Sustaining Phenolic Impregnated Carbon Ablator (PICA) for future NASA Robotic Science Missions including NF-4 and Discovery. E. Venkatapathy[1], M. Stackpoole[2] and S. Violette[3], [1]Ms 229-3, NASA Ames Research Center, Moffett Field, CA 94035, ethiraj.venkatapathy-1@nasa.gov, [2] NASA Ames Research Center, Moffett Field, CA 94035, [3]Fiber Materials Inc., Biddeford, ME 04005.

Abstract: Phenolic Impregnated Carbon Ablator (PICA), invented in the mid 1990's[1], is a low-density ablative thermal protection material proven capable of meeting sample return mission needs[2] from the moon, asteroids, comets and other "unrestricted class V destinations". It's low density and efficient performance characteristics have proven effective for use in Discovery to Flag-ship class missions. It is important that NASA maintain this TPS material capability and ensure its availability for future NASA use. The rayon based carbon precursor raw material used in PICA preform manufacturing had to be replaced at least twice in the past 25 years and a third replacement is now needed. The carbon precursor replacement challenge is twofold – the first involves finding a long-term replacement for the current rayon and the second is to assess its future availability periodically to ensure it is sustainable and that a replacement could be found in a timely manner if required. This presentation reviews the current SMD-PSD funded PICA sustainability activities in ensuring a rayon replacement for the long term is identified and in establishing that the capability of the new PICA from an alternative precursor is in family with previous versions of the so called "heritage" PICA. This presentation will summarize efforts in evaluating Lyocell based PICA manufacturing and present preliminary results comparing the properties and performance of Lyocell based PICA with heritage PICA.

Results: Under contract, FMI was successful in manufacturing fiberform using Lyocell. FMI manufactured both a single piece net shape cast fiberform at the OSIRIS REx scale as well as fiberform billets. The net casting allows a single piece of PICA to be manufactured into a heatshield while the billet form yields PICA blocks similar to those used in the MSL tiled PICA heatshield. Figure 1 shows the final net shape cast fiberform manufactured using Lyocell.

Figure 1. Lyocell based net-casted fiberform (same size as OSIRIS REx).

A series of thermal and mechanical properties were completed to compare with heritage materials. Arc jet tests were also performed at three different test conditions to evaluate and compare the thermal response and recession performance of Lyocell based PICA with heritage PICA. In Figure 2, in-depth thermocouple response between the two precursors are compared. The differences are minimal indicating that the Lyocell PICA performance is in family with rayon derived PICA at this high condition (~1550W/cm^2 and 1.3 atm).

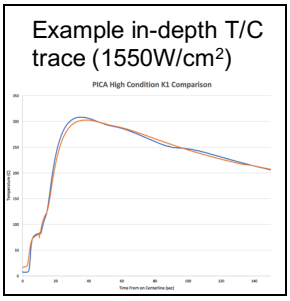

Figure 3. In-depth temperature comparison from an arc-jet test at ~1550 W/cm^2 and 1.3 atm shows the performance are comparable.

Summary: PICA manufactured from a Lyocell precursor, a domestic rayon, has presented no manufacturing issues and FMI has demonstrated manufacturing both fiberform and PICA in billet form as well as a net shape cast form. Lyocell derived PICA is within the density specification of standard (heritage) PICA. Preliminary arc-jet testing at high conditions indicates that Lyocell PICA behavior is in family with heritage material. From these preliminary results Lyocell PICA is likely to be a "drop in" replacement for future NASA mission needs. Since Lyocell is manufactured in the US in very large quantities and the need is in the commercial sector, Lyocell based PICA could be a sustainable source for the future mission needs.

References:

[1] Tran, H.K., "Phenolic Impregnated Carbon Ablators (PICA) for Discovery Class Missions", *AIAA Paper 96-1911*, June 1996.

[2] Wilcockson, W., "Stardust Sample Return Capsule design experience", 7th AIAA/ASME Joint Thermophysics and Heat Transfer Conference, *AIAA paper # 2854*, 1998.