The Art Institute of Chicago
Northwestern University
Joint Seminar Series
on
Conservation Science

Soft Materials and Hard Plastics in Art: Characterization, Degradation and Conservation

Thursday, November 15, 2012
William A. and Gayle K. Cook Hall
Conference Room 2058
Northwestern University

NORTHWESTERN
UNIVERSITY

PROGRAM

9:00am	Registration and coffee
9:30am	Welcome **Katherine T. Faber**, Northwestern University
9:40am	**David Yarusso** (3M Company, Corporate Research Materials Laboratory, St. Paul, MN) **"Adhesive Types and Materials with an Eye to Durability"**
10:25am	**Linda Broadbelt** (Northwestern University, Evanston, IL) "**Mechanistic Models of Polymer Degradation Chemistry**"
11:10am	**Kenneth Shull** (Northwestern University, Evanston, IL) "**Don't touch! A Non-Contact Method for Measuring the Mechanical Properties of Paint Coating**s"
12:00pm	Lunch
1:45pm	**Eric Breitlung** (Library of Congress, Washington DC) **"Non-Destructive Identification of Polymeric Binder Degradation in Audio and Video Tapes"**
2:30pm	**Yvonne Shashoua** (National Museum of Denmark, Department of Conservation) "**Conservation Adsorbents – How Effective Are They for Plastics?**
3:15pm	**Keynote speaker: Thea van Oosten** (Cultural Heritage Agency of the Netherlands (RCE), Amsterdam) **"Conservation Research: A Way to Understand Plastics"**
4:15pm	Q&A
4:30pm	Concluding remarks

ADHESIVE TYPES AND MATERIALS WITH AN EYE TO DURABILITY

David J. Yarusso
Corporate Scientist, 3M

A general review will be given of what it takes for a material to function as an adhesive. We will discuss the various types of adhesives including solvent and water based, hot melt, and chemically curing adhesives. However, special emphasis will be given to pressure sensitive adhesives, the sticky materials found on a roll of tape, which is the area of primary expertise of the presenter. Because of the wide variety of chemistries used in these materials, we will focus on the general classes of polymeric materials used in these various types of adhesives and their chemical stability. The various modes of failure of adhesives and adhesive bonds will also be discussed.

Biography

Dr. David J. Yarusso is a Corporate Scientist at the 3M Company, currently working in their Corporate Research Materials Laboratory. Dr. Yarusso received his Bachelor's degree in Chemical Engineering from the University of Minnesota in 1978 and his PhD in the same field from the University of Wisconsin in Madison in 1983 where his thesis research focused on the structure and properties of ion-containing polymers. He joined 3M in 1983 and has worked in a number of different divisions and corporate research laboratories, always involved in the development of pressure sensitive adhesives. He has worked on rubber based adhesives as well as acrylic adhesives in his various assignments and is an expert in the measurement of viscoelastic properties of adhesives and relating those properties to adhesive performance.

Linda J. Broadbelt
Chair and Professor, Chemical and Biological Engineering
Northwestern University

Pyrolysis is a promising method for resource recovery from plastic waste that thermally converts polymers in the absence of oxygen into valuable chemical feedstocks and monomer. It is also a detrimental process of degradation when polymeric materials are exposed to high temperatures. To provide further insight into polymer pyrolysis, a greater understanding of the mechanistic and kinetic details of the underlying reaction network is needed. To handle the complexity of mechanistic modeling of polymer degradation, we have developed both continuum and kinetic Monte Carlo (kMC) models. To facilitate creation of continuum models, we have formulated an automated modeling framework that assembles population balance models based on the method of moments from minimal user input. The population balances track the moments of a large number of radical and dead species, including monomer and small molecules that are relevant to degradation chemistry. We have applied this framework to study the degradation of polystyrene, polypropylene, polyisoprene, polystyrene peroxide and binary mixtures, and we are able to capture diverse experimental measures, including yields of individual low molecular weight products, as a function of reaction conditions. In order to solve the large models that are created, values of the rate coefficients for $O(10^5)$ reactions may be required. The approach that we have developed to specify rate coefficients is hierarchical, based on a combination of literature values, estimation methods, and computational chemistry.

Biography

Linda Broadbelt is Sarah Rebecca Roland Professor in and Chair of the Department of Chemical and Biological Engineering University at Northwestern University. She received her B.S. in chemical engineering from The Ohio State University and graduated *summa cum laude*. She completed her Ph.D. in chemical engineering at the University of Delaware in 1994 where she was a Du Pont Teaching Fellow in Engineering, a National Science Foundation Graduate Fellow, and a DuPont PhD in Engineering Fellow. At Northwestern, she was appointed the Donald and June Brewer Junior Professor from 1994-1996. She has completed the short course Business for Scientists and Engineers through the Kellogg Graduate School of Management.

