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April 11, 1980

(NASA-CR-160037) METHOD FOR PRODUCING THIN SHEETS OF PROTON-SENSITIVE CR-39 PLASTIC TRACK DETECTORS Final Report, 16 Mar. 1979 - 15 Mar. 1980 (California Univ.) 8 p HC A02/MF A01 CSCL 11D G3/24 N81-12175 Unclas 39953

Richard I. Weiss
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Code 282
Goddard Space Flight Center
Greenbelt, Maryland 20771

Subject: NASA Contract NAS 5-25453
Principal Investigator: P.B. Price

Dear Dr. Weiss:

Enclosed please find one copy of the Final Report for subject contract covering the period March 16, 1979 to March 15, 1980.

Sincerely,

Judy Blair

Judith M. Blair
Secretary to P.B. Price

Enclosure

CC: Charles E. Campbell (22)
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Space Sciences Laboratory
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FINAL REPORT

March 16, 1979 to March 15, 1980

NASA Contract NAS 5-25453

Principal Investigator

Professor P.B. Price

April, 1980

Space Sciences Laboratory Series 21, Issue 9

Final Report NAS 5-25453

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The major goals of our study were to:

1. Specify procedures for fabricating large sheets of CR-39 with uniform chemical reactivity and sensitivity and which retained a clear, smooth surface after prolonged etching;

2. Find a firm that will follow our specified procedures and will deliver high-quality CR-39 detector sheets at a reasonable price;

3. Learn to fabricate very thin sheets for certain Spacelab applications.

We are pleased to report that we have accomplished the second and third goals and have made considerable progress toward the first goal. We expect to continue this definition study with support sponsored by the LDEF Project Office.

I. Fabrication of uniformly sensitive CR-39 sheets.

After one year's work, we have not yet developed a completely reproducible procedure for making large volumes of CR-39 with constant sensitivity. We have, however, identified the parameter of greatest importance--the temperature-time cycle. To minimize the temperature gradient within the sample during its exothermic polymerization, one can solve a differential heat-flow equation and arrive at a curve of temperature vs time for a given initial temperature and cure time. Pershore Mouldings, a British firm, has made CR-39 for us using one of our calculated temperature-time cycles. It was quite uniform in chemical reactivity and sensitivity to radiation. It remains to be seen whether samples made at different times, using the same cycle, will have identical characteristics.

We have constructed and used a large water bath with programmable temperature-time cycle and have made our own CR-39. It is not quite as sensitive as that produced by Pershore. We have ordered a large hot-air oven with which to continue our studies. The air oven, though it does not make as good a thermal contact with the molds as does a water oven, has advantages. It is less messy. The glass molds can be reused without the necessity for thorough cleaning.

what plasticizer?

Our studies of gasket materials have led to a significant discovery. A plasticizer added to commercial PVC gaskets leaches out and diffuses into the CR-39, producing a highly smooth and transparent margin ~2 cm wide after the polymerized sheet is etched. The interior is much rougher than the margin after a long etch. A silicone gasket is quite inert and does not lead to the smooth margin. We have identified the plasticizer and have found that adding ~1% of it to the CR-39 monomer leads to a plastic that is uniformly smooth after a prolonged etch. This greatly improves the quality of the CR-39 as a detector.

Pershore has agreed to make a large quantity (250 kg) of CR-39 with 1% plasticizer added. We plan to test it in a balloon flight next fall.

We have succeeded in coating glass molds with a monolayer of a nonpolar molecule by a process called silanation, well-known to organic chemists. CR-39 sheet polymerized in such a mold does not adhere to the mold. It readily shrinks by the normal 14% during polymerization, but by a sideways shrinkage in the plane of the sheet rather than by a thickness decrease. This work is still in the exploratory stage and we are not yet ready to recommend that Pershore silanate its glass.

In one of our progress reports, we found that in a suite of samples of CR-39 polymerized at 40° C over six weeks, the sensitivity increased with initiator concentration. The sheets are now one year old. We have retested their sensitivity and find that they now all have similar sensitivity. One possible explanation is that after six weeks at 40° C, poltmerization is not complete. It is furthest advanced in samples with highest initiator concentration. After an additional one year at room temperature, all samples have probably attained close to their maximum polymerization independent of initiator concentration.

In samples cured at higher temperatures, presumably involving a greater degree of cross-linking, we have found no dependence of sensitivity on initiator concentration. We have, however, found long-term changes in several properties such as bulk etch rate and surface roughness after etching. These changes are least in the most thoroughly cured samples. Clearly, the detectors to be used in Shuttle experiments should be completely polymerized and aged until no properties change with time.

II. Commercial source of CR-39 detectors.

Only two firms have cooperated with us. Polytech (a St. Louis firm) allowed one of us to visit their plant, but have failed to deliver sheets of uniformly high quality. Pershore Mouldings, Ltd., is the only firm that has willingly experimented with small batches of CR-39 made exactly to our specifications. This firm makes the most uniform sheets of all firms of which we are aware. It also makes sheets thinner than other firms do. During our balloon flight in September, 1980, we will fly 500 kg of Pershore CR-39, half of it with 1% plasticizer and half without. All sheets will be cured following our recommended temperature-time cycle. We will expose a localized region of the stack to high-energy iron nuclei at the LBL Bevalac before the flight.

With support from our continuing NASA Headquarters grant, we will analyze the charge and mass resolution attained with the Pershore CR-39. If it meets our expectations we will argue strongly for a dedicated second LDEF with at least 50 m^2 of CR-39 and Lexan for a superheavy cosmic ray experiment. We recommend Pershore as the CR-39 supplier.

III. Method of fabricating very thin sheets of CR-39.

Early in the present contract we succeeded in developing a method for making sheets down to ~25 μm in thickness. The attached reprint explains the method.

IV. Future plans.

We intend to produce our own CR-39 in our air oven, beginning mid-June, 1980. We will continue to explore the glass silanation process and will determine the efficacy of monomer distillation and outgassing in contributing to uniformity of CR-39 detectors.

There are several applications for which a more sensitive polymer is needed. We would like to be able to detect particles with Z/β as low as 5. The present sensitivity is perfectly adequate for space experiments. In searches for exotic particles in mountain-top experiments, where there is no danger of excessive radiation damage such as can occur in repeated passage through the South Atlantic anomaly, CR-39 capable of detecting particles with $Z/\beta \approx$ would be valuable. We are pursuing these goals with our NASA supporting research grant.