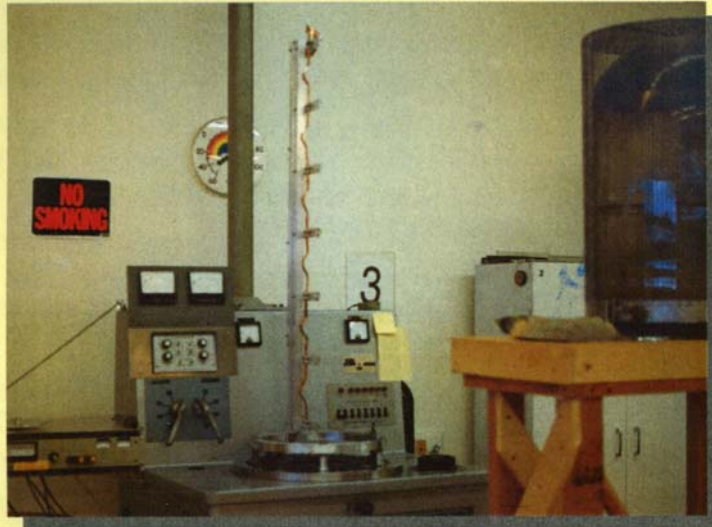


INTDS NEWSLETTER



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Contents

• Editor's Note	2
• In memory of David Blunt	3
• Retirement of Jean Pauwels	4
• Minutes of INTDS Board meeting 16 November 2001	5
• INTDS Conference Announcement	9
• <u>Technical Contributions</u>	
* Preparation of beryllium metal foils Xu Guo ji and Du ying hui Department of Nuclear Physics, CIAE, Beijing, China	10
* Progress report of the target laboratory W. Engel, J. Leandro and N. Ueta Instituto de Física da Universidade de São Paulo	11
* Target Laboratory Report A.R. Lipski Nuclear Structure Laboratory, State University of New York, Stony Brook	14
* Preparation of a Large Diameter 0.8 mg/cm ² Carbon Target Wheel for Experiments at ATLAS J. Greene, G. Savard and J. Stoner Jr. ¹⁾ Physics Division, Argonne National Laboratory, Argonne ¹⁾ ACF Metals, Tucson	15
* Preparation and Characterization of C ₆₀ -Perdeuterated Styrene Copolymer Nanofilms Zhang Lin, Du Kai, Zhang Houqiong, Fan Yongheng, Tu Haiyan and Luo Xuan Institute of Nuclear Physics and Chemistry, CAEP, China	20
• Notes and advertisements	24
• INTDS Newsletter distribution list	28

Cover picture: Apparatus that was used to make aluminum foils on sodium chloride parting agent on a flexible Lexan™ substrate 120 cm x 120 cm x 0.75 mm thick, at ACF-Metals in 1988. The substrate was bent into a cylinder approximately 38 cm in diameter. First sodium chloride, then aluminum, were evaporated from seven equidistant filament sources electrically in series and located on the axis of the cylinder, onto the interior of the cylindrical substrate. Then the cylinder was removed, unwrapped, and the foil was cut into a circle having diameter 91 cm while still on the substrate. The foil was then floated off and mounted on a mesh on a circular frame having diameter 100 cm. The foil can be seen in Nucl. Instrum. Meth. [A282](#), 176-179 (1989). The evaporator had a conventional 46-cm-diameter glass bell jar; for the purposes of making this foil, an aluminum cylindrical extension 91 cm high was placed under the bell jar.

Editor's note

Thank you to the contributors to this edition of the INTDS newsletter and I am particularly pleased that we have received contributions from Chinese target makers for the recent editions. I am very pleased to welcome these new members to the society and I hope that our contacts and information exchange will strengthen in coming years.

Please check address and email information at the back of this newsletter and send corrections to me. If you have laboratory or target photos that we could use for the covers of future additions, please post them or send electronic copies. Don't forget also to check out the INTDS web page <http://www.intds.org>, and send any suggestions, for new links for example, to Bill Lozowski, our web master.

Happy New Year to everyone

Chris Ingelbrecht
Editor



In memory of David Blunt
21 May 1946 – 10 June 2001

It is with a sense of deep sadness that the many colleagues and friends of David Blunt learnt of his untimely death on the 10th June 2001. David was a much-valued colleague in the Schuster Laboratory, Department of Physics, at the University of Manchester both as an accomplished target maker and earlier, in the physics workshop, as a precision engineer.

David joined the Department of Physics in April 1977 and spent the next 5 years in the departmental workshop. In conversation, he would often recall his happy times in the physics workshop, particularly those involving his work in support of the High Energy Physics Group of Professor Paul Murphy. This activity involved several visits to DESY (Deutsches Elektronen Synchrotron) at Hamburg, Germany, in support of the experimental programme there. Having, by nature, an adventurous spirit, David really enjoyed the opportunities which such travel offered.