Her research and teaching interests are in the areas of multiscale modeling, complex kinetics modeling, environmental catalysis, novel biochemical pathways, and polymerization/depolymerization kinetics. She was Associate Editor for Energy and Fuels (2002-2010). She is currently on the editorial boards of *International Journal of Chemical Kinetics* and *Chemical Engineering Journal*. Her honors include selection as the AIChE Women's Initiative Committee Mentorship Excellence Award winner, a Fellow of the American Association for the Advancement of Science, a Fulbright Distinguished Scholar Award, a CAREER Award from the National Science Foundation.

DON'T TOUCH! A NON-CONTACT METHOD FOR MEASURING THE MECHANICAL PROPERTIES OF PAINT COATINGS

Kenneth R. Shull
Professor, Materials Science and Engineering
Northwestern University

The engineering community commonly uses a variety of non-destructive techniques to evaluate the structural integrity of objects ranging from bridges to airplanes. A common implementation of these techniques relies on the propagation of sound waves through the structure so that structural defects can be imaged directly. This talk will focus on the development of conceptually similar techniques for quantifying the properties of a paint coating as it cures and ages. Examples illustrating the use of the technique will include both commercial paint formulations and models of the oil-based formulations used in oil-based artist paints.

Biography

Ken Shull is Professor of Materials Science and Engineering at Northwestern University. His research interests involve the interfacial properties of amorphous polymers, with a particular emphasis on adhesion and fracture. Recent interests include the large-strain deformation and fracture behavior of 'soft' materials including polymer gels, and the interfacial behavior of biopolymers. He received B.S. and M.S. degrees in Materials Science from MIT, followed by a Ph.D. in Materials Science from Cornell University, which he received in 1990. He worked as a research staff member at the IBM Almaden Research Center for 3 years before joining Northwestern in 1993. He is a fellow of the American Physical Society and of the Adhesion Society. He is current president of the Adhesion Society, chair of the Adhesion Gordon Research Conference for 2013, and is also active in the American Chemical Society and the Materials Research Society.

NON-DESTRUCTIVE IDENTIFICATION OF POLYMERIC BINDER DEGRADATION IN AUDIO AND VIDEO TAPES

Eric Breitung
Preservation and Testing Division
Library of Congress

The Library of Congress holds more than 750,000 magnetic tapes. Many are degrading rapidly, and a method to identify degraded tape is needed to allow for the treatment prioritization prior to copying and/or digitizing. Even in the most ideal storage conditions, tapes produced during the 1970-1990s, which often contain polyester-urethane (PEU) binders and are known to degrade. The main degradation pathway is hydrolysis at the ester linkage, which breaks down the polymeric network leaving shorter, more mobile fragments. When this occurs, it often causes squealing and/or shedding of magnetic material onto playback device heads.

There are no known non-destructive methods for rapidly identifying degraded magnetic tapes, and while several brands and models of tape are known to contain PEU binders, tapes are rarely held in their original packaging or even kept on original hubs, making classification by visual inspection impossible. Playing a tape is the currently accepted method for classifying it as degraded or not. Ongoing research at the Library is assessing the capability of Fourier transform infrared spectroscopy in conjunction with multivariate statistical analysis to non-destructively assess tape condition. This presentation will focus on the techniques used and the results to date for ¼" audio as well as its application to several video formats.

Biography

Eric Breitung is a physical organic chemist with ten years of industrial research experience in coatings and thin-films at General Electric's Global Research Center. He began working in the field of art conservation science in 2006 as an Andrew W. Mellon Fellow in the Metropolitan Museum of Art's Department of Scientific Research, where he developed novel methods for treating and producing scratch resistant large-format face-mounted photographs. A side project on novel anti-tarnish coatings for the protection of silver objects developed into a National Science Foundation supported program with collaborators at the University of Maryland and The Walters Art Museum. He has also studied natural and synthetic dyes at the Smithsonian Institution and is now focusing on modern materials research at the Library of Congress in the Preservation Research and Testing Division. At the Library, Eric is focusing on understanding how best to preserve and care for materials used to maintain both digital and analog information. He also runs a consulting business, E-squared Art Conservation Science, where he develops and validates protective coatings for cultural heritage objects.

CONSERVATION ADSORBENTS—HOW EFFECTIVE ARE THEY FOR PLASTICS?

Yvonne Shashoua
Senior Research Scientist, Department of Conservation
National Museum of Denmark

Since its launch, conservation research and practice for plastics have focussed on inhibiting breakdown by removing either the factors causing or accelerating degradation. Adsorbents or molecular traps are introduced to create a conservation microclimate. The few studies conducted to evaluate their effectiveness are based on analysis of plastics before and during storage.

