TEXTILES – A STUDY OF THERMAL PROPERTIES

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GOALS:
- to determine radiation effects in model samples of most common textiles of cultural heritage objects
- to assess efficiency of thermal properties measurements for fast detection of radiation changes

Preservation of various cultural heritage (CH) objects for future generations is a challenge that requires a multidisciplinary approach. The experience gathered by application of ionizing radiation for sterilization of medical devices and pharmaceuticals is the basis for radiation treatment of CH objects. More than 5000 wooden, paper, textile and leather items have been treated over the past 25 years at the Co gamma irradiation facility in Laboratory for Radiation Chemistry and dosimetry of the Rudjer Bošković Institute in Zagreb, Croatia (D. Katalinić-Radem, D. Ražem, M. Braun, Radat. Phys. Chem, 76 (2008), 7/8; 729-731.). The presented study is a part of collaboration established under IAEA Technical Cooperation Project RER/015 “Enhancing the Characterization, Preservation and Protection of Cultural Heritage Artefacts”.

ADVANTAGES OF RADIATION TREATMENT OF CULTURAL HERITAGE

OBJECTIVE
- nontoxic, does not induce radioactivity
- efficient through the (depth of) object
- temperature independent (objects might be frozen)
- interrupts biodegradation
- provides conservation
- might be used for consolidation

IRRADIATION EFFECTS AND THE ABSORBED DOSE

The change in thermal properties of flax and cotton on irradiation were expected because cellulose is known to be prone to radiation degradation. Still, considering the relatively high dose of 120 kGy the decrease in temperature of maximum rate of mass decrease in TGA is not pronounced. In DSC thermograms of both artificially aged and irradiated cotton and flax samples a high temperature peak appears that is not present in unaged samples. That peak shifts to lower temperatures on irradiation. Its heat significantly increases on irradiation of aged flax samples but after 6 days is about the same as in unaged irradiated samples.

TGA and differential TGA traces of unirradiated, aged and irradiated flax and cotton samples.

CELLULOSE-BASED TEXTILES

Unlike flax and cotton silk and especially wool samples seem to be completely unaffected even if irradiated to 120 kGy. This is somewhat unexpected because the corresponding proteins – sericin and fibroin in silk and keratin in wool are by themselves sensitive to irradiation although less than cellulose. It seems that complex structure of animal fibers offers significant protection to its protein component. Still, temperatures and heats determined by DSC indicate that transformations in those fibers are slightly lower irradiation, somewhat more in samples that were previously aged. No new thermal transformations were observed on either ageing or irradiation.

TGA and differential TGA traces of unirradiated, aged and irradiated silk and wool samples.

CONCLUSIONS:
- cellulose-based textiles (flax and cotton) are more sensitive to irradiation than protein-based ones (silk and wool);
- both unirradiated and irradiated artificially aged samples were somewhat less thermally stable than unaged ones;
- irradiation to doses needed for fungi control in CH textiles should not produce change greater than that observed on ageing;
- thermal analysis is fast and effective method for monitoring of radiation induced changes in CH textiles.

Textile CH objects are especially susceptible to biological damage and various methods are applied to solve that problem but with partial success and by using toxic compounds. Insects, fungi, molds and bacteria inhabit those objects and produce chemical changes resulting in discoloration, deterioration of mechanical properties and even full decomposition (K. Kavkler, A. Demčar, Polym. Degrad. Stab. 97 (2012), 5; 785-792.). Those effects are due to change of oxidation state and/or depolymerization of natural polymers that textiles consist of i.e. to chemical attack of biodegradants.

Textile artifacts, mostly of ethnological significance, were efficiently disinfected by irradiation to dose of less than 2 kGy. However, the application of higher doses for the control of fungi needs to be justified by investigating the effects of irradiation on textile fibers and to determine whether the treatment complex to the high standards of conservator specialists considering undesirable changes.

The most common textile materials in CH artifacts - silk, cotton, linen and wool were chosen and model samples were γ-irradiated to D=120 kGy in contact with air. Such high dose was chosen to ensure that all radiation effects are detected and could be later recognized in textiles samples irradiated to 10 times lower doses needed for fungi control. Prior to irradiation a part of samples was artificially aged. Ageding was carried out in Vötsch Climatic Chamber, Type VC 0020 at 80 °C and 65 % RH for 25 days. The samples were analyzed using Perkin Elmer Diamond DSC and Shimadzu TGA, in synthetic air atmosphere.

PROTEIN-BASED TEXTILES