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Foxing in Stamps: Long-term Effects of Sterilization and Treatment with NaCl

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Summary

A single exposure to gamma irradiation can prevent the appearance and stop the development of the foxing phenomenon in new or used postage stamps maintained in sealed polyethylene bags. No visible damage to the paper or to colours was observed seven years after treatment. Tyndelization of the stamps in an open autoclave is also effective but only for used stamps. Autoclave sterilization commonly decreases the phenomenon but does not completely prevent it. UV light has a destructive effect on colours of stamp and increases the foxing after short exposure times. There is a direct correlation between degree of foxing and phenol content. Soaking the stamps in 5–10 % NaCl solutions increases foxing, but with 30 % NaCl development of foxing stopped. These treatments cause no visible damage to stamps.

Key words: Foxing in stamp, – γ-Irradiation – Stamp conservation

Introduction

Postage stamps are essentially a paper product covered with glue on the one side and with colour print on the other. Over years of storage, some stamps may develop irregular yellowish-brown patches, a phenomenon referred to as "foxing".

Along the production line, stamps are being continuously exposed to contamination with microorganisms. Possible stages of contamination may include the paper production process, the application of glue, the printing, the cutting of the paper sheets and the perforation process. There is no scientific literature on foxing of stamps and only a few reports on book paper are available (*Baynes-Cope*, 1976; *Hey*, 1983; *Meynell*, 1979; *Meynell* and *Newsam*, 1978, 1979; and *Press*, 1976). This phenomenon is mentioned in phileatelic literature for amateur stamp collectors (*Schmulevich*, 1958). *Nol* et al. (1983) were the first to demonstrate that some fungi isolated from "diseased" stamps could cause blotches on new stamps incubated under high relative humidity conditions. All fungi exerted cellulolytic activity and produced the "rusty"

patches in stamps within periods of time ranging from six days to a few weeks. In addition, contaminated stamp paper contained mycelium in and surrounding the spots, on both its sides.

Fungi of the *Aspergillus* group are known to be tolerant to high osomotic pressure and prefer growth media supplemented with a high concentration of NaCl (*Kulik* and *Hanlin,* 1968). *Nol* et al. (1983) found that the main causal agents of foxing in stamps were capable of growing on malt agar supplemented with 7.5 % NaCl, corresponding to 31 atm. osmotic pressure. The "rust" pigment was identified as a phenolic compound produced by these fungi. This study also indicated that γ-irradiation eliminated the stamps of spores and mycelium. Nevertheless, the effect of γ-irradiation on the quality of the stored stamps with time had not yet been assessed.

The foxing phenomenon was noted more frequently in rare, expensive stamps which had been produced on low quality paper. Besides their cost, stamps may have sentimental and historical value for both collectors and philitelists. This study was initiated to find some means of sterilization and prevention of foxing in stamps.

Material and Methods

Stamps

Used single commercial stamps (Israel landscapes – Ein-Avdat, 0.30 IL issued in 1974) which were removed from envelopes by soaking and dried at room temperature, were treated. Most of them exhibited various degrees of natural foxing and had no glue. Control stamps were from the same issue and showed no foxing despite the years of storage. Stamps had been stored in an album at room temperature (10–30 °C) throughout the years. Unused new stamps (Israel landscapes, Gan-Hashlosha, 0.05 IL, 1972) coated with glue on one side were also used.

Sterilization procedures

a) Stamps placed between two aluminium foils were autoclaved for various periods of time at 121 °C in one atm.; b) Tyndelization was done by heating three times in an open autoclave at 100 °C for one hour each time; between each sterilization step, stamps were maintained at 30 °C for 48 h; c) Stamps were exposed to UV irradiation (200 uW/cm^2) for various periods of time; d) Stamps were sealed in polyethylene bags and subjected to γ-irradiation (2.5 mega-rad) from a Cobalt 60 source, at the Soreq Nuclear Research Centre, Yavne. Treated stamps were asceptically sealed in sterile polyethylene bags and stored.

