Title of Investigation:

Metallic Honeycomb Substrate for Zeolite Filters

Principal Investigator:

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External Collaborators:

Novelaire, Inc, Baton Rouge, Louisiana

Initiation Year:

FY 2004

Aggregate Amount of Funding Authorized in FY 2003 and Earlier Years:

$0

FY 2004 Funding Authorized:

$20,000

Actual or Expected Expenditure of FY 2004 Funding:

In-house: $1,500; Contracts: $16,000 to Swales and $2,500 to Novelaire

Status of Investigation at End of FY 2004:

To be continued in FY 2005 with funds remaining from FY 2004 and earlier years

Expected Completion Date:

January 31, 2005

Purpose of Investigation:

Many flight optics packages and spacecraft have used zeolite adsorbers to protect optics from outgassed contaminants, including those flown on the Hubble Space Telescope, GOES, the Tropical Rainfall Measuring Mission, and Swift. Outgassed contaminants are typically molecules of silicones and oils that evaporate in the vacuum of space and all too often condense on sensitive optics. The goal of this investigation is to develop a zeolite adsorber that uses an aluminum substrate, instead of the brittle ceramic substrates used today. The current adsorber design uses a brittle ceramic known as Cordierite that is coated with zeolite. Special frames are required to cushion and isolate the brittle adsorbers from loads. This investigation consisted of four parts: (1) determining the ability of the coating vendor to coat aluminum substrate coupons; (2) determining the best coupon surface preparation, (3) determining how well the coating sticks to the aluminum under loads and vibration, and (4) determining the adsorbing capacity of the coupons.

Accomplishments to Date:

Aluminum coupons were prepared and sent to Novelaire Technologies in Baton Rouge, Louisiana. Several different surface preparations were tried. The coupons were coated with zeolite (Linde 13X, Y-Faujasite) at Novelaire's facility and sent back to the Goddard Space Flight Center for evaluation. Novelaire cured the zeolite and binder in a vertical and a horizontal setup on the flat coupons, and three different processes were tested for the honeycomb. The most promising results are shown below.

Coupon/Process	Surface Prep	Coated Surface Area (m^2)	Coating mass (g)	Loading g/m^2
6061-T6 Aluminum Dipped & Dried vertically	Grit Blast	.0054	.1069	19.9
6061-T6 Aluminum Dipped & Dried horizontally	Grit Blast	.0026	.5196	201.3
Honeycomb core, .75" thick, 5052-1/16-.001"	"Process 3"	.1289	4.0993	31.8

Table 1

Coupons dipped and dried vertically had much thinner coatings, on the order of .001-.002" thick with a matte finish appearance. Coupons dipped and dried horizontally had a coating of .008-.010" in thickness that looked like sugar glaze. Virtually no zeolite was observed to fall off onto a witness plate when tapped repeatedly with a metal rod. No zeolite was observed to fall off during the shock test, when the plates were dropped from 48" onto a metal floor.

On the honeycomb samples, a thin coating of zeolite adhered to the walls of each cell. All of the 1/16" cells appeared to be open and not blocked by the zeolite. There was a small, but noticeable amount of particulate powder that fell on the witness plate when a honeycomb coupon was tapped by a metal rod. Bending the honeycomb did not appear to cause any more particulates to fall than by tapping it.

