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Extrinsic Stain Bleaching with a Peroxyacid and Hydrogen Peroxide

S. Majeti*, E.A. Reno, D.W. Volpenhein
Procter & Gamble Co., Cincinnati, OH, USA

ABSTRACT

It is generally recognized that peroxyacids are strong oxidizing agents and are superior in their reactivity to hydrogen peroxide (H_2O_2). Using magnesium monoperoxyphthalate (MMPP) as an example of peroxyacids, an investigation was carried out to compare its ability to bleach surface stains formed on bovine enamel relative to hydrogen peroxide. Materials and Methods: Pre-stained bovine enamel chips were soaked in water, 0.7% MMPP, 0.1% H_2O_2 for one hour. The pH of the solutions was maintained at 7.6 using citrate buffer. At 0, 5, 15, 30, 60, and 120 minutes of exposure, the color of the chips was measured with colorimeter and the results were expressed using the L*a*b* scale. Results: The buffer control, as expected, had very little effect on the color of the chips. At equivalent concentration and ambient temperature (25°C) MMPP performed significantly better than H_2O_2 DL* of 22.3 versus 6.8, respectively. This advantage for MMPP persisted even when the H_2O_2 concentration was raised to 1.5% (DL* 5.4). However, as the reaction temperature was increased to 37°C, H_2O_2 started to perform better (DL*14.7) and at 45°C, H_2O_2 delivered equivalent bleaching to MMPP (DL* 26.1). The temperature sensitivity of H_2O_2 appears greater than that of the peroxyacid . **In conclusion, the stained bovine chips can be used as a lab model to study relative stain bleaching effectiveness by oxidizing agents. At ambient temperature (25°C), MMPP is considerably more reactive than peroxide; however, this advantage becomes narrower as the temperature is increased to 37°C and eventually lost at 45°C.**

INTRODUCTION

The characteristic feature of all organic peroxides is the presence of the 0 - 0 bond. These peroxides are classified according to the number and kind of organic functional groups attached to the oxygen atoms - -hydrogen peroxide (HOOH), alkyl hydrogen peroxide (R-O-O-H), dialkyl hydrogen peroxide (R-O-O-R') peroxy acids (RCO-O-O-H), peroxy esters (RCO-OOR'), and diacyl peroxides (R-CO-O-O-CO-R'). Organic peroxides are capable of reacting via numerous pathways, the specific pathway for each individual reaction being dictated by its conditions, and the degree of reactivity also varies depending on the nature of the organic functional group attached to the 0 - 0 moiety. One of the trends observed is that the peroxides with lower electron density on the 0 - 0 bond generally are the stronger oxidants. Comparing the functional groups on the peroxides listed above, the order of increasing electron density on the O-O bond is alkyl > H > carbonyl. According to this trend, it is expected that the peroxy acids are the strongest oxidants. One way to promote the reactivity of less reactive peroxides such as hydrogen peroxide is to increase the reaction temperature which typically promotes the homolysis of peroxide to generate hydroxy radicals. Gels of various types containing hydrogen peroxide are marketed for whitening human teeth. The process requires the user to wear the trays containing peroxide gels everyday for at least two hours for extended periods of time, over 2 to 12 weeks. Compounds such as peroxy acids might prove to be superior tooth whitening agents, requiring shorter exposure periods. The objective of the study described here is to determine the relative reactivity of hydrogen peroxide and a strong oxidant, peroxy acid (MMPP), using an in-vitro stain bleaching technique.

MATERIALS AND METHODS

Materials

Water

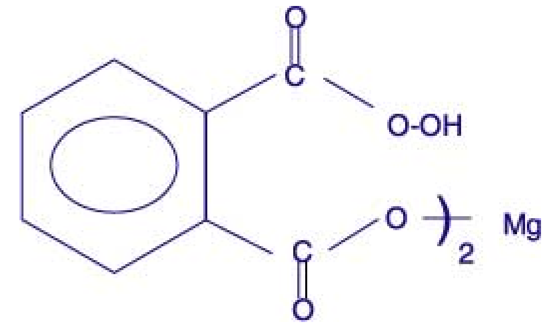
Distilled deionized water

Peroxide

Hydrogen peroxide at 50% from EM Science diluted to the desired concentration (MW:34)

MMPP

Magnesium monoperoxyphthalate hexahydrate from Aldrich as dry power. (MW: 494)



Bovine Enamel Chips

Random source bovine teeth were mounted in ~ 1 cm^3 plastic resin. The exposed side was polished until a smooth even surface was obtained. These teeth were stained using a concoction of coffee, tea, CHX and bacteria. After staining, the chips were divided into two groups. One group was used as it was stained and the second was brushed with a toothbrush and water for 200 strokes to remove loosely adhered stain.