In the 1970s target making at Manchester, in support of the large and very active experimental nuclear physics group there, was undertaken by Tal Morgan and Bob Darlington. With the commissioning of the Nuclear Structure Facility at the nearby Daresbury Laboratory in the late 1970s, there opened up an opportunity for a target maker there, and this position was filled by Bob Darlington. The head of Manchester Experimental Nuclear Physics at that time, Professor Bill Phillips, recognising David's talents and potential, offered him the opportunity to train in the target laboratory prior to Tal's early retirement. Thus it was that in October 1982 David Blunt moved from the physics workshop to train as a target maker. Within a relatively short period of time, David was able to contribute to the requirements of the members of the nuclear physics group for targets and thin foils with a wide range of thickness and of isotopic composition in support of gamma-ray and charged-particle spectroscopic studies and of the programme of in-house detector development. With the passing years, his experience and expertise grew and he became a very respected and accomplished target maker. David maintained many of the overseas links that Tal Morgan had formed and, in particular, the very fruitful collaboration with Pino Manente of the INFN Legnaro Laboratory continued and a warm friendship, which lasted until the time of David's death, was formed.

In May 1997, David retired early from his post. Three years earlier, he had purchased a dilapidated farmhouse near Finistere, north-west France and holidays before retirement were spent working to make the building habitable. In retirement, David moved to France to work on his property. What he had taken on was not for the faint hearted, but David was more than equal to the task of transforming his new house into a home, being a do-it-yourself enthusiast. It was with a great sense of triumph that, in one letter to the writer of this appreciation, he proudly announced that he had at last completed the installation of a flush toilet! Although he retired to France without any initial great fluency in the language, he nevertheless quickly integrated himself into the local community and this led to close friendships with his neighbours. Indeed, during his lifetime, David enjoyed many new challenges and formed many lasting friendships.

David was, above all, a family man who was deeply devoted to his sons, Gareth and Graham. He was a man of great warmth and compassion and we shall miss him. Our thoughts at this time are with his sons and with Susan.

Robert Chapman, Professor of Physics
 University of Paisley, Scotland

(Formerly Reader in Physics, University of Manchester.)

Jean Pauwels retires, December 2001



Jean Pauwels has finally decided to hang up his fighting gloves and his friends and colleagues from IRMM waved and sang goodbye to him in December 2001.

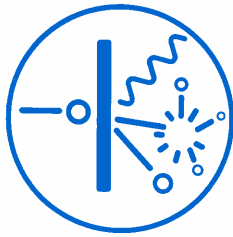
Jean will be well known to most of the INTDS members for his long years of service to the society and his many developments and publications of extraordinary diversity in the target-making field. Working, originally with Jan Van Audenhove, Jean established at IRMM (previously Central Bureau for Nuclear Measurements) most of the chemical and thin-layer deposition techniques, which are still in use today: spray-painting, electrospraying, dry hydrofluorination of U and Pu for evaporation, film thickness measurements by optical interference to name just a few. He was also responsible for a number of particularly spectacular successes, notably the development of plastic target substrates, leading to the established use of polyimide foils and the production and characterisation of very high quality ^6Li and ^{10}B layers for the redefinition of neutron lifetime.

Jean also served for many years on the board of the INTDS and his contributions to the society were acknowledged with an INTDS Achievement Award, presented in Strasbourg in 1996.

Jean's activities have encompassed much more than nuclear target preparation, however, and in 1995 he became Unit Head of the Reference Materials unit at IRMM and, in a few short years, expanded this activity into the cornerstone of the institute helping to establish BCR as the second largest reference materials supplier in the world (after NIST). Such expansions required brave decisions, notably the move into the biotechnology and clinical fields, which have become the most important growth sectors in the reference materials world.

Jean still has a contract with the institute to act as an advisor, and we hope to see him regularly; but I am sure that INTDS members would want to wish him much deserved enjoyment and relaxation in his retirement.

Chris Ingelbrecht



21st World Conference of the INTDS



Accelerator Target Technology for the 21st Century

November 4-8, 2002

Organizing Committee

John P. Greene, (ANL)
 Tel: (630) 252-5364
 Email: green@anl.gov
 George E. Thomas, (ANL)
 Margo Smith, (ANL)
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Joan Brunsvold, (ANL)
 Joanne Heagney, (Micromatter, USA)

Scientific Committee

David Gilliam, NIST (USA)
 John Greene, ANL (USA)
 Chris Ingelbrecht, IRMM (B)
 Bill Lozowski, IUCF (USA)
 Peter Maier-Komor, TU, München (D)
 Anna Stolarz, Warsaw U (PL)

Conference Venue

The conference will take place in the Physics Division of Argonne National Laboratory, a short walk from the Argonne Guest House, starting on Monday morning and concluding on Friday afternoon. During the conference participants will be reachable via the conference secretary, Margo Smith. The conference language will be English.

The conference will cover classical and innovative target preparation for low and high-energy accelerator experiments and for radioactive beam and reactor experiments.

- Deposition techniques for the preparation of targets, stripper foils, and detection systems.
- Chemical and mechanical processing of target materials and isotope enrichment.
- Mechanisms for producing secondary beams, including gas targets and catcher cells.
- Performance and characterization of targets used in super-heavy element synthesis.
- High power target and ion source designs for radioactive beam production

Deadlines

Registration:	July 31, 2002
Submission of abstracts:	August 30, 2002
Hotel bookings:	August 2002
Submission of papers:	November 4, 2002

Publication of Proceedings: Nuclear Instruments and Methods

Preparation of beryllium metal foils

Xu Guo ji, and Du ying hui
Department of Nuclear Physics, CIAE, Beijing, China

1 Vacuum evaporation

The apparatus^[1], shown in Fig.1, was mounted within a conventional metal bell jar 45cm in diameter and 70 cm high. The boat source could be seen by the operator through the windows of the apparatus and the bell jar. There was no straight-line exit from the apparatus to the interior of the bell jar for Be vapor originating from the boat.

