

L03 THE EFFICACY OF DEACIDIFICATION BY AEROSOLS OF MgO AND DOLOMITE MICROPARTICLES

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Introduction

It has long been widely acknowledged that paper which is produced in an industrial way is endangered by acid decomposition or oxidation¹. The degradation process can be stopped effectively by neutralisation and the insertion of an alkaline buffer².

Application of mass deacidification process is connected with problems in controlling its efficacy and quality. There are no unified criteria for evaluating particular processes of mass deacidification³. Alkaline reserve, pH, their homogeneity and effect of deacidification agents are among those used within the scope of evaluation^{4,5,6,7}. Nowadays, each organization brings own new parameters to evaluating the deacidification process. Evaluation according to the criteria of 'Library of Congress, Pittsburgh'⁴ is one of the options. Another option is evaluation of the process efficacy according to criteria of Swiss National Library, Bern^{3,7,8,9}.

Deacidification processes produce specific side effects on treated materials, according to their chemistry and method of application. Organic solvents used in, or produced during, liquid-phase processes can cause bleeding of dye stuffs (especially red dyes) in textile book covers, in inks, and stamps. All the deacidification methods using liquid can cause deformation and cockling of paper and binding⁸.

Alkaline particles, such as MgO and dolomite micro-particles in the air (SoBu)¹⁰, MgO and CaO in the air (Libertec)¹¹ and MgO in a perfluoralkanes (Bookkeeper)⁴ are also used in deacidification of books and archival documents containing cellulose base. The most significant effect of deacidification methods based on the application of sub-micron particles is a whitish powdery deposit on paper and binding surfaces, obviously the deacidification agent (magnesium oxide, calcium oxide, dolomite microparticles and calcium carbonate). It can be easily removed by brushing, but this creates additional and time-consuming work. If it remains in the book, it can

spray out during the use with the risk of health problems for the user⁸.

Experimental

Raw Material

Wood containing newsprint paper (grammage 45 g m⁻², surface pH: 5.6) containing mechanically bleached, groundwood (55 %), bleached sulphite pulp (20 %), cought trash fibres (15 %) and clay (10 %) was used in experiments. The test books (format A5) were sent for treatment to Sobu (Fürth) company providing commercial mass deacidification.

Accelerated Ageing Procedure

Samples of paper were conditioned according to TAPPI T402 om – 93¹² at 23 ± 1 °C, and at relative humidity of air RH = 50 ± 2 %. Seventy-five sheets of paper (A5 format) were encapsulated inside a PET/Al/PE bag. The samples were aged at 96 ± 2 °C for 0, 2, 5, 10 and 15 days according to ASTM D 6819 – 02: Standard test method for accelerated aging of printing and writing paper by dry oven exposure apparatus, in which sealed glass tubes were replaced by a composite foil made of polyethylene / aluminium / polypropylene (TENOFAN Al / 116S). After ageing, the papers were conditioned for testing according to TAPPI T402 om - 93¹².

Mechanical Properties

Breaking length was determined according to TAPPI T494 om – 88¹³ and the folding endurance was determined using the MIT apparatus according to TAPPI T511 om – 96¹⁴ with a tension of 0.3 kg instead of the standard 1 kg.

Evaluation of Treatment

Effectiveness

The comparison of treated/modified ($X_{t,m}$) and non-treated/non-modified ($X_{t,n}$) samples after the same period and conditions of ageing is expressed as:

$$S_{X,t} = \frac{X_{t,m}}{X_{t,n}}, \quad (1)$$

where $S_{X,t}$ stands for permanence coefficient by given treatment, \bar{X} – examined properties (the breaking length (l) and the folding endurance (ω)), t – ageing period

If $S_{X,t} > 1$, the permanence is increased; if $S_{X,t} = 1$, it is not changed; $S_{X,t} < 1$, the permanence is decreased¹⁵.

