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National Aeronautics & Space Administration
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IIT RESEARCH INSTITUTE

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Report Period 9/1/67 through 9/31/67

National Aeronautics and Space Administration
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Contract NAS8-21074
IITRI PROJECT U6061

I. INTRODUCTION

The Pegasus III spacecraft, which was launched from Cape Kennedy on July 20, 1965, was used for a unique experiment in terms of environmental effects on thermal-control surfaces. A large number of retrievable coupons were coated with various thermal-control materials and were placed on the Pegasus III satellite with the intent that they would eventually be (1) measured "optically" in situ, and/or (2) returned to earth for evaluation by a rendezvousing astronaut.

This research program was planned to provide the technical background that is necessary for the proper evaluation of the space-environment-induced damage sustained by Pegasus coupons.

II. WORK PERFORMED

A. Reconditioning the IRIF

IRIF Test 13 was planned for the month of September. However, the test was aborted prior to irradiation, but after evacuation, due to irratic behavior of the reflectometer portion of the facility that developed early in the test. The visible mode, utilizing the 1P28 photomultipher-detector circuit, was

in error and gave results at 0.7μ wavelength that were about 10% less in reflectance than those obtained at that wavelength with the infrared mode (employing the lead sulfide detector). This negative error was observed only on specimens that possessed a specular component of reflectance; it was not observed on the two specimens of Z93.

The error was attributed either to a disproportionate degradation of the photocathode surface or to dislocation of the photocathode in relation to the tube's glass envelope. This problem was treated by the author previously in relation to sphere-detector geometry (ref. 1) and the disparity between the two detector modes was attributed to non-hemispherical illumination of the photo-multiplier tube. As suggested by the C.O.T.R., Mr. E. R. Miller, we are presently considering using a "ruggedized" photomultiplier tube; an end-on detector will also be considered.

The photomultiplier tube was replaced; the new tube was lightly sandblasted to diffuse the incident light. During the down-time afforded by the replacement of the phototube, the integrating sphere was itself reconditioned. The entrance port was enlarged to a diameter of 0.75 in. and the old sphere coating was completely removed. An even coating of Z93 was applied to a thickness of 5 mils; the sphere was then smoked with magnesium oxide to a thickness of 0.5 mm in order to provide high reflectance in the ultraviolet region below zinc oxide's fundamental absorption edge (ZnO is the pigment employed in Z93).

The combination of steps employed to recondition the IRIF's optics have resulted in the achievement of the highest precision yet attained with this device. Less than 2% disparity is now obtained between the two detector modes at 0.7-μ wavelength -- even for polished aluminum.

B. IRIF Space Simulation Test 13

IRIF test 13 was initiated as a long term test (> 4000 ESH) employing essentially the same samples that were irradiated in IRIF test 10. A calculated solar irradiation factor of 6

equivalent ultraviolet intensities was employed. The test has been in progress for 1400 ESH as of this writing, although data has been reduced for 0, 75, 150 and 650 ESH only at this time.

The principal problem associated with this test is the strong glow discharge that occurred during pump-down. Even though we employed a glow-discharge-confinement screen at the oriface to the ion pump, glow discharge "tracks" were observed along the chamber walls at the sample-table level. This was the most intense discharge that we have ever observed and it occurred in conjunction with as slow a pump-down as we have ever recorded. (It should be noted that no source of contamination can be envisioned and that the sample loading and pump-down procedures were, on examination in retrospect, identical to past practices.)

Because we employed a porcelain enamel control in test 13, a surface that has not been observed to degrade under ultraviolet irradiation in vacuum, we decided to begin the irradiation even though glow discharge-induced damage has been reported as contributing to the degradation observed by ultraviolet irradiation (ref. 2).

The results obtained thus far in IRIF test 13 are presented in Table 1.

