BENIGN BLEACHING FOR HEALTH HOLOGRAPHY

Nick Phillips

Much of the development of holography has paralleled the earlier development of photography. For example, when 35mm film was introduced in the '30s there was a proliferation of developer formulae, sometimes containing substances as inappropriate as sugar, alcohol, cold tea and even beer. Often the inventors of these brews had the bad taste to give their own names to their "discoveries" (something no botanist would ever do). With the advent of display imagery, much the same has happened in holography: a host of processing formulae, many of them conceived in ignorance of what really went on in the processing. This is particularly true of rehalogenating bleaches.

When my students and I first revealed the use of para benzoquinone (PBQ) in 1980, we were publicizing a bleach system capable of first-class results when using pyrogallol staining developers. In fact, the technique still remains a workable (if toxic) method for making bright, low-noise holograms. When the develop-rehalogenate method is combined with pre-swelling, then He-Ne lasers can be used to give green images.

The toxic and environmental hazards of various chemicals have become a major preoccupation in the photographic industry and these hazards need to be carefully studied by amateur users such as holographic artists. It was thus logical to consider the use of a non-toxic alternative to PBQ, and this article discusses an alternative bleach capable of very bright results with low noise and virtually no toxic hazard. I have introduced this system for general use by students at the Royal College of Art in London and we shall use it there as a standard system for all work in transmission and reflection mode.

There is no magic about bleaching; it is simply a matter of understanding what the constituents do. Rehologenating bleaches of the normal type consist of:

1 An oxidizing agent (e.g. ferric nitrate)

2 A metal halide (e.g. potassium bromide)

3 Buffer compounds (e.g. sulfuric acid)

The oxidizing agent creates silver ions which can migrate before meeting a halide ion and producing a precipitate of, say, silver bromide. This migratory aspect is the basis of rehalogenation-without-fixing as a method of modulation of holograms (Phillips, 1983). In an early paper (Phillips and Porter, 1976) we showed how to combine ferric nitrate and potassium bromide as an effective bleach for transmission holograms. At that time, we did not appreciate that fixing of the image was *not* required to produce image modulation. Hariharan had in fact discussed the no-fix system as early as 1972.

When we introduced PBQ, it was as a system of bleaching where no fixing was involved. It led to easy production of green reflection holograms using an argon-ion laser. Eventually, we found that master transmission holograms could also be rehalogenated without fixing, also yielding greater efficiency and precision of imagery.

It is generally true that the method of development followed by rehalogenation is the only system that can truly lead to nearly 100% diffraction efficiency without shrinkage of the emulsion.

The drawback with this method lies with its inherent grain growth mechanism, which effectively transfers halide to the unexposed image, promoting Rayleigh scatter in the finished result. If a hologram is fixed before bleaching it will shrink, and will require reswelling at a final stage of processing. Maybe such a method might now work, with the hindsight of experience. However, the develop-rehalogenate method guarantees bright results with very little fuss.

The alternative bleach discussed here evolved some years ago from taking a careful look at what the photographic companies have done to make chemicals safer, and then using this knowledge to effect in holography. Our new bleach agent was a natural target for the Ilford company for example, and is indigenous to their own new chemistry.

Our safe bleach uses the Fe^{3} + complex with ethylene diamine tetra acetic acid, ferric EDTA for short. The substance can be created by using the di-sodium salt of EDTA with a simple ferric compound such as ferric sulfate. The following proportions work well as a bleach and are chosen for simplicity rather than molar accuracy.

distilled or deionized water	700ml
ferric sulfate $(Fe_2 (SO_4)_3$	30g
EDTA di-sodium salt	30 g
potassium bromide	30 g
sulfuric acid, conc.	10 ml
enough distilled water to make	1000 ml

-dissolve the constituents in the order given.

The solution keeps well and is essentially totally safe. Probably safety could be increased further by the use of a weaker acid such as acetic acid. Changes of acidity will however change the physical transfer characteristics and also alter the attack on the stain of pyrogallol developers. It is primarily the variation of stain that accounts for the differences of diffraction efficiency observed when bleaches are modified in ph.

A bleach of this type was used by Phillips and Van der Werf (1985) to produce reflective Lippmann layers by photography with reflectances in excess of 97% using the D lines of Sodium vapor as the illuminating radiation.

If workers wish to adjust the scatter level of the image they may experiment with the level of potassium bromide as discussed by Phillips and Porter (1976).

In my opinion, the complexing of silver ion by the sequestering agent EDTA assists the ionic migration of silver, and there is no doubt of the exceptional ability of this mixture to promote physical transfer during the bleach process.

As an early proponent of PBQ, I now strongly advise that all use of the substance be dropped because of suspect toxicity problems, and that workers universally adopt the recommended compounds.

NOTE: Rehalogenating bleaches of the type described do not remove the original sensitizers from the emulsion, and there is a tendency to print out when the hologram is exposed to strong light for long periods. This tendency can be largely eliminated by a final rinse in 1% acetic acid or Kodak stopbath.

September 1986

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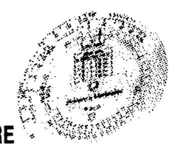

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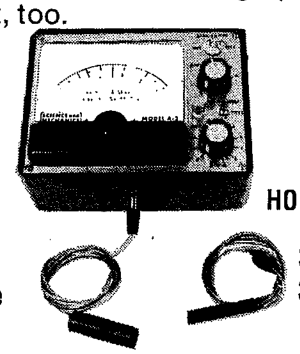

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