

Nitrocellulose

1. History of Nitrocellulose

The main component of celluloid is nitrocellulose. It is produced by reacting cotton (cellulose) with nitric acid. I researched the history of inventions related to nitrocellulose and summarized it in Table 1 ⁽¹⁾. The table shows years to indicate the flow of time, but these vary slightly depending on the source. Inventions are phenomena realized in test tubes that emerge into the world through various innovations. It is unavoidable that later historians differ in their judgment of which point constitutes an "invention".

Table 1: Chronology of Nitrocellulose-Related Inventions

Year	Subject	Inventor	Country	Old materials
1832	Nitrocellulose	Bracono	France	
1851	Collodion	Frederick	England	Animal glue
1845	Guncotton	Shanebein	Switzerland	Black powder
1883	Artificial leather	Fabricoid Corporation	America	Animal leather
1884	Artificial silk	Chardonay	France	Silk
1868	Celluloid	Hyatt	America	(Ivory)
1893	Movies, records	Edison	America	
1919	Lacquer	DuPont	America	Natural resin

2. Predecessors of Celluloid

Looking at Table 1, about 20 years after the successful synthesis of nitrocellulose, a viscous liquid called "collodion" dissolved in organic solvents and emerged. Collodion solidifies when the solvents evaporate. Since collodion is named after "glue" it is clear that it was used for adhesion. It was later used for photographic plates, but collodion itself was not photosensitive. The photosensitive agent was mixed into the collodion.

Nitrocellulose was also used as an explosive. Because of its cotton-like form, it was called "guncotton". It is also called "smokeless powder" because it produces no smoke when it explodes. The explosive used before this was black powder, which had been used since ancient China, a mixture of saltpeter, sulfur, and charcoal powder. Upon explosion, unreacted carbon would rise up, obscuring the surroundings, which was inconvenient. Guncotton is still used today. In the Ukraine war, it has been reported that Russia is purchasing Chinese cotton waste (called linters) ⁽²⁾.

Next, synthetic leather appeared. It was made by applying collodion to fabric and drying it. Synthetic leather developed in two directions. The first was bookbinding. High-quality books had been bound using genuine leather, but this was replaced. Subsequently, it was improved to functionality-oriented, textile-based materials. The binding method using this is "cloth binding" which is still widely used today. Along with the evolution of papermaking and printing technologies, it contributed to the realization of the mass

publishing era. Additionally, collodion-based synthetic leather was also used for camera bellows.

Another development of synthetic leather occurred in the clothing and household goods fields. DuPont, which was an explosives manufacturer, acquired the synthetic leather manufacturer Fabrikoid and entered synthetic leather manufacturing. In the petrochemical era, materials have diversified, manufacturing technologies have been developed, and products that are higher-performing and easier to use than natural leather have emerged. These are called "synthetic leather" to distinguish them from the old type that was simply "applied to fabric".

Next, fibers appeared. This has a long history comparable to alchemy. Because silk is highly rare, artificial production has been considered since ancient times. Silkworms eat mulberry leaves and produce silk. Anatomical findings revealed that the raw material for silk thread is in liquid form inside the silkworm's body. When this liquid is extruded from the silkworm's fine mouth, it becomes beautiful thread.

Therefore, various people attempted to (1) liquefy mulberry wood through chemical treatment, and (2) extrude it through fine pores and solidify it into thread. Since the main component of mulberry wood is carbohydrate and silk is protein, this was quite a short-sighted idea, but such things were not understood at the time.

They interpreted collodion as "liquefied wood components" and attempts were made in various places to extrude it through fine pores, solidify it, and make thread. The Frenchman Chardonnet won the intense development competition. This thread was called Chardonnet artificial silk, and because it was lustrous and beautiful, it was highly valued and spread rapidly. However, it had the drawback of being highly flammable and was replaced by later-developed viscose process and cuprammonium rayon.

3. The Emergence of Celluloid

Hyatt, the inventor of celluloid, was a printer. He apparently used collodion as an additive in printing inks (for viscosity adjustment, ensuring adhesion, etc.).

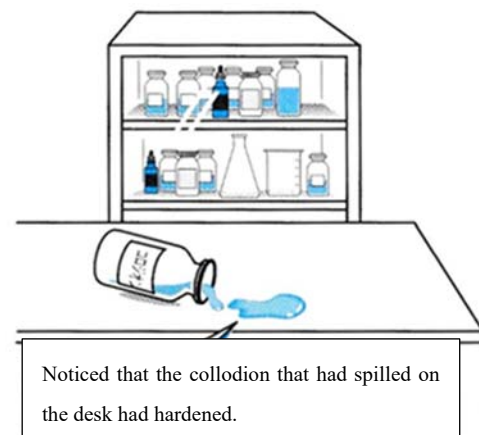
One morning, upon arriving at the factory, he found a glass bottle on his desk that had fallen over, spilling and hardening collodion solution (Figure 1) ⁽³⁾. Seeing this, he came up with the idea to enter a contest being held at the time for a "substitute for ivory billiard balls." This is the famous legend of the birth of celluloid.

