N85-32402

Technical Sessions

RELIABILITY PHYSICS

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Ranty H. Liang of JPL reported on Studies of Photothermal Degradation in Encapsulants. The fundamental mechanisms and associated reaction kinetics of the thermal and photothermal yellowing of EVA are described. EVA will yellow during dark-oven aging at elevated temperatures, and will also yellow in the presence of UV. But the UV will induce a partial photobleaching of the thermal yellowing. Because the kinetics of the thermal yellowing, UV yellowing, and UV bleaching are different, the overall yellowing of EVA is not simply related to UV intensity and temperature. The work described seeks to derive the overall reaction kinetics of EVA yellowing as part of the development of a life-prediction methodology.

C.C. Gonzalez and R.G. Ross, Jr., of JPL reported on Predicting Photothermal Field Performance. A preliminary kinetics model of EVA yellowing was generated from the fundamental work described in the previous presentation. Using this model and SOLMET weather data, predictions of the level of weather-induced yellowing in EVA from 30 years of simulated outdoor exposure in Phoenix were generated. Yellowing of EVA results in optical absorption of transmitted sunlight, thereby reducing the power output of solar cells encapulsated in EVA. This preliminary work indicated power losses amounting to near 3.5% for ground-mounted arrays, and power losses approaching 7.9% for roof-mounted arrays, which typically operate at higher temperatures than ground-mounted arrays.

J. Guillet of University of Toronto reported on Micromolecular Modeling. This contract work seeks to develop a reaction-kinetics-based model of the overall photodegradation process experienced by encapsulatants in an outdoor weather environment. Inasmuch as well over 50 individual reaction mechanisms have been identified, part of this work is to develop a computer ability to solve all of the rection kinetic equations simultaneously for life-prediction purposes, and for chemical information related to the selection of the most effective stabilizing additives for weather-sensitive encapsulants such as EVA. The computerized model indicates that a combination of a UV absorber and a hindered amine light stabilizer (HALS) would be an effective stabilizing system.

P. Gomez, S.K. Fu, and O. Vogl of the Polytechnic Institute of New York reported on Polymerizable Ultraviolet Stabilizers. Polytechnic Institute of New York carries out chemical synthesis of advanced polymeric and reactive stabilization additives for polymeric materials, such as EVA. These additives, such as protective UV-absorbing agents, are resistant to high-temperature physical losses. The latest developments in this area were presented.

P. Willis of Springborn Laboratories, Inc., reported on Encapsulated Materials Research. Springborn Laboratories updated its continuing work on long-life, weather-stable encapsulation materials for photovoltaic modules.

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The program emphasis at Springborn has shifted from material development and identification to life-assessment experiments, and to the identification and/or development of stabilization additives for encapsulation materials. Two items of significance were presented: (1) preliminary experimental testing is supporting the combination of a UV absorber and HALS as an effective stabilization system, as theoretically derived at the University of Toronto, and (2) the significant usefulness of the outdoor heating racks (called OPTs in the Springborn presentation) as an accelerated weathering technique.

J. Koenig of Case Western Reserve University reported on EVA-Glass Interface Bond Stability. Koenig and Boerio (see below) have developed the technology to investigate a chemically bonded interface for direct acquisition of chemical information on both bonding and aging mechanisms. The technology is based on Fourier transform infrared techniques (FTIR). Koenig presented FTIR spectra of the bonded interface between EVA and glass, which had been hydrolytically aged for at least one week in 80°C water. The early results indicate strong possibilities for a long-term weather-stable interfacial bond. The EVA-glass primer system is the one developed by Dow Corning Corp. for FSA, of which experimental quantities can be obtained from Springborn Laboratories under the designation A-11861.

J. Boerio of the University of Cincinnati reported on Interface Bonding Stability. Boerio's efforts are identical with those of Koenig, except that the emphasis of his study is on polymers and metals, such as EVA and aluminum. These interfacial chemistries can be quite distinct from those between EVA and glass, for example. Recently Dow Corning observed that EVA bonds strongly to aluminized back surfaces of solar cells, when using the standard A-11861 EVA-glass primer system. Ordinarily EVA bonds weakly to aluminum foil or sheet stock, using the same primer, and therefore this observation with the solar cells was not expected. Boerio described his examination of the aluminized back surface using SEM and EDS, and reported his initial findings that the back surface appears to be a mixture of aluminum and silicon. If it can be assumed that the silicon may be present as an oxide or hydroxide, then perhaps the back surface has glass-like chemistry, which would help to explain the Dow Corning observation. If true, the self-priming EVA being developed jointly by Dow Corning and Springborn for glass would also work with solar cells. More work in this area is planned.

G.R. Mon of JPL reported on Topics in Electrochemical Degradation of Photovoltaic Modules. Various topics related to the potential for electrochemical degradation of photovoltaic modules during 30 years of service in the natural outdoor weathering environment were presented. These included (1) the relationship between leakage current and electrochemical degradation, with emphasis on the efforts of positive and negative polarity, and the dependency of temperature and humidity; (2) a discussion of leakage current response mechanisms, and (3) considerations related to laboratory simulation of outdoor behavior to derive acceleration factors for module life prediction, and module qualification tests related to electrochemical susceptibility.

J. Orehotsky of Wilkes College reported on Polymer-Water Interaction Studies. Electrochemical susceptibility requires absorption of water by the encapsulation pottants, such as EVA and PVB. A new contract activity has been initiated at Wilkes College to determine experimentally the magnitudes and rates of the absorption and desorption of atmospheric water vapor by pottant materials. This study includes the dependency on magnitude and change rate of temperature and relative humidity. The discussion included the background for the experimental studies, details of the experimental techniques, and preliminary experimental data related to (1) water absorption and desorption kinetics in EVA and PVB, (2) humidity dependence of electrical properties of EVA and PVB, and (3) influence of plasticizer in PVB on water absorption and electrical properties.