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Reflections on the Material History and Materiality of Photographic Gelatin

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Abstract
This paper discusses the material history of photographic gelatin and argues that gelatin's material agency, or material characteristics, has a direct link to the employment of gelatin in photography. A distinction between the types of gelatin such as size, glue, consumption grade gelatin is briefly discussed and the history and manufacturing of photographic grade gelatin is contextualised. The progression of the implementation of gelatin for photographic purposes in the nineteenth and twentieth centuries is illustrated and the physiognomies that support gelatin emulsion making are explored. Finally this paper illustrates the relationship between distinctions in the material characteristics of various gelatin photographic papers, and the role that these play in photo history and in the marketplace.

Brief History

Gelatin, known as animal or hide glue, has a long tradition in the arts, crafts and furniture making in many parts of the world, and has been used from at least the nineteenth century for domestic purposes such as cooking and recipes for stocks, aspics, custards, marmalades and jellies can be found in 19th Century cookbooks such as the Carolina Housewife.[1] The employment of gelatin which is obtained by boiling animal hides, hoofs, horn, bones and other cartilage-like animal parts dates back 3500 years to when the Egyptians used gelatin for binding pigments and building coffins for the Pharaohs.[2] It is probable that gelatin's use is even older however the focus of this paper is gelatin in photography, and as such, its ancient history is beyond the scope of this paper.

In the middle ages we can find gelatin referenced in art sources such as the manuscripts of Jehan Le Begue, who mentions boiling parchment clippings to make glue or size for paper, parchment, cloth and wooden panels in order to draw better on them.[3] Other manuscripts on art and painting mention sizing the canvas or wood panel prior to painting on it.[4] In fourteenth Century Europe animal glue (gelatin) was introduced as sizing agent in manufacturing paper.[5] Thomas Lambert defined sizing in a publication from 1905, as "undried glue that exists as a tremulous jelly, possessing all the adhesive properties of the latter, but in a much less concentrated form."[6] Size is essentially a bye-product in the manufacture of glue and gelatin, and used in "…calico-printing, by painters, decorators, and in the carpet, straw-hat box, wallpaper and other trades."[7] Consumption gelatin and isinglass were purer forms of glue used in the nineteenth century primarily for culinary purposes, to provide firmness to a dish.[8] Gelatin-based products like liquorice and lozenges were made in the same factories where gelatin was manufactured.

Use of Gelatin in Photography

One of the great attractions of gelatin is its physiognomy. Gelatin is transparent. It dissolves in hot water and gels into a clear film upon cooling. It swells in cold water and holds up to four times its own weight, and when dry it is a rigid yet flexible film. These characteristics, together

with its adhesive properties, are what initially attracted photographic manufacturers and what makes gelatin the material of choice in the implementation of photographic emulsions.

The history of the use of gelatin in photography originates in England, with William Henry Fox Talbot, inventor of paper photography. In 1852 Talbot began employing gelatin in his photographic engraving process where a steel plate is coated with gelatin "that is strained when hot, through linen cloth to purify it."[9] That Talbot stressed the need for filtering suggests the desire for a purer form of gelatin than was commonly available at that time. In one of Talbot's letters he makes reference to the use of gelatin to size paper in his Polytype process.[10] On December 24, 1842, Antoine Francois Claudet writes and asks Talbot if gelatin-sized paper meets his (Talbot's) approval in printing with the Calotype process.[11] Although a reply to Claudet's question cannot be found amongst these letters, Professor Bertrand Lavédrine mentions in his publication *Photographs of the Past: Process and Preservation*, that Talbot recommended paper to be coated with an extra coat of gelatin prior to sensitizing so as to produce better image results.[12]

Reference to the use of gelatin as finishing technique or coating, can be found in E.G. Heineken's excerpt from the Journal of the Photographic Society of London. Heineken recommends coating gelatin onto the paper photograph after printing, to achieve a high gloss.[13] Gelatin was furthermore used in various pigment processes such as the carbon process introduced by Alphonse Poitevin in 1855 and improved by Swan in 1866 and in the photomechanical Woodburytype process developed in 1864.

