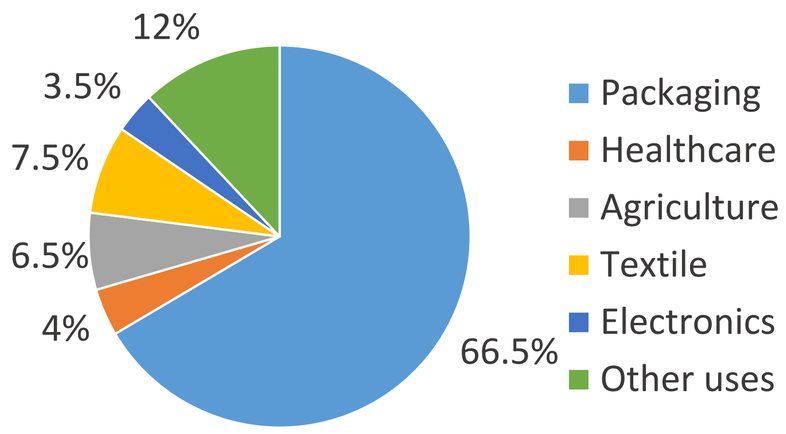
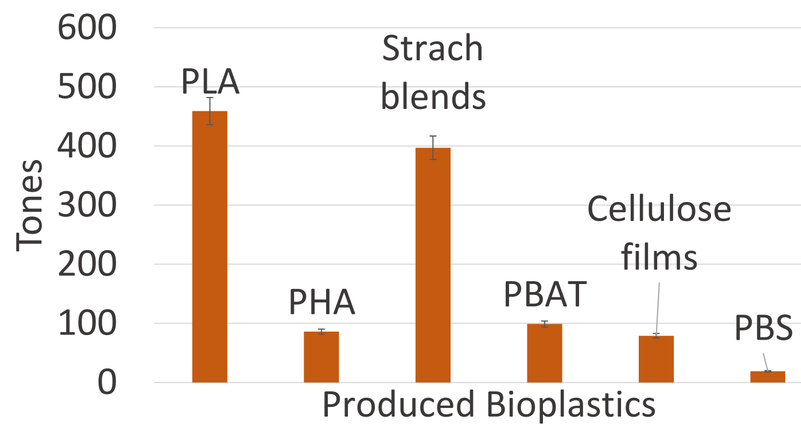
Sustaining the Future: Conserving Bioplastics in Cultural Heritage

***P. Morfis**, S.R. Collinson, J. Bowen, E. Dewberry, L. Dennis*
Faculty of Science, Technology, Engineering and Mathematics, The Open University, Milton Keynes, MK7 6AA
Museum of Design in Plastics (MoDiP), Arts University Bournemouth, Poole, BH12 5HH

1 *Introduction*

- More than **1,139 kilotonnes of bioplastics** were produced in 2023, driving sustainability in the **global biodegradable polymer market.**[1]
- Bioplastics now appear in museums and galleries.
- The **UK heritage sector contributes £44.9 billion** to the economy, making conservation essential.[2]
- **A major employer:** The heritage sector supported over 523,000 workers from **2015 - 2022.**[2]



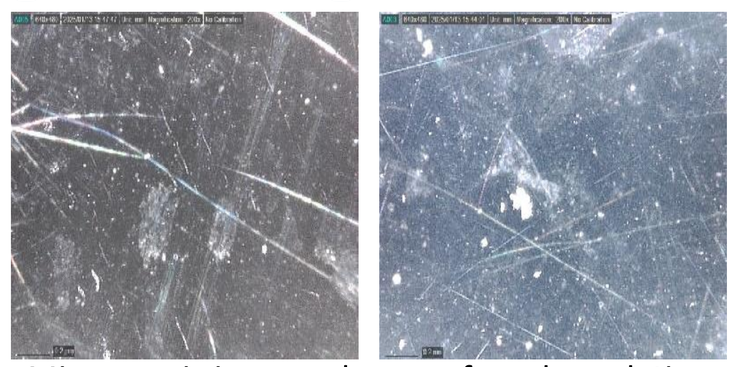


Can museums preserve materials that are designed to degrade?

2 The Challenge

- Bioplastics, e.g. polylactic acid (PLA), deteriorate over time, **becoming brittle and discoloured.**
- Exposure to **dirt, light, humidity and temperature accelerates degradation.**
- Conventional conservation methods are often ineffective, requiring new strategies and studies.

