Surface Analysis in the World of Fine Art

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ABSTACT
Connections between the science of surface analysis and the science of cultural heritage, such as it is, have been neither historically strong nor particularly productive, unfortunately for both fields. We are developing new collaborations aimed at changing this. Not all cultural heritage conservators adopt a scientific approach, and not all of those that do are willing to expand their scientific approaches to include surface-sensitive techniques such as XPS and TOF-SIMS. To be fair, we surface scientists don't have all the answers and can't get them. Not all surface scientists are interested in pushing the boundaries of their sample types into such unconventional realms, and not all of those that are interested have the patience to develop the new sample-handling and sample-preparation techniques applicable to XPS and TOF-SIMS analysis. This presentation will draw upon several recent examples from the speaker's research team to show how XPS and TOF-SIMS can be used to shed some light on mechanisms of chemical and physical degradation, proposed and applied methods of stopping such degradation, and proposed and applied methods of repairing such degradation. The examples will come from a range of paintings and other art objects spanning from the Italian Renaissance to the post-Modern era.

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BIOSKETCH
Dr. Beebe received his B.A. in Chemistry from Franklin & Marshall College in Lancaster, in 1982, and his Ph.D. in Physical Chemistry from the University of Pittsburgh in 1987, where he worked under the direction of the late Professor John T. Yates, Jr. on studies of the reactions of small molecules on model catalytic surfaces. While in graduate school, Beebe spent 4 months with the late Dr. D. Wayne Goodman, then at Sandia National Labs in Albuquerque, on studies of the reactivity of methane on various nickel single crystal surfaces. From 1987 to 1989, Beebe worked jointly as a postdoctoral fellow in the labs of Dr. Miquel Salmeron and Professor Gabor A. Somorjai at Lawrence Berkeley Labs, and with Dr. Wigbert J. Siekhaus at Lawrence Livermore National Labs, where he and his co-workers were among the first to apply scanning probe microscopes to biological systems.

Beebe's independent professorial career began at the University of Utah in 1989. In 2001, Beebe moved to the University of Delaware, Department of Chemistry & Biochemistry, where he also holds a secondary appointment in the Department of Materials Science and Engineering. Beebe is Professor and Director of the UD Surface Analysis Facility, past Director of the Howard Hughes Medical Institute's Summer Analytical Chemistry & Biochemistry Program for High School Students and Teachers, and past Director/Principal Investigator of a newly established NIH Center of Biomedical Research Excellence, entitled *Molecular Design of Advanced Biomaterials*, where he directed the $15-million NIH-funded Center consisting of over 12 faculty, 25 graduate students and 12 postdocs in four academic departments and two colleges at the University of Delaware.

Beebe is an internationally recognized expert in the fields of biomaterials, surface chemistry, and surface analysis. He and his research group developed several research programs that continue to be major themes in his research program today. The first research theme is the surface science of biological systems, including living cells and biomaterials surfaces. Beebe and his colleagues were among the first to measure single-molecule ligand-receptor bond-rupture forces in biological systems, and to photograph DNA using a new microscope that Beebe constructed. Beebe also developed a research theme that involves the use of nanometer-sized pits on the surface of highly oriented pyrolytic graphite, or "molecule corrals," to confine small ensembles of organic molecules, and as templates in which to grow nanostructures. Beebe and his colleagues were the first to produce such novel nanostructures and to show that they could be used for dozens of new experiments designed to understand the field of molecular self assembly under confined conditions. Beebe is also an internationally recognized expert in the application of modern, state-of-the art surface analytical techniques to the challenging problems faced by art conservators, particularly as those problems relate to degradation of paintings and other art objects. All aspects of Beebe's research are collaborative and cross-disciplinary in nature