Linear dependence was obtained after calculating the logarithm of double folds. Time values for $\log \omega = 0$ were calculated from linear equation. Values were used for relative comparison the efficacy of deacidification process to non-treated control sample.

The lifetime of the paper ends when logarithm of the folding endurance becomes zero ($t_{\log \omega} = 0$)

The coefficient of relative increase of the lifetime for folding endurance ($S_{\tau,\omega}$) is to be expressed as eq (2).

$$S_{\tau, \omega} = \frac{t_{\log \omega=0, m}}{t_{\log \omega=0, n}} \quad (2)$$

Results

Kinetic dependences of changes in mechanical properties of paper were evaluated. Average values and average divergences that only indicate the variability recorded in measurement, are given for all kinetic dependences.

Stability of paper treated by aerosols of MgO and dolomite microparticles was compared to non-treated paper.

The loss of breaking length under ageing is shown in Fig. 1.

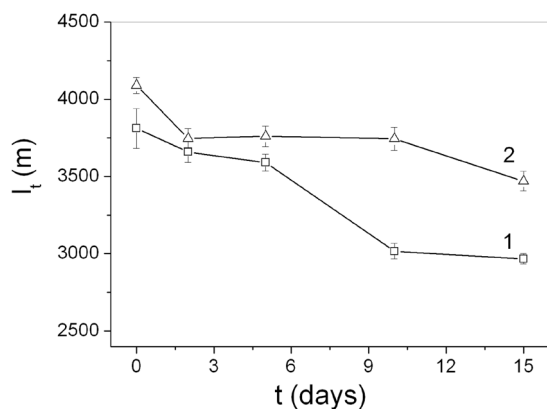


Fig. 1. Effect of ageing time [days] on breaking length [m]:
 1 – non-treated newspaper paper
 2 – newspaper paper treated by aerosols of MgO and dolomite microparticles

The breaking length of unaged non-treated paper was 3,811 m. After 15 days of ageing, the loss of strength decreased by approx. 22 % (2,968 m). After deacidification by aro-

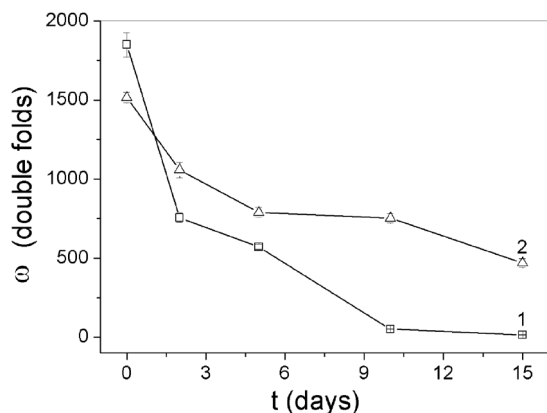


Fig. 2. Effect of ageing time [days] on folding endurance [double folds]:
 1 – non-treated newspaper paper
 2 – newspaper paper treated by aerosols of MgO and dolomite microparticles

sols of MgO and dolomite microparticles, the measured breaking length was 4,090 m. After 15 days of ageing, the loss of strength decreased by approx. 15 % (3,470 m). Permanence coefficient of the breaking length for unaged paper was evaluated $S_{lt,0} = 1.1$, the modification caused slight strengthening effect. The permanence of breaking length after 15 days of ageing was $S_{lt,15} = 1.2$, hence the modification caused positive stabilization effect.

The following picture (Fig. 2.) shows folding endurance (ω , double folds, load 0.3 kg) as a function of ageing time.

The number of double folds of untreated paper was 1850. After 2 days of ageing, the number of double folds decreased rapidly (754). After 15 days of ageing, the folding endurance was reduced to 51 double folds. After the deacidification by aerosols of MgO and dolomite microparticles 1515 double folds were determined. The number of double folds kept decreasing during the ageing process, however, the decrease rate was slower comparing to non-treated sample. After 15 days of ageing, the folding endurance was reduced to 470 double folds. The permanence coefficient of folding endurance for unaged paper was evaluated $S_{\omega,0} = 0.8$, which implies that the modification process did not result in strengthening effect, however, stability increased significantly after 15 days of ageing reaching $S_{\omega,15} = 33.6$.