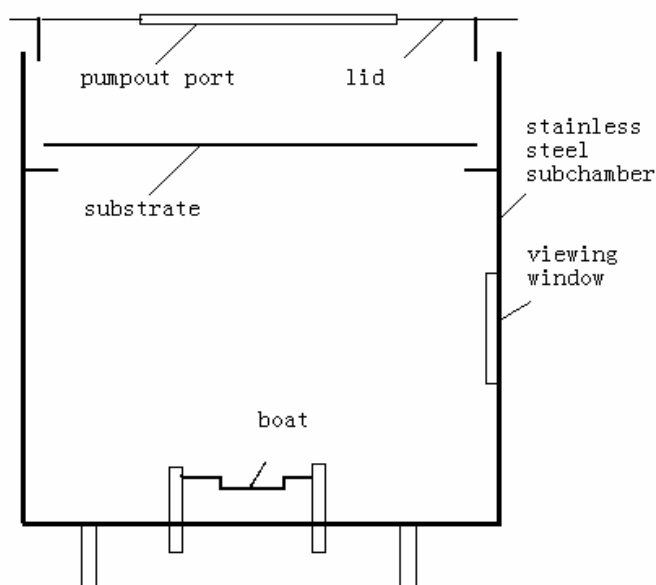


Fig.1 Apparatus for the evaporation of beryllium

A tantalum boat, 13mm wide, 28mm long and 0.1mm thick, was used as evaporation source. The distance from the boat to the substrate was 15 cm. A microscope glass slide coated with betaine was used as substrate. The Be foils produced by resistance heating were removed from the glass by dissolving the betaine in distilled water. Self-supporting Be targets of 0.02-0.97mg/cm² have been obtained.

2 Rolling

Be foil of 0.08 mm was inserted into a pack, which was made of stainless steel. Reductions were limited to approximately 1% reduction per pass and the rolling speed was of the order of 2m per min. Rolling was continued until a total of 12% reduction was achieved. The Be foil was then removed from the pack and was vacuum heat-treated at 600-650 ° C for 0.5h. The heat-treated foil was then reinserted in a new pack. The foil was oriented so that the rolling direction of the foil was perpendicular from the previous one^[2]. Rolling and heat-treating were repeated. This process was continued until the final foil thickness was attained. Be foils of 0.75-4.6 mg/cm² have been obtained using the procedure described above.

- [1] Stoner, J.O. Large-area beryllium metal foils. Nucl. Instrum. and Meth., 1997, A397, 68-74.
- [2] Karasek F.J. The rolling of Be, W and V foil. Nucl. Instrum. and Meth. ,1979, 167:165-166.

Progress report of the target laboratory

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During the last years some improvements were obtained in the target laboratory installed within the Pelletron accelerator facilities of the Nuclear Physics Department. A Univex 450 Leybold evaporation unit with cryopump was installed. The cylinders of the old roller (0.75 kW - Brook Motors Ltd) were rectified and the machinery readjusted. The floor and ceiling of the room were changed reducing somewhat the dust in the air.

With the new evaporation unit the evaporation of high sublimation temperature materials can be done without problems. Nevertheless one has to learn the best way to take profit out of the new equipment. The high power affords high evaporation rate so that big holes can be carved soon. The uniformity of the evaporated layer depends very drastically on the shape of the bulk material. The obtained film thickness depends on the position of the glass slide on the substrate holder relative to the evaporation source. The x and y movement of the electron beam must be used properly maintaining the evaporation rate as constant as possible. A rotating substrate holder would solve these problems, this will be the next aim in the list of improvements of the laboratory.

The home made optical film thickness measurement device (ref 1) used for stripper foils was calibrated for the carbon foils made in the Univex 450 unit. Low energy ^{16}O beam was used in elastic scattering measurements using the Pelletron accelerator. A scattering chamber described in ref 2 was used with four surface barrier silicon detectors. The calibration is the same as the previously made for carbon foils evaporated on the Edwards E12 unit on the same release agent (RBS), within statistical errors. The same device was also calibrated to be used with glass slides with carbon foils. Only substrates with films of appropriate thickness are used to fish the stripper foils.

The nuclear targets which were made using the Edwards E21 evaporation unit are listed below:

Element	Form	System	Characteristics	Thickness $\mu\text{g}/\text{cm}^2$	Quantity
Ni	met	e.b.	self-supporting	100	8
⁶⁰ Ni	met.	e.b.	self-supporting	70	10
⁵⁸ Ni	met	e.b.	self-supporting	80	10
Mg	MgO	e.b.	Liquid N ₂ refrigerated system, carbon backing, thin layer of Bi on Mg.	20	10
²⁵ Mg	MgO	e.b.	idem	50	11
Li	LiF	e.b.	carbon backing	50	10
Ca	CaCO ₃	e.b.	carbon backing, Gold layer on Ca	90 - Ca 80 - Au	10
⁶³ Cu	met.	e.b.	self-supporting	80	10
⁶⁵ Cu	met.	e.b.	self-supporting	70	12
Ge	met	e.b.	self-supporting	70 - 80	20
⁷² Ge	met.	e.b.	self-supporting	70 - 80	20
Mo	met	e.b.	self-supporting, folded targets	30 - 40	10
⁹² Mo	met	e.b.	self-supporting, folded targets	30 - 40	10
²⁰⁸ Pb	met.	Joule	carbon backing	300 - 400	50*
Ag	met.	e.b.	self-supporting	100	10
Al	met	Joule	self-supporting	30 - 100	30

