What is the Process of Creating a Photographic Emulsion and How Does it Compare to Commercial Materials in Sensitivity, Image Quality and Durability

By Cora McHugh

Contents

Introduction

the use of photographic photosensitive mediums has existed for far longer than any of the large companies that supply photographic materials today. most early photographers created the chemicals they used to from scratch. it stands to reason this is still very much possible today. the only questions are how dangerous is it and how does it compare to commercially made paper? modern emulsions consist of two main elements, a photosenitive compound which is almost always silver halides, and a binding agent which is almost always gelatin. in order to make silver halides you a silver compound must be combined with a compound containing bromine, chlorine, iodine or ~~fluorine~~ fluorine. this must be done under amber safety lights as as soon as the compounds mix they become photosensitive. Silver nitrate is usually used with some combination of potassium bromide, potassiun iodide, or ammonium bromide, in the most simple

recipies silver nitrate, the only components are the two chemicals for the halides and the gelatin. more complicated recipes involve 3 to 4 halide chemicals and suggest straining the emulsion through a cheese cloth. none of the chemicals are particularly dangerous when correct protection is worn. Commercial emulsions are created in very controlled environments and with precise measurements, allowing for complete control over it's properties. the ISO or sensitivity of light sensitive products is determined by the size of the silver halides suspended in it, larger halides will create more sensitive products and larger grains while smaller halides will result in fine grain, low sinsitivity products. the slower the components are added together the larger the halides will be. photograpic materials create an image by reacting with photons which cause changes in the electron structures of halogens (e.g. flourine, chlorine, bromine, iodine) when combined with silver. this image becomes visible when brought into contact with a developer, when the silver is remove it becomes stable

Recipe

in a normally lit room mix 2 separate solutions

Solution 1: 10g cooking gelatin, 62.5 ml distilled water, 8g potassium bromide

gently mix gelatin and water in a beaker. warm in at water bath to 50°C. add potassium bromide and stir until disolved.

Solution 2: 10g silver nitrate, 62.5 ml distilled water

disolve silver nitrate in the distilled water in a beaker. Warm to 40°C in a water bath.

the following steps must be completed under safety lights

mix solutions together over around 10 minutes, which is roughly 5mls poured in every 30 seconds, stir constantly.

Website's notes on use of emultion

- use normal developer, run tests
- ISO is 4-12 roughly
- originally used for film, can be repurposed for paper
- ~~develop~~ developing chemicals can't be too warm or gelatin may come off
- develop 3 mins, fix 2 mins
- emulsion is easily chipped and scratched

Initial Notes

Making the emulsion

Before the emulsion is made a light tight container needs to be ready to put the emulsion in. An old developer chemical container might work well if cleaned very thoroughly. It is probably safest to store the container in a light tight bag. when the emulsion is made the darkroom will need to be clear and the water baths set up near the sink. all work should be done over the sink when in the darkroom.

applying the emulsion

For application emulsion needs to be heated until it is a spreadable consistency, this can be done by leaving the container in a jug under constantly running hot water for several minutes. for consistent results paper should be the same size and the same paper across the board. Variations planned for application should be recored on the back of paper before application. test strips should be made as well. leave paper on drying rack in

complete darkness until dry then store in paper box until used.

experiments

for consistent results it may be best to mark out a standard image size in tape under enlarger. all technical information should be recorded including exact times in all chemicals. dried image may be prone to scratching, Varnishes should be tested. ideas for experiments include:

- commercial paper control
- 1 layer emulsion (same settings as control)
- 1 layer emulsion (settings for best image)
- 2 layers emulsion (" " " ")
- 1 layer emulsion + 1 layer resin varnish
- 1 layer emulsion + 1 layer normal gelatin
- 1 layer fotospeed LE30 emulsion
- 1 layer emulsion on glass
- 1 layer emulsion on glass + resin binder varnish
- 1 layer emulsion on plastic
- 3 layers emulsion
- 1 layer emulsion + 1 layer spray varnish

Preparing the light-tight Container

the film developer chemical container needs to be cleaned very well. I put it through two or three rounds of wash aid with a water wash between each and a long one at the end. the container is also not completely light tight initially because the white plastic of the bottle does not block all light. this is best done with several layers of black acrylic paint over the entire outside of the bottle, then possibly a coat of spray varnish to prevent chipping. Being that this container is very much improvised and there is not enough materials to make a second batch of emulsion light safety is of the utmost importance. the container should be stored upright in a fridge or cool place, prefferably in a dark bag. the container needed several coats of black paint to become fully light tight, I checked any needs for touchups by looking into the container and holding it to the light to see if there was shine through. it also needed two coats of spray varnish.

