Sustainability of mass deacidification of library objects

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Abstract

Mass deacidification treatment has been applied to books, in the libraries and archives that were in jeopardy due to their acidity. Although it has been employed based on extensive research and tests, sustainability of mass deacidification was questioned due to lack of quality control systems and a risk of alkaline treatment to the original books, which have naturally aged for up to 150 years.

In the present study, the aims were not only the assessment of the performance of mass deacidification processes applied for the last two decades, but also the study of the influence of mass deacidification on a molecular level of cellulose, focusing on β-elimination triggered by alkali in combination with oxidative functionalities. Over 400 books from the German National Library and the Berlin State Library were analyzed. Surface pH was measured, and determination of alkaline reserve was carried out for selected original books by means of titration, X-ray fluorescence (XRF), and scanning electron microscopy-energy dispersive X-ray spectroscopy (SEM-EDX). Twenty-five deacidified books and their identical non-deacidified papers were analyzed by gel permeation chromatography (GPC) coupled with fluorescence and multiple angle light scattering detectors after fluorescence labeling of carbonyl groups, which offered deeper insights into degradation mechanisms of deacidified papers before and after accelerated aging.

Strictly speaking, according to the current Deutsches Institut für Normung (DIN) recommendations, mass deacidification that was applied to the books during 1994–2006 was not sufficient enough to meet the standards for pH and alkaline reserve for all the books measured. Variability in data of surface pH and alkaline reserve was brought about

mainly by the deacidification processes and the year of publication.

The Papersave™ process was found to perform relatively better than the others in terms of the amount of alkaline reserve as well as homogeneity. Fine and homogeneous distribution of alkaline reserve into the paper matrix as well as on the surface of the paper was found to be critical to enhance the efficacy of mass deacidification in the long run. The amount of alkaline reserve directly correlated with cellulose stability after accelerated aging, despite different conditions of the original book papers, which led to questions about the adequacy of current standards for the amount of alkaline reserve. Model book papers containing different amounts of alkaline reserve indicated that even an excessive amount of alkaline reserve did not completely cancel out the beneficial effect of alkaline reserve as a barrier against acidic attack.

β-Elimination triggered by keto/aldehyde groups along the cellulose chain seems to be unavoidable after mass deacidification as well as during accelerated aging. However, thanks to the characteristic distribution of carbonyl groups found in naturally aged book paper, β-elimination did not cause severe chain scission to an extent that lowered the molecular weight. The study of accelerated aging added to this finding. Degradation of original deacidified paper was overruled by the benefits from alkaline reserve, reducing acid hydrolysis remarkably, without being affected severely by β-elimination. Degradation of cellulose after accelerated aging did not correlate with the initial carbonyl group content prior to accelerated aging or to the lowered content of along-chain carbonyls after accelerated aging, which is a sign of β-elimination. Therefore, a threat of alkaline degradation under conditions of the mass deacidification tested was minor.