Search For a New Additive Imaging Solution

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VCU Fine Art

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An AutoChrome Detective Story

Aguste and Louis Lumière

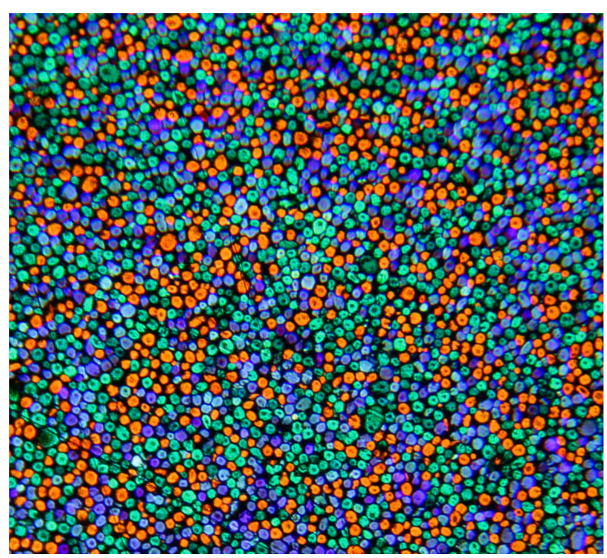
The Lumière brothers, Auguste and Louis, pioneered major advances in cinema and photography with the first projected film and one of the first solutions for color photography.

I am interested in artistic processes that allow me to be involved in the creation of the image or object. The 'additive' Lumière approach offered this potential. The challenge: how did they create the color filters which were used to expose the black/white negative and display the final image?

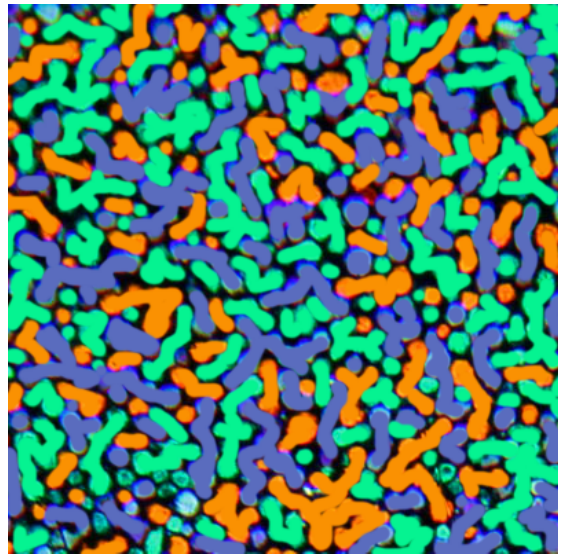
According to Wikipedia, the Lumières used a very thin layer of dyed starch particles, glued to one side of the glass plate. This was the nugget that launched my search for a solution.

Microscopic Starch Particles

I found a number of descriptions of the Lumière process on the Web – and ordered a book that provided more details on their process. A particular size of potato starch particle was used to create an Autochrome filter plate. The particles were dyed, mixed and applied in a thin layer, with lampblack to fill in the gaps – as shown in the micro photo to the right.



Reports on Autochrome production focus on the size of individual starch particles – between 10 and 20 microns. When I looked closely at Autochrome plate images, however, I found that the starch particles are grouped by color in strings and small clumps. Each dot of color is actually 60 to 180 microns across, as shown in the micro photo to the right.



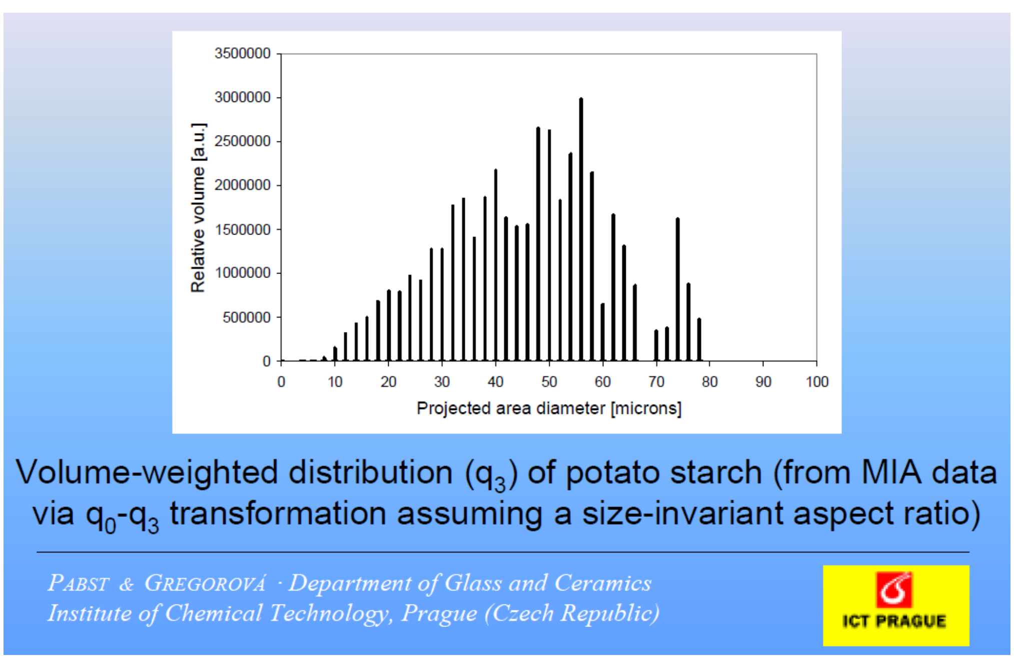
This became important with Phase 2 tests, described later.

