important when visual function needs to be restored. [2, 4–7, 10–12, 14].

## Material and Methods

This article is based on an intensive literature research of current and historic literature via PubMed, Google Scholar and Google in order to document the life and to evaluate the scientific impact of Otto Wichterle's work.

## Results: A remarkable biography of an exceptional scientist

Otto Wichterle was born on October 27, 1913, in Prostějov, now the Czech Republic but, prior to World War I, a part of the Austro-Hungarian Empire. He was the youngest child of a manufacturer of agricultural machines. After his time at school, at first he was interested in becoming an engineer, but was convinced by a friend to study chemistry at the technical University of Prague, at that time Czechoslovakian Republic. In 1936 he received his PhD degree. He stayed at the University of Prague; his major interests were medicine and polymer chemistry; his scientific work at that time dealt with sugar chemistry. In 1939 he fulfilled all the necessary requirements to receive the title and function of an Associate Professor for Organic Chemistry. The Inaugural Lecture was planned for end of November the same year. Due to the war activities the Universities were closed by the Germans before Wichterle could implement this lecture. Wichterle's intransigent attitude towards the authorities made him a disliked person for the communist regime. Instead of giving in, he endured bureaucratic difficulties and hindrances by being tenacious and steadfast.

Because research activities had been blocked during the German occupation, Wichterle joined the research institute of the company Bata in Zlín, which was the world's biggest manufacturer of shoes at that time. During his time at Bata he kept busy developing synthetic fibers, predominantly Polyamide 6. His work was significantly important for the international reputation of the Czech industry: 1941 Wichterle developed the first polyamide fibers, which were suitable for spinning. Industrial production under the name Silon was delayed for 10 years because on one hand this invention was kept as a secret by the German Occupation, on the other hand because of post war problems of the Czech industry.



FIG. 1. Prof. Dr. Otto Wichterle (1913–1998) [4]

During the war Wichterle was imprisoned by the Gestapo, set free after a few months.

After the war Wichterle decided to go back to university research, he joined the technical institutes in Brno and Prague. Finally he had the possibility for his Inaugural Lecture and was appointed Professor for Polymer Chemistry at the Technical University of Prague. In 1952 he was nominated as Dean of the newly established Institute for Chemical Technology in Prague — six years later he was dismissed from this position because of political activities of the communists — Wichterle had to leave the institute.

During an international symposium the Czech State Administration was persuaded to found an institute for synthetic polymers which was established in 1958 as “Institute for macromolecular chemistry” of the Czechoslovakian Academy of Science (CSAS) — Wichterle had joined this society in 1955 [1, 5, 6, 9, 13, 24].

## Otto Wichterle and his contribution to Ophthalmology

From 1952 Wichterle focused his scientific interest on the development of hydrogels which could be used as replacement for the vitreous body of the eye. The most important experiments which led to the development of a hydrophilic gel were performed in the kitchen of his tiny flat in Prague. As a member of Otto Wichterle's team the Czech chemist and Wichterle's assistant Drahošlav Lím worked on the development of a clear hydrogel with a water absorption of approximately 40% which showed acceptable mechanical properties: HEMA

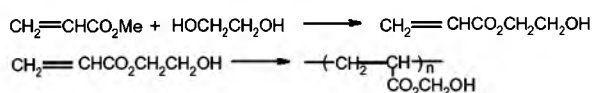


FIG. 2. HEMA (Hydroxyethylmethacrylate), first soft Contact Lens material developed by Otto Wichterle

(Hydroxyethylmethacrylate, FIG. 2), the material later used for the first soft contact lenses. Lim discovered the tridimensional structure of reticulated polymers. Their work was published in "Nature" and was also subject of US patents, they filed patent PV 187-53 for a whole range of hydrophilic materials, sparsely cross-linked hydrophilic gels and their applications. In discussions with Dr. Maximilian Dreifuss, a Czech ophthalmologist, as well as supported by clinical trials carried out by Dreifuss Wichterle came the idea for the production of contact lenses made from the new material HEMA. Dreifuss fitted some of the early soft lenses at the Second