* used at Ganil

In the Univex 450 evaporation unit the following targets were made:

Material	Form	Backing	Power(W)	Pressure (mbar)	rate(g/s)	quantity	thickness ($\mu\text{g}/\text{cm}^2$)
Nd	Nd ₂ O ₃	C	255	5.0×10^{-6}	10		
C	C	-	340-400	5.0×10^{-6}	15-20	300	5-40
Zn	Zn	C	255	5.0×10^{-6}	3-15		20
Mo	Mo	-	400-700	1.6×10^{-7}	5-15		10
Mo	⁹² Mo	-	400-700	1.6×10^{-7}	5-15		20
Mo	⁹⁴ Mo	-	400-700	1.6×10^{-7}	5-15		25
Mg	Mg	C	170-340	5.0×10^{-6}	10-30	10	40-70
Gd	Gd	C	330	10^{-6}	-	-	not uniform
Ca	CaCO ₄	C	85	4.0×10^{-6}	-	10	50
Bi	Bi	-	85-100	1.6×10^{-6}	-		100
Co	Co	-	250	1.6×10^{-6}			50-100
Ti	Ti	-	250-340	1.6×10^{-6}		10-20	50-100

Gadolinium targets were obtained by rolling using Gd foils (25 mg/cm² foils packed in Argon atmosphere imported from Goodfellow). Polished steel sheets of 0.5 mm thickness is now available in the market. AISI 304 steel sheets protected with plastic film from Brasil Steel were bought and cut in appropriate shape to sandwich the Gd foils.

One strange sample of Gd of unknown purity could not be rolled as the other pieces. The material was then heated in the Univex 450 by electron bombardment and a nice pellet was obtained. This pellet was then rolled as usually done.

A very good performance was obtained in the rolling process of these Gd foils. Glow discharge was used to clean the foils after the rolling procedure. Thirty targets of 3.0 cm x 3.0 cm and about 1 mg/cm² thickness were obtained to be used at Ganil.

Gold targets were also obtained by rolling using pieces of a 2 mm diameter wire (Riedel 99,99%) as shown bellow:

Quantity	Approximate thickness (mg/cm ²)
2	5
2	4
2	3
2	1.5
2	1

ref. 1 - N. Ueta, M. Emura, D. Pereira, E. S. Rossi Jr., L. C. Chamon and C. P. da Silva, Nucl. Instr. and Meth. A 334 (1993) 181 - 184

ref. 2 - L.C. Chamon, D. Pereira, E. S. Rossi, C. P. Silva, G. R. Razeto, A. M. Borges, L. C. Gomes and O. Sala Phys. Lett. B 275 (1992) 29.

Target Laboratory Report

A.R. Lipski
Nuclear Structure Laboratory,
State University of New York at Stony Brook, NY 11794-3800, USA

The list of the targets prepared between Jan. 1999 and Dec. 2000

target isotope	thickness $\mu\text{g}/\text{cm}^2$	backing	fabrication
^{174,176} Yb	0.8 – 1.2	ss	r
CsI	1.2	Ta	e
BaO	1.4	Ta	e
⁸⁹ Y	7.0	ss	r
^{116,117,119} Sn	0.5 – 4.0	ss, ²⁰⁸ Pb	redox + e,e
^{120, 122, 124} Sn	0.5 – 4.0	ss, ²⁰⁸ Pb	redox + e,e
¹⁰⁶ Pd	2.0	Pb	r + e
^{nat} In	1.0 – 1.2	ss	r
⁵⁶ Fe	1.7	Pb	redox, r + e
^{124, 126, 130} Te	2.5 – 3.0	ss, Pb, Au	e
²⁰⁸ Pb	0.2 – 2.0	ss, C	redox, e
¹²³ Sb	2.0	Pb	e
^{62, 64} Zn	0.5 – 2.0	ss, ²⁰⁸ Pb	r, e
⁹⁴ Zr	0.4	ss	r
^{92, 94, 98, 100} Mo	0.7 – 3.0	Pb	r + e
⁵⁸ Ni	0.7 – 0.8	ss	r
^{nat, 11} B	0.4 – 0.8	ss	e
Pt	0.5 – 1.0	ss, Pb	r
^{144, 154} Sm	1.0 – 2.0	ss	redox + r
⁴⁶ Ti	0.3 – 0.4	Au	e
¹⁰⁷ Ag	0.7 – 0.8	ss	r

r = rolling
e = vac. deposition
redox = reduction of metal oxide
+ = and

98 targets were fabricated in the form of foils or sandwiches ready to be mounted on frames with opening between 0.5 – 1.5 inch in diameter. The list only partially represents the activity of the target laboratory.

Preparation of a Large Diameter 0.8 mg/cm² Carbon Target Wheel for Experiments at ATLAS

John P. Greene and Guy Savard

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John O. Stoner, Jr.

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Abstract

Recent mass measurements of short-lived nuclei at Argonne National Laboratory (ANL) with the Canadian Penning Trap (CPT) employed intense beams from the Argonne Tandem Linear Accelerator System (ATLAS) and required the use of a rotating target wheel of large diameter. Previous work involving reactions with heavy ion beams on thick, rotating carbon targets of modest aperture were limited by low counting rates. A new target station and beam rejection system was constructed to enable the acceptance of much higher beam currents and is currently in operation. Here we present a description for the preparation of a 0.8 mg/cm² C target wheel used for these experiments.

