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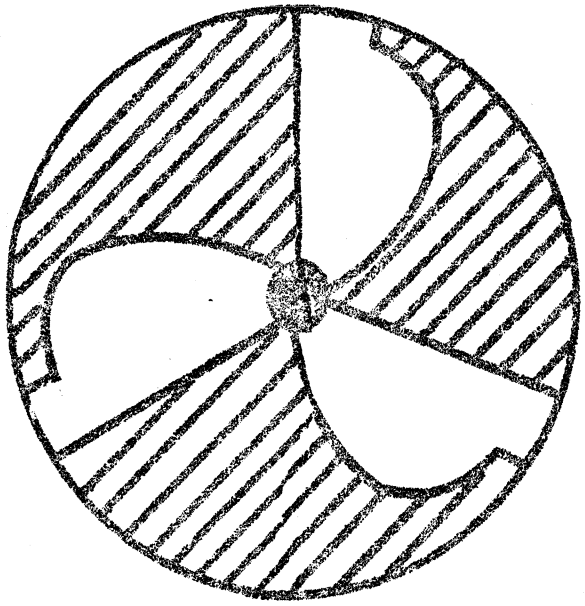

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# Preparation of Thin Film Deposits from Biological, Environmental and Other Matter*

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ABSTRACT

A technique for preparing uniform thin film deposits (10-1000 $\mu gm/cm^2$) of practically all materials of biological, environmental and nuclear physics interest is proposed. The technique involves preparing a solution or colloidal suspension of micron size particles of the substance of interest, generating a nebulized (practically invisible) mist from this liquid and condensing the mist on a rotating substrate. The cost in time and money for several materials is minimal.

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## INTRODUCTION

In the elemental analysis of materials employing nuclear reaction and scattering techniques,[1,2,3] it is necessary to prepare the sample in the form of a thin film (10-1000 $\mu gm/cm^2$). For metallic samples and some of their inorganic compounds the technique of vacuum evaporation is commonly employed. However for biological and environmental samples a new technique is needed. In the section below we describe a technique that enables one to prepare thin film deposits from such diverse materials as mineral and rock samples, animal tissue, blood and soluble salts using relatively inexpensive equipment. In certain materials like a whole fish, the uniformity of the deposit depends on the uniformity and size of the particles in the colloidal suspension that is prepared.

## PREPARATION AND DEPOSITION

Any material to be deposited must be first reduced to a solution or a suspension of microscopic particles ($\sim$1-10$\mu$) in an inert solvent (pure water is best for most materials). Table I gives a listing of the techniques used by the authors towards accomplishing this objective. The suspended or the dissolved material is placed in the container shown in the apparatus (called a Nebulizer[5]) in Fig. 1. The compressed gas (preferably

inert) forces the liquid through a small hole (at the top of the tube partially immersed in the liquid) in the form of a high speed spray which in turn impinges on an obstruction and thus breaks up into droplets of various sizes. The finest of these droplets are swept along by the gas escaping out of the nozzle. These droplets are so fine that they are not visible to the unaided eye. Illuminating the mouth of the nozzle reveals a cloudy mist (hence the name nebulizer) but the individual droplets are still not seen. The nebulized mist is then allowed to deoposit on a rotating substrate. By mounting the nebulizer bottle on a stand that performs a slow up and down (or sideways) oscillatory motion such that all parts of the substrate receive the mist for the same length of time, a very uniform deposit can be obtained. The microscopic size of these droplets is crucial to the success of this method in obtaining a thin uniform deposit for two reasons: i) The droplets evaporate immediately so that you do not get any streams of running fluid on the substrate and ii) Any one droplet brings such a small quantity of the suspended or dissolved matter with it that with a reasonably prolonged ($\sim$30 minutes) period of deposition, a uniform layer of the dissolved or suspended matter is obtained. (It is for these reasons that an atomizer is found to be useless for this application.) The heating coil in the figure is to inhibit

condensation of the mist in the nozzle (which gets cold due to the expansion of the compressed escaping gas) thus ensuring an unobstructed flow of the mist.