Lots of Google Searches

How large are potato starch particles in microns? How about other starch particles from corn, rice etc? Stories about the creation of Autochrome talk about the Lumières searching for the 'right potatoes' and a partnership with Francisque Demure to filter the starch and produce fine particles for the Autochrome production process. I needed more information.

Voila!

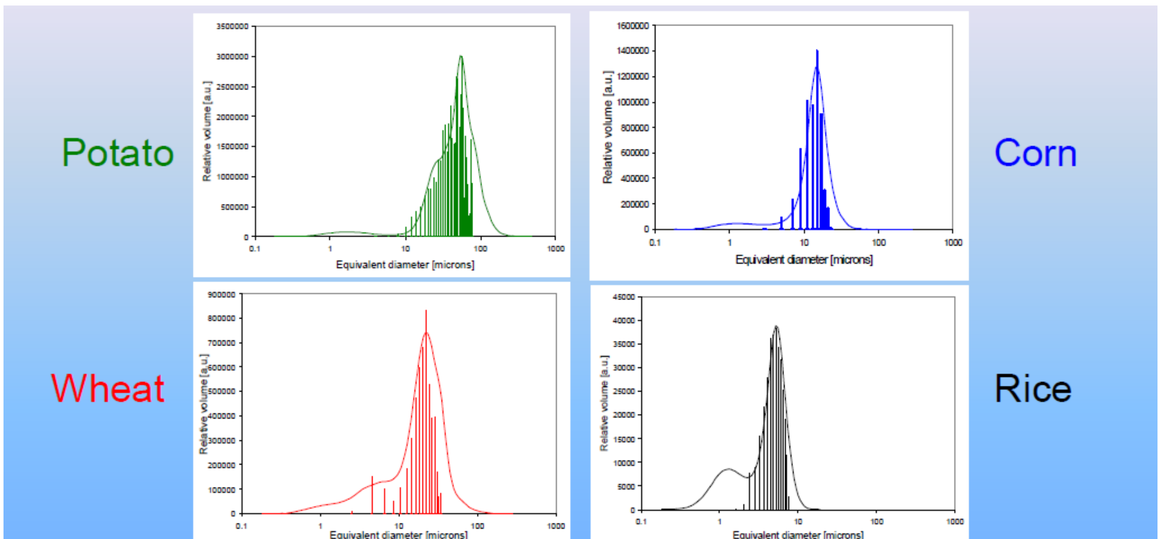
I found a great research paper created by a team in the Czech Republic that analyzed every common type of starch. Here is the size range in microns for potato starch particles:



This report shows that stories on the Web about the Lumières using 5 to 10 micron potato starch are inaccurate, because 10 microns is the lower limit for potato starch.

The report also made me wonder, “Why did the Lumières choose potatoes?” Maybe that was the only high quality type of starch that was available. Maybe other types of starch are not as transparent or do not accept dyes well due to their structure. Maybe they could not filter anything less than ~20 microns.

We now know the exact minimum, maximum and average size of particles in common types of starch:



Particle size distributions of starch measured via laser diffraction (curves) and via microscopic image analysis (histograms)

Source: PABST & GREGOROVÁ · Department of Glass and Ceramics
Institute of Chemical Technology, Prague (Czech Republic)

With today's high quality starch, film and filters, we do not face the same limits. Maybe I could:

(a) Avoid the trouble and cost of 'squashing' potato starch particles with a press, and

(b) Achieve a higher resolution, higher quality version of Autochrome with rice or corn starch, and

(c) Create a new completely new approach to Autochrome

Preparation for tests with starch particles:

1. I started by focusing on small <10 micron particles, with a set of filters that could be used with corn starch to remove particles larger than 10 microns. Rice starch is all <10 microns, with a tight cluster between 4 and 9 microns – so the filter was not needed.
2. I located a high quality source of rice and corn starch and ordered a set of samples.