Making the emulsion

on re-reading the method it would be best to set water bath up in the Science lab. the water baths take 5-10 minutes to warm up. components disolve surprisingly quickly, however make sure beakers are wide enough not to fall over in water bath. when solutions are mixed together they become a white creamy colour immediately. ~~when the~~ a small amount was added every 30 seconds however I did not set up to time the overall time or to exactly measure the amounts put in each time. I am not sure how long it took, and the amounts were not entirely regular. this means the actual ISO is unsure and ISO may vary even within the batch. after the emultion was poored into the light tight container and sealed the container was put in a light tight bag and locked in a cupboard. When I went to clean the beaker I noticed there was some large residue lumps at the bottom which did not make it into the container. this may affect the emultion ~~residue~~ or it may be ~~included~~ needed residue.

Applying the emulsion

emulsion needs to be warmed in a water bath until it is spreadable, this takes around 5 minutes in water from the hot tap however it cools quickly. it is smart to have another jug to put the brush in after you're done. having a drying rack to put the paper on so it doesn't stick is good. do all coating over an empty and clean developing tray. Have paper towel to wipe up drips. if possible lift paper every so often to prevent sticking. close emulsion container as soon as coating is finished to prevent distruction of batch if lights are turned on (☹). while drying it is best to keep paper in a sealed cupboard to prevent light accidents. remember to also make test strips where needed. label all paper before coating, particularly with the number of layers.

Experiments

in order to draw any meaningful conclutions a series of Controls must be established. first; the same negative will be used for every print, it is a photo taken outside dickson college on a mildly overcast day using 400 ISO 120 film and a rollei-flex camera. (I specifically chose to use a 120 enlarger as I am the only person who uses it, meaning I can leave it set up, it also has a more accurate timer). second; all prints will be the same size, this will be controlled by a taped out size under the enlarger. third; no filters will be used. fourth; where possible photos will be printed on the same apature as the control. fifth; all paper will be the same unless explicitly noted. emulsion paper cannot be left in chemicals too long because it will soften the gelatin which will come off, it is sturdy when fully dried though. emulsion forms pure black specks in a range of sizes, there are small grains spread across most prints and also large spots on some prints.

Figure 1: Commercial control

technical settings: f.16, 3 seconds, no filter.
chemical times: 1 minute developer, 30 seconds stop bath, 5+ minutes fixer, rinse in water

the test strips for this were done at f.11, 1.5 seconds was the correct exposure so I brought the apature down a stop and the time up a stop to get a whole number. Contrast and detail are perfect as expected. this image has a good range of tones from black to white.

Figure 2: 1 layer LE30 emulsion

technical settings: 10 seconds, f.16, no filter
chemical times: 1 minute developer, 30 seconds stop bath, 3-5 minutes fixer, 5 minutes water

the contrast in this image came out with very good contrast, possibly even better than the contrast in fig.1. there is slight discoloration towards yellowing on the image, this could be a property of the emulsion or a result of residue chemicals on the application brush or a problem with chemical processing. there are a great number of small round white spots, this is almost definitely from air bubbles forming and popping during application, this could be fixed with a second layer of emulsion after the first has dried. darker patches in the photo are likely from thicker emulsion. the small textured brown spots may be from residue expired emulsion (fig.7) as dispite thorough washing some may have carried over.

Figure 3: 1 layer emulsion, Control

technical settings: f.16, 3 seconds, no filter
chemical times: 1 minute developer, 30 seconds stop bath, 3 minutes fixer, quick water rinse

this is an extreamly under developed image, which was expected as it was treated as commercial paper during printing. Considering this it came out well, as on close inspection the image is decernable. there is also very little discoloration in the emulsion, posibly because of a longer time in the fixer. the print has very noticable black speckles, this is part of the emulsion, it could be because of a small light leak in the container, residue chemicals, clumping of grains, variation in grain sensitivity or something else. note the image may have been better if the recipee instructions were followed for developing.

Figure 4: 1 layer emulsion

technical settings: f.16, 40 seconds, no filter
chemical times: 3 minutes developer, 30 seconds stop bath, 2-3 minutes fixer, quick water rinse

the image is quite dark and does not have very good contrast, there are also faded patches which may have been a result of residue fixer continuing to remove silver after as the emulsions nature prevents it from being left to rinse. there is a large black spot in the lower part of the image, it was not visible before developing and is not different in texture to the rest of the paper. it could be a drip of concentrated emulsion, an impurity in the paper which reacted with the emulsion or something else. this image also contains the black grains seen in fig.3 and a lesser amount of the bubbles seen in fig.2. the image turned out well when the 3 minute developing time suggested in the recipe was followed.