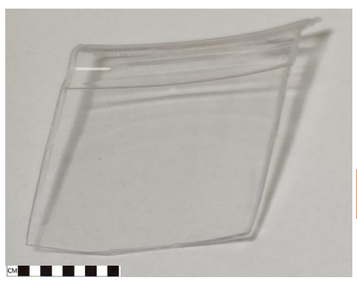
Long-term Degradation of Bioplastics: A MoDiP Plant Pot case study (2016–2024)



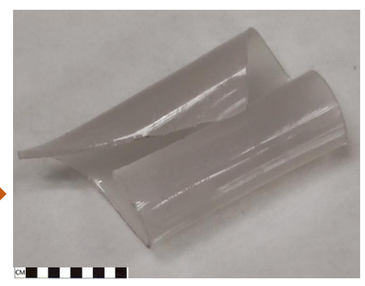
Microscopic images show surface degradation before (left) and after (right) environmental aging of a PLA bowl after 1 year.

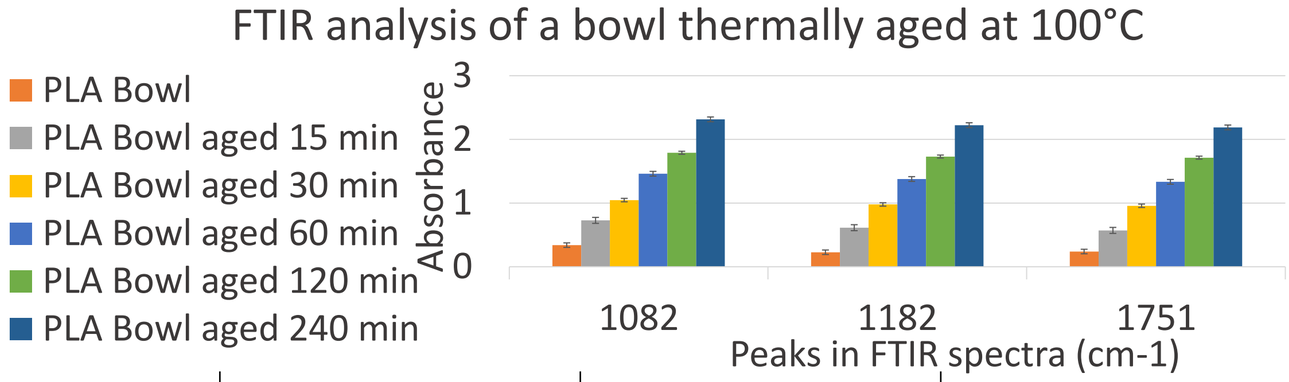
3 Our Approach

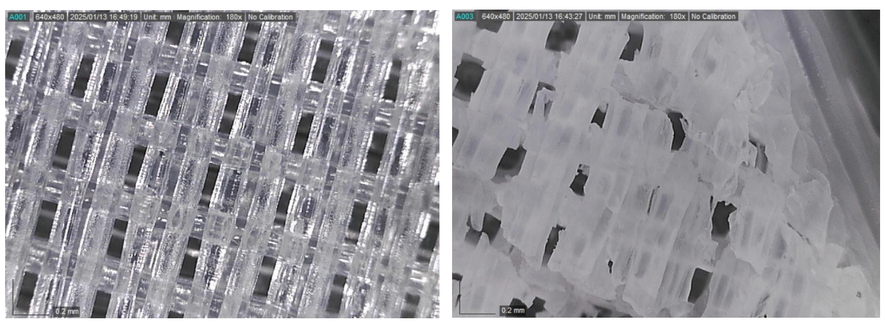
Simulating Ageing: Thermal ageing tests of 3D printed samples and consumer products to predict long-term degradation.
Testing Solvents: Analyse by several techniques the safety of cleaning methods for bioplastics.
Eco-Friendly Cleaning: Evaluating sustainable gels (carbomer, agar, gellan gum) as alternatives.