Dye colors:

Autochrome plates were covered with potato starch particles dyed orange, green and violet. This is obviously different from modern RGB (red, green, blue) color models. I analyzed the colors which match the RGB colors shown to the right.

0 211 157	134 81 234	255 146 12

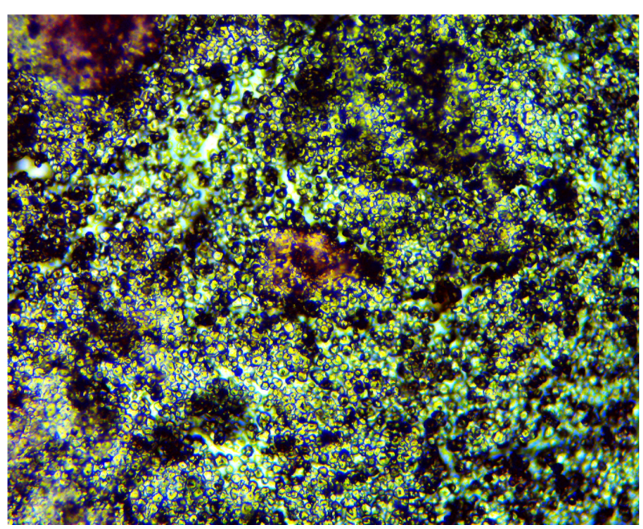
I tried to order commercial dyes. The companies would not sell their dyes to a student, however – so I used water based art dyes.

Production notes:

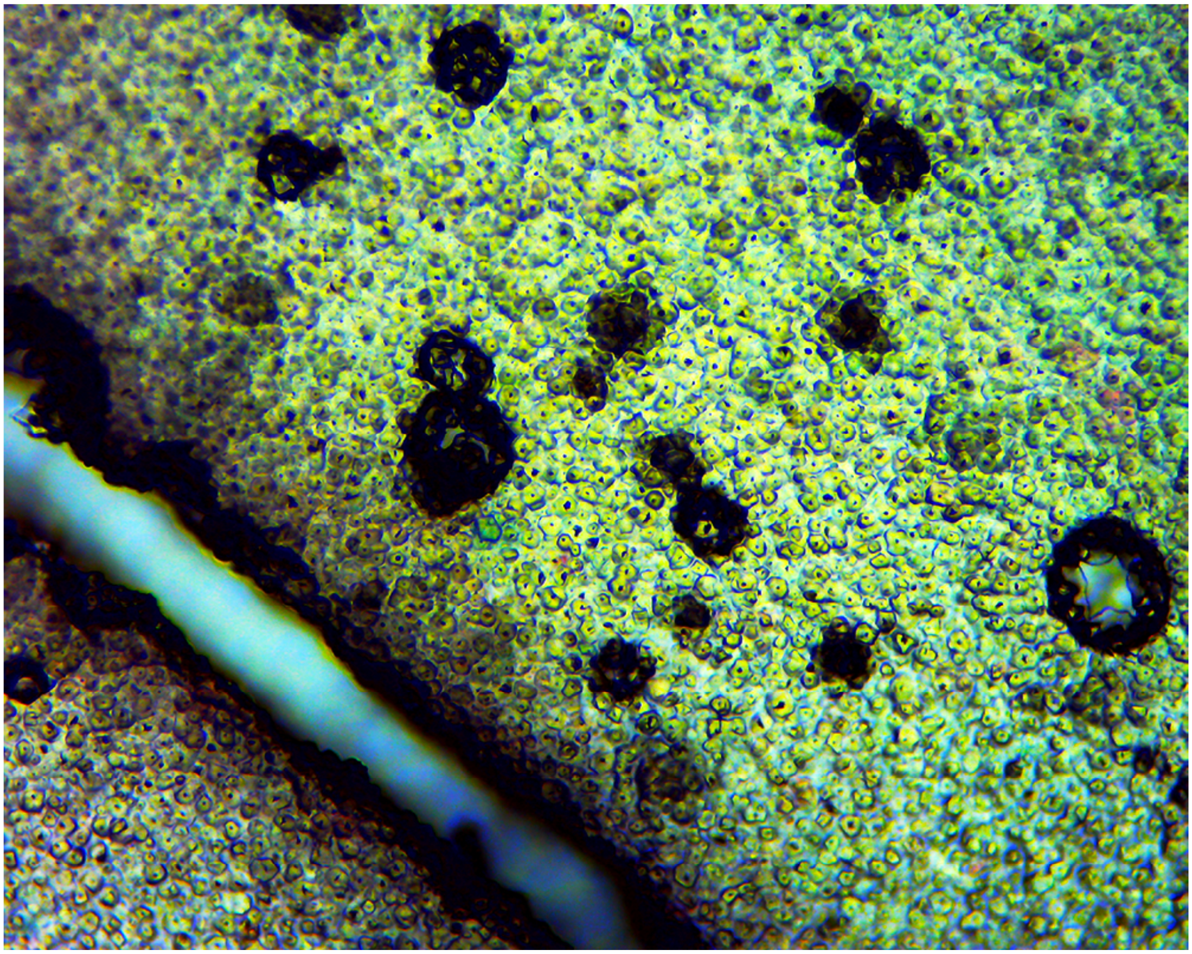
- I was dealing with micron level starch powders, which are undoubtedly a bad thing to inhale. So I wore a high quality dust / fume mask.
- I needed to dry the starch thoroughly after it was filtered and dyed. So I purchased a standard food dryer, which works at a low temperature.
- I also purchased a low cost microscope with digital photo capture, to see the results of the tests.