Figure 5: 2 layers emulsion

technical settings: f.16, 40 seconds, no filter
chemical times: 3 minutes developer, 30 seconds stop bath, 2-3 minutes fixer, quick water rinse

this print turned out with much better contrast and was much brighter than fig.4. this could be because multiple layers of emulsion results in better contrast or it may have been because of differring developer concentrations as the images were printed on different days. this print also shows the faded patches and black spots of fig.4. it also has coating inconsistencies and had to be put through a second water rinse after it initially dried as it smelled strongly of chemicals.

Figure 6: 3 layers emulsion

technical settings: f.16, 40 seconds, no filter
chemical times: 3 minutes developer, 30 seconds stop bath, 3 minutes fixer, quick water rinse

this is the best looking print so far, which may just be luck or may have been because of the multiple layers of emulsion. there were some patches which had a rough texture, possibly from clumping of halides. the print showed minimal fading and spotting. for future prints 3 layers is probably best.

Figure 7: 1 layer LE30 emulsion (expired)

this print did not work. it originally seemed to dry well, it had a small amount of undried emulsion in the corner but it was not much. originally there was cause for concern as the unheated emulsion in the tub was liquid as oposed to being set and needing melting. when the paper was developed the emulsion turned grey and began to come off the paper. after the chemical processing there was no image of any description and the emulsion continued to drip off the paper. this meant the original print had to be thrown away as emulsion which is liable to come off easily is hazardous. shown on display is a digital photo of the paper after developing.

Figure 8: 3 layers emulsion on perspex

technical settings: F.16, 40 seconds, no filter
chemical times: 1 minute developer, 30 seconds stop bath, 1-2 minutes fixer

as expected for the non-varnished perspex print the emulsion began to lift off of the perspex. this meant it could not be developed for the full 3 minutes, it also could not be fixed for the full time. originally when the emulsion was applied it was a pale cream colour, it remained that colour until it was fixed at which point the unexposed or semi exposed emulsion turned clear. the emulsion also folded in some places. the image is visible in some areas, but only just. hopefully varnish will help it stick to the perspex's smooth surface when applied underneath. a hairdryer helps to some what remove creases

Figure 9: 3 layers emulsion on perspex ñ varnish

technical settings: F.16, 40 seconds, no filter
chemical times: 1 minute developer, 30 seconds stop bath, 1-2 minutes fixer

the varnish did not assist the emulsion's ability to adhere to the perspex, results were similar if not identical to fig.8. this is frustrating as there is not enough space in this experiment to explore solutions. chemicals were not agitated during development to try and keep the emulsion intact. it began to detatch from the perspex during the stop bath application. the varnish used was a single coat of a protective adhesive varnish. possibly a matte or paint on varnish would have adhered better. the length of time needed in each of the chemicals is what is causing the emulsion to come off, this can not really remidied in the stop bath or fixer but may be help by playing with the developer concentration. leaving the emulsion to dry between the stop bath and fixer helps

Figure 10:3 layers emulsion on perspex w varnish & strong developer

technical settings: F.16, 40 seconds, no filter
chemical times: & 20 seconds 1:1 developer, 30 seconds stop bath, 2 minutes fixer

this was developed in 500ml of 1:1 dilution developer as oposed to the normal litre of 1:19 dilution developer. this allowed the print to be developed for around 20 seconds instead of 3 minutes. this worked however calculations were a little off and the print overdeveloped, & the emulsion also began to detatch during fixing, resulting in underfixing in some places, leaving a few small patches of opaque emulsion.

Possible other experiments

there are many paths for further inquiry in this experiment. these can be broken down into two catergories: solving the process's currant problems and finding different ways to apply the emulsion.

Solving current problems

emulsion sensitivity

the emulsion made in this experiment is about 13 times less sensitive than standard printing paper and 4 times less sensitive than commercial emulsion. the sensitivity of the emulsion depends on the size of halides, which is determined by the speed with which the parts are added together. a buret could be & used to add a drop at a time at a constant rate. ISO could also be measured & recored for this.

print contrast

the contrast of the prints made on emulsion paper is significantly lower than commercial equivalents. differently made emulsions capture light in different ways, meaning some colours are

represented darker or lighter in greyscale in different emulsions. this is how contrast filters alter how an image is shown in greyscale. the standard contrast filters may not effect the emulsion the same way it effects commercial paper. experiments may need to be done with differently colored plastics.

adhering emulsion to perspex

there was little to no success when it came to making the emulsion stick to the perspex for the whole developing process even with one layer of varnish underneath. it is work trying a matte varnish, a resin varnish with emulsion applied while resin is tacky, sanding the perspex to create a rough surface, adding extra layers of plain gelatin, developing differently etc.

Extension experiments

different chemicals

it is possible to make a vegan emulsion by substituting out gelatine for other binding agents like agar agar. different halide compounds could also be tested with sufficient research

Alternate recipes

there are many different emulsion recipes on the internet, some may yield better results than the recipe used in this experiment.