During the first 75 years of the nineteenth Century only technical grade and consumption grade gelatin existed. George Nelson's consumption gelatin patented in 1837 appears to be the purest form of gelatin available at the time and references to its use in photography can be found in the *Photographic News* for making glass plate negatives.[14] In 1871 Richard Leach Maddox published his experiments using gelatin as a "dry" binder, or emulsion, for the light sensitive silver salts on glass plate negatives. Maddox used George Nelson's fine culinary gelatin for his experiments on glass plate negatives. He claimed it was its transparent quality that made gelatin a useful binder for lantern slides and sensitive plates.[15] With the invention of the gelatino-bromide emulsion in 1873, by J. Burgess, marketed as an emulsion that had to be coated onto the glass plate by the photographer himself, and the manufacturing of ready-made dry gelatino-bromide plates by the Liverpool Dry Plate Company in 1874, an alternative to the wet collodion process was offered.[16] Finally, in 1875, the editor of the *The British Journal of Photography*, recommends Nelson's gelatin for "developed plain paper."[17]

It isn't until the late 1870's however that gelatin specially made for photographic purposes was manufactured. In 1877, the first references to photographic gelatin are for Nelson's No. 1 Photographic Gelatin.[18] Although published evidence was not found, other gelatin factories probably started producing photographic grade gelatin by the mid 1890's or at the turn of the Century.[19] The J and G Company made Cox Gelatin as early as 1845 and references to Cox gelatin such as used by "enamelling" photographs are found in photographic literature as well.[20] The Knox Company in the United States was founded in 1890 and it is not unthinkable that these companies saw an opportunity for producing gelatin for the up and coming photography market.

Manufacture of Photographic Gelatin

In 1840, Nelson published his improved and patented method of preparing his gelatin, in *Mechanics Magazine*. In the publication he mentions that he takes cuttings from hides and skins 'as glue pieces are commonly made of' and makes two grades of gelatin with them. The first grade, which is purer, and is later used for photographic purposes, is made via an alkaline method using caustic soda and lime. Once the skins are soft they are washed with cold water for 6 or 7 days and briefly exposed to 'sulphuric acid gas', and heated until all are dissolved. Then the mixture is strained of the 'residuum' and left in heated vessels to clear. A second grade of gelatin in which the 'residuum' is mixed with sulphuric acid is also made.[21] Nelson's patent does not discuss photographic gelatin as this wasn't produced until the late 1870s but similarities between photographic gelatin and Nelson's first grade are discussed below.

From "ABC of Modern Photography" W K Burton 1884

Similarly to Nelson's patent, gelatin in the 20th Century is made in similar ways: an acidic (type A gelatin) and an alkaline (type B gelatin) method. Type A gelatin is made from pork skins and Type B gelatin, under which photographic grade gelatin falls, is made from beef hides.[22] The biggest difference in the modern manufacture of photographic gelatin after 1950 is that it is made mainly from bones (instead of hides). Type B gelatin is very similar to the way Nelson produced his purer grade. The skins are cut into strips before being steeped in lime baths for several days. These baths might be mixed with caustic soda but this is dependent on the patent under which the manufacturer is working. Soaking the skins in lime separates the fleshy matter from the protein and dissolves any fat. Upon removal, the skins and hooves are washed with "stampers" or in a cylinder apparatus with plenty of cold water to remove all alkalinity. Afterwards they are bleached of colour by sulphuric acid and then "digested" in baths having a maximum temperature of 85 degrees Celsius. Three "boilings" are necessary to extract the gelatin from the skins, of which the first two boilings extract the gelatin and the last is used to filter off the sizing.[23] The gelatin is clarified with potash alum and filtered with animal charcoal, which filters and clarifies as well as reduces odour. This process produces a very high-grade gelatin that is cut into small pieces, washed in cold water and re-melted at 80 degrees Celsius. It is then dried in sheets which, depending on the use, are shredded into small strips to make them easier to dissolve, left in sheets, or crushed into small particles. As can be seen Nelson's method for making pure gelatin appears very similar to the method described above. The modern manufacturing of gelatin may provide insightful as to Nelson's methodology such as with the use of sulphuric acid gas. It could have the same objective as the use of sulphuric acid today, to bleach the gelatin of its colour. Nelson didn't use potash alum and animal charcoal but did leave the gelatin to settle to optimize clarity.

Manufacturers now take weeks instead of days to lime the bones and they use stainless steal vessels instead of porcelain tanks for the extraction. According to the *Gelatin Handbook*, produced by the Gelatin Manufacturers Institute of America, the temperature of extraction

(known in the 19th century as "boilings") is adjusted for each extraction and the extractions are deionized, making the gelatin more concentrated.

