SEAHA CENTRE FOR DOCTORAL TRAINING IN SCIENCE AND ENGINEERING IN ARTS HERITAGE AND ARCHAEOLOGY

SEAHA Studentship:

The role of plasticiser loss in the degradation of plastic objects in heritage collections

Nearly all museums, libraries and archives include plastics in their collections. Although they are often among the most recently acquired items in a collection, plastic objects can be the least stable, with many objects showing evidence of degradation within 5-25 years of acquisition.[1]

One of the most important degradation processes observed in certain plastic artefacts is loss of plasticisers, which are added to a material to modify its processing temperature, flexibility, impact resistance, and other properties. Over time, plasticiser can migrate to the surface of an object and into the surrounding environment. Damage related to plasticiser loss is a particular problem for cellulose acetate (CA) and polyvinyl chloride (PVC), which historically have been plasticized with phthalates. Plasticiser loss has been shown to lead to an increase in Young's modulus and a decrease in the strain at break of a material, indicating increased brittleness, distortion, and an increased risk of damage such as cracking [2][3].

Previous research in plasticiser migration has focused in PVC in the contexts of the medical and food industries. However, migration of plasticisers into air from CA is a less well-studied phenomenon. In the case of PVC objects, research has shown that the environment in which an object is stored has a significant impact on the extent to which diffusion or evaporation controls plasticiser loss [4]. There is a need therefore for a more in-depth understanding of the processes and parameters involved in plasticiser migration from plastic objects found in heritage collections, and in particular how these relate to material properties and to the distribution of plasticiser in a material. This project explores the following research questions:

1. **What are the dynamics of plasticizer loss in CA and PVC objects found in heritage collections?**
2. **Which material properties (crystallinity, molecular orientation, shape, porosity) define the rate and spatial distribution of plasticizer loss?**
3. **What is the relationship between plasticizer loss and observable macroscopic changes, such as deformation and crack formation?**
4. **What is the dependence between plasticizer loss and environmental parameters (temperature, relative humidity and ventilation)?**

The research will be based on a combination of experimental techniques. Samples of CA and PVC objects of known shape and with different plasticizer formulations will be produced by injection moulding at the Smithsonian Museum Conservation Institute (MCI). These samples will be aged under controlled conditions of relative humidity, temperature and air movement. Plasticizer loss over time will be monitored using a range of experimental techniques available in UCL and MCI, such as hyperspectral imaging techniques to track material composition and the spatial distribution of plasticiser loss as well as Raman Spectroscopy, Gas Chromatography/Mass Spectrometry. Digital Image Correlation will be used to quantify the spatial distribution of deformation and crack formation at different stages of ageing. Mechanical properties such as Young's modulus and glass transition temperature will be determined using tensile testing, Atomic Force Microscopy (AFM) and Dynamic Mechanical Analysis. Differential Scanning Calorimetry will be used to reveal the degree of crystallinity.

This research will lead to an improved understanding of the degradation of plastic artefacts due to plasticizer loss, and will inform storage guidelines for museums.

UCL UNIVERSITY OF OXFORD University of Brighton EPSRC

The student will benefit from the knowledge of polymer degradation and preventive conservation of the Institute for Sustainable Heritage (Dr. Josep Grau-Bové and Dr. Katherine Curran), the expertise in heritage plastics of the Smitshonian Museums Conservation Institute (Dr. Odile Madden) and the advice on industrial manufacturing processes of Dow Chemical (Dr. Michael Petr).

Academic entry criteria

This exciting project will provide the successful candidate a valuable set of interdisciplinary skills material analysis, polymer degradation, transport phenomena, experimental design and heritage management, as well as professional skills to develop their future career in a wide variety of multidisciplinary environments ranging from academia and conservation to engineering consultancy.

The successful candidate will have a good first degree in a relevant discipline such as engineering, science, physics, material science, conservation or heritage science. Previous knowledge of polymers and/or some of the experimental techniques involved is a plus.

This project is part of the EPSRC Centre for Doctoral Training in Science and Engineering in Arts, Heritage and Archaeology at University College London, University of Oxford and University of Brighton (www.seaha-cdt.ac.uk). Funded by the Engineering and Physical Sciences Research Council (EPSRC) through the Centre for Doctoral Training, the four year doctoral research programme will be supervised jointly by the UCL Institute for Sustainable Heritage (http://www.bartlett.ucl.ac.uk/heritage) and the Smithsonian Museums Conservation Institute. For further details contact the first supervisor, Dr. Josep Grau-Bové (josep.grau.bove@ucl.ac.uk).

As a SEAHA student, you will have unparalleled access to research infrastructure and expertise across three universities and more than 50 heritage, research and industrial partners. In addition to the university doctoral training requirements, SEAHA students take part in an exciting range of cohort activities, ranging from residential events and group projects, to conferences and careers events. Please visit the SEAHA website (www.seaha-cdt.ac.uk) for details.

The SEAHA Studentship will cover home fees and an enhanced stipend of up to £17,690 per year (to be confirmed at point of offer) for eligible applicants (http://www.seaha-cdt.ac.uk/opportunities/eligibility-criteria/), and a substantial budget for research, travel, and cohort activities.

To apply, submit your online application to study on the MRes Science and Engineering in Arts, Heritage and Archaeology, via http://www.ucl.ac.uk/prospective-students/graduate/taught/degrees/science-engineering-arts-heritage-archaeology-mres.

In addition, your application should include:

- A covering letter clearly stating:
    - Your motivation and how the course will contribute to your career development
    - Your residency status and eligibility for funding according to the information provided http://www.seaha-cdt.ac.uk/opportunities/eligibility-criteria/, or how you intend to sponsor your studies if not eligible for funding
    - Your academic eligibility
- Names of two academic referees (or one academic and one professional if applicable)

- Proof of meeting the UCL English language proficiency requirements where necessary. For SEAHA candidates, an advanced level certificate is normally required (details of English language proficiency requirements can be found at http://www.ucl.ac.uk/prospective-students/graduate/apply/english-language/index)
- A 2500 word project proposal, explaining a work plan that aims to answer the research questions, and which is based on the relevant literature.

The applications should be sent by email to the SEAHA Manager (manager@seaha-cdt.ac.uk) but you are encouraged to contact the SEAHA Manager or the project supervisor Dr. Josep Grau-Bové (josep.grau.bove@ucl.ac.uk) before producing the application.

Application deadline: 1st September 2016.

Please note that shortlisting and interviews will take place on a rolling basis during the recruitment period

References

[1] Y. Shashoua, "Degradation of plastics," in *Conservation of Plastics*, Oxford: Elsevier, 2009, p. 152.

[2] E. Linde and U. W. Gedde, "Plasticizer migration from PVC cable insulation - The challenges of extrapolation methods," *Polym. Degrad. Stab.*, vol. 101, pp. 24–31, 2014.

[3] J. S. Tsang, O. Madden, M. Coughlin, A. Maiorana, J. Watson, R. J. Speakman. Degradation of 'Lumarith' cellulose acetate: examination of a salesman's kit, *Studies in Conservation* vol. 54, issue 2, pp. 90-105.

[4] Y. R. Shashoua, "Effect of indoor climate on the rate and degradation mechanism of plasticized poly (vinyl chloride)," *Polym. Degrad. Stab.*, vol. 81, pp. 29–36, 2003.