

PETRA VÁVROVÁ, PETR KOTLÍK, MICHAL ĎUROVIČ  
AND VLASTA BREZOVÁ

## Damage to Paper Due to Visible Light Irradiation and Post-Radiation Effects after Two Years of Storage in Darkness

### Abstract

All light contributes to the deterioration of library and archives collections by providing energy to fuel destructive chemical reactions within the paper. Light also damages bindings, photographs, and other media, including the inks, dyes and pigments used in many library and archives materials. The influence of visible light on archives and libraries documents – lignin containing paper – is discussed in this article.

Materials like paper, parchment, photographic paper, textile etc. stored in archives and libraries are made of natural polymers. These materials contain numerous amounts of different substances besides cellulose, respectively hemicelullose, also lignin, quinone structures, flavonoids, glues and other substances. Degradation and damage of these materials is strongly affected by external degradation factors, for example by light. There are a lot of studies dealing with paper degradation from ultraviolet light, but almost no attention has been given to the action of visible light. The problem is not linked to storage in the depositories, because archives or library documents and books are stored or should be stored in darkness. However, documents or books are exposed to the action of visible light during exhibitions and in study rooms. During the exhibition of historical paper documents and photos, deterioration of these materials due to light, specially ultraviolet and visible radiation, can occur. Even after the end of an exhibition (during storage in darkness in a depository) damage can also be observed to occur – so called post-irradiation effects – a not so well known and very often forgotten problem. A few years after having been exhibited and thus irradiated, documents or books stored subsequently in very stable and good conditions (low temperature, proper relative humidity, darkness), continue

to show signs of being resp. damaged. This article is concerned with the influence of post-irradiation effects on colour changes and paper degradation. After documents have been exhibited, while they are being stored in the dark in a depository, damage occurs.

In this study, two types of paper, one with high lignin content – CTMP and the other without lignin – BP and four types of light sources (blue, green, red and day light) were used. Post-irradiation effects, which occurred during two years of storage in darkness and stable climatic conditions, are examined.

The conditions of the artificial ageing and measuring methods for optical properties (UV/VIS spectra, coordinates of colour space CIE Lab) are described. Conditions of post-radiation effects on non-irradiated and irradiated samples, which occurred during storage in darkness, are described. The influence of relative humidity of air (3 different values) at stable temperature was studied (temperature of  $22 \pm 5$  °C and relative humidity RH=43, 53 or  $62 \pm 5$  % in desiccators in the darkness). Finally, the test results and results of post-irradiation effects are briefly discussed.

The most significant indication of the influence of visible light on paper degradation is colour change. Colour changes (total colour difference  $DE^*$ ) in paper samples are observable. BP paper samples (pure cellulose) are very stable, but CTMP paper samples change colour very intensively under the influence of post-radiation during two years storage in darkness. The colour changes also depend on the RH of storage. It is possible to explain this finding by the high lignin content in CTMP paper. Danger of post-irradiation effects consists of changes in paper colour and paper degradation reactions and built of degradation products also at the end of exhibition and storage in the depository in the darkness.

The damage to paper documents caused by light is usually very extensive and unfortunately is often irreparable and irreversible. Preventive conservation (use of yellow filters, shortening of exhibition time, decrease of light intensity) and the control of photometric values of light sources are important and necessary. Possibilities of measuring and controlling light source parameters will be described. A résumé of exhibition light should form one of the most precious archival documents. It

is necessary to be aware of the danger of post-irradiation effects and monitor this phenomenon. The results in this paper give extra weight to the importance of reducing light damage to archival documents. Institutions should follow the guidelines given for measurement of light levels and control of light exposure. All sources of light illuminating collections should be known, and the exposure of collections to visible light should be strictly controlled.

It is necessary, in future research, to study and identify products present in light-damaged and stored irradiated paper samples that show colour degradation.