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# THE CHEMISTRY OF PHOTOGRAPHY IN FULL DAYLIGHT

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**ABSTRACT:** Photography, the daughter of art, is also considered the well-bred child of science. From its very beginnings, the new visual art fully utilized the most advanced scientific discoveries pertinent to its development; particularly those occurring in the field of chemistry. The most notable advantage of photographic chemistry, in relation to chemical education, is found in its unique scope, which combines interesting inorganic, organic and physical chemistry with a powerful visual communication medium of tremendous social importance. Chemical educators dwelled on both the theoretical and the experimental aspects of photographic chemistry. Yet the proposed experiments do not involve the magical process of image development. In the present work, methods involving the rehalogenating bleaching of black and white photographs are presented and also experiments for the "development" of the bleached image in full daylight. The chemical topics that can be covered by such experiments range from the dissolution of metallic silver in dilute nitric acid to the reduction of silver ions using common organic reducing agents. [*Chem. Educ. Res. Pract. Eur.*: 2000, *1*, 175-177]

**KEY WORDS:** *photography; photographic chemistry; silver image bleaching; daylight development*

## INTRODUCTION

The visualization of the latent image during development constitutes the most magical part of the photographic process ever since its invention a century and a half ago. From the time of the making of the motion picture "*Blow Up*" by Michelangelo Antonioni, movie-makers in particular capitalized on the intriguing power of photographic image development. The same motives, no doubt, underlined the making of the instant photography machines in the early seventies (the SX-70 Polaroid-land family of photographic cameras, and their Kodak counterparts) which were, and still are, capable of furnishing a picture which develops in front of our own eyes in broad daylight.

## BACKGROUND

Chemical educators resort to photography-related experiments for the purpose of demonstrating either photochemical principles (Sasaki, 1992; DiSpezio, 1987) or the reductive power of certain organic compounds such as dihydroxybenzenes (Neubauer, 1997) or *p*-aminophenol (Rothenberger, 1991) on ionic silver. In particular, they employ black and white photographic paper, which upon contact with an alkaline solution of hydroquinone or some other reducing agent, turns black due to the reduction of the silver halide contained in its emulsion into black metallic silver.

Because such an experiment, however instructive, lacks the above mentioned magic of the photographic process, we developed an alternative procedure which utilizes a "bleached out" black and white photographic image in the place of the ordinary photographic paper. The bleached out paper can be developed using organic developers, in full daylight, yielding full tone photographic images.

The students obtain the required photographic bleached image when they are asked to immerse a black and white photograph of their own choice in a dilute warm solution of nitric acid. The latter contains potassium bromide. The dissolution of metallic silver, contained in the photographic emulsion, by dilute nitric acid, although not found in photographic literature, serves the educational purpose, since it exemplifies well the role of nitric acid as the best silver solvent (eq. 1). [Most rehalogenating bleaches used in photography contain either potassium ferricyanide or potassium permanganate as the main silver dilutient (*Photo Lab Index*, 1977).] In addition, the rehalogenation of the ionic silver thus obtained, by the potassium bromide present in the solution, demonstrates the formation of the light sensitive silver halides and their insolubility in oxidizing acids such as nitric acid (eq. 2).

$$3Ag_{(s)} + 4\,HNO_{3(aq)} \rightarrow 3\,AgNO_{3(aq)} + NO_{(g)} + 2\,H_2O_{(l)} \quad (1)$$

$$AgNO_{3\,(aq)} + KBr_{\,(aq)} \rightarrow AgBr_{\,(s)} + KNO_{3\,(aq)} \quad (2)$$

Furthermore, toning procedures (*toners* are chemical solutions which change the color of black image of a print) which convert the silver ions to colored silver compounds such as the one depicted in eq. 3 could be used to both illustrate the principles of double replacement reactions and expose the students to past time photography aesthetics.

$$AgBr_{\,(s)} + Na_2S_{\,(aq)} \rightarrow Ag_2S_{\,(s)} + 2\,NaBr_{\,(aq)} \quad (3)$$

## EXPERIMENTAL PROCEDURE

**SAFETY NOTE:** *Nitric acid can produce very toxic nitrogen oxides; therefore, fumes coming from nitric acid spills are hazardous. Solutions of nitric acid can destroy eye or skin tissues. Hydroquinone is moderately toxic and it primarily affects the eyes. The use of safety goggles and gloves is strongly recommended. In case of contact with either of these chemicals, immediate wash of the affected part with large quantities of water is necessary.*

A black and white photograph is immersed in a tray containing a warm aqueous solution (40° C) of 1:1 nitric acid to which 4.0 g/100 mL of potassium bromide was added.

While the bleaching of the silver image starts after a few seconds (the bleaching of a resin coated paper takes about 1 min), the print remains in the solution until only faint traces of the halftones are left and the black of the shadows has disappeared.

The bleached print can be used, after 1-2 min washing in running tap water, for every desirable demonstration such as reduction by alkaline hydroquinone solution, toning with sodium sulfide solution etc.

The reduction (development) of the bleached image requires immersion and rocking in a tray, containing an aqueous solution of 12 g of hydroquinone and 70 g of anhydrous sodium carbonate per liter. After about 1-1 ½ min the black and white image is fully developed.

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