Phase 1 results:

I filtered the corn particles, then dyed, dried and mixed the colors and applied them to a tempered glass plate which was pressed against a metal plate to flatten the particles. A micro photo of one example is shown to the right.



It was difficult, however, to achieve a smooth and transparent layer of starch particles. For example:



The Lumière brothers built a special press to flatten starch particles on their plates – using a thin metal rod that rapidly moved back and forth across the glass plate to flatten the particles. Brilliant! This became a difficult barrier to cross for me, despite all of our modern technology. I did not have the time or money to build a custom machine.

Phase 2 research:

Facing this barrier, I wondered if there was another way to achieve a similar result: a pattern of transparent color dots on a tempered glass panel that could be used as a filter.

The resolution of Lumière potato starch particles can be matched by digital print heads, e.g. electrodeposition, inket and laser. One micron = 25,400 DPI so a 1,200 DPI print head has a resolution of approximately 21 microns. .

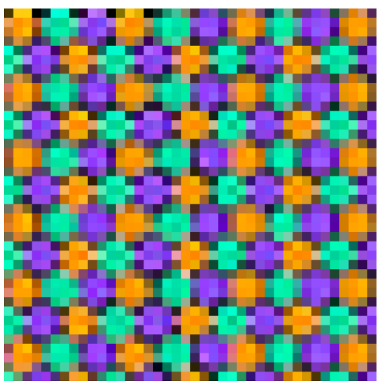
The key question was dot quality; would the density of dots and intensity of color be sufficient to function as a color filter?

This effort would also be a combination of digital and analog. A computer could create the filter patterns, but print heads create rough spots of color that are not precise and digital.

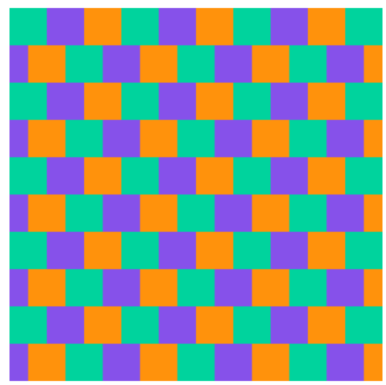
Digital filter design

I started by creating a number of color patterns to test different digital print heads. The three colors used in original Autochrome plates can be arranged in circles similar to starch clumps with black / dark spaces, plus a 2x2 pixel pattern with no spaces:

Three color Lumiere pattern

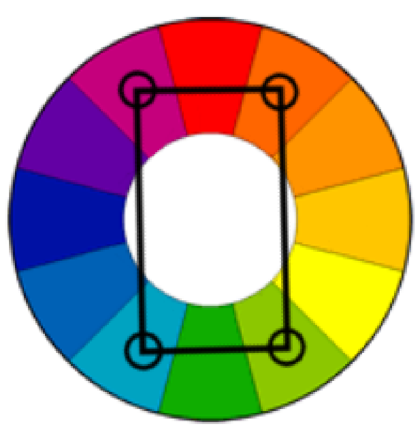


Three color 2x2 pattern



Four color model

The color model and balance can also be changed – a creative plus. In a basic color wheel, square and rectangular ("tetradic") color models look like this:

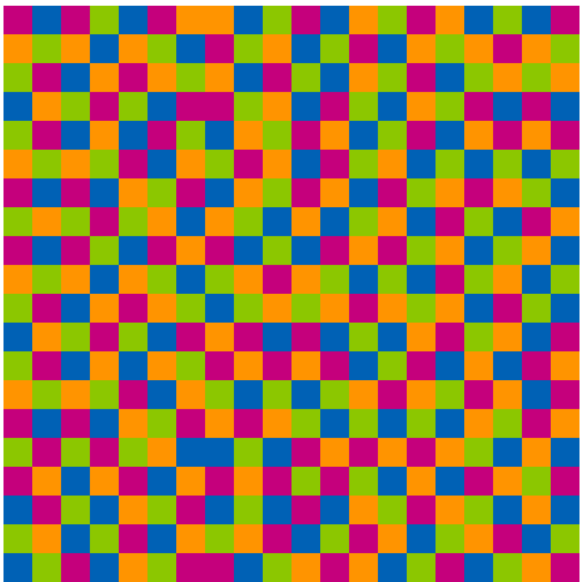


I tested these two color models with a 1x random pattern:

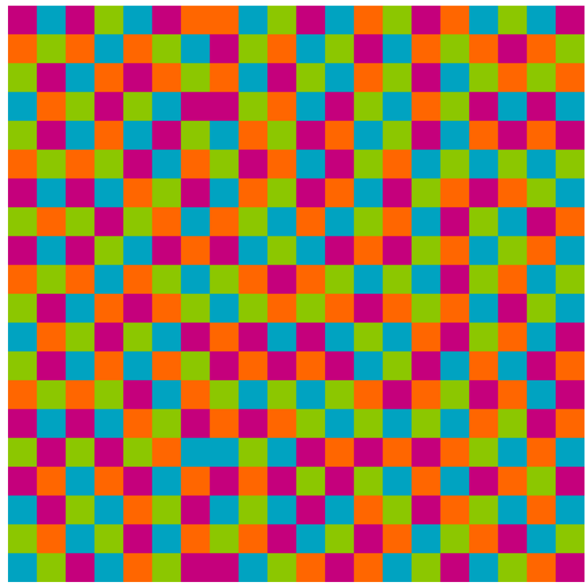
Four color square #2

Four color rectangle #2

Random pattern with Square #2



Random pattern with Rectangle #2



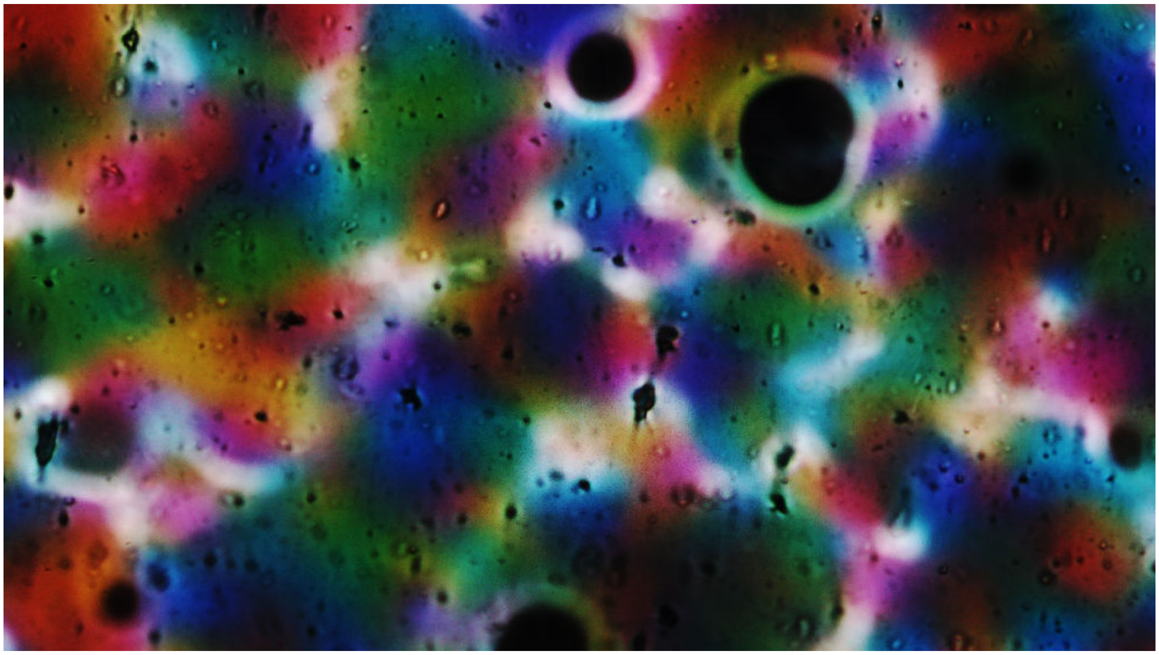
Problems with print quality

Although these color patterns start as digital image files with accurate colors and pixel dimensions, print drivers and software applications are designed for standard printers and modify images automatically to improve print quality, e.g. for photographs. These automated changes damaged Neo Autochrome filter images