In the 1880's improvements were made in the manufacture of photographic emulsions such as ripening and noodling, which led to a greater light sensitivity of the photographic emulsion. Ripening produced larger silver halide crystals by heating the emulsion, and noodling removed unwanted nitrate by squeezing the emulsion through mesh and washing it in cool water.[24] Gelatin plays an important role in grain size, grain distribution and grain shape.[25] Sensitizers that are added to emulsions increased the light sensitivity of the emulsion[26] and thus gelatin gradually took the place of collodion in popularity.[27] Also during this time, Obernetter's Aristotype gelatin silver printing-out paper, which was introduced in 1867, was slowly replacing popular albumen papers.

In 1930 large photographic companies such as the Eastman Kodak Company established their own gelatin production plant. The Eastman Gelatin Corporation was situated in Peabody, Massachusetts.[28] The diet and food sources of the cows used to produce photographic gelatin had to be maintained because small differences could alter the speed of the emulsion. To ensure control over these aspects, large corporations such as Eastman Kodak kept their own cows on privately owned grazing fields. Grazing in a neighbouring field caused an alteration in light sensitivity of an entire batch in the 1970's.[29] Thinking about the raw materials necessary for making gelatin, and the control over these materials, it becomes clear that the commodities market and photography are entwined. The food industry, paper-making industry, farming industry and the chemical industry all are essential components for photographic papers.

Photographic grade gelatin is nearly tasteless and odourless and is a glasslike, brittle solid that has a very pale yellow colour. Gelatin is composed of 50.5% carbon, 6.8% hydrogen, 17% nitrogen and 25.2% oxygen.[30] It is characterized by its insolubility in cold and solubility in hot water. In dry state and at normal conditions, photographic gelatin contains 8 - 13% moisture. In this state photograph gelatin is stable and if stored in airtight containers its quality can remain unchanged for many years. The pH of photographic gelatin is between pH 5.65 and 5.85.[31] It is since its introduction as photographic binder in the 1870s, the preferred binder for light sensitive silver salts and colour dyes in analogue photography. Today modified gelatins and mixtures with synthetic polymers such as polyvinyl alcohol (PVA) are used, but gelatin still plays the essential role in the analogue photographic process.[32]

Gelatin versus Other Binders used in 19th Century Photography

All photographic processes up to the introduction of gelatin emulsions were two-step processes and had to be sensitized by the photographer prior to use. Binders for light sensitive silver halide salts were introduced as early as 1850 when the albumen process was published. Chicken egg white was beaten, denatured, salted and coated onto a thin, high quality paper or glass. The albumenized paper was commercially available or could be hand-made. Albumen paper replaced the salted paper process quickly and contemporaries like Wharton Simpson, the editor of the *Photographic News* suggest why, "From the earliest production of paper proofs, photographers have had a hankering after some means of giving increased depth and transparency to their shadows; or, rather, of giving full effect to all that really exists in the picture. The mode in which photographic prints are obtained has always had a tendency to produce the picture slightly within

the texture of the paper, rather than entirely on its surface, and hence a slight loss of detail and transparency in the shadows".[33]

The gain of brilliance and depth of image details in albumen paper was a great advantage to salted paper and the albumen gloss became increasingly popular by the public in commercial portraiture.[34] However, by the mid-1850s permanence problems with albumen were recognized and as a result a Committee was established by the Photographic Society of London to investigate the question of the fading of positive prints.[35] The editor of the *Photographic News* writes in the Foreword of the January 2, 1863 journal, that yellowing and fading were major drawbacks in albumen printing and experiments to find more stable binders were ongoing. He goes on to say, "Still very little is understood of the rationale of the albumen process, and very little certainty exists as to the permanency of the results. Mr. Spiller's important discovery of the presence of free nitrate in the whites of finished prints, and Mr. Cooper's experiments with resinized paper will tend, it's probable, to the diminished use of albumenized paper; and in our conviction, thus to the removal of one of the causes of fading.[36] The answer to the permanence of albumen presented itself eight years later when Maddox presented his experiments on the gelatin emulsion and applied it to glass and paper. "One kind of paper that evidently was largely adulterated by some earthy base dried without any brilliancy, but gave, under exposure of a negative for thirty seconds, very nicely-toned prints when developed with a weak solution of pyro, having very much the look of a neutral-toned carbon print without any glaze."[37] In a time where photography on paper exhibited stability problems, comparing gelatin prints to Carbon prints was a large compliment.