*Work supported by the U.S. Department of Energy, Nuclear Physics Division, contract No. W-31-109-ENG-38.

1. Introduction and Motivation

For experiments at the Canadian Penning Trap (CPT) aimed at measuring the mass of very short-lived nuclei [1], sufficient statistics are achieved by using high beam currents and robust targets capable of withstanding the damage induced by the intense beams. A typical reaction would be $^{12}\text{C}(^{58}\text{Ni}, 2n)^{68}\text{Se}$ using a carbon target and 230 MeV ^{58}Ni beam with currents of 50+ pA. It had been found in recent investigations by Fischer et. al.[2] that this was indeed, an optimal reaction for producing ^{68}Se . In the past, these stationary targets have been gas cooled within the scattering chamber by employing a rotating entrance window, at times incorporating the window/target into a single rotating foil. Recently, several improvements have been made to the experimental set-up [3]. These included installation of optical components for increased recoil acceptance, a Wien filter system for beam rejection and the construction of a large diameter ($r=155$ mm) rotating target wheel and chamber upstream of the previous target position.

In the previous investigations, thick carbon foils of 1 mg/cm² obtained from ACF Metals (2239 E. Kleindale Road, Tucson, AZ 85719) were employed both as stationary targets on standard ATLAS frames as well as rotating target chamber entrance windows with apertures up to 35 mm diameter. For these pressure windows the carbon foils would be reinforced with a collodion coating to facilitate handling and pressure filling of the target chamber. For the new set-up, a large diameter rotating target wheel consisting of sixteen individually mounted 0.8 mg/cm² carbon foils needed to be prepared. The target frame design shown in Fig 1. was based on a modified version of the target frames presently in use for the rotating target wheel employed at the Fragment Mass Analyzer (FMA). The area of the frame's open aperture conforms to the availability of target foils produced by vacuum deposition onto standard microscope slides. The individual targets are easily mounted around the wheel circumference by four small screws.

2. Production of Thick Carbon Foils

The substrates for the foils were 50 mm x 75 mm glass microscope slides, precoated with a thin layer of Creme-Cote detergent (James Varley & Sons, 1200 Switzer Avenue, St. Louis, MO 63147) which was then polished off using a clean cotton towel. The slides were placed in a cylindrical rig [4] that permitted simultaneous coating of 48 slides. The substrates were near room temperature (typically 30 degrees Celsius), but were warmed slightly by the evaporation process. Carbon was arc-evaporated onto the slides in an extensive series of evaporations; approximately 32 evaporation cycles were needed to reach the desired thickness range corresponding to 800 $\mu\text{g}/\text{cm}^2$. The axial location of the arc relative to the substrates was varied from run to run as needed to obtain a reasonably uniform thickness distribution over all the substrates.

Carbon foils made in this way were heavily stressed, and without treatment, broke up spontaneously when removed from their substrates [5]. This was prevented by annealing the foils on their substrates. Typically this was done by heating them to about 250 degrees Celsius in an oven flushed with dry nitrogen, for a period of one hour. After the foils were allowed to cool, they were easily floated off and stored between weighing-paper sheets in polystyrene boxes lined with urethane foam.

The thickness of a foil on its substrate was subject to variability due to irregularities in the amounts of carbon evaporated in different directions by the arc [6], and by small variations in distance from the arc to different points on the substrate. Optical evaluation [7] of typical thickness variations of much thinner carbon layers showed that most individual foils were uniform in thickness to better than $\pm 5\%$ of the mean value on a substrate. Variations in thickness among foils produced simultaneously in the same rig could easily be $\pm 20\%$ or more. Because of this variability, it was necessary to measure each foil's areal density by weighing.

3. Mounting of the 0.8 mg/cm^2 C Foils

The foils were obtained individually packaged between weighing paper and although somewhat fragile, were easily handled with wafer tweezers. Adherence to the aluminum target frame was accomplished using a light film of Apeizon grease; Type L (M&I Materials, Ltd. P.O. Box 136 Manchester M₆₀ 1AN, UK) applied using the finger. The freestanding carbon foil was maneuvered onto the frame and, once positioned, gentle pressure was applied using a cotton swab to attach it to the frame. Any excess material was trimmed away using a scalpel or razor blade. Carbon paint was next applied to the perimeter of the foil using a small brush. Finally, the carbon foil covering the mounting holes was carefully removed and additional carbon paint applied, if necessary. Seventeen foils (16 plus one spare) were prepared in this fashion without any breakage and mounted onto the wheel.

4. Target Wheel Performance

Carbon films of 0.8 mg/cm^2 thickness are rather sturdy and therefore the mounted foils individually were quite robust, making the target wheel easy to handle and mount onto the drive mechanism. Wheel rotation is provided by a synchronous motor outside the target chamber employing a ferrofluidic feedthrough [8]. Included in the drive system is a digital encoder, which, through hardware and software, provides a signal to ATLAS for sweeping the beam to avoid hitting the wheel spokes. Similar rotation schemes have previously been used for the APEX [9] experiment and at GAMMASPHERE [10].

A photograph of the completed wheel is shown in Fig.2 with a close-up inset of an individually mounted foil. This wheel was exposed to a 60 pA beam of $230 \text{ MeV } ^{58}\text{Ni}$ from ATLAS for several days over two experimental runs and shows little sign of deterioration. This work is still in progress and enough foils are available to complete a second spare target wheel for use in the future.