A microphotograph of the deposit from a sonicated whole fish (some skin removed) prepared in accordance with the procedure outlined in Table I is shown in Fig. 2. Particles of all sizes upto 5μ are seen with the majority in the range of 0.2-2μ. The larger particles are probably bone fragments and can perhaps be further broken down by using ultrasound of higher frequency and intensity or else eliminated by using a microfilter. None of these procedures were tried in the present work as the fish sample obtained seemed reasonably thin and uniform for our purpose. The density of deposit in the microphotograph was purposely kept low to clearly reveal the sizes of the various particles in the deposit. It should be noted that the various particles seem "larger than life" in the microphotograph because of diffraction effects.

## ELASTIC α-PARTICLE SCATTERING FROM A THIN WHOLE FISH DEPOSIT

An example of the use of a thin (~40μ gm/cm$^2$) whole fish deposit on formvar in a 22 MeV α-particle scattering measurement is shown in Fig. 3. The object of this measurement is to show the potential of the heavy particle nuclear scattering technique to reveal the complete elemental composition of a biological (or

any other complex material) specimen. The energy resolution (essential for separating neighboring heavy elements[3]) is not the best achievable but is quite adequate for revealing most elemental components of the sample analysed here. The large Hg peak corresponds to a $\sim 10^{-9}$ gm concentration in the sample. Details of this and other analyses for elemental composition of fish, human blood, milk, etc. are given in a separate paper[3] by the authors.

## CONCLUSION

The technique is very simple, quick and inexpensive for preparing thin uniform deposits of any material that can be reduced to a solution or a colloidal suspension of microscopic particles. The uniformity of the deposit thickness depends on the size of the particles in the sense that several layers of very small particles will certainly produce a uniform deposit.

## ACKNOWLEDGEMENTS

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## REFERENCES


1. B.L. Cohen and R.A. Moyer, Analytical Chem. 43, 123(1971).
2. R.K. Jolly, C.R. Gruhn, and C. Maggiore, IEEE, Vol. NS-18, No.1 p. 91(1971).
3. R.K. Jolly and H.B. White (to be submitted to Nuclear Inst. and Methods).
4. For example one marketed by McCrone Research Associates Ltd. 2 McCone Mews, LONDON NW3.
5. For example Nebulizer 180 commerically marketed by DeVilbiss Company of Somerset Pa.

TABLE I

Reduction of Biological, Environmental and Other Matter to a Solution or Colloidal Suspension

| Class of Materials | Technique for Reduction |
|---|---|
| I. Animal Tissue, Plants etc. | Slow freezing to rupture the cells followed by i) reduction to a liquidized form by a high speed blender (e.g. Waring Scientific Blender. 15,000 rpm model.) and ii) immersion of an ultrasonic probe in the liquidized sample for several minutes (length depending on the quantity and type of material). |
| II. Blood, Milk etc. | Sonication with an ultrasonic probe if necessary to break up the individual cells (25-50μ). In some applications (proton scattering, x-ray florescence) these substances may be deposited without any sonication. |
| III. Rock, Dry Wood etc. | Grinding in a tungsten carbide mortar and pestle or a micronising mill[4] and subjecting a paste of the material to sonication (with an ultrasonic source) if necessary. |
| IV. Beverages and soluble Materials, etc. | May be simply dissolved or diluted in pure water before deposition. |