Gelatin had many advantages to albumen in paper photography but also to collodion, which was the binder of choice for glass plate negatives. Not only was gelatin's one-step process an advantage, ether and other harmful solvents necessary for the collodion process, were no longer necessary. Additionally, gelatin proved a stable material and didn't discolour. Wharton Simpson, a prized photographer, leading member of the Photographic Society of London, and editor of the *Photographic News*, was a typical enthusiast for gelatin. His visit to Nelson's Gelatin plant in 1880, illustrates this enthusiasm;

> But a few years ago gelatino was only known to photographers as one of the substances used to mount their prints. At a later date it became of greater importance as one of the chief sensitive agents in the carbon, or, more properly speaking, the pigment printing process. Today it promises to replace collodion as the medium or vehicle for forming the sensitive layer of the glass plate for use in the camera; and, if we may venture on a prophecy, tomorrow it will replace that plate, and become itself the transparent support of the sensitive medium.[38]

Later he claimed;

> There is every reason to believe that before long a gelatino-bromide or a gelatino-chloride paper will come into very general use for printing purposes, not only on account of the rapidity and ease with which prints may be obtained, but also on account of the fact that such pictures are likely to be much more permanent than the ordinary prints on albumenized paper.[39]

As forecasted, gelatin's use increased throughout the twentieth century.

In 1987, Roger Bunting summarized the advantages of gelatin to all previous binders in his publication, *The Chemistry of Photography*. Bunting writes that gelatin has all the necessary properties. Its adhesive properties enable the silver halide crystals to be fixed to the support. It is transparent, allowing light to enter the emulsion to react with the silver halide crystals. It is fairly rigid to prevent silver halide particle movement. It swells in water and allows aqueous solutions to penetrate without dissolving the gelatin, which makes chemical development and processing possible.

The helix structure of gelatin is pH sensitive. At its natural pH the helix structure is tightly wound making it difficult for reactions within the emulsion to occur. This characteristic is used during processing where the acidic stop-bath forces the helix structure to tighten after the immersion in the alkaline developing bath in which the helix structure is opened so that development of the image may occur.[40] Gelatin can also be combined with chemicals and additives such as matting agents and optical brighteners and the surface texture can be physically altered providing variations in gloss and texture.

Throughout the twentieth century we see that gelatin papers were sold in an infinite variety of textures and gloss. Trade books and photo paper catalogues exhibit samples of available papers and provide recommendations as to which paper is best for what application. It is during this time that photography continues its branching into the various segments: art, documentation, fashion, advertising etc. and papers were developed to meet the needs of the market. For instance cream-colored papers were recommended for portraiture and textured papers for adding ambiance to the image. Kodak recommended a high contrast photographic paper with deep blacks and white highlights for advertising and realistic images.[41] As Bunting points out, there is not a binder that has replaced gelatin since its introduction in 1871. It appears as though Maddox had found the ultimate material for emulsion making in analogue photography.

Gelatin and its Role in Art Photography

Throughout the various movements in photography that have come and gone, requiring different things from the print surface, gelatin has remained. It is not only a perfect material for emulsion-making, allowing a silver halide crystal to become materialized into a metal, which, in turn shapes the form of the image, but as mentioned earlier, its material properties can be altered almost infinitely to suit the desired effect.

Imagine the various artistic art movements that have defined twentieth century photography. At the time that gelatin was first introduced, Pictorialism was established and the Photo-Secessionists such as Alfred Stieglitz and F. Holland Day argued that photography was art. Artists originally trained in painting like Edward Steichen, Gertrude Kaesebier and Oscar Reijlander, experimented with photography and then used it throughout their artistic careers. They printed in processes such as Platinum and the various pigment processes. During this time, gelatin papers that that copied the surface and tonal qualities present in these processes were put on the market. They bared names that made reference to the processes they intended to mimic such as the Matte Platino-Bromide Paper manufactured by Kodak in the 1890's to attain "a picture exactly like platinum" even though the paper had no platinum in it.[42] It made use of a gelatin emulsion in which starch particles were added to diffuse the light reflecting off the surface, causing a very matte appearance. The silver image appeared much softer and more

embedded in the fibres of the paper. In 1891, the Fry Manufacturing Company introduced a 'Naturalistic' Bromide Paper on a rough-surfaced Whatman paper base, which the *Amateur Photographer* reported as readily producing "soft tones, almost equalling those of a platinum print."[43]

Even though materiality is often strongly associated with Pictorialism, more modern movements are no less indebted to the gelatin surface. When photographers like Renger-Patsch and Moholy-Nagy introduced their 'new vision' Kodak and others produced papers to help them do it. Papers having more gloss and contrast were produced so that the image confronted the viewer not only in its composition but also in the material technical aspects of the papers. Form and space, after all, are not only created by composition, but by the material agency of the paper on which they are printed.