5. Conclusion

A series 0.8 mg/cm^2 C foils were prepared as a large diameter, ($r=155 \text{ mm}$) rotating target wheel by individually mounting the sixteen foils on large, open aperture frames. The target was successfully used to produce the short-lived nuclei ^{68}Se for mass measurements using the Canadian Penning Trap (CPT) at ATLAS. The target performed well under the intense ^{58}Ni beams required by the experiment.

Acknowledgements

The authors would like to thank Dr. Donald Geesaman, the Physics Division Director, and Dr. Kim Lister, the Heavy Ion Chief, for their continuing encouragement and support of these efforts. This work is supported by the U.S. Department of Energy, Nuclear Physics Division, under Contract No.W-31-109-Eng-38.

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- [4] John O. Stoner, Jr., *Appl. Optics* 17, 321 (1977).
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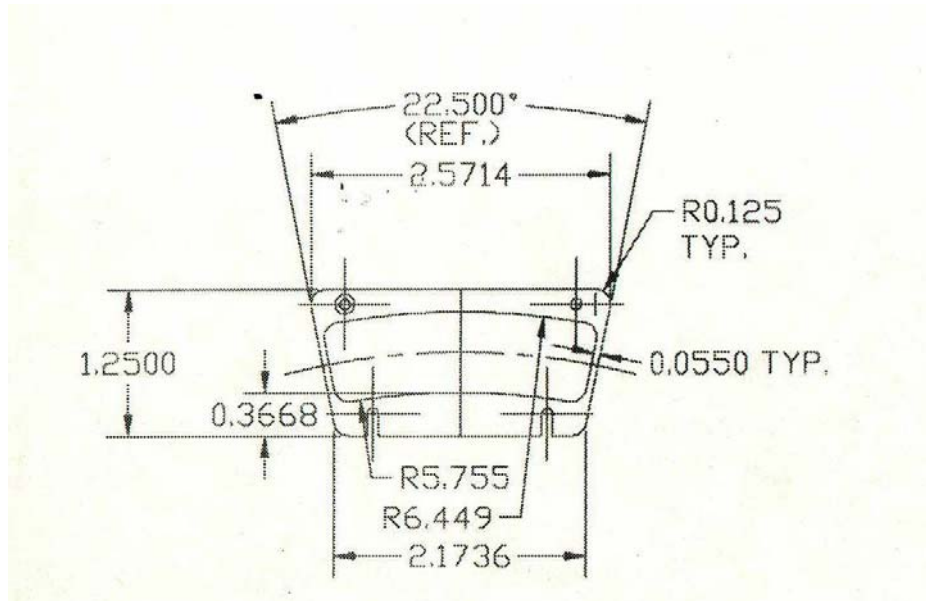


Figure 1. A machine drawing of the target frame for the new large diameter ($r=155$ mm) target wheel (units are inches).

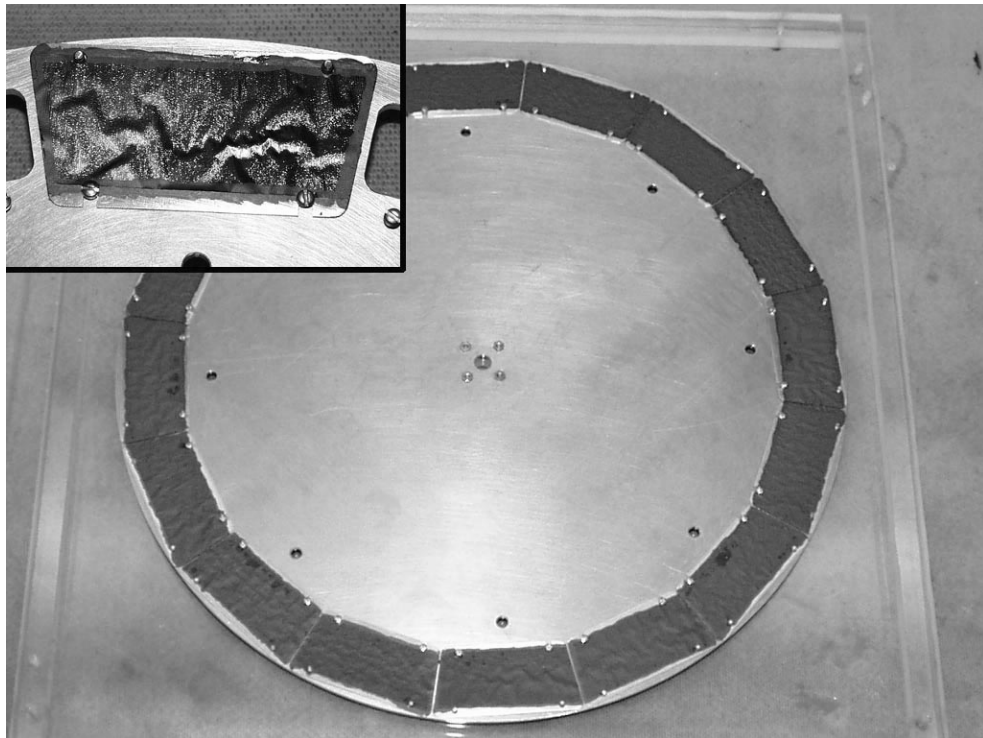


Figure 2. A photograph is shown of a completed target wheel with a close-up inset of an individual target foil.

