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Formulation of MS-74 White Thermal-Control Coating and Revised Application Procedures

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FORMULATION OF MS-74 WHITE THERMAL-CONTROL COATING AND REVISED APPLICATION PROCEDURES

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PREFACE

This report supersedes X–757–76–169 (August 76) "Formulation And Application of MS–74 White Thermal-Control Coating." It reflects present application techniques optimized on the basis of recent experience. The report describes the procedures for formulating, blending, and applying the MS–74 white thermal-control coating and CC–1 primer, developed at the Goddard Space Flight Center. MS–74 has proven effective on a number of spacecraft programs, including Apollo–14, –15, and –16, and on ATS–6. It has recently been combined with electrically conductive coatings, and has been flight qualified. The combination was used in the International Sun-Earth Explorer program.

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FORMULATION OF MS-74 WHITE THERMAL-CONTROL COATING AND REVISED APPLICATION PROCEDURES

INTRODUCTION

MS-74 is a white thermal-control coating for spacecraft, which has been developed and formulated at the Goddard Space Flight Center (GSFC). It was first prepared in May 1965 for an experiment for the Republic Aircraft Corporation. During the following two years, the blending and application procedures were refined to improve the ultraviolet stability and to achieve high emittance and low absorptivity characteristics. The experiments also improved the adhesion characteristics for a number of substrates. The procedures described in this document were adopted by GSFC in July 1967 and revised in April 1977.

Test data on this coating was first published on May 8, 1967.*

The stability and durability of this coating is indicated in the flight data from OSO-H where the α/ϵ changed from 0.23 to only 0.24 after 8225 orbits. This represents an exposure to approximately 8225 solar hours. In a later application, on IMP-H, the α/ϵ degraded from 0.20 to 0.28 after exposure to 4500 equivalent Sun hours and 3×10^{15} protons/cm^2 of 1.3 keV average energy.†

MS-74 was used effectively on many of the experimental packages left on the Moon by Apollo-14, -15, and -16. It was also used on ATS-6 to protect the backs of the solar paddles.

In an effort to improve the adhesion characteristics of MS-74, when applied to substrates such as epoxy fiber glass, it was found that a GSFC developed clear silicate coating, CC-1, could be used as a primer. This combination of CC-1 and MS-74 is now frequently employed on hard-to-coat substrates.

The following procedures have been derived from the authors' laboratory notebooks.

*Evaluation of Undirectional Thermal Radiation Properties of Materials, TRW Inc., Contract NAS-9-5073

†These values represent the most current data available from Mr. Jack Triolo, GSFC Code 732, at the time of publication.

MS-74 COATING

The compounds and equipment used in the formulation of MS-74, although readily available, are not described by GSFC specifications. In some cases there are limited sources available for the materials, and the following generic designations are qualified by manufacturers' designations to indicate the exact compound which has been used to date. Table 1 lists the equipment or compound, the known source, and the quantity of the compound used. The yield from this formula is approximately one pint of coating. Attempts to prepare this coating in much larger quantities have been unsatisfactory.

BLENDING PROCEDURE

Weigh and record the weight of the mixing container before starting, so that the weight of the compound may be determined accurately later.

WARNING

> Use care in handling the hydroxides and acids. When diluting acids, always add the acid to the water.

Measure 120 grams of water into the pyrex blender beaker. While stirring with the lab motor and a glass stirring rod, add 15 grams of potassium hydroxide. Continue stirring and add 90 grams of zinc oxide to the beaker. Finally, add 90 grams of titanium dioxide and 60 grams of aluminum oxide to the mixture and stir until a reasonably homogeneous compound is obtained.

Place the blender motor over the beaker and adjust the speed to obtain noticeable vortex.

While continuing to blend, apply heat and adjust the temperature to maintain the mixture at approximately 82° C (180° F). Add water, as required, during the blending process.

The blending and heating should be performed for approximately 80 hours, although it need not be continuous. If the procedure is to be suspended at the end of each 8-hour shift, the heat should be turned off one hour before the blender is stopped.

After 80 hours of blending and heating, add 300 grams of potassium silicate, and resume the procedure. Weigh the mixture after three days, and daily thereafter, until the mixture weight is 675 grams.

WARNING

The resulting mixture is a caustic compound, and must be handled and stored carefully.

The blend may then be stored in clean polyethylene bottles until required.

Table 1
Materials Required

Material	Source	Quantity (in grams)
Potassium Silicate (PS-7)	Sylvania Electric Products Inc. Towanda, PA	300
Zinc Oxide (SP-500)	New Jersey Zinc Co. Bethlehem, PA	90
Aluminum Oxide (Type C)	Union Carbide, Linde Division San Diego, CA	60
Titanium Dioxide (RF-1)	New Jersey Zinc Co. Bethlehem, PA	90
Potassium Hydroxide Solution, KOH	Fisher Scientific Pittsburgh, PA	15
Water (Distilled or Deionized)		120*
Silicic Acid, H_2SiO_3		
Balance (0.1-1000.0 g)		
Pyrex Beaker (1000 ml)		
Hot Plate	Available through Fisher Scientific	
Lab Motor (Fultork)		
Stirring Rod		
Blender (Waring or Oster)		
Thermometer		
Blender (Waring or Oster)		
Spray Gun (Binks #15 syphon, #18 pressure pot, or equivalent)		
Compressed Dry Nitrogen		
Spray Booth or Exhaust Hood		

*This is the nominal value for water in the final compound. During blending there will be considerable evaporation. The quantity of water used initially and the amount added during the blending process are not critical.

