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NATURAL AND ACCELERATED AGEING OF THE PRINTING SURFACES

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Abstract:
The influence of the near UV and visible part of the electromagnetic spectrum (natural ageing) and of the elevated temperature and relative humidity (accelerated ageing) on the recycled, art (glossy) and offset paper has been examined. The results of our previous measurements show that the coloured substrates do not dominantly change their optical characteristics comparing them with uncoloured samples. So, in this paper, we decided just to measure optical characteristics of the uncoloured surface substrates. The spectrophotometric measurements have been performed using X-Rite spectrophotometer, Digital Swatchbook, in the visible range of the electromagnetic spectrum (390-700) nm and Data Analysis and Technical Graphics Origin 6.0 Professional calculated the results.
The results of these measurements show the significant changes in optical characteristics of the uncoloured samples exposed to the natural and accelerated ageing.

Key words: natural ageing, accelerated ageing, recycled paper, offset paper, art (glossy) paper, optical characteristic

1. Introduction

Durability of paper depends on mechanical and physical properties of raw materials used in paper production, such as: fibre type, fibre size, fillers, coatings and colorants. The influence of manufacturing processes including drying, water retention, refining techniques, method of bathing, sizing procedure, calendaring, speed, as well as crystallinity and fibres bonding are recognizable. Cellulose as molecule creates crystalline (inert and relatively impermeable to water) and amorphous (flexible and water accessible) regions in fibrils and it has properties, which are caused by its structure.

According to DIN 6730, the term ageing is defined as the sum of all irreversible physical and chemical processes occurring in a material in the course of time.

The quality of paper and its ingredients determine how resistant it is to ageing. Generally speaking, wood-containing paper grades, i.e. paper made from mechanical pulp, have a shorter life span as they contain lignin, which makes the paper turn yellow after prolonged exposure to sunlight or to artifical sources of UV and visible electromagnetic radiation. If the product is intended to last a really long time, woodfree paper is to be recommended, i.e. paper made from chemical pulp.

In this article the influence of natural ageing on some of optical characteristics of printing substrates exposed to electromagnetic radiation (visible and near ultraviolet) and of accelerated ageing (elevated temperature and relative humidity) have been examined. Under this conditions the changes in the values of the relative reflection during the definite time intervals are occured. Because of that changes the changes of color appearance (CIE Lab) are occured too.

2. Experimental

The used printing substrates were recycled and offset papers, grammage of 100 g/m^2 and art glossy paper, grammage of 120 g/m^2.

In a specially prepared chamber the increased temperature in the presence of a reasonable level of relative humidity (RH) is responsible for accelerated ageing. Ageing of printed samples is done at the 80°C temperature and 65% RH in the period of 21 days.

Natural ageing was performed by two light sources: electric lamp that emits visible part of electromagnetic radiation and electric lamp that emits visible and near UV. Examined samples were exposed to radiation in time interval of 2 hours for UV irradiated samples and 5 days for visible irradiated samples.

Following exposure to the various light sources, samples were kept in the closed steel cabinet in the paper testing room maintained at 23°C and 60% relative humidity. Both types of lamps were mounted about 60 cm above the samples. The temperature of the samples exposed to UV radiation reached the value about 37°C and the samples exposed to visible radiation about 28°C.

Spectrophotometric measurements have been performed using X-Rite Spectrophotometer, Digital Swatchbook. Relative reflection has been measured in the interval of the wavelengths from 390 nm to 700 nm for every 10nm, for all samples exposed to accelerated and natural ageing. The standard illuminant was D65, 10° observer.

3. Results and discussion

3.1. Spectrophotometric results

The spectrophotometric measurements on art glossy, offset and recycled substrates (papers) by three types of ageing processes are performed. It should be pointed out, accelerated and natural (with controlled visible or UV radiation) ageing processes are chosen in presented measurements.

The results for accelerated aged samples of art glossy, offset, recycled papers are presented in Fig.1. to Fig.4., respectively. The relative reflection curves are denoted with the line _BA, before ageing, the line _AA, after ageing while the line _diff belongs to the difference of the relative reflection of both of them. The shapes of the relative reflection curves of art glossy and offset paper (Fig.1. and Fig.2.) are similar.