Preparation and Characterization of C₆₀-Perdeuterated Styrene Copolymer Nanofilms

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Abstract

C₆₀-Perdeuterated Styrene Copolymer (C₆₀-DPS) was synthesized by the free radical polymerization. The C₆₀-DPS nanofilms were prepared by the Langmuir-Boldgett (LB) technique. The surface morphology and friction performance were characterized by atomic force microscopy (AFM). Results exhibit the presence of spherical granules in the compact LB films, which result from self-polymerization of C₆₀ and showed friction of the LB films increased basically as C₆₀ content of C₆₀-DPS decreased.

Introduction

Polymer nanofilms are useful in many practical and commercial applications such as sensors, detectors, displays, electronic circuit components and the investigation on interfacial phenomena of polymer[1,2]. Different techniques are used to prepare polymer nanofilms. The Langmuir-Boldgett (LB) technique is one of the most promising techniques for prepare super quality nanofilms, because it enables (1) deposition of thin films on almost any kind of solid substrate; (2) homogeneous deposition of large area of nanofilms; (3) the precise control of the nanofilms thickness; (4) deposition of multiplayer nanofilms with various composition[3]. Although the preparation and performances of the C₆₀ doping polymer thin films have attracted significant attention recently, the investigation on C₆₀ doping perdeuterated polymer have been reported rarely. In the present study, the C₆₀-Perdeuterated Styrene Copolymer (C₆₀-DPS) was synthesized by free radical polymerization and the nanofilms of C₆₀-DPS were prepared by LB technique. The measurement of surface morphology and friction performance of the nanofilms showed friction of the LB films increased basically as C₆₀ content of C₆₀-DPS copolymer decreased, and some rift-type defects in the nanofilms increased its friction.

Experiment Details

Perdeuterated styrene was purchased from Aldrich Chem. Co. It was treated with NaOD heavy water solution and pure heavy water, dried with calcium chloride and calcium hydride before used. C₆₀ was prepared by arc method, and purified through the alumina column. Added some amount of C₆₀ and catalyst into the toluene solution of the perdeuterated styrene, heated 24h at 60° C in an aqueous bath, washed reaction system with distilled water, and precipitated with methanol. The polymer powder was obtained by drying the precipitate in a vacuum oven. The IR spectra of the C₆₀-DPS samples were measured by the Nicolet 200SXV FT-IR spectroscopy.

C₆₀-DPS was dissolved in chloroform with a concentration of 3mg/mL. The LB trough used is produced by China Southeast University. A 0.4mL of the sample solution taken up by a micro syringe was spread on the aqua subphase in the LB trough. The C₆₀-DPS monolayer was formed at the high target pressure of 50mN/cm, and then the monolayer was transferred to a silicon wafer with dipping velocity 2mm/min. The silicon wafers were cleaned by soaking them in a hydrofluoric acid 24 hours, neutralizing with ammonia, washing ultrasonic with ethanol and

chloroform, rinsing thoroughly with ultra-pure water from Millipore Milli-Q plus water purifying system, and finally drying in a oven at 80°C.

Nanoscope IIIa AFM (Digital Instruments Inc.) was used to characterize the surface morphology and friction performance of the C₆₀-DPS nanofilms.

Results and Discussion

The C₆₀ content of the C₆₀-DPS used in the experiments are listed in Table 1. No significant difference was found between FTIR spectra in the C₆₀-DPS and perdeuterated polystyrene (DPS) (see Figure 1). This means that a small quantity of C₆₀ has no influence on the spectral property of DPS.

The surface pressure-molecular area (π -A) curve (see Figure 2) of C₆₀-DPS (4[#]) shows that solid condensed film is formed. The surface area per molecular is ~0.2nm²

. As the consequence

of C₆₀ doping, DPS, a typical hydrophobic molecular, is endowed with the amphiphilicity. The Langmuir film of the C₆₀-DPS can be formed at the air/water interface, and then be transformed on a solid substrate to prepare LB film.

Table 1 The C₆₀-DPS used in the experiments

No.	C ₆₀ content (wt%)
1	1.5
2	1.3
3	1.0
4	0.75
5	0.5
6	0.25

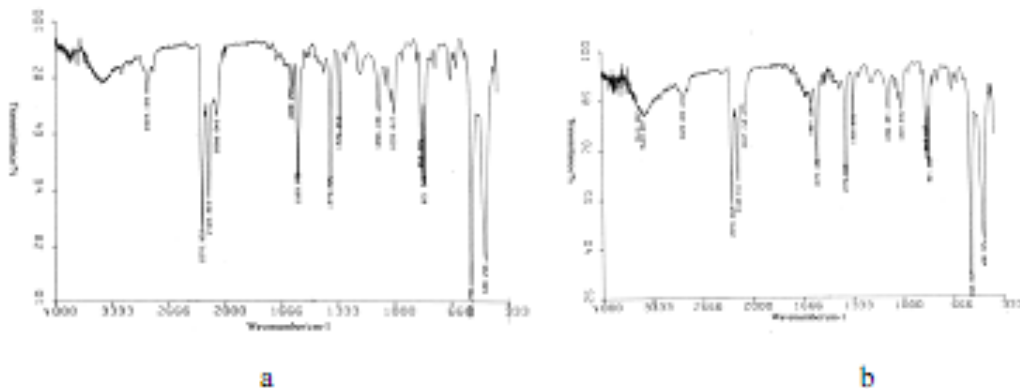


Figure 1 The FTIR spectra of DPS (a) and C₆₀-DPS (b)