Other mediums

prints may be made or at least attempted on glass, wood, ceramics, fabric, canvas, coloured paper, metal, scrunched paper/fabric, objects which will create distortions, plaster etc.

incorperated elements

small elements such as dyes, glitter, dried flowers or anything that will not react directly with the emulsion can be mixed into it after it is made.

bleach washes

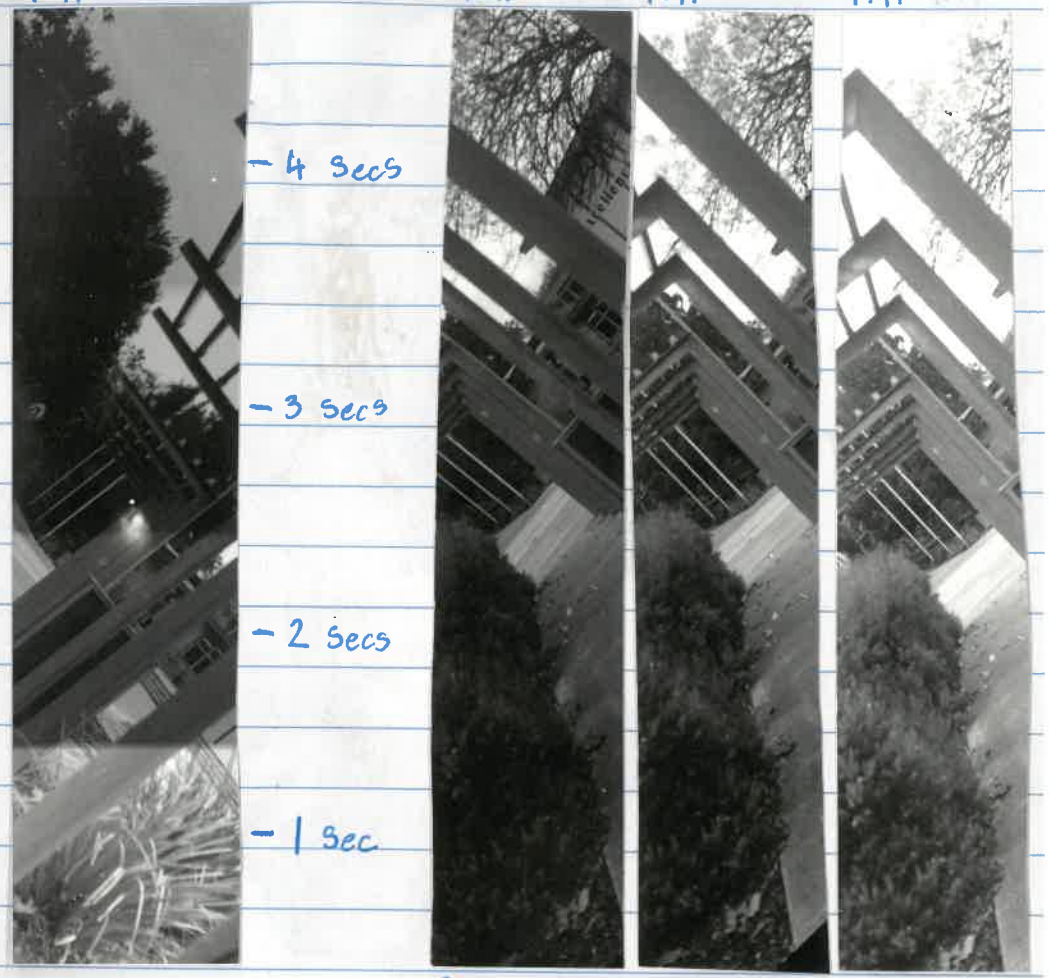
in older photographic processes people would sometimes include a bleach wash to create a positive print from a plate negative. not sure if this will apply to current photographic chemistry but a photo printed on a dark background and put through a bleach wash or printed on a clear medium and mounted on something dark may create an interesting effect.

Conclusion:

when it comes to objective quality few things are better than commercially produced photography materials. however handmade emulsion is of a high enough quality that images can be printed which are presentable. the versatility and specific asthetic of handmade emulsion is also appealing. commercial paper is around 13 times more sensitive than handmade emulsion and considerably more durable during the development process however durability is comparable after prints have dried. there is much more research to be done surrounding this topic, hopefully there are more opportunities to do this in the future.

Appendix: test strips

fig. 1



1.5 secs is best exposure

Fig.4
f.11

~20 secs

~15 secs

~10 secs

~5 secs

~20 secs

~40 secs

~60 secs

~80 secs

40 seconds best exposure

Fig.2
See visual diary for test strips

best exposure 8 or 12 seconds (at f.16)

Fig.8, Fig.9, Fig.10

Waste emulsion left in chemical trays