More recently, in the 1960's, the Cibachrome paper's high gloss surface is indebted to the gelatin on cellulose acetate or polyester support. Cellulose acetate and polyester have a natural high gloss causing the gloss of the gelatin to adopt the gloss of the substrate. Cibachrome papers were especially common in advertising and fashion where images had to "jump-out" at the viewer.

Gelatin and Materiality

Material agency or affordance can be described as the restriction or encouragement of certain actions that result from the specific properties of a material. Based on James Gibson's theory of affordance or material agency, anthropologist Timothy Ingold argues that objects and people, nature and culture are inseparable and shape each other in mutual processes of becoming.[44] Ingold insists that one study the interactions between makers and materials, as well as the properties, workings and changes of materials.[45] When administering his theory to gelatin in photography, and gelatin's role in the creation of a photograph, we gain an understanding to the link of the material agency of gelatin to the photograph's aesthetic appearance.

Gelatin is not just a substance that holds the image in place. It adds to atmosphere, radiance and clarity, contrast or softness depending on the aim of the consumer. Even before the so-called "material turn" in art history, historians like former director of Musée des Beaux-Arts in Lyon and later Professor at Yale University, Henry Focillon talked about matter having "... a certain calling or, if you will, a certain formal mission. It has a consistency, a colour, and a texture. It is form and, as such, it calls on, limit, or develops the life of artistic forms. It is chosen not only because it is convenient to work with or, to the extent that art serves needs in life, because it is a good thing to use it, but also because it lends itself to a particular treatment, because it imparts certain effects."[46] When reviewing gelatin's material characteristics, it becomes evident that they answer to Foucillon's description of matter and that gelatin is not only convenient to work with, but it imparts characteristics to the image contributing to its materiality and aesthetics.

Focillon's theory allows for the consideration of various levels of form. When translated to silver gelatin photography, the first level could be the nature of gelatin to hold the light sensitive silver salts, a second level may be the light projected through the focused lens that enters the gelatin upon exposure in the camera, travelling to the silver salts and causing the reduction of silver metal. The next level of consideration is the action of the developer, which creates a certain image depending on light exposure and the art and nature of development. Each of these levels

ultimately contribute to the final image and thus to the aesthetic nature of the photograph. In an extention of his theory one could perhaps argue for yet another level, - the action of time on the image (natural aging), which creates a patina in the photograph, which may contribute to its aesthetic character over time.

The materiality of gelatin and its embedded image can also be considered using German architect and art critic, Gottfried Semper's, definition of material makeup. By his definition material matter is that which determines the aesthetic qualities.[47] In Semper's view, gelatin's qualities such as transparency, its capability of holding the image forming substance, and the various textures and surface glosses that it is manufactured in, all contribute to the aesthetic qualities of the photograph as object. The above theories on materiality support the view that gelatin contributes to the aesthetic nature of the image and to the photograph as material object.

Conclusion

Gelatin plays a major role in the material history of photography and becomes photography's most widely used binder containing the image forming substance. Prior to its use as emulsion, gelatin is used throughout the 19th century history as a sizing, coating, and in various photographic processes. Due to gelatin's application in photography and the need for a purer product, the manufacture of photographic gelatin begins in the late 19th Century. Throughout the 20th Century technological advances contribute to the quality and the light sensitivity of the emulsion.

Characteristics such as transparency, adhesion, firmness and the swelling nature of gelatin in cold water contribute to its employment in emulsion making and ensure that gelatin remains in use as long as analogue photography is manufactured. These affordances together with other material agencies of gelatin argue for the theories of Focillon and Semper that the material supports the aesthetic nature of the photograph. Gelatin's far-reaching employment in photography combined with the material qualities it possesses, affects the material and aesthetic character of the photograph and how historians will view history in the future.

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