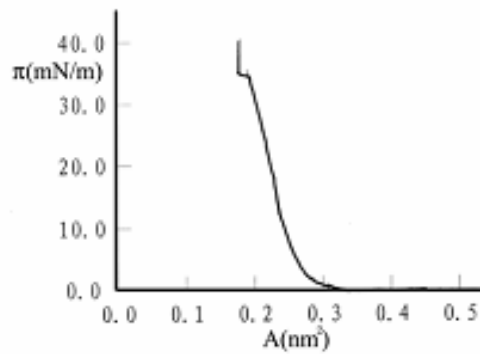


Figure 2 The π -A isotherms of C_{60} -DPS

The AFM images (Figure 3) of C_{60} -DPS LB films (surface pressure 50mN/m, dipping speed 2 mm/min, 6 layers) clearly display compact character of the LB films and exhibit the presence of spherical granules, which result from self-polymerization of C_{60} . Compared with reference [4], the C_{60} -DPS LB films are denser and more ordered. The friction performance measurement by lateral force microscopy (LFM) demonstrate friction of the LB films increase basically as C_{60} content of C_{60} -DPS decrease. In the sample b and c, friction of the LB films increased remarkably due to rift-type defects.

The AFM images of C_{60} -DPS LB films deposited at the different dipping speed show that the LB films formed at higher dipping speed don't possess the ordered structure (Figure 4).

Figure 5 a and b are the images of C_{60} -DPS LB films deposited at the different surface pressure. As shown as in the Figure 4, there are voids in the C_{60} -DPS LB films deposited at lower surface pressure. The voids disappear as the surface pressure increases.

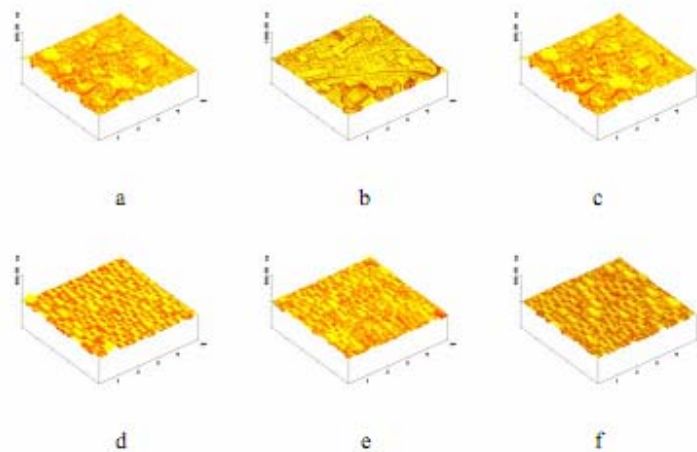


Figure 3 The AFM images of C_{60} -DPS LB films (surface pressure 50mN/m, dipping speed 2mm/min, 6 layers) a: 1[#], C_{60} -DPS, b: 2[#], c: 3[#], d: 4[#], e: 5[#], f: 6[#]

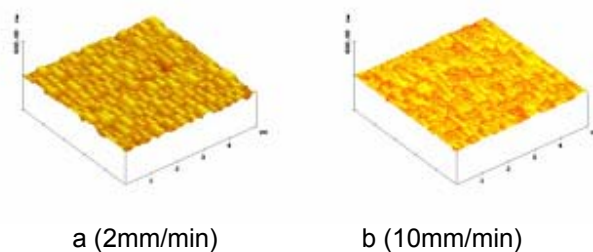


Figure 4 The AFM images of C_{60} -DPS LB films deposited at the different dipping speed

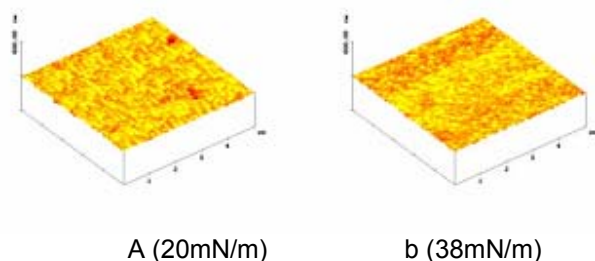


Figure 5 The AFM images of C_{60} -DPS LB films deposited at the different surface pressure

Conclusion

The paper reported the synthesis of C_{60} -Perdeuterated Styrene Copolymer (C_{60} -DPS) by the free radical polymerization and the preparation of LB films of the C_{60} -DPS. The AFM images showed the LB films were basically dense, and spherical granules, which result from self-polymerization of C_{60} in existence. The friction of the LB films increased basically as C_{60} content of C_{60} -DPS decreased. Some rift-type defects in the LB films increased friction of the LB films.

Reference

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REQUEST FOR INFORMATION

For experiments with LiNbO_3 we need transparent electrodes on our LiNbO_3 crystals. We tried to deposit a layer of ITO (Indium Tin Oxide) onto the surface, but our attempt failed – the layer was neither transparent nor conductive. After we put it into an oven for two hours at 400 °C, the layer became sort of transparent but still not conductive. Additionally the layer quality became faulty, since the color was not homogeneous and the layer was beginning to flake.

We used indium tin oxide vacuum deposition grade (99.99 %, metal base, In_2O_3 : SnO_2 90: 10 wt %) for the thermal evaporation.

What do we have to do to achieve a transparent conductive electrode of ITO?

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