Figure 1. **RICA Sample** during plasma wind tunnel testing.

RICA	Phenolic Content (~%)	Carbon Content (~%)	Density (gm/ml)	Plasma Wind Tunnel Heat Flux (MW/m^2)	Heat Duration (s)	Integrated Heat Input (J/m^2)	Mass Loss (gm)	Average Recession (mm)	Average Surface Temp from Pyrometer (c)	Average Thermal Gradient (K/mm)	Heat of Ablation (J/kg)
5C	17	83	1.41	1.4	478	6.69E+08	7.84	4.218	1978.1	44.37	49E.+07
SA (1)	27	73	1.39	14	22	3.08E+08	3.33	1.96	3336.1	34.32	1.1E+08
3A	24	76	1.36	1.4	478	6.69E+08	3.32	0.342	1962.5	54.50	8.5E+07
5B	33	67	1.37	1.4	476	6.67E+08	3.73	1.217	1990.8	53.68	7.7E+07
3B	31	69	1.35	1.4	477	6.67E+08	3.70	1.143	1967.5	51.11	8.5E+07

(1) Tested in Air; all others tested in Methane

Table. **Material Properties** and initial test results.

flux of 14 MW/m^2 for 22 seconds. Methane tests were also carried out for potential application in Saturn's moon Titan, with a nominal heat flux of 1.4 MW/m^2 for up to 478 seconds. Three slightly different material formulations were manufactured and subsequently tested at the Plasma Wind Tunnel of the University of Stuttgart in Germany (PWK1) in the summer and fall of 2010. The TPS' integrity was well preserved in most cases, and results show great promise.

There are several major elements involved in the creation of a successful ablative TPS material: the choice of fabric and resin formulation is only the beginning. The actual processing involved in manufacturing involves a careful choice of temperature, pressure, and time. This manufacturing process must result in a material that survives heat loads with no de-lamination or spallation. Several techniques have been developed to achieve this robustness. Variants of RICA's material showed no delamination or spallation at intended heat flux levels, and their potential thermal protection capability was demonstrated. Three resin formulations were tested in two separate samples each manufactured under slightly different conditions. A total of six samples was eventually chosen for test at the PWK1. Material performance properties and results for five of those are shown in the table. In the most extreme case, the temperature dropped from ≈3,000 to 50 °C across 1.8 cm, demonstrating the material's effectiveness in protecting a spacecraft's structure from the searing heat of entry.

With a manufacturing process that can be easily re-created, RICA has proven to be a viable choice for high-speed hyperbolic entry trajectories, both in methane (Titan) as well as in air (Earth) atmospheres. Further assessment and characterization of spallation and an exact determination of its onset heat flux (if present for intended applications) still remain to be measured.

This work was done by Jaime Esper of Goddard Space Flight Center and Michael Lengowski of the University of Stuttgart. Further information is contained in a TSP (see page 1). GSC-16183-1

Self-Cleaning Particulate Prefilter Media

This technology has application for air filter manufacturers for self-cleaning particulate prefilters.

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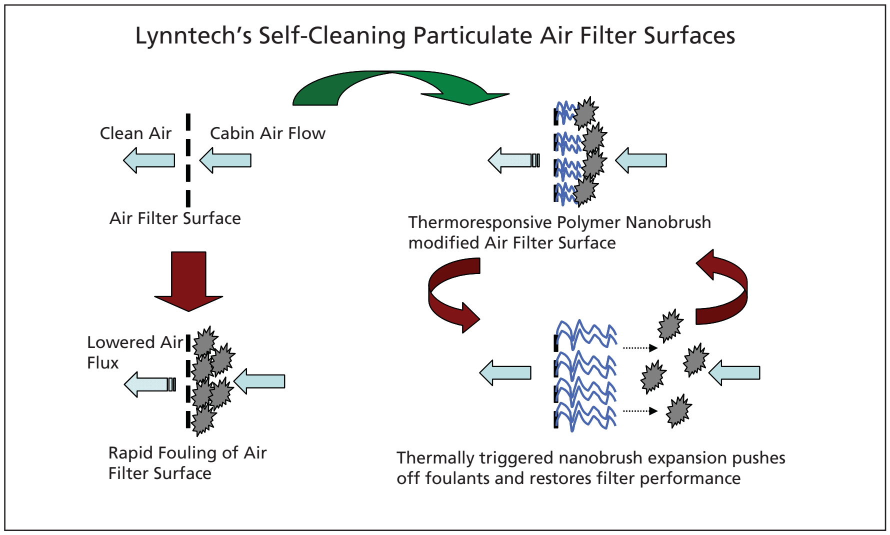
A long-term space mission requires efficient air revitalization performance to sustain the crew. Prefilter and particulate air filter media are susceptible to rapid fouling that adversely affects their performance and can lead to catastrophic failure of the air revitalization system, which may result in mission failure. For a long-term voyage, it is impractical to carry replacement particulate prefilter and filter modules due to the usual limitations in size, volume, and weight. The only solution to this problem is to reagentlessly regenerate prefilter and filter media in place. A method was developed to modify the particulate prefilter media to allow them to regenerate reagentlessly, and in place, by the application of modest thermocycled transverse or reversed airflows. The innovation may allow NASA to close the breathing air loop more efficiently, thereby sustaining the vision for manned space exploration missions of the future.

A novel, self-cleaning coatings technology was developed for air filter media surfaces that allows reagentless in-place regeneration of the surface. The technology grafts thermoresponsive and nonspecific adhesion minimizing polymer nanolayer brush coatings from the prefilter media. These polymer nanolayer brush architectures can be triggered to contract and expand to generate a "pushing-off" force by the simple application of modestly thermocycled (i.e. cycling from ambient cabin temperature to 40 °C) air streams. The nonspecific adhesion-minimizing properties of the coatings do not allow the particulate foulants to adhere strongly to the filter media, and thermocycled air streams applied to the media allow easy detachment and in-place regeneration of the media with minimal impact in system downtime or astronaut involvement in overseeing the process.

The novel feature of this self-cleaning coatings approach is that this is an enabling technology that can actively, controllably, and reagentlessly regenerate filter media. The coatings application is amenable to industrial-scale manufacturing processes and should allow significantly increased useful lifetime for the filter media in an inexpensive fashion. The energy required to trigger the thermocycled self-cleaning is minimal, and can easily be diverted from heat exchange modules further downstream in the air revitalization system. The approach will further lower loads downstream in the air revitalization system, thereby contributing to increasing the lifetime of these modules, and decreasing the amount of replacement modules. These salient features will enable NASA to design more efficient and reliable, and less cumbersome, air revitalization systems for future manned missions.



Lynntech's **Self-Cleaning Coatings** technology for air filter media surfaces allows reagentless in-place regeneration of the surface.

This work was done by Olivia Weber, Sanjiv Lalwani, and Anjal Sharma of Lynntech, Inc. for Glenn Research Center. Further information is contained in a TSP (see page 1).

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Innovative Partnerships Office, Attn: Steven Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-18848-1.