Physical and chemical tests of stamp paper

Folding endurance was measured by the M.I.T. folding endurance tester which bends a 15 mm wide strip of stamp through 270° arc under 0.5 kg tension until failure. Tear resistance was measured in grams by Elmendorf tear resistance tester (*Barrow,* 1974). Copper number, tensile strength and reflectance was done according to *Casey* (1966). Changes in paper pH were measured according to *Barrow* (1967) and possible liberation of alum, sulphate and chloride was carried out by the spot tests suggested by *Barrow* (1969).

NaCl treatment

Stamps were soaked in NaCl solutions for 24 h and dried at room temperature. The crystallized salt on the stamp surface was removed with a soft brush.

Estimation of phenols

Foxed stamps (300 mg) were homogenized in 60 ml of absolute ethanol in an Omnimixer (Sorvall) and filtered through Whatman No. 1 filter paper. To 0.5 ml aliquots of the stamp suspension we added 2.5 ml ferrous reagent {equal parts (v/v) of 0.05 % $K_3 Fe(CN)_6$ and 0.1 % $FeCl_3$ in distilled water, freshly made}. After five min, 0.5 ml HCl 0.5N were added to stop the reaction and solutions were read in a Coleman Junior II spectrophotometer at 600 nm, using catechol as standard (*Kritzman* and *Chet,* 1980).

Humid chamber

Two-liter, hermetically closed flat glass tanks were filled with water to a depth of one cm. Stainless still stands (four cm high) were placed in the water and tested stamps were put on top of the stands and incubated for 60 days at room temperature (25–30 °C). The vapour pressure created a constant relative humidity of approximately 100 % in the thanks (*Winston* and *Bates,* 1960).

Planning of experiments

All treatments were carried out in 1977 using 50 stamps per treatment and repeated twice. The effects of the sterilization and NaCl treatment were assessed in 1983 after two months of incubation in the humid chambers. Results are means of 50 stamps for each treatment and are from a representative experiment. In those cases where the foxing patches were irregular, an increase in growth was determined at the rims of each patch.

Results

Effect of sterilization on stamp foxing

Two steam sterilization procedures and two irradiation treatments were carried out on used foxed stamps. The irradiation treatments were also done on new stamps. The parameters which were assessed were increased in size and number of the foxed patches. Seven years after treatment stamps were transferred to humid chambers for two months. Then, the effect of the treatment was monitored.

The best treatment for both used and new stamps was γ-irradiation (Table 1.) A single irradiation completely stopped further development of these patches and prevented the appearance of new ones. Steam tyndelization was also successful but could not be used for new stamps coated with glue. No damage to colours was observed seven years after treatment. Steam sterilization had a restraining effect on the phenomenon. The longer the stamps were subjected to the steam, the smaller was the increase in size and number of the patches obtained. Nevertheless, steam sterilization did not give complete control.

UV irradiation had a destructive effect on the stamps tested. Increased foxing severity was observed when stamps were subjected to exposure periods of less than one hour. Irradiation for one and a half hour or more reduced the extent of foxing, but damage to stamp colours was observed. Furthermore, the irradiation created new colours on the stamps that were not there before (Table 1). No change in paper properties tested was observed seven years after the four sterilization treatments.

Table 1. Effect of sterilization treatments on increasing of foxing patches, growth and number, after seven years in used and new stamps

