

1. PHD PROJECT DESCRIPTION (4000 characters max., including the aims and workplan)

Project title: The role of microorganisms in the biodeterioration of historic silk textiles

1.1. Project goals

Silk is a support for numerous valuable historic items and works of art, including gonfalons, funeral clothes (archeological objects), oriental paintings. Organic materials, when moistened, suffer microbial attack and signs of biodeterioration such as stains, deposits, structural weakening and loss of material are becoming visible. The mechanisms of these alterations are well-known in case of historical items containing the cellulose (paper, canvas, wood) or the collagen (parchment, leather). The results of this research are essential for conservators of works of art to evaluate the state of preservation of an object and when choosing the conservation or preservation methods.

Silk is a material resistant to biodeterioration and vulnerable to light, heat, and humidity (Koperska et al., 2014, 2015). The crystalline core of the fibre, which consists of fibroin, is responsible for the high resistance to the microbial decay. There are a few publications analyzing the biodeterioration of silk (Szulc et al., 2021; Kisová et al., 2020; Forlani et al., 2000) but the authors rarely examine the mechanisms of the decay of fibroin by microorganisms. The goal of the presented project will be to indicate which microorganisms may decompose the silk from archeological samples relying on Polish sources, to isolate of the strains active in fibroin decay and to detect the mechanisms of fibroin decay using different methods.

1.2. Outline

1. Characteristic of deteriorated silk samples - metagenomics, SEM analyses, pH measurements.
2. Isolation and identification of bacteria and fungi from the deteriorated silk samples.
3. Research on the biodeteriorating potential of the isolates.
4. Incubation of the most active isolates on raw new and artificially aged silk samples.
5. Research on the mechanisms of fibroin decay by the most active strains using different methods:
 - spectrophotometric determination with Coomassie brilliant blue,
 - viscosity measurements ,
 - analysis of the structural changes in fibroin using FTIR spectroscopy.

1.3. Workplan

First year

- Preparation of the grants for NCN "Preludium" and for IDUB,
- Characteristic of biodeteriorated silk samples - metagenomics, SEM, pH measurements,
- Isolation of microorganisms from the deteriorated silk samples,
- Identification of isolated bacteria based on the gene 16S rRNA sequence and fungi based on the ITS sequence,
- Research on the biodeteriorating potential of the isolates - proteolytic, cellulolytic, keratinolytic and fibroinolytic activities,
- selection of the most active strains and their biochemical characteristic.

- Selection of types of silk for the culturing of the most active strains,
- Artificial aging of the silk samples.

Second year

- Culturing the most active isolates on raw silk samples – new and artificially aged; examinations of degradation processes using the respirometric method,
- Visual evaluation, SEM, pH measurements of samples after culturing,
- Preparation of a publication based on the results obtained,
- Metabolomic analysis of the deteriorated silk samples.

Third year

- biochemical determination of the decay of fibroin by the most active strains using Coomassie brilliant blue applying spectrophotometer UV,
- viscosity measurements – analysis of the microbial activity in the decay of threads of soluted silk,
- analysis of the structural changes in fibroin using FTIR spectroscopy.

Fourth year

- complementary analysis of results
- presentation of results at conferences
- preparation of the doctoral dissertation
- dissertation defense

1.4. Literature

- G. Forlani, A. M. Seves, O. Ciferri (2000) A bacterial extracellular proteinase degrading fibroin. *International Biodeterioration & Biodegradation* 46, 271–275
- M.A. Koperska, D. Pawcenis, J. Bagniuk, T. Łojewski, J. Łojewska(2014) Degradation markers of fibroin in silk through infrared spectroscopy, *Polymer Degradation and Stability* 105, 185–196
- M. A. Koperska, D. Pawcenis, J. M. Milczarek, A. Blachecki, T. Łojewski, J. Łojewska (2015) Fibroin degradation – Critical evaluation of conventional analytical methods, *Polymer Degradation and Stability*, 120, 357-367
- D. Pangallo, L. Kraková, K. Chovanová, M. Bučková , A. Puškarová, A. Simonovičová (2013) Disclosing a crypt: Microbial diversity and degradation activity of the microflora isolated from funeral clothes of Cardinal Peter Pázmány, *Microbiological Research* 168 (2013) 289–299.
- J. Szulc, **J. Karbowska-Berent**, A. Drązkowska, T. Ruman, I. Beech, J.A. Sunner, B. Gutarowska (2021). Metabolomics and metagenomics analysis of 18th century archaeological silk, *International Biodeterioration and Biodegradation* 156, 105-120

1.5. Required initial knowledge and skills of the PhDcandidate

- an interest in the risks associated with biodeterioration of cultural property
- knowledge of biology, microbiology and biochemistry
- experience and ability in a microbiology laboratory
- ability to work in a team
- communication skills, creativity, analytical thinking, perseverance

1.6. Expected development of the PhD candidate's knowledge and skills

- ability to perform microbiological analyses related to the dissertation topic and research beyond the scope of the PhD activities
- ability to present research results at national and international conferences
- internships in research centres in Poland and abroad
- ability to obtain funding for research
- didactic skills to present information to students
- engagement in popularizing research