SLAC-PUB-1700
January 1976
(E)

QUANTITY PRODUCTION OF POLARIZED TARGET MATERIAL*

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ABSTRACT

A simple, inexpensive device for quickly making large quantities of small, uniform, frozen beads of alcohol for polarized targets is described. It has been successfully used at Stanford Linear Accelerator Center for about two years.

(Submitted to Nucl. Instr. and Meth.)

*Work supported by U.S. Energy Research and Development Administration.

I. INTRODUCTION

Maintaining the hydrocarbon in polarized targets at acceptably low temperatures in the presence of the thermal gradients produced by beam and microwave heating requires that the material be broken up in pieces of characteristic dimension of 1 or 2 mm.

Making small spheres by letting drops from a needle fall on a surface of liquid nitrogen has been a traditional solution[1]).

Surface tension would quickly coalesce adjacent drops on the surface during the several seconds before they freeze and sink. Hence, the drops must be made slowly and in separated regions - a very slow process, but acceptable when small amounts are infrequently made.

The high radiation damage inherent in an experiment at SLAC meant 25 to 50 cc of material would be required each day. As this corresponds to $\gtrsim 10^4$ beads, a less individual means of manufacture was needed.

II. EXPERIMENTAL APPARATUS

The principle of the device (Fig. 1) is in placing a potential on the syringe needle.

First, the additional force on the drops produced by the gradient gives much smaller drops than obtained with even a very small needle; furthermore, the size is controllable by the voltage selected.*

Secondly, the drops retain sufficient charge that they dramatically repel one another on the surface, allowing simultaneous production of large numbers.

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* Although the drop repulsion feature and application are unique, this is the N^{th} rediscovery of the effects of electrostatic fields on liquid drops[2]). A commercial typewriter now also uses this method to form and deflect an ink jet, much as a CRT.

A 20 gauge hypodermic needle 1.5 cm long, with square cut tip, is mounted in lucite and secured with a screw which serves also as electrical contact. The "grid" consists of a thin copper sheet with a 2 cm diameter hole placed beneath the needle. In fact we use five independent needles mounted at ~15 cm spacing on a common lucite plate which also serves as a cover for the liquid nitrogen basin below.

This basin is simple made of two aluminum boxes with 2.5 cm styrofoam insulation with the inner container serving as "anode". Although the best operating voltage depends on needle size and geometry, about 2 kV gives a ~1.7 mm diameter drop without an unstable spray.

The alcohol mixture is fed to the five needles from five plastic 60 cc syringes through 2 mm diameter polyethylene tubing. The syringes are mounted in a frame with a single bar attached to the plungers. The bar is driven by a dc motor through a slotted shaft and threaded rod - an apparatus quite similar to commercial syringe pumps. An appropriate rate was about 1 cc per minute per syringe, giving several drops per second at each needle.

Typically, 200 cc of liquid is distributed among the syringes and the run lasts 45 minutes.

Initially, the frozen drops attach to the sides of the container until a sufficient charge develops to repel others - which then deposit on the bottom. Maintaining the liquid nitrogen level and a clean nitrogen atmosphere is important to the survival of these beads on the sides.

The very low electrical conductivity of glasses results in a long time for discharging the beads - and obviously they cannot be compactly stored until this occurs. By placing a small rod underneath the nitrogen box and gently rocking the entire assembly, enough agitation is produced to roll the beads around.

Otherwise a piece of cardboard makes an admirable stirrer. After about 15 minutes they are sufficiently discharged to collect in a mesh net and place in closed tubes in a commercial 40 liter nitrogen dewar for long-term storage.

III. RESULTS

This device was used last year to prepare butanol-porphyrexide beads for the SLAC-Yale 50 kG-1^{o}K polarized target used in a deep inelastic scattering experiment of polarized electrons from polarized protons.

Four hours in the lab (including material preparation) produced some 250 cc of beads - for a week or more of running. In all, more than one liter was prepared this way.

The average bead diameter was 1.7 mm. Density measurements of a bulk sample and of the solid, per se, gave a packing fraction of .65 ± .03.*

As a test, some material was prepared in a conventional fashion and used in the target with identical results (some could imagine bizarre effects from the electric field used in production on the free radicals, for example).