What was admirable about Hyatt was that he recognized the high potential of celluloid beyond billiard balls. He also developed dentures, musical instrument keys, and more. He particularly focused on the "thermos-plasticity" of nitrocellulose. When cellulose is reacted with nitric acid, it becomes solvent-soluble and also melts at high temperatures. Products can be made by placing molten nitrocellulose into molds and cooling it. Using this method eliminates the need for solvents and minimizes volume change during solidification.

Plasticizers improve the flow characteristics when melted. Camphor, which had been used in pharmaceuticals, fragrances, and insect repellents, was used as a plasticizer. Movies and cylinder phonographs, invented around the same time, also achieved rapid development with the emergence of celluloid.

DuPont, which started with explosives, launched low-viscosity collodion as a coating. Because it was inexpensive and fast-drying,

Figure 1: Spilled Collodion



it greatly contributed to the mass production of automobiles that followed. It is thanks to high-performance coatings that ships can be made from rust-prone iron.

4. Nitrocellulose as the Starting Point of Modern Industry

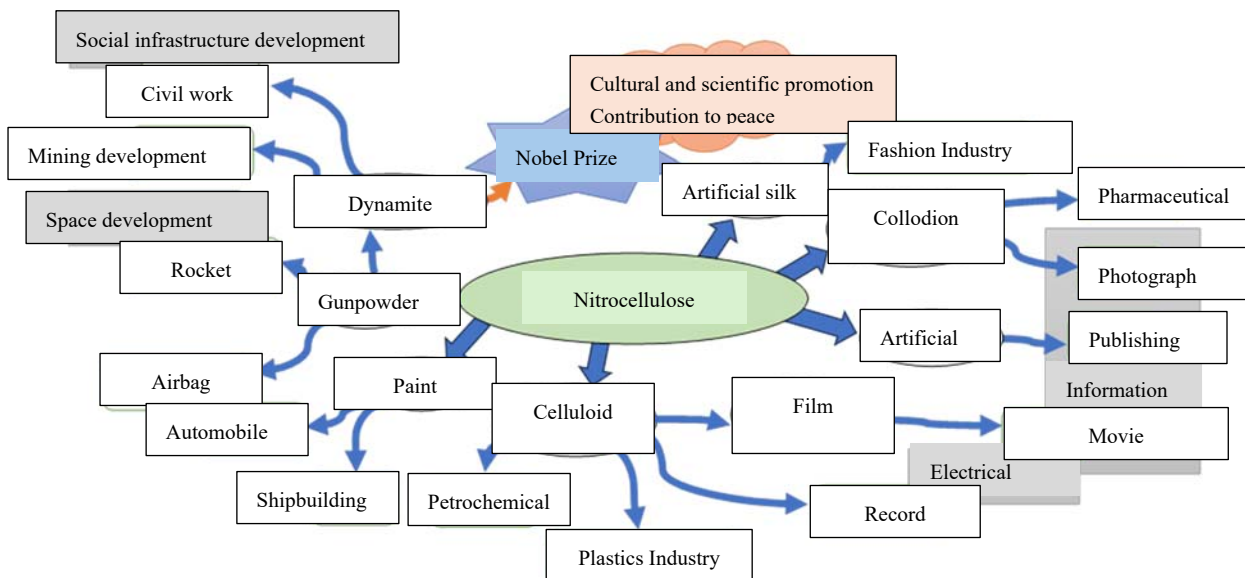
As we have seen, nitrocellulose gave birth to many industries. Explosives were improved for easier handling and came to be used in mining and civil engineering. Nobel, who accomplished this, established the Nobel Prize and contributed to cultural and scientific promotion and world peace. Coatings are indispensable materials for automobiles and ships. Airbags, which appeared in later times, are also products that utilize explosives. The artificial silk thread founded by Count Chardonnet changed manufacturing methods and materials, giving birth to the textile and fashion industries. Edison, the king of electrical inventions, utilized newly emerged celluloid to commercialize movies and phonographs. As you know, his inventions were the starting point of the electrical industry, which eventually led to the birth of the information society.

The celluloid founded by Hyatt, with molding methods based on heating/cooling operations, became more refined and diversified, establishing the plastics processing system. It changed the starting raw materials to petroleum and gave birth to the petrochemical industry.

Looking at it this way, we are reminded again that nitrocellulose gave birth to modern industry in many fields. Nitrocellulose chemically modified the natural substance cellulose to impart various functions. This can be interpreted as having opened the door to synthetic chemistry and triggered the transition from the era of hunting and gathering to the industrial era.

The contribution of nitrocellulose to modernization is summarized in Figure 2.

Figure 2: Nitrocellulose as the Starting Point of Modern Industry



5. References

- (1) Cellulose Handbook (Asakura Publishing, 1958) P5 and others
- (2) <https://nikkeimatome.com/?p=27617>
- (3) Isao Sato, Illustrated Trivia: Plastics (Natsume Publishing, 2001) P13