After extensive testing, I found a solution that preserved the original pattern and colors. This required close examination of dozens of tests, using a digital microscope.

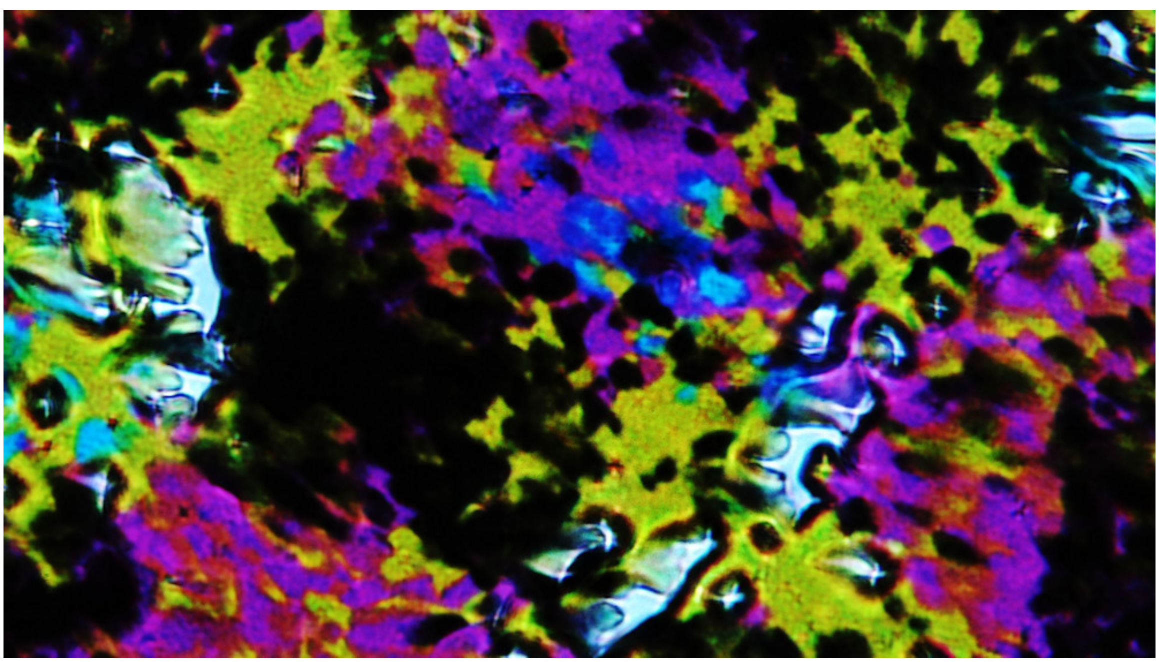
Phase 2 tests also highlighted an interesting fact: we think of computer driven printers as “digital” because we send digital files to them. In fact, these printers use ink and molten dye particles similar to Lumiere starch particles. The results are anything but precise and digital.

For example, here is a close-up of an early filter print:

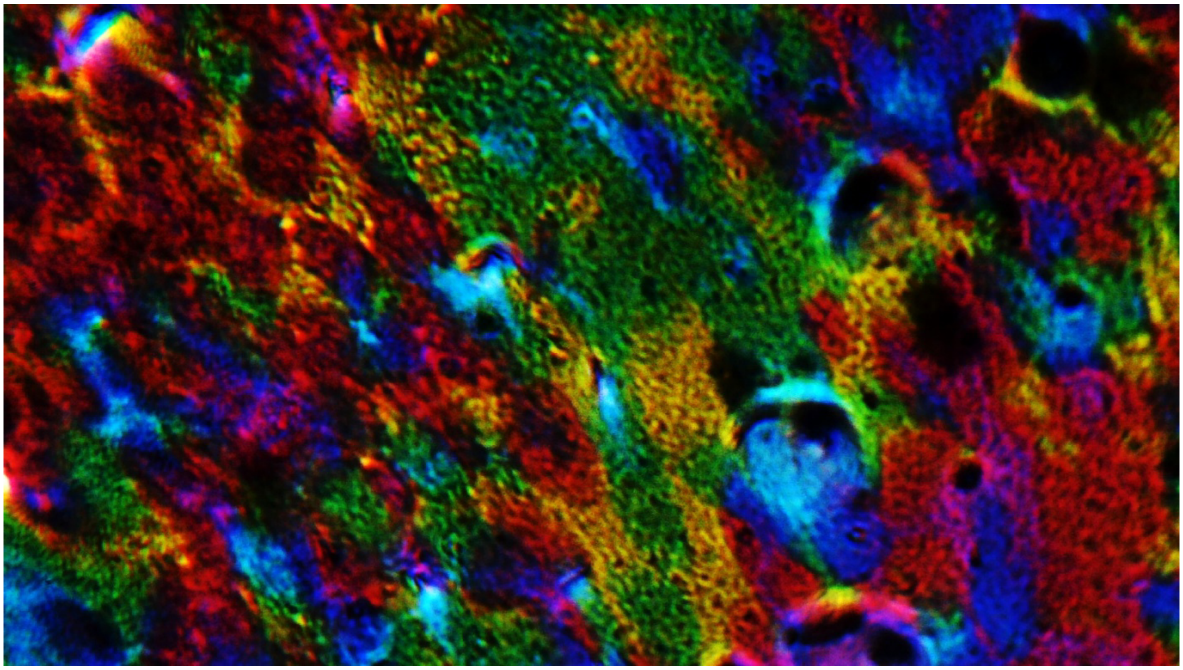


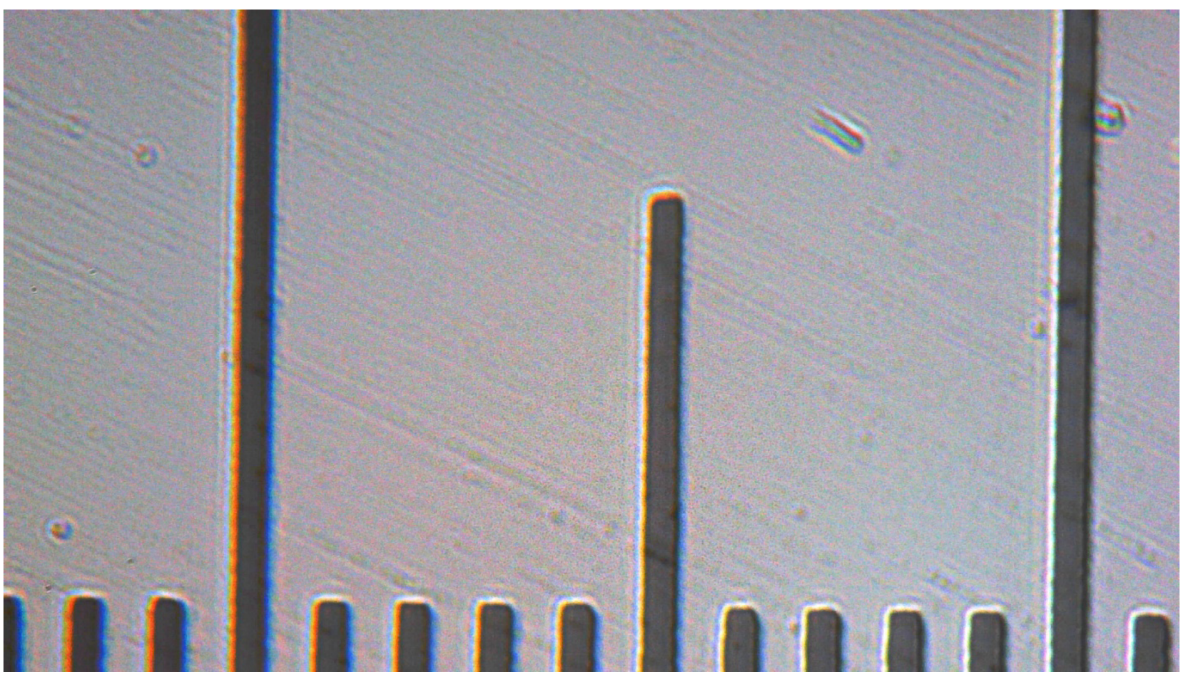
Note how the color ink dots merge, mix and vary in size – similar to starch particles. This is not a 'digital' image!