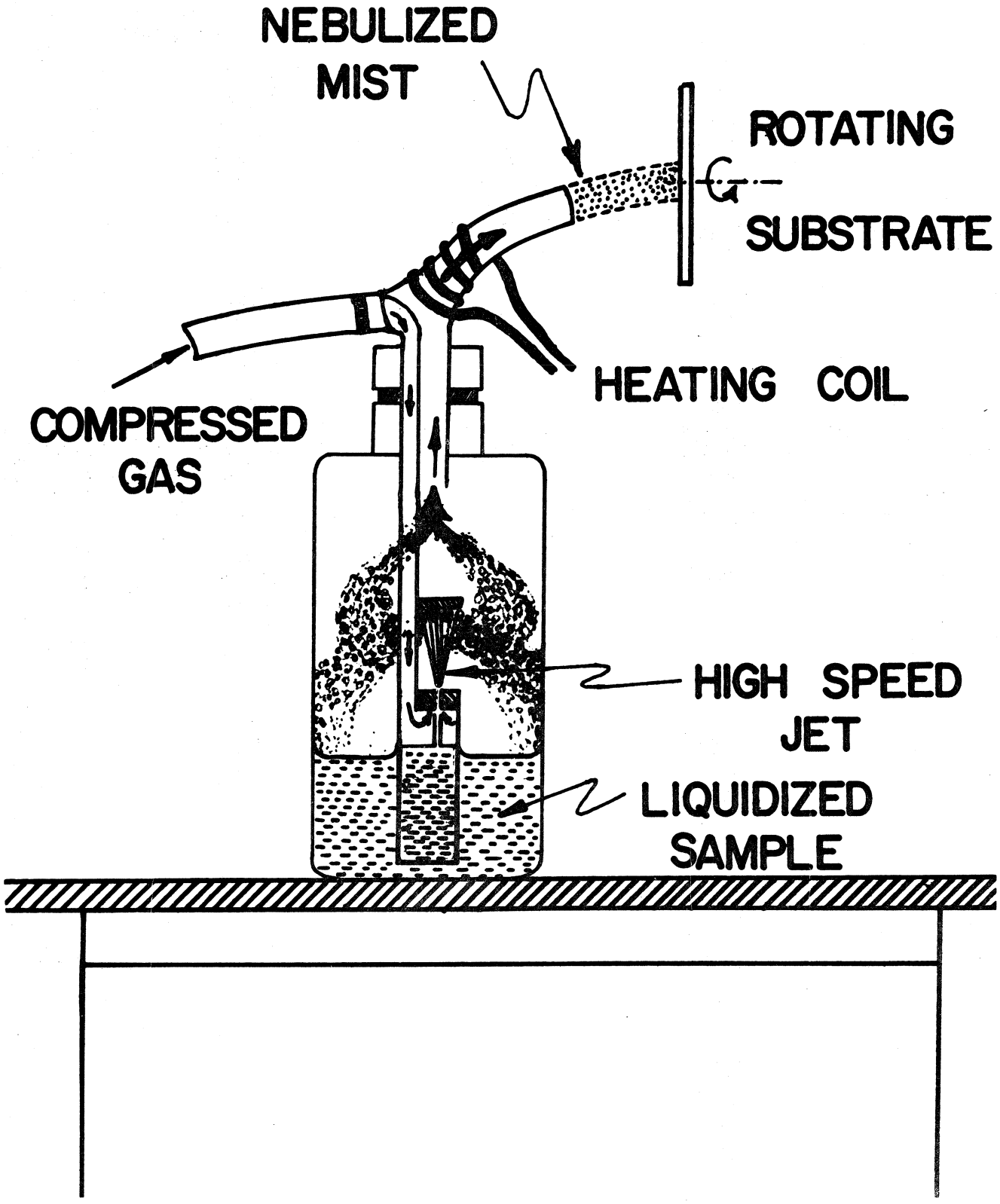
## FIGURE CAPTIONS

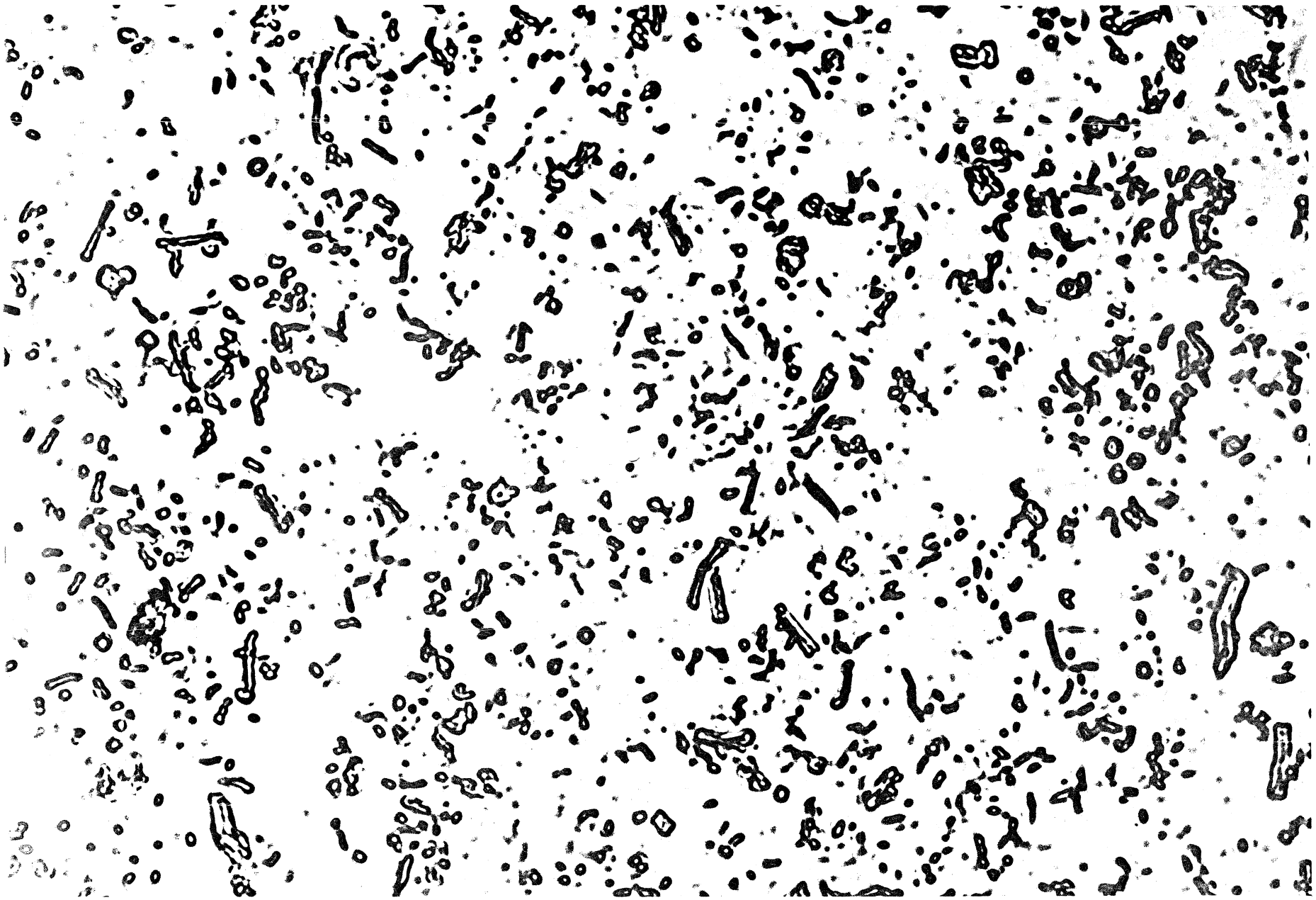
Figure 1 An illustrative drawing of the apparatus used for depositing a thin film of dissolved or suspended matter on a substrate. The heating coil is to inhibit condensation in the nebulizer nozzle. See text for details.

Figure 2 A microphotograph of particles of whole fish deposited on a glass slide. The scale is shown at the top of the microphotograph. The deposit is delibrately kept thin to reveal the sizes of the various particles. See text for details.

Figure 3 An energy spectrum of α-particles scattered from the various elemental components (indicated above each elastic peak) of a whole fish. The fish target ($\sim$80 $\mu$gm/cm$^2$) was prepared using the technique outlined in the present paper. See text for references to the scattering technique for elemental analysis.

