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Original Paper

The Evolution of Photographic Arts Is Linked to Progress in Chemistry: A Review of Two Centuries of Symbiosis

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Abstract

Photography is a major component of present art. It has applications in arts, in sciences and mainly health sciences, in social interaction. The evolution of photography since its advent 200 years ago relied and was dependent on the knowledge of chemistry. This is a review of the chemical techniques used in the recording and reproduction of photographs and of its applications. In the last two centuries, numerous chemical substances: inorganic, organic and polymeric, influenced the aspect and quality of the photographic techniques and of photographs. Teaching photography requires knowledge of chemistry, while chemistry education needs knowledge of esthetics as offered by photography.

Keywords

arts, chemistry, history of science, medicine, photography

1. Introduction

The photography is now a daily component of present life. It started almost 200 years ago thanks to Niepce (Baldwin, 1991) but the name was given by Herschel (Magurean Dumitrascu, 2014). One of the major pioneers of photography Felix Nadar was born just 200 years ago in 1820. Therefore, it is time to review the way in which progress of chemistry progress is reflected on photographic techniques during this interval (Painter & Coleman, 2008). Photography is now considered an independent art, by itself, but it has also applications in almost all scientific fields of science: health, biology, earth sciences,

space, sea, microcosmos, etc. The development of the photography is not tributary only to chemistry, but also to physics. Indeed, without development of light studies and optics, photography would not have reached the right standard of today (Feleki, 2009). The aim of this review is to reveal the changes in photographic applications in arts and science (with emphasis on health sciences) in the perspective of chemistry evolution. Emphasis is put on chemical aspects of light rays' uptake, recording and reproduction, including diverse inorganic, organic and plastic materials. Many of them, like celluloid, were replace in time by better materials and technologies.

2. Result

2.1 Evolution of Photographic Techniques

Discovery of photography is based upon the perpetual humans' seeking to reproduce their own face and body, later to record the environment around them. Even the start of the visual arts, as reported by historians of art (Painter & Coleman, 2008) is due to the wish to reproduce human beings. All the development of visual art along the centuries was in fact subordinated to the need to reproduce reality (Newhall, 1982; Sonntag, 1977). Aiming to perfection, they started to imagine tools to reproduce reality with higher fidelity that visual artists of the time were able to realize.

Using light to process the reproduction of reality became a necessity. The proposed technique of camera obscura is a technical solution based on the physics of the light rays. Camera obscura was able to reproduce the subject but not able to record it. However, it remains considered a forerunner of true photography (Newhall, 1082). But to be able to record the image captured from the light rays, chemical procedures were necessary (Sattar, 2017).

In the period after the first photograph realized by Niepce in 1825, many techniques were proposed to create photographs. These are displayed in Table 1. All rely on the uptake of the light effect on a chemical substrate. The presentation of the historical steps in the evolution of photography is useful for the knowledge of the chemistry contribution to photography. Without photography, visual arts would be less reach and science less developed.

Table 1. Photographic Techniques and Their Chemical Substrate

Year	Technique	Chemical substrate
1825	Heliography by JN Niepce	Layer of bitumen (Syrian asphalt) on metal plate
1835	Calotype by HF Talbot	Paper covered by silver nitrate
1839	Coined the word photography	
by J Herschel	Glass plate; natrium hyposulphite for fixing	
1839	Daguerreotype by JLM	Silver plated copper plate and

	Daguerre	mercury vapors
1839	Dichromated gum prints by M Ponton	Dichromated gum
1842	Cyanotype or cyanography (blueprint) by J Herschel	Photosensitive solution of ammonium citrate and potassium ferricyanide
1842	Chrysotype by J Herschel	Gold emulsion on the plate
1847	Albumen print by LD Blanquard-Evrard	Paper covered by albumen and sodium/ammonium chloride; fixing with thiosulphate; selenium stabilizer
1850	Ambrotype by FS Archer	Iodized colloidon covered by silver nitrate
1853	Tintype and ferrotype by AA Martin	Tin or iron plate covered on emulsion on enamel or laquer
1855	Carbonic print by A Poitevine	Carbon added to dichromated gum
1858	Colour prints by P Pouncy	Pigments added to Arabic gum
1861	Colour photo by JC Maxwell	Use of red/green/blue filters
1873	Platinotype by W Willis Jr	Platinum salts
1903	Autochromy by A & L Lumiere	Color photo on glass covered with starch microparticles

In 1875 Richard Maddox invented the gelatin silver process used even now for black and white photographs, due to its property to be easier sed.