Figure 1. Thin-coat, thick-coat, and honeycomb zeolite adsorber coupons

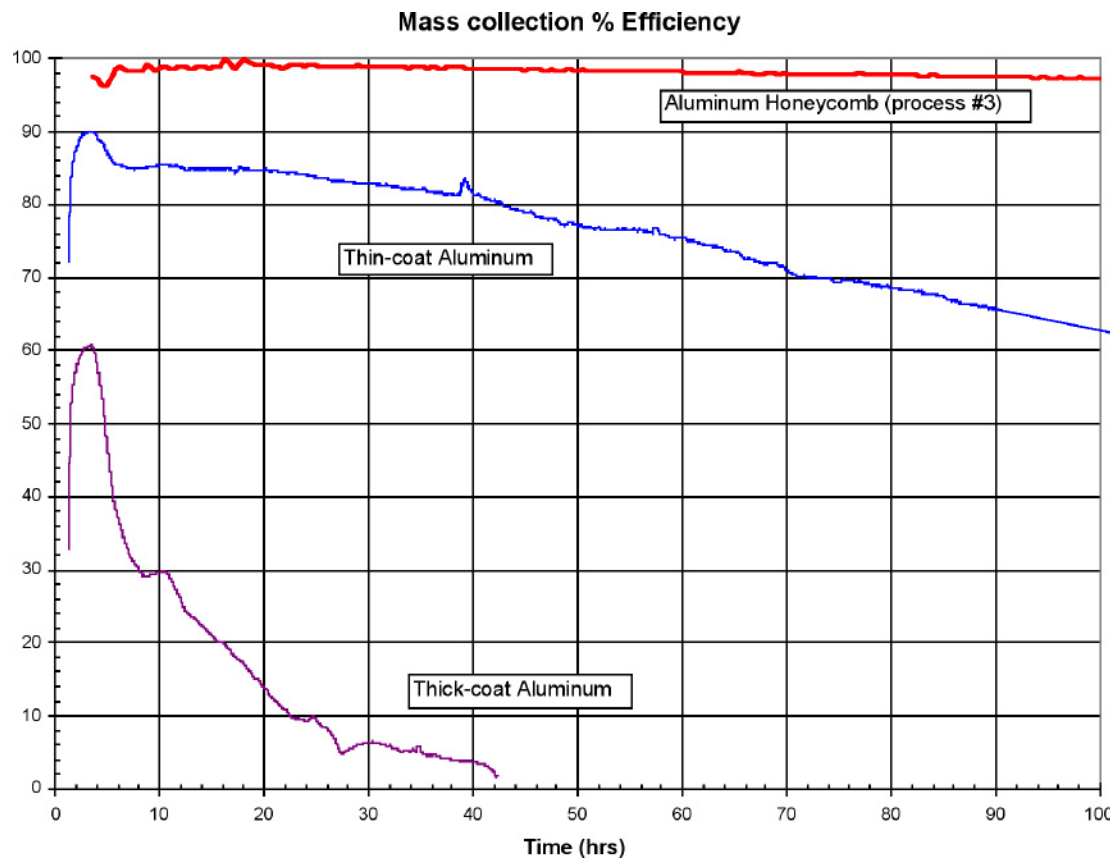
The Goddard Material Branch Veeco chamber, located in Building 4, was used to conduct the thermal vacuum exposures of the adsorbers. A temperature-controlled adsorber-mounting fixture was created to hold the coupons in place. The coupons were maintained at a constant temperature of between 10o C and 20o C to simulate the future exposure temperature for this material on the inner structural panels of a spacecraft. The outgassing source was Stearyl alcohol. A QCM set to -50o C or lower was also present in the setup to collect the outgassed mass at a certain temperature deemed low enough to mimic the total outgassing of Stearyl alcohol.

The setup was designed so that the outgassed source molecules had a high probability of hitting the adsorber plate at least once before exiting the shroud. Molecules are either retained or they are bounced off the adsorber plate and exit through the dedicated vent hole. The QCM, which tracked the outgassing rate over time, was positioned at this vent hole.

A sample baseline run was performed prior to each adsorber test run using a blank aluminum plate. This provided a steady background to compare the adsorber coupons.

QCM delta-frequency data was plotted to determine effectiveness of the adsorber coupons. Based on the QCM results, the mass collection efficiency was calculated, as shown in Figure 2.

Figure 2
The honeycomb coupons produced the highest effectiveness and the thin-coated adsorber plates demonstrated a much greater ability to retain outgassed material than the thicker coats. The table below shows the capacity of each type of coupon compared with the standard zeolite adsorber design currently in use.



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Adsorbing material	Capacity per unit area	Capacity Comparison to Round Adsorber
Standard Round 3.3” dia. Ceramic	3.3 mg/cm^2	-
2” Square Alum. Honeycomb	2.3 mg/cm^2	70%
Alum. Plate with Thin-coat Zeolite	0.158 mg/cm^2	~5%
Alum. Plate with Thick-coat Zeolite	0.0086 mg/cm^2	<0.3%

Table 2

Coating a flat aluminum surface with zeolite can be quite useful and efficient. For example, the STEREO inner-aluminum panel area is estimated to be ~68,000 cm2 and almost 11 grams of molecular mass could potentially be collected by the walls, whereas 61 round ceramic-coated adsorbers would be needed to provide the same benefit.

The aluminum honeycomb samples should provide a significant cost benefit due to the ability to capture molecular mass at a fairly similar rate as the round ceramic disks. The honeycomb can be formed to any desired shape and can withstand the thermal space environment for use in a variety of applications. Bulky adsorber-mounting brackets are not necessary since the aluminum honeycomb is not brittle.

Planned Future Work:

No additional work is anticipated under this investigation. The zeolite coating technology has been shown to work. The next step is for a project to fund a qualification effort for a flight zeolite adsorber using the coatings and substrates developed here.

Further investigations might consider adding carbon black additive zeolite slurry to give the coated surfaces a slightly black finish. The alpha and emissivity values may not be adequately high enough for thermal engineers. In addition, it might be helpful to develop zeolite slurry for inclusion with Z307 or Z306 paints or to be brushed on over the top of these paints. These black paints are typical coating for inner-structural walls and electronic boxes.

Summary:

Substituting aluminum for ceramic in zeolite adsorbers has shown to be feasible. The Goddard Space Flight Center can benefit because the substitution will save money and mass and provide the same or better absorptive capacity on future spacecraft and instruments. We met the criteria for success. We showed that the zeolite coating sticks to aluminum and adsorbs outgassed contaminants. The surface chemistry that allows the binding of zeolites to substrates is not well understood and appears to be achieved primarily through empirical testing. This investigation relied upon a vendor who used previous experience to develop coatings that worked.