Light Bleaching of Paper without Aqueous Immersion

Assessing the Possible Damage

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Introduction

Aqueous light bleaching is considered to be a relatively safe and effective method of reducing many types of discolouration on paper artifacts. An object is usually immersed in water and irradiated with intense UV-filtered light for several hours. Today, fluorescent lights are typically used. A major limitation of this procedure is that it can only be used on artifacts that can withstand prolonged immersion in water. It is not well understood why light bleaching – believed to be an oxidative process – requires water. Exposure to light without water is, however, believed to be damaging to paper. This project investigates whether non-immersion light bleaching treatments result in significant damage to cellulose (the main component of paper). Irradiation in dry conditions and irradiation in water vapour inside a humidity chamber were compared to traditional aqueous light bleaching. The main aim was to evaluate any resultant damage, rather than bleaching effectiveness. The effects of media, and of paper components other than cellulose, such as sizes and fillers, were not considered in this project.

Experimental

Test samples

Whatman's #1 filter paper was used. This very pure paper is made of cotton and consists of 98% pure cellulose. It contains no sizes or additives and is pH-neutral, making it ideal for use in controlled experiments.

One half of the samples were aged in a Despatch environmental chamber at 85ºC and 50% relative humidity for 13 days so as to imitate a partially deteriorated paper that a conservator might realistically work with.

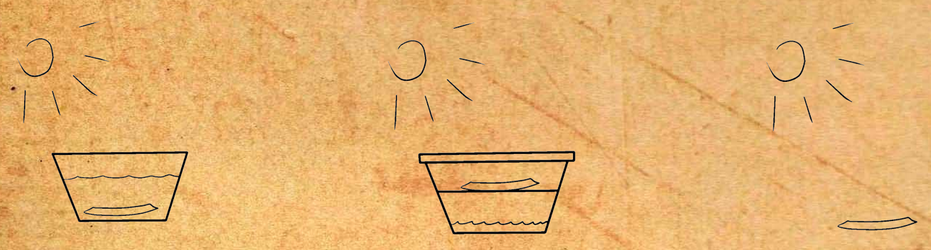
Historic paper was not used due to the difficulty of determining its composition.

Test samples

Irradiation treatments

A bank of daylight fluorescent lights with UV filters was used to irradiate the samples. Three irradiation treatments were used:

1) Aqueous light bleaching
2) Irradiation with light in a humidity chamber (~65% RH)
3)Dry irradiation with light



All irradiation treatments were done for 5 hours.
Untreated controls of both aged and unaged paper were also used.

Tests and Results

1) Colorimetry

A Minolta colorimeter in the CIELAB L*a*b* colour space was used to detect colour difference between treated samples and controls. A slight increase in the brightness (L* value) and decrease in yellowness (b* value) were observed in the aged samples for all treatments. Aqueous light bleaching resulted in the greatest colour change; dry and humidity-chamber irradiation resulted in smaller changes, similar to each other. Curiously, a slight decrease in yellowness (b* value) was also observed in the unaged samples for all treatments. In all cases, the colour changes were very slight (<1 unit); however, this is likely due to the fact that prior to treatment, the aged samples exhibited only barely perceptible discolouration (ΔE of 1.5 as compared with the unaced controls) after 13 days of aging. A longer aging period and more pronounced discolouration would likely have yielded more pronounced bleaching.

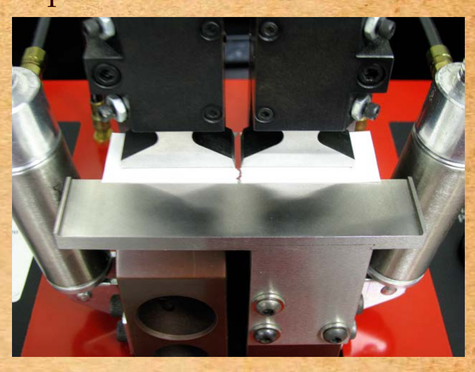
Tests and Results

2) Zero-span breaking strength test

The test was completed at the Canadian Conservation Institute in the TAPPI room under standard conditions (22.46ºC, 49.3% relative humidity). A Pulmac TroubleShooter instrument was used. The test is considered useful for establishing the strength of fibrous materials, such as paper. The samples were held between closely spaced clamps and pulled apart until broken.

Broken samples following the zero-span breaking strength test

Results indicate no difference in strength between the treated samples and the controls.



Pulmac TroubleShooter

A Fenske viscometer

3) Viscometry

Viscometry is a procedure allowing indirectly to establish the degree of polymerization of a polymer (in this case, cellulose) via the viscosity of the polymer in solution. Intrinsic viscosity is measured by recording the time required for the solution to flow through a thin tube.

Cadoxen was used to dissolve the samples. The solution was passed through a Fenske viscometer #100.

Although aged samples had a much lower degree of polymerization than unaged samples, little or no difference was observed between the treated samples and the controls, suggesting that no degradation took place due to the treatments. However, the results of this test are not conclusive because insufficient number of trials precluded statistical analysis.

4) pH by cold extraction

Measurements of pH were undertaken to establish whether harmful acidic substances were formed in the paper due to any of the irradiation treatments.

Although aged samples were more acidic than unaged samples, no difference in pH was detected between treated and untreated samples.

Conclusion

The test results seem to indicate that the cellulose component of paper, both new and slightly deteriorated, is not harmed by non-aqueous and non-immersion light bleaching procedures. A further study is required, which would use more heavily deteriorated filter paper, obtained via a longer artificial aging period, Further studies on the behaviour of other components of paper, such as common sizing agents and fillers, are also desirable

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