The advent of celluloid slides was a big step forward, allowing image transmission and even scientific communication. Celluloid is a plastic material composed from nitrocellulose and camphor. It was discovered in 1879 by photographer John Carbutt. It was used for cinema and for photography films (Mehnert, 1965). Later celluloid was replaced by acetate.

The progress continued with the advent of instant photography, discovered in 1947 by Edwin Land (James, 2015). The impression of the pictures is rapid because the reagents are disposed in small packages. Polaroid originally used iodoquinine sulphate crystals embedded in polymers of nitrocellulose.

The most recent progress is the translation to digital photography. Obtaining digital photography requires digital printing. This can be obtained using printing techniques transferring digital files from any soring device. Best methods are obtained by electrophotography with zinc or selenium or by traditional inkjet printing.

Later Du Pont developed a new photographic process based by the observation that photosolubilization offer the possibility to render positive images, unlike the traditional photography which renders negative images. The difference from the traditional and conventional photographic technique, this new one was based on the following steps: exposure-development-fixing. Thus, the technique of Du Pont was leading to positive instead negative picture has a changed sequence of the steps: exposure-developing-fixing (Anonymous, 1964).

While photography offers a static reproduction, the dynamic representation is possible thanks to movie films. The chemistry of the movie films is largely similar to those of photographic films.

Photography used the first plastic material, celluloid, from the second half of the 19th century, soon after its discovery (8). This first synthetic plastic material, based on the polymerization of nitrocellulose and camphor-forming a colloidal homogenous dispersion-and lived a period of glory before being substituted hundred years later by synthetic polymers developed from synthetic components and thus easier available in large quantities. The advantage of celluloid is that is not absorbing humidity and thus remains dry. It is easy to be processed and can be transformed in thin layers. Therefore, the negative of the pictures can be printed on both sides of the film.

The advent of celluloid represented an important leap forward in the industry of photography and later of movie. Celluloid replaced soon the glasses as support of photography. It is lighter, more robust and allows a better storing of the images captured by photographers. Thanks to celluloid, the photography evolved from a tool to reproduce people and environment into a tool for visual artists and scientists.

2.2 Applications of Photography in Visual Arts

Just after the discovery of different photographic techniques, visual artists used photography as an aid or as a complementary activity, i.e., for the presentation of landscapes and humans.

Later photography became more and more popular between artists and the quality of their work increased continuously. Nowadays photography is an art and an educational field in any university or academy of visual arts. Now one cannot conceive any museum without a collection of photography and many collectors invest more and more in photography.

The artistic pictures rely now very much on color photography compared to artistic photography decades ago. The chemistry of color photography involves several possibilities (Theys & Sosnovski, 1997). Thus, using the subtractive theory of color, the light interacts with silver halide (a silver salt of a halogen element) which is embedded in a gelatin emulsion and coated on a substrate (earlier glass, later paper) and is transformed into metallic silver. The developing agent reacts with a certain coupling agent to produce a color. In the techniques of instant photographs, one use insoluble colored compounds in the emulsion. The colored insoluble compounds are solubilized by chemical reactions and form the color photograph. Electronic photography is another recent alternative. The term C-print from chromogenic print is a term developed to define the color prints of high-quality. These were first obtained by halide salts and now more and more by digital prints. They are called digital C-prints or Lambda-prints. High-quality ink-jet prints are named giclee.

Teaching chemistry in visual arts is necessary for the students of the departments of photography. This is very important given the tight connection between both types of visual representation (De Font-Reaulx, 2020) and also to offer a scientific background to visual artists. In order to offer a rational, useful and logical curriculum, the content of the teaching sessions should include several lessons (Sattar, 2017). The proposed topics are displayed in Table 2.

Table 2. Steps of Chemistry Education in Photography Teaching

Physics of the light spectrum
Reflection, absorption, transmittance.
Additive colors and color filters
Ionic and covalent compounds used in photography
Oxidation of metal ions.
Gum dichromate process
Cyanotyping
Chemistry of the diazo process
Chemistry of silver
Salts on paper
Collodion
Flexible supports: cellulose nitrate or
Polyesters and photography
Printing
Albumen and black and white picture processing
Salts properties influencing sensitivity
Developing, chemistry of pH sensitive reactions
Color photography
Chemistry of image reversal
Digital photography

These steps are logical (Sattar, 2017) and cover main fields students in arts should know.