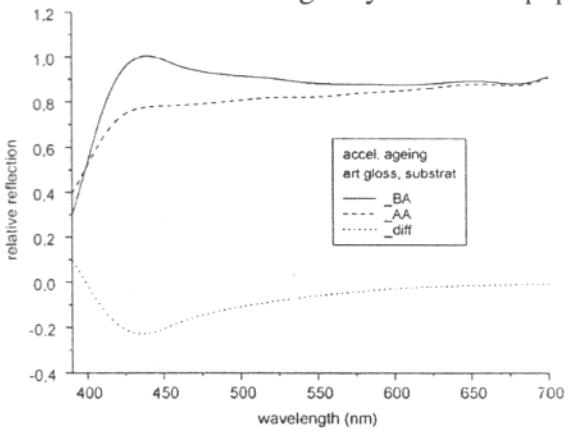

Fig 1. Art glossy, accelerated ageing

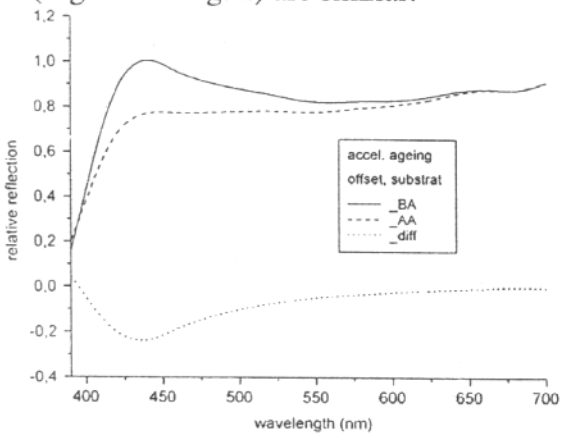

Fig 2. Offset paper, accelerated ageing

Both curves show the relative reflection between 0.90 to 0,95, before ageing, with the significant increased value of the reflection in the range of shorter wavelengths (430-450nm). In this interval the relative reflection reaches the values more then 1,0 (100%) what can be caused by the fluorescence of the whitening agents. After ageing, the values of the relative reflection decrease just in the mentioned interval of the shortwavelengths, so the curves are "smoothed". The changes of the relative reflection of art glossy and offset papers (_diff lines) are the highest just in this interval showing the minimum values of about –0.22 to –0,24. The negative sign of the changes means the reduction of the relative reflection during the accelerated ageing, perceptible in all curves. Recycled paper, Fig.3., shows significantly lower values of the relative reflection in the whole interval of the measured wavelengths; especially for the shorter wavelengths these values are about 0,6 to 0,7. These samples, of course, don't contain the whitening agents and consequently their relative reflection is significantly lower then the reflection of the art glossy and offset papers. The differences of the relative reflection for all papers measured by accelerated ageing are presented in Fig.4. The curves show the highest changes of the relative reflection in interval of the wavelengths (410 to 450 nm) for all papers so the shapes of the changes are similar, but higher for art glossy and offset paper (about –0,25) and smaller for recycled paper (about –0,1). All changes of the relative reflection can be caused by the deterioration of the primary paper compounds (cellulose, water content, binders) produced during the accelerated ageing. The higher changes in the relative reflection of the art glossy and offset paper, compared to recycled paper include, beside the mentioned deterioration, also additional damages arisen due to the additives (optical whiteners), not presented in recycled paper.

We can point out, there is no visible electromagnetic radiation in accelerated ageing. So, the damages occurred in these type of ageing are influenced only by the temperature and relative humidity conditions.