Accelerated thermal aging at 100°C



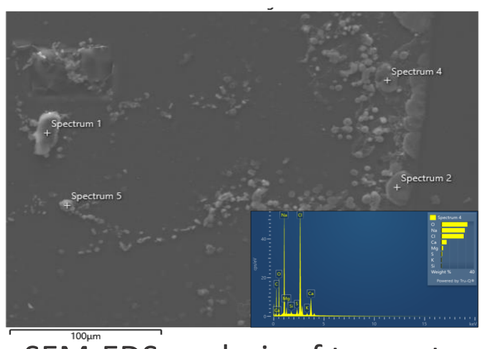




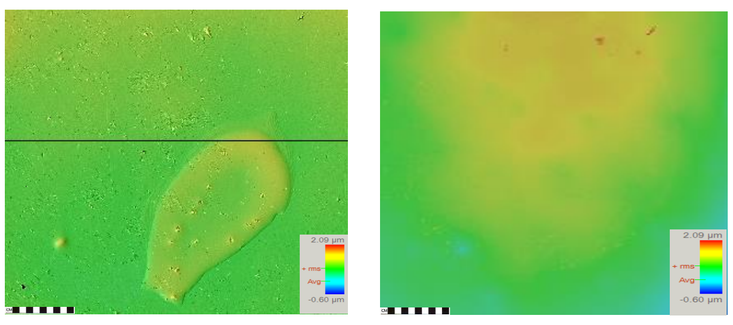
Untreated 3D-Printed Bioplastic (Control) (left) vs Acetone-Treated Sample - Severe Degradation

Solvent	Colourimetry ΔE Colour Change (%)	Nanoindentation Surface Hardness Change (%)	Microscopy Visible Damage (%)
Ethanol	✔ 5.80	✔ 3.00	✔ 3.00
Methanol	⚠ 14.80	⚠ 15.00	⚠ 28.00
Acetone	✘ 54.40	✘ 75.00	✘ 60.00

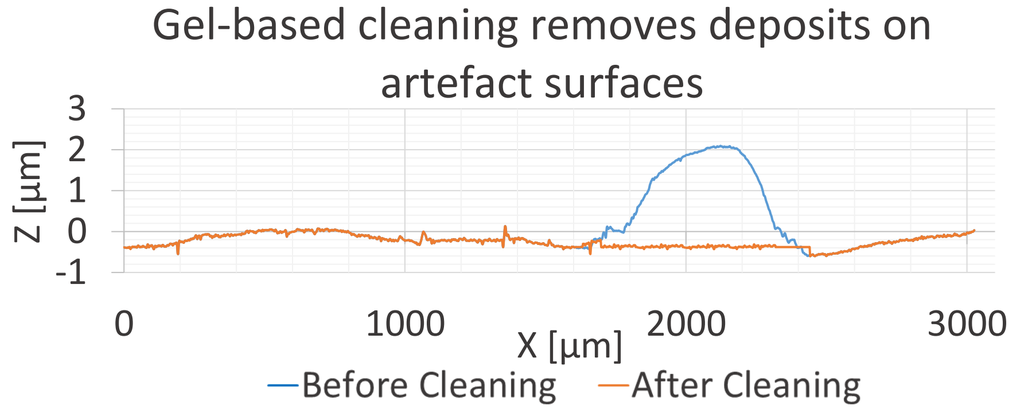
✔ **Safe or minimal impact** | ⚠ **Some risk, caution needed** | ✘ **Severe degradation, avoid**



SEM-EDS analysis of tap water deposits showing mineral residues including Ca, Na and Mg



Tomography Analysis of Water deposit Removal: Comparing Gel-Based Cleaning Effects



4 Key Findings

PLA exhibits embrittlement, discolouration, and crystallinity changes.
Acetone and methanol cause **significant degradation**; **ethanol** is the **safest** cleaning solvent.
Eco-friendly gels **clean PLA effectively** while preserving integrity.

5 Conclusion & Impacts

✅ This research **enhances sustainable conservation strategies for bioplastics, addressing a critical gap in museum preservation.**
✅ Findings can **inform heritage care and sustainability policies**, reducing the environmental footprint of conservation.

6 Future Work

Next steps: Real-world museum testing of bioplastic conservation methods and further engagement with conservators and curators.
Raising public awareness on the role of bioplastics in society and cultural heritage.

[1] Maximise Market Research (2023) Biodegradable Polymers Market - Global Industry Analysis and Forecast (2023-2029)
[2] Historic England (2023) The Economic Value of the Heritage Sector | Heritage Counts | Historic England.

Join the conversation on bioplastic conservation! *Contact Panagiotis at* **panagiotis.morfis@open.ac.uk**