The logarithm of folding endurance related to ageing time is shown in Fig. 3.

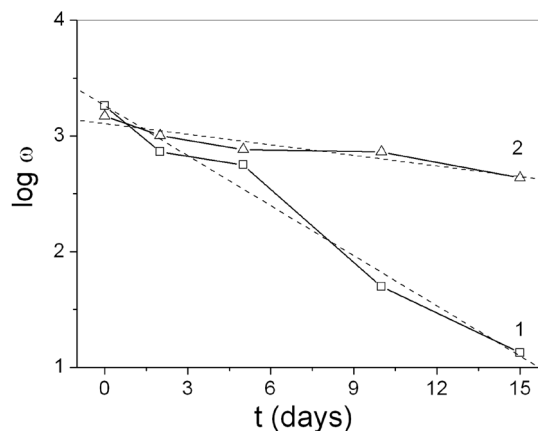


Fig. 3. Effect of ageing time [days] on logarithm of folding endurance:
 1 – non-treated newspaper paper
 2 – newspaper paper treated by aerosols of MgO and dolomite microparticles

Time values for $\log \omega = 0$ were calculated from linear equation. The coefficient of relative increase of the lifetime was calculated from formula (2) $S_{\tau, \omega} = 4.7$; which means that stability of modified paper increased by 470%.

To compare the air–MgO–dolomite microparticles technological platform (TP) to other recent TPs, the following criteria of multifactorial evaluation system of Consortium Kniha^{SK} and Library of Congress⁴ have been used:

- Innovation potential. Potential of the future development, research, and further education.
- Efficacy in term of increase stability of mechanical properties and life-time prolongation.

It is the criterion of efficacy of deacidification process according to the Library of Congress⁴ on tested paper, which is expressed as the rate at which paper loses strength upon accelerated ageing at 90°C / 50 RH for up to 30 days, shall be decreased by at least a factor of 3.0, when the logarithm of the folding endurance is plotted against time in days ($S_{\tau, \omega}$). The permanence of the treated paper shall be increased by a factor of 300%.

- pH and alkaline reserve,
- Price
- Risk:

Deterioration of documents, possibility of deacidification of books without their damage, sensorial properties

Explosion hazard

Flammability hazard

Health hazard

Environmental hazard

On the basis of criteria of multifactorial evaluation system the air–MgO–dolomite TP deacidification fulfills the Consortium Kniha^{SK} and Library of Congress⁴ requirements for the lifetime increase ($S_{\tau, \omega} = 4.7$), improves the mechanical permanence sufficiently ($S_{\omega, 15} = 33.6$; $S_{lt, 15} = 1.2$). It is the most advanced, the cheapest and safest one as well (in terms of danger of fire or explosion). Platform HMDO is progressive, however, danger of fire or explosion is significant and is severalfold more expensive. The other TPs are less suitable for deacidification or not suitable for deacidification of books.

The most ecological methods are based on platform water/air regarding the environmental quality, tenability and future prospects. Freons are used in less eco-perspective TPs of which global warming potential is by 320–8,400 times higher than that of CO₂.

Conclusions

The paper was aimed at evaluating the deacidification by aerosols of MgO and dolomite microparticles. The research was based on examination of mechanical properties through multifactorial evaluation according to the requirements of Consortium Kniha^{SK} and Library of Congress⁴.

The air–MgO–dolomite deacidification TP fulfills requirement for the lifetime increase ($S_{\tau, \omega} = 4.7$), it does improve the mechanical permanence sufficiently ($S_{\omega, 15} = 33.6$; $S_{lt, 15} = 1.2$). It is most advanced, the cheapest, the most ecological and safest one as well (in terms of danger of fire or explosion or health hazards).

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