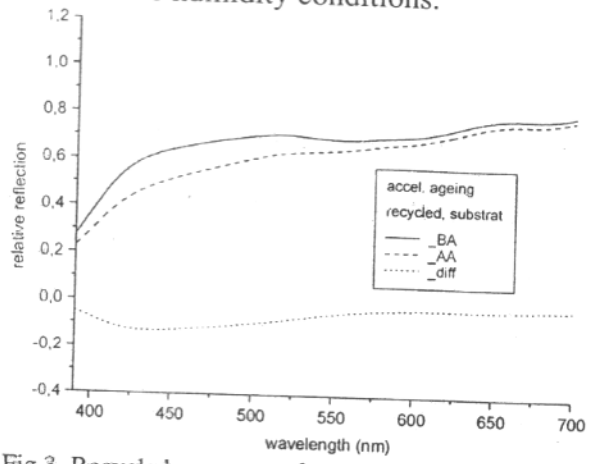

Fig.3. Recycled paper, accelerated ageing

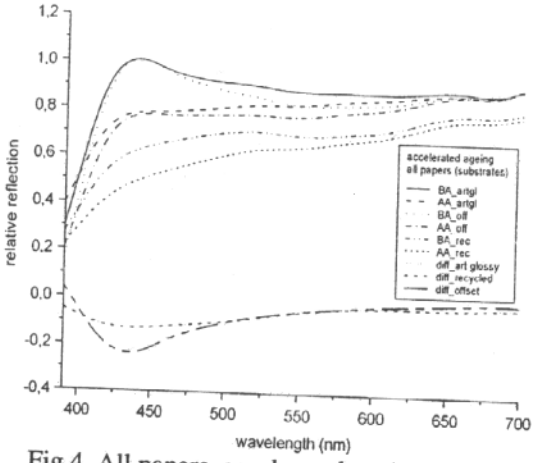

Fig.4. All papers, accelerated ageing

The changes of the relative reflection of the naturally aged samples, exposed to the source partially contained near UV radiation, are represented in Fig.5. to Fig.7. for all types of paper. The samples were under the influence of the radiation in the whole time interval of 2 hours and 15 min. The reflection curves every 30 min have been measured, so the changes are considered during the time and one can discuss about the dynamic of the changes. The relative reflections show increasing during the time, similar those by accelerated ageing, but after some time of exposition ("saturation time") the relative reflection decreases; the directions of the changes are converted. This phenomenon, didn't observe by accelerated ageing, can be influenced by the interaction between the electromagnetic radiation and the samples. The changes of the reflections are smaller, but not significantly; -0.15 for art glossy and offset samples and –0,10 for recycled papers. The interval of the changes for shorter wavelengths is wider (420-500 nm) then by the accelerated ageing. UV irradiated samples show the changes of the reflection in the interval of the longer wavelengths, also not observed by accelerated ageing (especially conspicuous for offset paper, Fig.6.). The recycled paper posses the broad interval of the changes (400-530 nm), Fig.7.

The results of the changes in the reflection curves of the samples exposed to the source of the controlled spectrum of visible radiation are presented in Fig.8., for all types of paper. These changes are the smallest compared to accelerated and UV natural ageing.

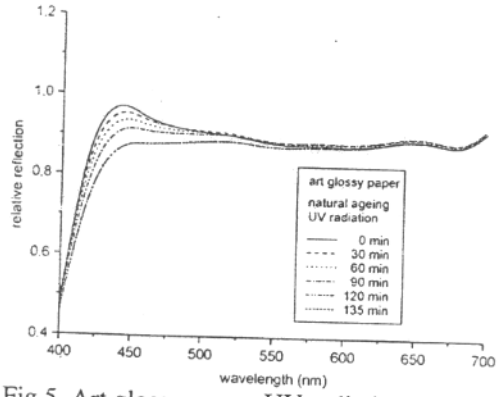

Fig.5. Art glossy paper, UV radiation

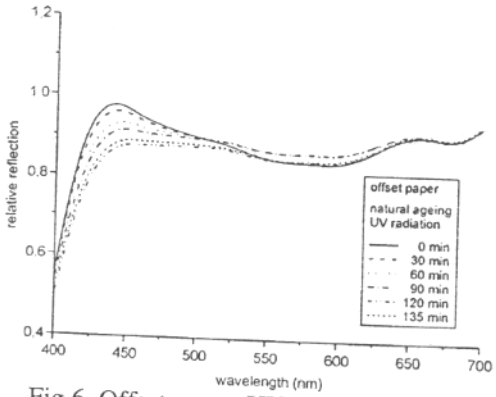

Fig.6. Offset paper, UV radiation

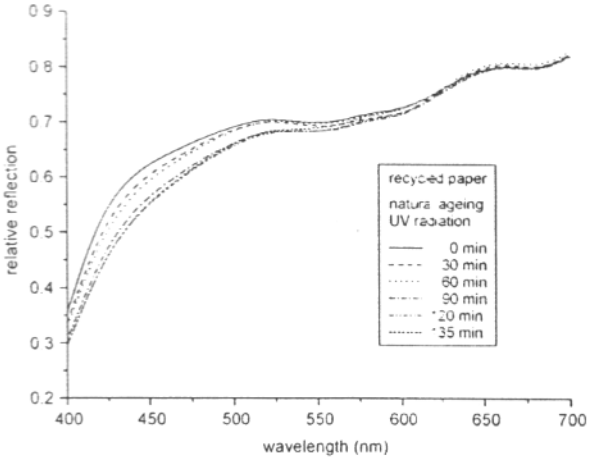

Fig.7. Recycled paper, UV radiation

Because of the simplicity of the representation of this ageing, only the reflection before and after ageing is expressed. The changes of the reflection are similar to that occurred by UV natural ageing for art glossy and offset paper. Recycled paper show higher changes in the whole interval of the wavelengths with the important observation; the directions of the changes are two times converted, (in Fig.8., the lines of the smallest relative reflection).