Examination of these data shows that the significant aspect of test 13 is the severe damage sustained by the two methyl silicone paints, S-13 and S-13G. The S-13 specimen exhibited a $\Delta\alpha_s$ of 0.12 in 650 ESH compared to 0.08 in 800 ESH for an identical specimen irradiated in test 10 (Report No. IITRI-U6061-5, Table 1, p. 4). A specimen of S-13G, the methyl silicone paint pigmented with silicate-treated zinc oxide, exhibited a $\Delta\alpha_s$ of 0.07 in the present test for a 650 ESH dose. This specimen was prepared from hand-mulled powder that has been shown to be unstable in comparison to pigment that is ground only in the vehicle (ref. 3). (A specimen of S-13G prepared from hand-mulled pigment was observed to undergo a $\Delta\alpha_s$ of 0.05 in 1400 ESH in IRIF test 12 (ref. 3).)

Table 1

EFFECT OF UV IRRADIATION IN THE IRIF ON SELECTED THERMAL-CONTROL SURFACE COATINGS (IRIF Test 13)
(Solar Intensity 6X)

Sample No.	Surface	ESH*	α_1	α_2	α_s	$\Delta\alpha_s$
1	S-13 Cleaned (Pegasus)	0	.130	.101	.231	-
		75	.157	.138	.295	.064
		150	.161	.139	.300	.069
		650	.196	.154	.350	.119
2	ZrO2/PS7 (Tam's C.P. at 4.3 PBR)	0	.121	.152	.273	-
		75	.138	.153	.291	.018
		150	.144	.153	.297	.024
		650	.164	.156	.320	.047
3	Z93 (Fresh)	0	.138	.084	.222	-
		75	.141	.082	.223	.001
		150	.142	.084	.226	.004
		650	.146	.084	.230	.008
4	MTL3	0	.348	.219	.567	-
		75	.347	.214	.561	- .008
		150	.350	.214	.564	- .003
		650	.354	.219	.573	+ .006
5	GT1275	0	.203	.120	.323	-
		75	.206	.117	.333	.010
		150	.210	.129	.339	.016
		650	.216	.132	.348	.025
6	HAC Surveyor Paint (Plasmoclay/$K_2O \cdot SiO_2$)	0	.129	.123	.252	-
		75	.148	.125	.273	.021
		150	.155	.125	.280	.028
		650	.186	.129	.315	.063
7	Lithafrax (LMSC)	0	.051	.081	.132	-
		75	.113	.087	.200	.068
		150	.125	.089	.214	.082
		650	.218	.093	.311	.179
8	Z93 (Old)	0	.125	.074	.199	-
		75	.128	.069	.197	- .002
		150	.132	.070	.202	.003
		650	.138	.070	.208	.009
9	FEP Teflon second-surface mirror	0	.097	.075	.172	-
		75	.109	.081	.190	.018
		150	.108	.080	.188	.016
		650	.114	.078	.192	.020
10	Rutile-opacified-porcelain enamel	0	.148	.144	.292	-
		75	.152	.144	.296	.004
		150	.152	.145	.297	.005
		650	.160	.145	.305	.013
11	GT 1015	0	.148	.098	.246	-
		75	.198	.095	.293	.047
		150	.217	.096	.313	.067
		650	.287	.100	.387	.141
12	S13G (prepared from hand-mulled pigment)	0	.132	.104	.236	-
		75	.150	.110	.260	.024
		150	.160	.111	.271	.035
		650	.193	.114	.307	.071

*Equivalent sun-hours of UV irradiation in vacuum

Although test 13 is slightly more severe on the GT1015 specimen at the higher irradiation dose, it was of almost identical severity at the lower dose. That is, the $\Delta\alpha_s$ was 0.09 and 0.12 for 200 and 800 ESH, respectively; in test 10, this compares to values of 0.07 and 0.14 for 150 and 650 ESH, respectively, in test 13.

On the other hand, the zirconium oxide specimen in the current test is undergoing considerably less degradation than exhibited by an identical specimen in test 10. The specimens at MTL-3 and Z93 irradiated in test 13 are behaving almost identically with those irradiated in test 10. The Alodine 1275 specimen, which was not taken from the same batch in the two tests, is exhibiting slightly more degradation in the current test (observed for both doses of irradiation).

