THE OPTICAL STUDY OF THE AGEING OF PAPER

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Summary

Results of research, and remission tests, concerning ageing render it possible

— to produce durable papers

— to estimate, and account for, deterioration during use and storage of papers and printed matter

— to perform the tasks which arise in connection with the identification of paper-types, and in connection with expert opinion on the treatment papers and printed matter had been exposed to.

It is well known that paper loses its original properties within a short time, in other words, it ages rapidly. According to some assessments, the service-time of 90 per cent of the printing papers is less than fifty years. The massive use of novel, less expensive but also less durable sorts of half stuff is chiefly the explanation of this.

All the basic processes of ageing and of artificial ageing can be traced back to changes of a chemical nature (fission of chemical bonds, formation of new bonds and new functional groups). The consequences of these processes can be kept track of by means of mechanical, optical or other physical and chemical methods.

The mechanical methods generally and frequently applied in research on the ageing of paper are suitable for the detection of changes in the number of crosslinkings and in the degree of polymerization in a paper; in certain instances, however, the rather large spread of the limit of errors renders the evaluability of the data dubious indeed, especially when ageing of but a low degree is being studied.

The recording of the remission spectra of artificially aged papers is a sensitive, well reproducible method to keep track of phenomena of ageing.

The effects of all the important parameters that play some role in the process of ageing, i.e. composition, temperature, moisture-content, and duration of ageing can be traced by means of recording the (light) remission of a paper.

* From the Thesis of J. Hazai-Horváth, Technical University, Budapest, 1985.

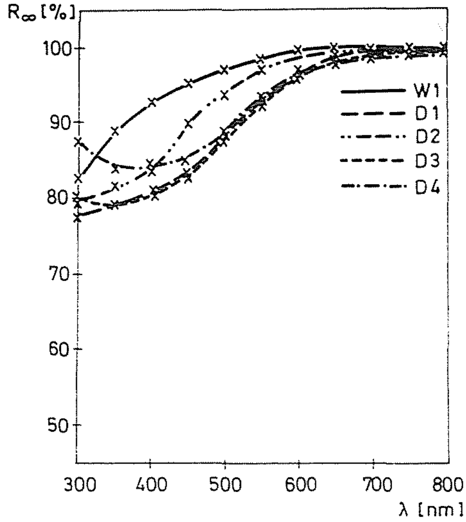

Fig. 1. The change of R_∞ due to artificial ageing. (Conditions of ageing: 100 °C, $\varphi \sim 50\%$, 120 hours, reference standard: not-treated paper)

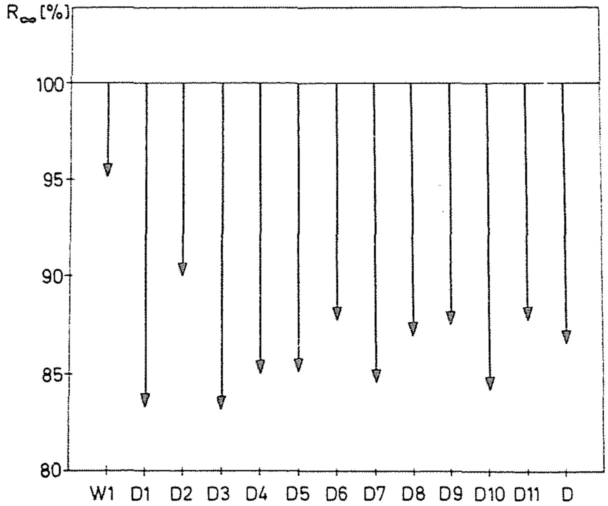

Fig. 2. The diminution of R_∞ due to heat-treatment, in the case of variously composed papers; at 450 nm. (Conditions of heat treatment: 100 °C, $\varphi \sim 50\%$, 120 hours, reference standard: not-treated paper.) (See Table I)

A Pye-Unicam SP 8-100 spectrophotometer, within its wavelenght-range between 300 and 800 nm, was used for recordings, with the help of an integrating sphere that fills the specifications C.I.E. and the geometrical arrangement of which is 8°/diffuse reflexion.