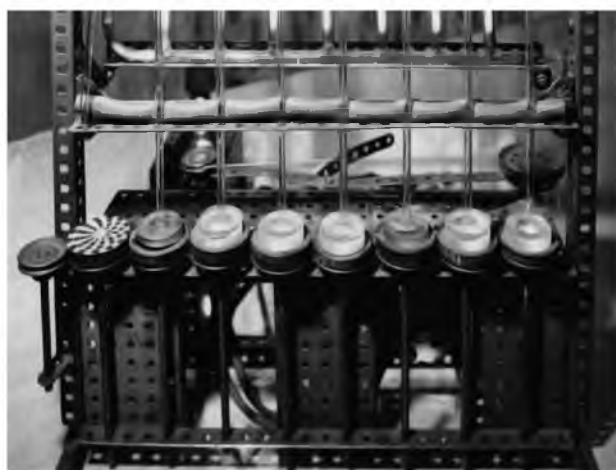


FIG. 3. By using a "Merkur" construction kit for children, a motor of a phonograph and a dynamo for bicycles the first Contact Lenses were produced 1961 in Wichterle's home [4]



FIG. 4. The first soft Contact Lenses „Spofa“ and „Geltakt“ were stored and delivered in glass vials filled with saline solution [7]

Ophthalmological Clinic in Prague and proved that soft contact lenses could work. The Ministry of Health, however, decided to stop funding his research so Wichterle continued the experiments at home. [1, 5, 6, 8, 9, 13, 17, 20, 22, 26-28].

Using a children's mechanical kit called Merkur, the motor of a phonograph and a dynamo meant for bicycles, Wichterle produced in 1961 the first soft contact lenses by using a spin cast technique, which needs only one mold that is turned by a motor (FIG. 3, 4). Using the centrifugal forces contact lenses can be manufactured this way (this technique is still used today). That same year the material "HEMA" was submitted as a patent to the Czech authorities. The following year, Wichterle developed, again in his own flat, a half-automatic spin cast device — a method which allowed mass production of contact lenses [1, 3-7, 18].

The international interest in these new "soft contact lenses", with a comfort surpassing by far the "hard" PMMA contact lenses in use, was high from the very beginning. As a consequence — without Wichterle's awareness and without any form of monetary compensation or recognition extended to him — the Czech Institute of Science sold Wichterle's patent for circa 330.000 US\$ to Dr. Robert J. Morrison, an American optometrist who saw the potential in Wichterle's invention in 1964. Even having no technical background Martin Pollack und Jerome Feldman of "National Patent Development Corp" (NPD) offered Morrison 1 Mio US\$ and bought 1965 the patent from him. One year later the NPD sold the patent to Bausch & Lomb for 3 Mio. US\$. From this moment mass production of soft contact lenses began in the United States. The first Contact Lens Congress took place in Prague (CR) in 1965.

As time went on the importance of Otto Wichterle's revolutionary development received recognition, rather belated. In his honor, the asteroid 3899 was named after him in 1993. Otto Wichterle died shortly before his 85<sup>th</sup> birthday on August 18, 1998 [1, 3-8, 10-14, 19].

## Discussion

Otto Wichterle's life shows the career of a Czech chemist, anti-ideological in personality who was the inventor of the polyamide fiber and the soft contact lens, which was hardly noticed. He also represents the tragedy of people, whose country, emerging from the chaos of World War 2, endured occupation for half a century with steadfastness and pragmatism whatever the circumstances were. Otto Wichterle well deserves his place as a Czech in the pantheon of international science.

For optical supply of eyes with irregularities of the cornea generally hard or RGP Contact Lenses are fitted. These

special contact lenses should only be fitted by rare Contact Lens specialists who have great experience in optical supply of those special eyes. Soft Contact Lenses, developed by Otto Wichterle, are widely used in Europe and other parts of the world to compensate eye errors as an alternative to glasses. Soft contact lenses are also used for cosmetic reasons as tinted lenses can change eye color and cover some cosmetic eye defects. Another common use is in Refractive Surgery as bandage Contact Lenses after so called surface laser ablation, namely PRK or LASEK. Soft contact lenses also help to treat eyes with epithelial defects.

Even with using modern Refractive Surgery techniques Contact Lenses have still their place in helping people with refractive errors. Many people with refractive errors prefer soft contact lenses over glasses or refractive surgery.

Contact lenses are nowadays available for almost all refractive errors; they are available as spheric, aspheric, toric and multifocal models made from numerous variations of hydrogels [15, 21, 23]. With a total of 13.1% of the 15–64 years old population wearing contact lenses in Europe, Sweden is leading the penetration ranks, ahead of Denmark (11.6%) and Norway (10.1%). Lowest is Germany (3.2%) [25].

Prof. Otto Wichterle was an outstanding man of honor and a remarkable scientist. His vision of life without glasses became reality by his high tenacity and exceptional commitment to science, even in adverse conditions for which he was not responsible. Due to his attainment in creating soft, hydrophilic contact lenses millions of people suffering from refractive errors have been able to achieve natural vision again.

From Prague around the world — in only 50 years Otto Wichterle's invention conquered the globe!

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