Sterilization treatment	Sterilization time (h)										Irradiation 2.5 (mega-rad)		Damages to the papers or to colours
	0		0.5		1		1.5		8				
	Increase of patches (mm)	Number of new patches	Increase of patches (mm)	Number of new patches	Increase of patches (mm)	Number of new patches	Increase of patches (mm)	Number of new patches	Increase of patches (mm)	Number of new patches	Increas of patches (mm)	Number of new patches	
Steam	–	–	4.46^{b}	7.1^{bc}	0.88^{a}	0^{a}	0.58^{a}	0^{a}	–	–	–	–	No damage
Tyndelization	–	–	0^{a}	0^{a}	–	–	–	–	–	–	–	–	
UV**	–	–	8.6^{c}	12.1^{c}	7.92^{c}	11.64^{c}	0.6^{a}	0^{a}	0.6^{a}	0^{a}	–	–	Change of colours or new colours
UV***	–	–	7.9^{c}	10.6^{c}	8.3^{c}	10.9^{c}	4.6^{b}	1.6^{b}	0.2^{a}	0^{a}	–	–	
γ**	–	–	–	–	–	–	–	–	–	–	0^{a}	0^{a}	No damage
γ***	–	–	–	–	–	–	–	–	–	–	0^{a}	0^{a}	–
Unsterilized	5.16^{b*}	8.71^{bc}	–	–	–	–	–	–	–	–			

– not tested.
* Numbers followed by different letter at each parameter (separetely) differ significantly at $P \leq 0.05$.
** used stamps.
*** new stamps.

Effect of soaking foxed stamps in NaCl solutions

Used foxed stamps were soaked in NaCl solutions, dried and stored. After seven years of storage, stamps were transferred to humid chambers for two months. The effect of NaCl concentrations was then measured.

Stamps subjected to NaCl concentrations of 5 % and 10 % showed increased foxing (Table 2); 15 % NaCl or higher decreased the size and number of the foxing patches, and 30 % NaCl prevented the occurrence of the phenomenon. NaCl crystals on the stamps were easily removed with the aid of a soft brush, without visible damage to stamps. The direct relationship between the phenol content of stamps and foxing was also observed in this experiment. The NaCl caused no damage to colours or to the paper of the tested stamps.

Table 2. Effect of NaCl concentration on development of foxing patches on stamps after seven years

NaCl concentration (%)	Increase in patch diameter (mm)	No. of new patches on stamps	Phenol content (mg)		Visible damage to stamps
			Before treatment	After treatment	
0	4.9*[a]	5.6[a]		5,86[a]	
5	6.1[b]	8.1[b]		5.97[a]	No damage
10	6.3[b]	8.0[b]		5.91[a]	
15	2.8[c]	2[c]	5.86[a]	4.12[b]	Slight salt crystallization on stamps
20	0.8[d]	0.1[d]		3.87[b]	Medium salt
30	0[d]	0[d]		3.61[b]	Crystallization

* Numbers followed by different letters at each parameter differ significantly at $p \leq 0.05$.

Discussion

Foxing of stamps, especially of rare and expensive stamps, is a major problem for stamp collectors all over the world. Control of this phenomenon is therefore essential and has great economic value. Although the severity and losses are of economic importance, to the best of my knowledge, no scientific report of foxing of stamps was published during the last decade.

Based directly on the study by *Nol* et al. (1983) demonstrating that the phenomenon was of microbial origin, we tested several sterilization procedures commonly used in prevention of microorganisms, among them steam sterilization, UV and γ-irradiation. The fact that the foxing phenomenon was prevented by sterilization procedures gave further support to the findings of *Nol* et al. (1983). Gamma irradiation services are provided in almost every country which has a nuclear reactor, and it can be used for both new and used stamps. Naturally, the polyethylene bags containing the stamps should be kept hermetically sealed, from the moment of sterilization on.

Tyndelization also has positive effects, but it can be used only with used stamps, to avoid melting of glue in the wet steam.

Increase in osmotic pressure may also prevent development of fungi in the stamps. However, the natural causal agent of foxing were favoured by relatively high NaCl concentration such as 5 % or 10 %. Only at very high NaCl concentrations was further development of the phenomenon prevented. Thus, in spite of its efficiency this procedure does not seem practical.

It can be concluded from this study that by proper means of sterilization the stamp collector can maintain his stamp collection in excellent condition for long periods of time. It is essential, however, that a study focusing on prevention of foxing in unfoxed stamps, especially those which are still in the commercial philatelic market, be undertaken.

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