Several samples of pentanol were also prepared without difficulty.

The technique and device described offer considerable advantages in speed, volume, and reproducibility in the production of polarized hydrocarbon targets.

REFERENCES

1. S. Mango, Ö. Runólfsson, and M. Borghini, Nucl. Instr. and Meth. 72 (1969) 45.

2. B. Raghupathy and S. B. Sample, Rev. Sci. Instr. 41 (1970) 645.

3. O. K. Rice, J. Chem. Phys. 12 (1944) 1.

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* This is in accord with the observation that practical assemblies of spheres are 15% to 20% less dense than the hexagonal close packed value of .735[3]).

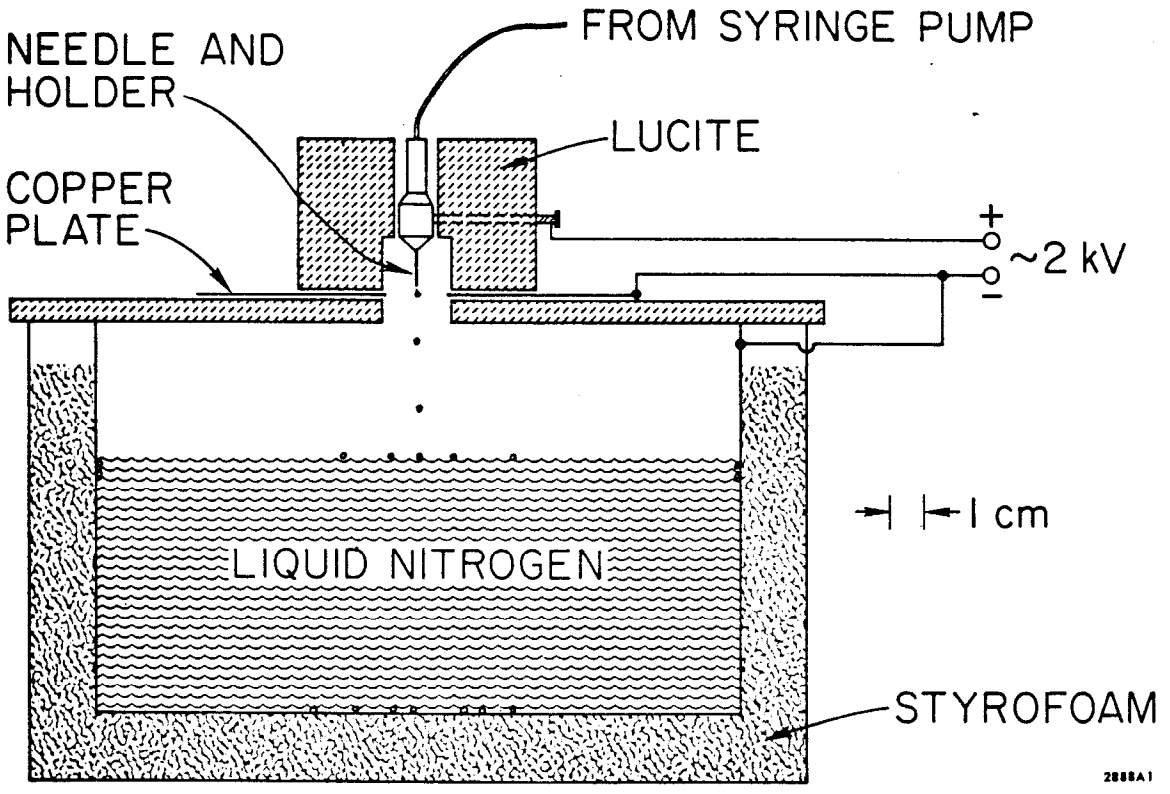

Fig. 1

A cross section through the 1 meter long device at one of the 5 equispaced needles. This schematic is roughly to scale but geometry is not crucial. Compatible needles, syringes, tubing, and Luer-lock adapters were obtained through a medical supply catalog.