Fig. 1


NEBULIZED
MIST
ROTATING
SUBSTRATE
HEATING COIL
COMPRESSED
GAS
HIGH SPEED
JET
LIQUIDIZED
SAMPLE




SONICATED WHOLE FISH

Fig. 2

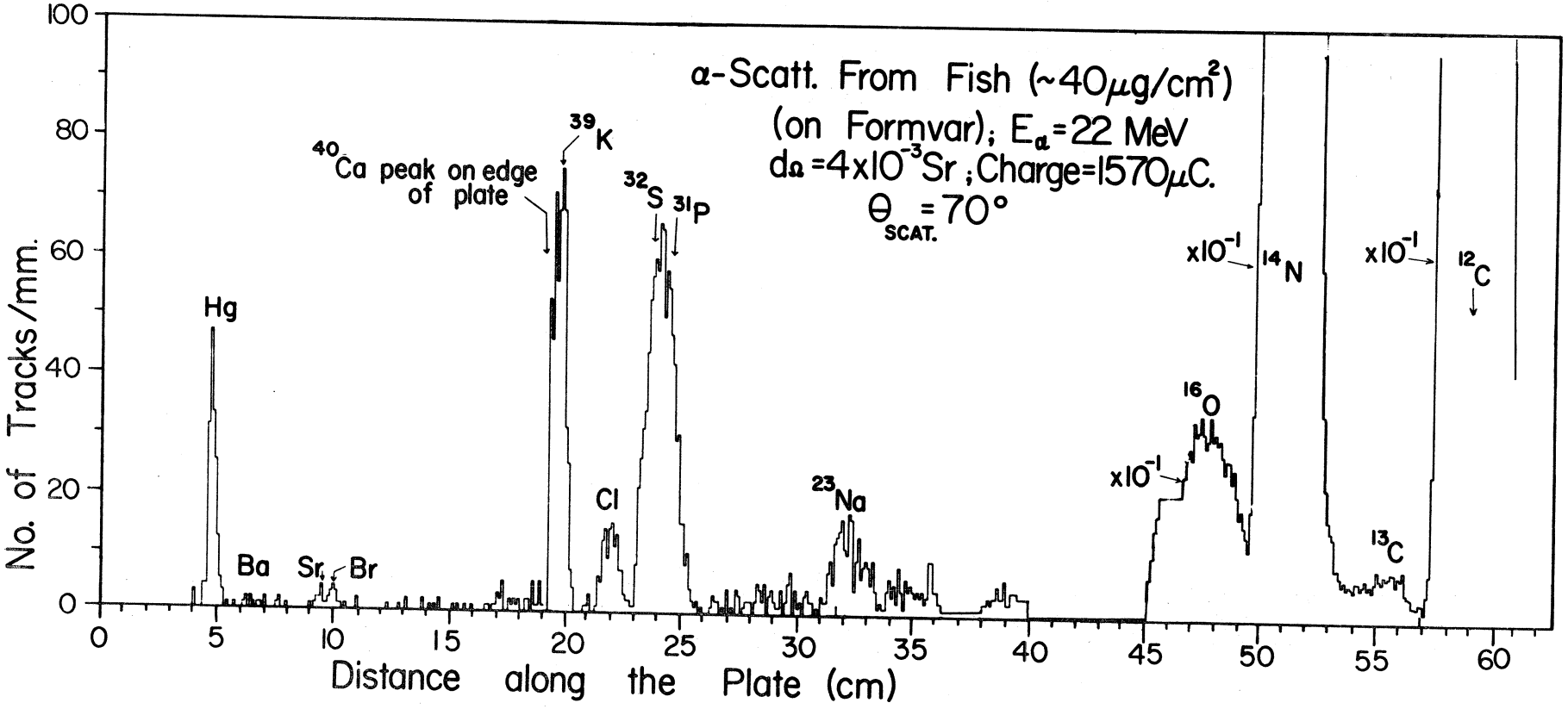

α-Scatt. From Fish (~40μg/cm²)
(on Formvar); Eα=22 MeV
dΩ=4x10⁻³Sr ; Charge=1570μC.
θ SCAT. = 70°
40Ca peak on edge of plate
39K
32S
31P
Hg
Ba
Sr
Br
Cl
23Na
x10⁻¹
16O
14N
13C
12C
No. of Tracks/mm.
Distance along the Plate (cm)
0
5
10
15
20
25
30
35
40
45
50
55
60
0
20
40
60
80
100

Fig. 3