In the absence of confirming tests we have reached the following-general conclusions concerning the two tests:

(1) The two tests compare well at the lower irradiation levels for all specimens except S-13, S-13G and zirconia-pigmented potassium silicate.

(2) The generally poor stability of the S-13G specimen was not surprising in view of the fact that it was prepared from hand-mulled, silicate-treated zinc oxide. However, we did not expect the degree of severity observed after only 650 ESH of ultraviolet irradiation in vacuum.

(3) The results of the two tests at the higher levels differ little for MTL-3, Z93 and Alodine 1275. Thus the fact that S-13 and S-13G exhibit greater damage at both dose levels is believed to be due primarily to the extensive glow discharge observed in the current test -- an irradiation component that may have little or no effect on the other completely inorganic surfaces.

(4) The differences noted are most likely due to either or both the fact that (a) test 10 involved admission of air between the 200 and 800 ESH irradiation levels, and (b) test 13 involved excessive glow discharge during evacuation.

The agreement between a 2-yr-old specimen and a freshly prepared specimen of Z93 is most encouraging. The $\Delta\alpha_s$ of 0.01 in each case again confirms the generally good stability of this material as reported in the part.

Of the two alkali silicate-based paints pigmented with china clay (Plasmoclay) and lithium-aluminum-silicate (Lithafrax), the china clay specimen exhibited both the highest stability and the highest solar absorptance. The $\Delta\alpha_s$ of these coatings was 0.06 and 0.18 for the Plasmoclay and Lithafrax, respectively; the initial Δ_s however was 0.25 and 0.13 for these same coatings, respectively.

Perhaps the most important result of IRIF test 13 has been the confirmation of the report (ref. 4) that an aluminized FEP Teflon second-surface mirror is comparatively stable to ultraviolet irradiation in vacuum. The FEP Teflon surface exhibited a $\Delta\alpha_s$ of only 0.02 in 650 ESH of ultraviolet irradiation.

The $\Delta\alpha_s$ of 0.013 in 650 ESH of irradiation of the rutile-opacified vitreous porcelain enamel again confirms the excellent stability of these surfaces.

C. Gas Adsorbate Studies

In Technical Progress Report No. IITRI U6061-4, the proposed system to control the gas pressure and the sample temperature was described. IITRI submitted purchase orders to the appropriate vendors. The necessary equipment, except for the pressure sensors, has been purchased and is ready for installation.

By memorandum to Clarkson Engineering Company, The Fredericks Company sales representative in Chicago, The Fredericks Company stated that their Model 1C pressure transducers could be used at 20 torr with error limits satisfactory for our requirements. The order was submitted to Clarkson Engineering in July; delivery was promised for less than six weeks.

Subsequently the Fredericks Company notified IITRI that they could not meet the specifications which they had promised. In essence, their first statement was that if an accurate recorder is used, their sensor and power supply control was such that

20 torr ±2 torr could be maintained. However, they have since stated that they never tried the accurate recorder method, and do not believe that this method would work (ref. 5).

IITRI will resolve the problem of pressure control by using an NRC #720 Alphatron guage with a range from 1 micron to 760 torr.

The apparatus for gas adsorbate studies is currently being constructed for use in conjunction with IRIF I (IRIF II has been delivered and is currently being cleaned and readied for final assembly and vacuum testing as a system.)

III. SAMPLE PROCUREMENT

We have received communication from Dr. Lionel Bailin of Lockheed Missiles and Space Company that specimens of the three Lockheed surfaces will be furnished within a week. Except for the Tabor and Hass coatings, the specimens chosen at the onset of the program have all been either received or rejected for technically cogent reasons.

IV. WORK PLANNED

Work planned for the next report period will include: (1) continuation of IRIF test 13 now in progress, (2) preparation of IRIF coupons for IRIF test 15 (the next test scheduled for this program,) (3) completion of the construction of the facility for gaseous adsorbate studies.

Respectfully submitted,
IIT RESEARCH INSTITUTE

Gene A. Zerlaut
Senior Chemist-Group Leader
Polymer Research

Approved by:

T. H. Meltzer
Assistant Director of
Research Chemistry

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