

To: Helena Armandula 8/3/2005  
From: Mark S. Anderson  
Subject: LIGO Mirror Buffer: Molecular Contamination Analysis (Baffle Glass)

### Purpose

The mirror buffer surfaces (4ITM07) were sampled using solvent wipes. This was to determine the level and identity of molecular (oily) contamination on the surface.

### Method

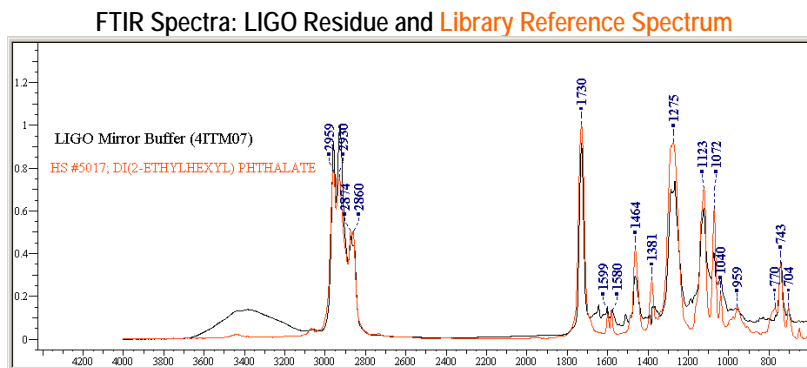
The analytical swabs consisted of extracted fiber-free lens tissue using dichloromethane solvent. The areas sampled were between 200 and 250 square centimeters. The low volatility residue was analyzed using Diffuse Reflectance/ Fourier Transform Infrared (DRIFT/FTIR) spectroscopy. FTIR provides chemical functional group information for quantitative analysis and qualitative identification of materials. The analysis followed the ACL-120 procedure that complies with Mil-STD-1246C Notice 3 and is sensitive to the most stringent level (A/100).

### Results

Only trace levels of a plasticizer [di(2ethylhexyl) phthalate]\* were removed from all 4 areas. The FTIR spectrum is shown below. The levels may be bounded to approximately a monolayer thickness or less on the surface. This is very similar in amount and composition to a previous mirror analysis on 1/16/04 given in the attached report.

Sample Location	Chemical Functional Group	~Amount, micrograms/cm <sup>2</sup>
Area 1 side 1	di(2ethylhexyl) phthalate*	0.01
Area 2 side 1	di(2ethylhexyl) phthalate	0.02
Area 3 side 2	di(2ethylhexyl) phthalate	0.01
Area 4 side 2	di(2ethylhexyl) phthalate	0.02
Control Swab	-	No phthalate detected <0.005

\*Note: This is di(2-ethyl hexyl) phthalate or a mixture of similar phthalate esters that are used in many plastics. A 1.0 microgram per square centimeter level is a 10-nanometer (nm) average film thickness (assuming a density of 1.0).



### Discussion

The swabs did not remove a significant amount of molecular (oily) contamination residue. The amount is in the monolayer to sub-monolayer regime. This is assuming the dichloromethane (previously found to be an excellent solvent for phthalates) removes most of the residue. It should be noted that there was visible dust on the surface. The molecular contamination method

is relatively insensitive to dust. Visible dust, based on our experience with spacecraft optics, is a more likely cause of throughput loss in the near IR than the monolayer level of residue detected. Particle counting and analysis is recommended.

**JPL ANALYTICAL CHEMISTRY LABORATORY**  
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**P010-updated**

To: Helena Armandula 1/16/2004  
From: Mark S. Anderson  
Subject: LIGO Mirror: Molecular Contamination Analysis

### Purpose

Mirror surfaces were sampled using solvent wipes. This was to determine the level and identity of molecular contamination on the surface. The 2ITM04 and RM01 mirrors were analyzed.

### Method

The analytical swabs consisted of dichloromethane (pre-tested) with specially extracted fiber free lens tissue. The areas sampled were 50 and 100 square centimeters. The low volatility residue (LVR) was analyzed using Diffuse Reflectance/ Fourier Transform Infrared (DRIFT/FTIR) spectroscopy. FTIR provides chemical functional group information for quantitative analysis and qualitative identification of materials. The analysis followed the ACL-120 procedure that complies with Mil-STD-1246C Notice 3 and is sensitive to the most stringent level (A/100).

### Results

Only minor, trace levels of plasticizer (diallyl phthalate) were removed. The levels may be bounded to a monolayer thickness or less on the mirror surfaces.

Sample Location	Chemical Functional Group	Amount micro-grams/cm <sup>2</sup>
2ITM04 Side AR edge 1	Trace Ester	< 0.01 (~-0.004 as diallyl Phthalate)
2ITM04 Side AR edge 2	Diallyl Phthalate	~0.01
2ITM04 AR Center	Diallyl Phthalate	~0.01
2ITM04 HR edge 1	Trace Ester	<0.01 (~-0.001 as diallyl Phthalate)
2ITM04 HR edge 2	Diallyl Phthalate	~0.02
2ITM04 HR Center	Trace Ester	< 0.01 (~-0.004 as diallyl Phthalate)
RM01 HR Center	Diallyl Phthalate	~0.02
RM01 HR Edge	Trace Ester	< 0.01 (~-0.005 as diallyl Phthalate)

*Note: This is dially phthalate or a mixture of similar ester based plasticizers that are used in many plastics. A 1.0 microgram per square centimeter level is a 10-nanometer (nm) average film thickness for a residue with a density of 1.0. A rule of thumb is a monolayer is ~1 nm.*

### Discussion

The mirror surfaces were relatively clean in terms of molecular contamination. Approximately a monolayer level of contamination is typical for surfaces stored in a clean room. The optical attenuation effect of this level of contamination in the 1-micron wavelength region would be negligible.