1) *The role of composition.* The determinant factor in the process of ageing is the change of the pulp. In the case of cotton cellulose (W 1) the diminution of R_∞ from 550 nm is conspicuous when exposed to the ageing effect of heat; at 300 nm to 82 per cent. A characteristically greater change occurs in the case of bleached sulphite cellulose (D 1) when the falling off of intensity definitely occurs at 650 nm already (cf. Fig. 1). On this Figure also the changes of remission spectra of bleached sulphite cellulose with severally 10 per cent straw pulp (D 2), 1 per cent and 5 per cent groundwood (D 3, D 4) can be followed. The change of R_∞ due to ageing can be increased or decreased by additives used in the paper industry,—possibly in a various manner as "function wavelength"—but it cannot be stopped. This is shown in Fig. 2 where R_∞-values noted at 350 nm are to be seen.

In the presence of rosin, as well as in that of fillers the spectrum is shifted towards the ultraviolet.

Table 1

Symbols of investigated paper-samples

Symbols / Components	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D
Bleached sulphite	100	90	99	95	90	90	90	90	90	90	90	90
Straw	–	10	–	–	10	10	10	10	10	10	10	10
Groundwood	–	–	1	5	–	–	–	–	–	–	–	–
$Al_2(SO_4)_3$	–	–	–	–	2.5	2.5	2.5	2.5	2.5	–	2.5	2.5
Starch	–	–	–	–	–	–	1.0	1.0	1.0	–	1.0	1.0
Dynacoll HV	–	–	–	–	–	1.25	1.25	1.25	1.25	–	1.25	1.25
China Clay A3	–	–	–	–	–	–	–	11.25	11.25	–	11.25	11.25
Pergopak M2	–	–	–	–	–	–	–	–	4.0	–	4.0	4.0
Tinopal UP	–	–	–	–	–	–	–	–	–	0.9	0.9	0.9

2) Also the study of the *role of temperature* and *moisture content* shows that the sensitivity of the pulp to heat and moisture is a decisive factor. Already an increase by 20 °C as a factor of ageing (from 80° to 100 °C) causes a significant change measurable by the change of R_∞.

Rosin-sizing increases the effect of temperature and moisture content. Fillers diminish the heat-sensitivity of sized paper: the change of R_∞ in the domain between 80° and 100 °C can be studied. The well evaluable deviation appears below 550 nm, above this value deviation is small. Deviations found between 400 and 500 nm inform us about the degree of yellowing.

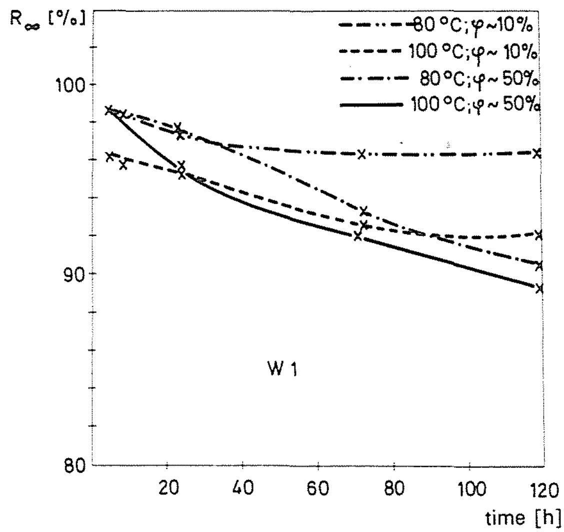

Fig. 3. Changes in R_∞ in the case of a W 1 (cotton) filter paper at 350 nm, due to varied conditions of artificial ageing

3) The study of the reduction of R_∞ as a function of *ageing time* shows that the initial section of about 20 to 30 hours of the process is more rapid. During the later period ageing generally slows down.

In the case of cotton cellulose, under conditions of dry-ageing ($\varphi \sim 10\%$) the process stops after about 70 hours of heat-treatment both at 80 °C and 100 °C. The possible explanation of this is that the structural water present in the paper plays an important role during the initial period of ageing.

Higher moisture-content maintains the process (cf. Fig. 3).

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