PRIMER PREPARATION

The following procedure describes the preparation of a clear silicate protective coating (CC-1) which may be used as a primer coating prior to applying MS-74. This primer is frequently required to improve the adhesion on substrates such as epoxy fiberglass.

WARNING

> Some of the ingredients used in this procedure, and the resulting compound, are caustic. Exercise care in handling at all times.

Prepare compound 31-Li 33 by measuring 450 grams of water in a blender. While blending, add 44.1 grams of lithium hydroxide (LiOH), and continue blending until solution is clear. Continue blending, and add 216 grams of silicic acid. Blend until solution again clears. Set this 31-Li 33 solution aside in a clean bottle.

Place 216 grams of water in a clean blender. Add 100 grams of the 31-Li 33 compound to the water, while blending.

Place 216 grams of water in a clean beaker, and add 88 grams of potassium silicate (PS-7) while stirring manually.

Add the PS-7/water solution to the 31-Li 33/water solution and blend for five minutes.

Store this primer mixture in a clean polyethylene bottle until needed.

APPLICATION PROCEDURES

The use of MS-74 on treated surfaces is not satisfactory and should be avoided. Dow Corning compounds, zinc chromate, anodize, alodine, iridite, etc., finishes should be removed from surfaces before coating. Only the primers recommended below should be employed.

SURFACE PREPARATION

A) Aluminum, steel, mild steel, stainless steel, copper, beryllium and epoxy fiber glass.

   1. All surface treated (anodized, alodined, irridited) material to be avoided. Stripping is required.

2. Sandblast, brite dip, or abrade with Scotch Brite or 180-240 grit silicon carbide paper.

3. Wash with liquid soap and rinse thoroughly and wipe dry.

4. Wipe on CC-1 Primer, in polishing manner and wipe dry. On beryllium or in absence of CC-1 use paint thinned with 25% water, by weight as primer. Wipe paint primer dry as with CC-1.

5. Check surface, for cleanliness, by water break method.

6. If surface is clean, apply paint within 1 hour. If not clean repeat preparation steps.

APPLICATION

A) Equipment

1. Binks spray gun #15 syphon or #18 pressure pot or equivalence.

2. Compressed dry nitrogen if available.

3. Spray booth or exhaust hood.

B) Spraying

1. An experienced coatings person should be employed.

2. Spray equipment must be cleaned by disassembling and washed with soap and water then thoroughly rinsed.

Do not attempt to build up coating as it will run or sag. Allow to dry for 1 or 2 minutes and apply second coat as the first. A third coat should not be needed but if any shadowed areas are evident then a third coat can be applied.

Caution must be used in applying all coats to avoid dry spray. This is caused either by applying too fast or too light of a spray.

To avoid this in spraying make sure painted surface is wet when applying or adjust fluid nozzle for heavier spray.

CLEANING AND HANDLING

The painted surfaces should not be handled with bare hands. If any dirt or contamination becomes evident, remove it with light sanding. If this sanding breaks through the painted surface, use the touch-up procedure which follows.

TOUCH-UP

When the coating layer has been broken as a result of cleaning it may be restored as follows. Clean the area of all debris. Rinse it thoroughly with distilled water. Reapply paint onto dampened area, using brush or spray.

PROTECTION OF PAINTED SURFACE

For optimum protection the paint should be allowed to air cure for 168 hours at room temperature or it may be baked for 1 hour at 120^{o}C. The painted surfaces should then be wrapped in polyethylene bags. Strip coating is not presently recommended.

SHELF LIFE

The shelf life limit of the MS-74 has not yet been determined. Three-year old coatings have been used successfully.

CHARACTERISTICS

The maximum recommended thickness for this coating is 0.13 mm (0.005 inch); this thickness weighs about (0.0036 lb/ft^2) 177 g/m^2. Experience indicates it will yield an α/ϵ of approximately 0.19 initially. The maximum degradation experienced to date is the change of α/ϵ to 0.28 on IMP-H as previously mentioned.

Flight data indicates all known white paints degrade significantly in the charged particle environment of synchronous orbits and in solar wind environments. Flight data indicates MS74 degrades less or as slowly as other known white paints when solar wind is encountered (IMP H). It degrades severely, but at a known rate, in synchronous orbit as evidenced by ATS-1 flight data*. No published data has been found on other white paints in synchronous orbit. The referenced ATS-1 data indicates a change of a/ϵ from 0.20 to 0.45 after one year in orbit.

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*Proceeding of Society of Photo Optical Instrumentation Engineer Vol. 121, August 1977 p 46-66.