Cellulose acetate (CA) has been used since 1910 to produce spectacle frames, Lego bricks, Gabo sculptures and movie film. It hydrolyses auto-catalytically to acetic acid. After exposure to new and real time degraded cellulose acetate, silica gel, activated carbon, zeolite 4A, Corrosion Intercept and archival card were desorbed using GC-MS and evolved gas analysis. Silica gel, activated carbon, zeolite and archival card were found to adsorb non-selectively. In addition to water, silica gel adsorbed acetic acid and phthalate plasticizer from CA. Zeolite 4A also adsorbed plasticizer from CA film, inducing shrinkage. Activated carbon adsorbed both plasticizer and flame inhibitor. Similar results were obtained in an earlier study of plasticized PVC.

In conclusion, the non-selectivity of conservation adsorbents suggests that they may be ineffective or even accelerate degradation of plastics. Storage in an archival box removed more acetic acid and less plasticizer than adsorbents.

Biography

Yvonne Shashoua is a Senior Researcher at the National Museum of Denmark investigating the degradation and conservation of plastics. After graduating in industrial chemistry she worked as a paint technologist for Berger Paints in England. She joined the British Museum as a conservation scientist in 1988, specialising in the deterioration reactions and conservation of cellulose nitrate, cellulose acetate and rubber. She has more than 80 publications including a monograph ´Conservation of Plastics-materials science, degradation and preservation´ published by Elsevier in 2008. Yvonne Shashoua was coordinator of International Council of Museums – Committee for Conservation´s working group Modern Materials and Contemporary Art until 2008. She researched cleaning of plastics as part of the collaborative EU 7th Framework Research project POPART (Preservation of Plastics Artefacts in Museums) between 2008 and 2012. Between January and July 2012, she was a Getty Conservation Institute scholar researching the effectiveness of adsorbents for cellulose acetate film. Current research interests include the detection of early onset of degradation of plastics, real time degradation of polymers, adsorbents to slow the rate of degradation of plastics early film and collaborating with artists to optimise their selection of synthetic materials for artworks in museums.

CONSERVATION RESEARCH: A WAY TO UNDERSTAND PLASTICS

Thea van Oosten
Senior Conservation Scientist, Cultural Heritage Agency of the Netherlands (RCE)

Museum collections nowadays contain increasing amounts of plastic objects. Since the production of the first plastics at the beginning of the twentieth century, a wide variety of plastics have been brought on the market. With the introduction of the injection mould in the 1930s it became possible to mass-produce plastic objects. The purpose was to produce an object or item of packaging as cheaply as possible. Plastic objects often have a relatively short life cycle and need to be replaced after a certain period of time.

Nowadays, there are hundreds of different types of plastics, each with specific properties to suit their purpose. How should we recognize and identify plastics in our collections? Can we recognize plastics or different types of plastics on their degradation phenomena? Can we find curative treatments for the degrading synthetic polymers? Due to unfamiliarity and complexity of modern plastics, recognition of modern plastics by their visual appearance, is not so easy and chemical analysis is often required. Even if the identity of plastics and their degradation processes are known, it is still difficult to predict the 'life expectancy' of a plastic object. While the deterioration of traditional materials such as yellowing, crazing, matness and patina is known and accepted, the different states of appearances of degraded plastics are not yet fully understood and appreciated. For instance: are we cleaning too far if we do not know about patina/s of ageing plastics?

At the Cultural Heritage Agency of the Netherlands (RCE) significant research has been carried out during the last 22 years into the conservation of plastics used for and applied in modern and contemporary art and design objects.

Biography

Since 1975, Thea B. van Oosten has been employed as a conservation scientist at the Central Laboratory for Objects of Art and Science (CRL) which was also known a Netherlands Institute for Cultural Heritage (ICN) and from January 2011 called Cultural Heritage Agency of the Netherlands (RCE). In 1989 she started as senior conservation scientist the research programme on plastics and she has been developing that ever since. Specialised in the conservation of modern and contemporary art and design objects of Cultural Heritage she has contributed to several publications and books, such as 'Modern Art, who Cares', 'Plastics, Collecting and Conserving' and 'Plastics in Art' and 'Preservation of Plastic Artefacts in Museum Collections'. One of her research topics was the consolidation of polyurethane foams, which resulted in a book published in May 2011 called; PUR Facts, Conservation of Polyurethane foam in Art and Design. She further tries to disseminate her knowledge and experience by teaching courses and workshops and giving lectures on this topic both in the Netherlands and in various workshops around the world. Since July 2011 she is on retirement and is working as a free-lance conservation scientist for the research into plastics and the conservation of modern and contemporary art.