Another example with blended color particles and black filling the gaps between, like Autochrome plates. Again, this is not a 'digital' image:



A close-up view is shown below, with a calibration slide to measure parts of the image. Each small division on this 'ruler' equals 10 microns:

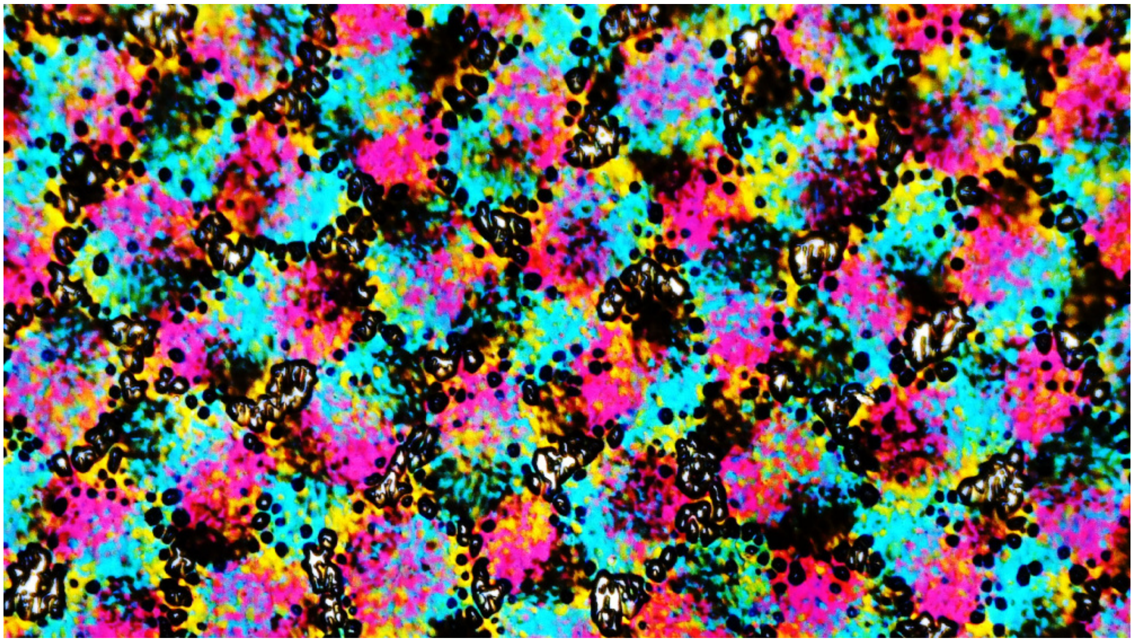




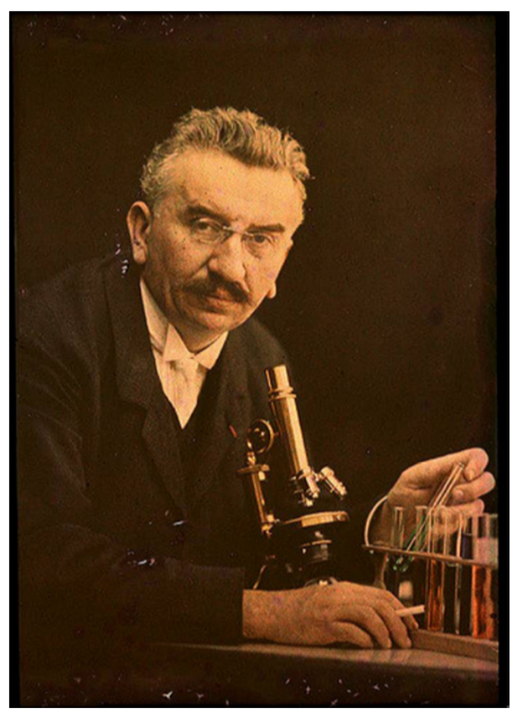
The dye particles are only ~2 to 3 microns across. They clump and chain like Lumière starch particles and average ~30 microns, finer resolution than is possible with potato starch.

Improved resolution

Additional tests produced Neo Autochrome filters with more precise spacing and shape. White space was nearly eliminated, as shown below:



Summary and Current Status



Phase 2 of my Neo Autochrome project used digital technology to create new analog color filters. Extensive testing was required to see how digital patterns are interpreted and applied – to optimize the results.

The dye particles clump and merge similar to Lumière starch particles – which made a microscope essential to analyze the results. The Lumière brothers also used microscopes to assess their results – as shown in the photo to the right of Louis Lumière.

The first test photos were shot in December and are being converted into positives to review with the Neo Autochrome filters.

I am also designing a new type of diascope to display the additive images.