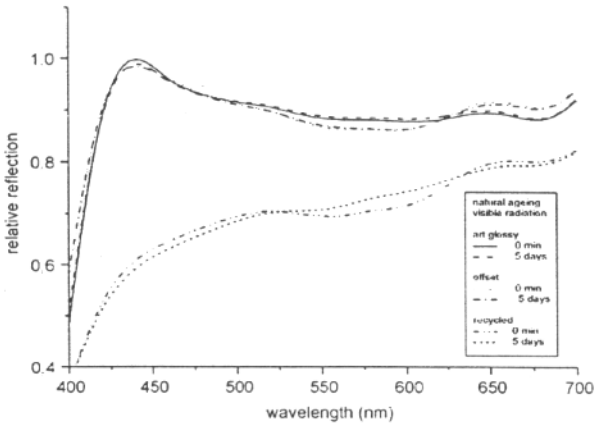

Fig.8. All papers, visible radiation

3. 2. Colorimetric results

We have chosen CIE Lab colour space for presenting the colour appearance changes of the substrates exposed to all types of the ageing. Fig.9. shows these changes for all papers, for accelerated ageing. In accelerated aged measurements the significant decreasing of lightness, L, with associated changes of the colour appearance in a and b values, after ageing, is observed. Offset paper, UV irradiated, have been chosen between all measured papers, Fig.10. This type of ageing show also the changes in colorimetric values (L, a, b) during 20 minutes time intervals. The values of a decrease during the time from +2 to 0, and the values of b show significant increasing from –6 to –1. These changes are occurred because of the changes in relative reflection.

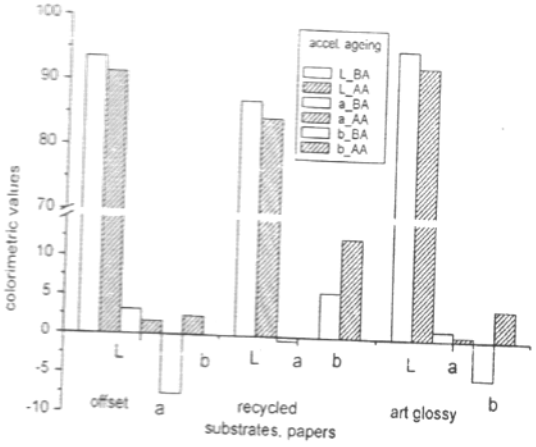

Fig. 9. Recycled paper, accelerated ageing

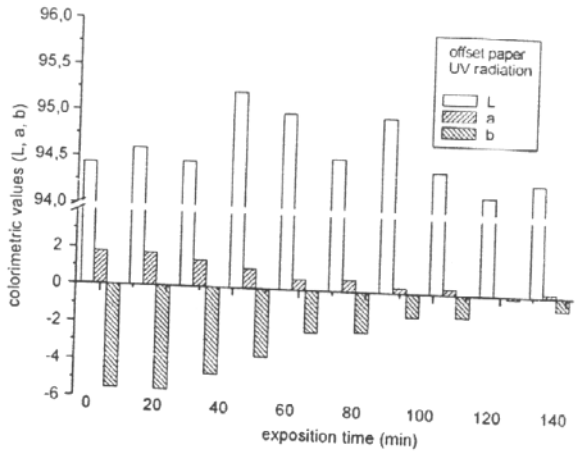

Fig.10. Offset paper, UV radiation

4. Conclusion

Examination of the printing surfaces exposed to the accelerated and natural ageing shows the changes in both types of the measurements; the relative reflection and colorimetric measurements. For all types of chosen paper and for all types of ageing processes (accelerated and natural) the decreasing of relative reflection in shorter wavelengths interval has been observed. The increasing interval is narrower, 410-450 nm, by accelerated then by natural ageing, 420-500 nm; besides the changes of the relative reflection are higher by accelerated then by natural ageing in these intervals. The damages occurred in shorter wavelengths interval, we suppose, are influenced by the temperature and relative humidity conditions. The deterioration can be a consequence of the changes of the primary paper compounds (cellulose, water content, binders) produced during the ageing.

The significant changes for the longer wavelength interval only by natural ageing have been observed. These changes occurred as the decreasing or increasing in the relative reflection. The conversion of the relative reflection changes appeared in the measurements of the dynamic changes during the time expositions, in them "the saturation time" as the time of the conversion for some wavelength interval has been observed. These types of changes can be the consequence of the interaction between the electromagnetic radiation and the printing surfaces.

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