QUANTITATIVE ANALYSIS OF ICE FILMS BY NEAR-INFRARED SPECTROSCOPY

by

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One of the outstanding problems in the Space Transportation System is the possibility of the ice buildup on the external fuel tank surface while it is mounted on the launch pad. During the T-2 hours (and holding) period, the Kennedy Space Center Ice Team is allowed to approach the external tank and monitor/measure the frost/ice thickness on it. However, after the resumption of the countdown time, the tank surface can only be monitored remotely. Currently, remote sensing is done with a TV camera coupled to a thermal imaging device. This device is capable of identifying the presence of ice, especially if it is covered with a layer of frost. However, it has difficulty identifying transparent ice, and, it is not capable of determining the <u>thickness</u> of ice in any case. Thus, there is a need for developing a technique for measuring the thickness of frost/ice on the tank surface during this two hour period before launch.

The external tank surface is flooded with sunlight (natural or simulated) before launch. It may be possible, therefore, to analyze the diffuse reflection of sunlight from the external tank to determine the presence and thickness of ice. The purpose of this project was to investigate the feasibility of this approach.

A near-infrared spectrophotometer was used to record spectra of ice. It was determined that the optimum frequencies for monitoring the ice films were 1.03 and 1.255 microns. These two bands have absorption cross sections appropriate for the film thicknesses of interest (0-3 mm).

A special holder for growing ice of controlled thicknesses on a copper substrate was built. This holder was used in conjunction with an integrating sphere to obtain diffuse reflectance spectra of ice films on copper. In Figure 1 a plot of Absorbance at 1255 nanometers (1.255 microns) versus path length is given. The open squares are data points from diffuse reflectance spectra in which the path length is assumed to be twice the film thickness. The solid squares with the line drawn through them were obtained from transmission spectra of ice grown in cuvettes. In this case the film thickness is equal to the path length of the cuvette. The diffuse reflectance data is reproducible although not linear. With the exception of one data point, all of the data taken in the diffuse reflectance

mode had a larger absorbance than predicted from the data taken in the transmission mode. This is believed to be due to multiple scattering effects. In other words, the actual path length of an average photon is larger than twice the film thickness. Similar results were obtained from absorbance data at 1.03 microns. Currently, there is an attempt being made to fit these data to a model involving multiple scattering effects.

Additional experiments need to be conducted to investigate the effect of varying other parameters, such as the light collection angle, the distance between the detector and the surface, and the substrate.

Ice - NIR Data
1st Derivative of Absorbance

Path Length (mm)