Transactions of the American Nuclear Society, vol. 49

5. The Neutron Activation Autoradiography Program at the Smithsonian Institution, *Yu-Tarng Cheng, Jacqueline S. Olin (Smithsonian Inst)*

Use of the neutron activation autoradiography method for painting studies was first developed[1] in the mid 1960s and some pioneering autoradiographic projects include a lengthy study[2] of the works of Ralph Albert Blakelock at Brookhaven National Laboratory (BNL). More recently, a study was conducted on the works of Rembrandt, Van Dyke, Vermeer, and other Dutch masters at the New York Metropolitan Museum of Art,[3] also using the reactor at BNL.

The method makes it possible to study the creative process of the artist. After the thermal neutron activation process, elements in the paint pigments form radioactive nuclei that in turn decay at known half-lives with the emission of gamma rays and charge particles. The charge particles are responsible for generating images on the radiographic film, which is held in close contact with the painting by a very slight vacuum. A carefully designed film exposure schedule helped to separate the images of elements that have different half-lives. The autoradiographs show the distribution patterns of the pigments where the elements occur. The gamma radiation decay activities are also analyzed to measure quantitatively the contents of different elements in the painting.

The Conservation Analytical Laboratory (CAL) of the Smithsonian Institution recognizes the potential of this technique for the study of paintings and is currently collaborating with the National Bureau of Standards (NBS) in developing an autoradiography facility using the NBS research reactor. Details of the development have been reported elsewhere.[4] Essentially, the facility, when completed, will allow paintings up to 2 × 2.5 m in size to be activated by thermal neutrons for autoradiographic studies.

Along with the need for new analytical tools is the concern for painting safety. If the neutron activation autoradiography technique is to gain acceptance among people interested in studying paintings, the radiation dosage of ~300 rads that the painting will be subjected to during the activation process, though very small by industrial standards, must be addressed. The approach we have taken first is to try to minimize the dosage level. This requires the development of a more efficient charge particles area detector than the current Kodak DEF film system. Kodak DEF film is mainly exposed by the charge particles emitted from the activated painting materials. However, the sensitivity of film to light is largely untapped in our present setup. So an experiment was conducted to learn the effectiveness of different film and light scintillation screen combinations. Table I shows the number of disintegrations from gold foil needed to register a density of 1 D on the various systems. The Kodak XAR film coupled with Dupont Quanta III screen appears to give the fastest response—almost a factor of 8 improvement over the current system using only the DEF film. Prolonging the film development time from the standard 5 min to 10 min further enhances the speed by another factor of 3.5. Thus, if all these speed improvements can be realized, one can reduce the radiation level that the painting is exposed to for the autoradiography study to a level less than what it would receive in a typical x-ray examination. We are currently conducting measurements to see that the minute dosage is not meaningfully affecting the normal aging process of the painting. Previous painting radiation studies done at BNL have shown that there is no measurable effect immediately after activation with dosages up to the 1-Mrad range.[3] However, it has not addressed the question of long-term effect. Six 1- × 1-m painting panels are being prepared with either oil or glue ground and various pigment combinations. Ultraviolet lights will be used to simulate and accelerate the aging process. The newly aquired GCMS equipment at CAL will be utilized to measure end products of ultraviolet, neutron, and gamma radiations.

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4. YU-TARNG CHENG, JACQUELINE S. OLIN, ROBERT S. CARTER, MARTIN GANOCZY, CHARLES H. OLIN, IVAN SCHRODER, "Modification of the National Bureau of Standards Research Reactor for Neutron-Induced Autoradiography of Paintings," *Proc. Boston Museum of Fine Arts Application of Science in the Examination of Works of Art, 1983.*

TABLE I

Kodak Film Type	Scintillation Screen Type	No. of Disintegrations Needed to Register a Film Density of 1 D
OH	Kodak Standard	2.44×10^6
OG	Kodak Standard	4.15×10^6
DEF	--	3.32×10^6
DEF	DuPont Quanta III	2.36×10^6
XAR	DuPont Quanta III	9.24×10^5
XAR	--	6.61×10^6