The reciprocal situation should also be mentioned: including in the chemistry education of esthetical principles. Thus, Ling et al. (2020) encourage and recommend the training of chemistry students into esthetic education, combining experimental setting with artistic creation. Thus, disciples are invited to photograph the outcomes of chemical reactions, i.e., color precipitates, with their own smartphones. This task is divided in three steps: perception, appreciation, and exploration. In such manner students do not only apply chemical experiment into arts but explore their own esthetic training. Beside this, students can improve experimental and photographic methods and contribute to the elaboration of scientific works on photography.

A similar approach has Roesch and Helmerdig (2017). As the authors correctly point out, previous generations of professors of chemistry used to stimulate the curiosity of the disciples. The artists who use photography for expression need to have appropriated knowledge of chemistry. This is useful to underline the intrinsic connection between chemistry and photography. Indeed, photography is a link between arts and science (Jacobsen, 2001).

2.3 Application of Photography in Sciences

All sciences use photography, thus benefit of the evolution of chemical processes behind image capture, recording and reproduction. Among the sciences, medicine has in common to arts the interest for human body and of its expressions. Like in arts, medical photography has got a very important role for medical decisions and is largely used by clinical practitioners and for the medical education (Williams, 1984). Beside natural light, diverse radiations are used to obtain images from the body of human and animal beings, which are recorded and reproduced by photography. One of the most important applications is represented by the famous picture of the hand of Roentgen's wife created by X-Rays in 1895 (Rogozea et al., 2014). This was the first roentgenograph and one of the first serious uses of the photography in health sciences. X-rays photographs or roentgenogrammes are using barium sulphate or other contrast reagents to render visible parts otherwise not features on photogrammes. After X-Rays, other radiations were used to obtain photographs. Now one cannot conceive any medical field without photography. The translation from digital to analogue was smooth but total. Digital pictures can easier be stored and retrieved, and totally replaced the films or the celluloid prints.

First use of medical photographs was for recording patients reports or interventions, in a easier and more credible way than by painting. Of course, forensic medicine was an important field of application. Soon pathologists used photography to record their microscopic examinations. In the second half of the 19th century photographs were included in textbooks of medicine.

Dental medicine is so depended on photography now that a good dental treatment cannot be conceived by an X-Ray photograph. There are many studies emphasizing the role of photography in detecting and following up dental and oral cavity pathology (Sofyanti et al., 2020, Dave et al., 2020, Costa et al., 2020, Tobias & Spanier, 2020, Konishi et al., 2020).

With de simplification of photographing procedures, and with the advent of new devices, including smartphones and tablets, medical documentation is largely accessible. Anybody can now use photographs to illustrate any aspect of medical documentation (Tobia & Spanier, 2020). The restriction remains in respect to the respect of the confidentiality and of the consent of the subject.

Self-photographies called also selfies are used now even by to transfer information to physicians. This has now implications in all fields of clinical medicine, not only dental medicine. Microscopic photographs are also very much used by pathologists while endoscopists used photography of the lumina of viscera. Numerous publication report data sustained by photographic recording of pathological conditions ((Daemen et al., 2020, Huener et al., 2020, Fatemi et al., 2020).

On the other hand, the attempt of some irresponsible people to take selfies in dangers places have lead to hundreds of deaths related to selfies (Bansal et al., 2018).

Many applications of the photography are in physics. For instance time-resolved shadowgraph photography may be used for the study of fragmentation heat transfer from solvated gold nanoparticles to water (Stavich et al., 2020).

Astronomy is using photography to transfer pictures from the space. For this field of photography, the term astrophotography was coined. The first photograph of a sky object is dated as early as 1840 and represents the moon. Later, photographers were able to record seen celestial objects and nowadays even objects not seen with the eye, thanks to their light spectra. This progress was rendered possible by techniques of long-time exposure with either analogue and later digital cameras. Indeed, longtime exposures allow the recording of new stars and nebulae. In fact, telescopes are nothing else than huge cameras recording from the space the light, on photographic plates (Malin & Cicco, 2009; Ray, 1990).

Underwater photography represents an important application as well as the space photography. It started in 1893 with Louis Boutan (1900) who photographed Emil Racovita as diver, captures with the help of a magnesium flash, but first attempts date back to the Crimean War. First underwater color photographs where obtained by Charles Martin in 1923 using also a magnesium-powered flash (Bourjon et al., 2018).

3. Conclusions

Photography has relied during its bicentennial evolution on the progress of chemistry. Diverse inorganic, organic and polymeric substances and compounds have left their print on photography. Its applications in arts and science, mainly in health sciences, relieve beside the refinement of image capturing techniques, also the state of art of image recording and reproduction, according to the standards of the chemistry, in each epoch.

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