Chromoskedasic Painting

by Dominic Man-Kit Lam and Bryant W. Rossiter

It is a novel method for producing color images on black-and-white photographic paper without using pigments or dyes

Passion --- the chromoskedasic painting reproduced on these two pages --- dazzles the eye with oranges, yellows, greens and blues. The hues are surprising because they were created by applying colorless chemicals to black-and-white photographic papers. Almost all paintings and color photographs consist of pigments that reflect certain parts of the visible spectrum of light and absorb others. But the original chromoskedasic painting contains no such pigments, only white paper and particles of silver.

These tiny particles produce colors not by reflecting or absorbing radiation but by scattering light. Particles of different sizes scatter different wavelengths of light, yielding various colors. The term "chromoskedasic" is derived from Greek roots meaning color by light scattering.

The basic methods of chromoskedasic painting were discovered serendipitously one autumn evening in 1980. I (Lam) was developing black-and-white photographs of a retina, as part of a research project at Baylor College of Medicine. I noticed that some photographs were covered with patches of brown and yellow. Other photographers have undoubtedly observed this same effect. The colors usually appear because the photographic solutions were mixed improperly, because the solutions had deteriorated or because the photographic paper was defective. I wondered how colors could emerge from the use of black-and-white photographic paper and solutions, materials that do not contain dyes or pigments. Having seriously pursued painting for 20 years, I hoped to control the production of these colors and thus exploit the unusual characteristics of the new medium [see "Painting in Color without Pigments, " THE AMATEUR SCIENTIST].

Without understanding in depth the mechanisms that generated the different colors, I systematically searched for the light and temporal conditions needed to produce different colors predictably on photographic paper. I also experimented with the concentrations of such solutions as activators, developers, stabilizers and fixers. By 1983 I had established a procedure for creating the primary colors - red, blue and yellow - and I could combine the three colors to create various shades. During the past eight years, I have refined the techniques by trying different kinds of papers and solutions, and I have attained better control of colors, tones and composition.

Although my empirical approach led to a technique for producing color from black-and-white photographic materials, I had not given much thought to the physical and chemical mechanisms underlying such a process. In the summer of 1989 my co-author (Rossiter) came to visit me in Houston and took an interest in my paintings. He noticed the brilliant red and yellow hues, the occasional metallic sheen, the three-dimensional character of some objects and the unusual light stability. (Some paintings had been exposed to direct ambient sunlight for more than seven years and had not faded.) From these observations and others, he deduced that the colors in my paintings were a consequence of light scattering from tiny silver particles in the photographic paper. He coined the term "chromoskedasic".

The colors of most paintings rely on a process known as subtractive color. Blue pigments, for instance, reflect blue light while absorbing most other wavelengths. The colors in conventional photographs are also the result of a subtractive process. But instead of pigments, photographs require color sensitive emulsions and developing agents that produce or release dyes (see "The First Color Photographs" by Grant B. Romer and Jeannette Delamoir; SCIENTIFIC AMERICAN, December 1989).

焰 Passion 1984 100 x 250cm

Most black-and-white photographic papers contain silver salts. Under the influence of light and chemicals, the salts decompose to form silver particles. Ordinarily, these particles merely absorb light, yielding tones of black. Those salts that are not exposed to light do not yield silver particles and are washed away allowing the white paper to show through. Chromoskedasic paintings are made using methods very similar to those employed in black-and-white photography. But chromoskedasic techniques require that the particle growth be carefully controlled through exposure to light and chemicals.

In chromoskedasic painting, the silver particles produce colors through a process known as Mie scattering. In 1908 Gustav Mie first described this scattering process in mathematical terms. He studied how light scatters through a medium consisting of spheres of similar size and electrical characteristics. He found that the wavelength of light scattered by such a medium depends on the size of the spheres.

Mie's theory helped to explain why the sky is blue or why the sun appears red at dawn or sunset. The sky is blue, in part, because dust, water vapor and other particulate matter in the atmosphere are of such a size as to scatter light selectively from the blue region of the spectrum. Similarly, atmospheric particles of different sizes produce some of the brilliant colors of the rising or setting sun. (To be sure, many kinds of scattering, absorption and refraction processes contribute to the color of the sky.)

Particle formation in a complex, modern photographic emulsion is very different from the ideal conditions that Mie assumed. Chromoskedasic paintings consist of silver particles that vary greatly in shape and size. Nevertheless, the Mie equations predict the correlation between particle size and the colors created in chromoskedasic paintings.

Using electron microscopy, Donald L. Black of the Photoscience Research Division at Eastman Kodak in Rochester, N.Y., confirmed that regions of a particular color in a chromoskedasic painting contain silver particles that are relatively uniform in size. In agreement with theory, silver particles that produced yellow light were from 10 to 30 nanometers in diameter, whereas particles that scattered red light were 35 to 65 nanometers wide. Scientists still do not understand in detail how the size and shape of the particles influence the scattering of light and hence the colors of chromoskedasic paintings.

Many of the artistic possibilities of chromoskedasic painting have yet to be explored. Artistic expression is intimately related to materials and media. Watercolors are usually softer than oil paints, black-and-white photographs often bring out textures better than color photographs, and marble sculpture is often more ponderous than steel. Chromoskedasic techniques bring out rich metallic colors that mingle, mix and wash over one another. The methods preserve the artist's expression for decades because the colors endure as silver particles firmly embedded in paper.

That techniques give artists many different ways to produce color images. They can manipulate a variety of darkroom conditions, such as light intensity, chemical concentrations and reaction time. They can precisely control the conditions to create representational paintings. Or they can allow nature to play with light and chemistry to generate abstract images. Chromoskedasic methods can also be easily integrated with conventional photographic techniques or with media such as acrylic, oil, watercolor and enamel paints. We hope chromoskedasic techniques will continue to inspire both artists and scientists.