Imaging

Measurements were made on a Nikon P-F- 4 colorimeter and recorded in CIB L*a*b* color space.

Methods

The bovine chips were individually numbered and a representative area of coloration in ~ 3 mm in diameter was located in each one. The position of their area was recorded in each one and zero time point L*a*b* value measurements were obtained. The chips were then immersed in 20ml of treatment solution or placebo buffer, with the enamel surface face up, kept at the desired temperature for 5, 15, 30, 60, and 120 minutes. The L*a*b* values for each chip were obtained at each time point.

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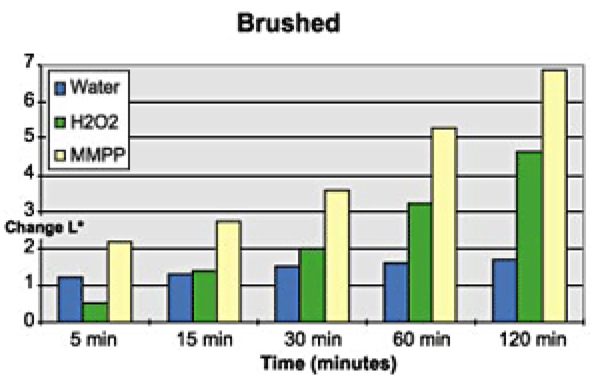
Solution Formulations

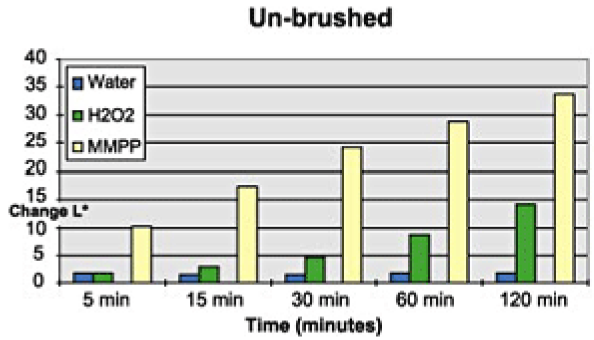
Hydrogen peroxide and MMPP solutions were formulated such that they delivered equivalent amounts of available oxygen (%AvO). The placebo buffer was prepared using potassium hydrogen phosphate and potassium dihydrogen phosphate so that a final pH of 7.6 was obtained. The pH of treatment solutions was similarly adjusted to pH 7.6.

RESULTS

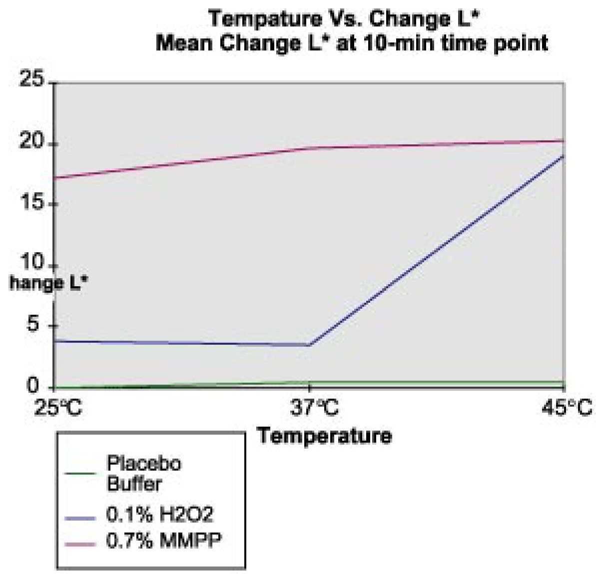
The bleaching kinetics were measured as a function of time, oxidant concentration and temperature.

A. Concentration and time dependency.





B. Temperature Dependency



CONCLUSION

-MMPP is more reactive than H_2O_2 at all time points when the reaction is carried out at 25°C both on unbrushed as well as brushed enamel chips.

-At equivalent concentrations, H_2O_2 is much less efficient in bleaching the stain than MMPP at 25°C and this relationship holds true even after 2 hours of exposure.

-As the reaction temperature is increased, peroxide becomes more reactive until it finally equals MMPP at 45°C. MMPP is relatively in-sensitive to temperature change.