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A NEW DEPOSITING METHOD OF LANGMUIR-BLODGETT FILM OF FATTY ACID SOAP AS A RADIOACTIVE SOURCE

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A stable radioactive source in vacuo was obtained by a new depositing method of Langmuir-Blodgett (L/B) film. In spite of the slight consumption of the substrate solution (only 2-2.5 ml) for preparing a 15 mm x 25 mm sized L/B film containing four molecular layers of ^{109}Cd-eicosanoate, the deposition of the film was complete.

A Langmuir-Blodgett(L/B) multilayer film is superior to the ordinary vacuum deposition films in the homogeneity of the lateral direction and the uniformity of the thickness together with other advantages of their easy and reliable controllability. The L/B film of soap of a radioactive metal is, therefore, expected to be an excellent radioactive source. One big problem is, however, that a great amount of radioisotope is necessary for the preparation of a high radioactive L/B film by the commonly used depositing method, i.e., the vertical dipping method.[1] To reduce the amount of the radioactive material in its built-up process, a new depositing method was devised. To make sure the reliability of the new method, the linear relationship was confirmed between the radioactivity and the deposited amount of the source obtained by the new method, and the stability of the source under high vacuum was also examined.

A sample of eicosanoic acid (purity of 99.5%, Fulka AG. Swizerland) was dissolved in benzene to make a spreading solution of 1 x 10^{-3}M. 500 μCi of carrier free cadmium-109 was supplied from Amersham (Buckinghamshire, England) as $^{109}CdCl_2$ in 0.1 M HCl. After the isotopic dilution with $CdCl_2$ and the removal of the HCl by distillation from the solution, the aqueous solution of

radioactive $CdCl_2$ (specific activity of 0.9 Ci/mol) was prepared. The concentration and pH of the solution were 1.2×10^{-4} M and 7-7.8, respectively.[2] The pH of the solution was adjusted by the addition of the small amount of the aqueous solution of NaOH (electronic grade, Kanto Chemical Co., Tokyo). Ferric octadecanoate (the purest grade of Tokyo Kasei Industry Co., Tokyo) was used for the pretreatment of the surface of a resistive substrate plate (15 mm x 25 mm x 1 mm, Japan Fine Co., Tokyo) which was made from a mixture of ruthenium oxide with glass and printed on an alumina plate. Water for the underlying ^{109}Cd-solution was triply distilled, the second distillation from alkaline permanganate, and was contained in a very shallow Teflon trough (15 mm x 120 mm x 1 mm or 0.5 mm) whose inside was hydrophilic by the glow discharge in an oxygen gas atmosphere,[3] and whose rims remained hydrophobic by protective adhesive tapes. The hydrophilic property of the inside of the trough is very important because an aqueous solution on a hydrophobic surface has a large contact angle and does not spread fully on the surface. If the inside of the shallow trough is hydrophobic, the small amount of the aqueous solution, therefore, can not fill the trough. Only 2-2.5 ml of solution was required to fill the hydrophilic trough. After sweeping the solution surface by a hydrophobic glass barrier treated with dimethyldichlorosilane,[4] a thin mica plate (13.5 mm x 15 mm x 0.1 mm) coated with paraffin was placed on the surface and used as a movable barrier. The floating barrier can move smoothly by the repulsion[5] between the hydrophilic trough and the hydrophobic ends of the movable barrier. The monolayer of ^{109}Cd-eicosanate was deposited at the surface pressure of 30 mN/m with 9-octadecenoic acid (the purist grade of Merck AG., Darmstadt, German) by using a new apparatus shown in Fig.1-a. After touching the resistive plate slowly on the monolayer surface from its one end, the plate was turned gradually, lifted and removed finally from the surface. Two molecular layers of the ^{109}Cd-eicosanoate were deposited on the resistive plate by this process. The repetition of this process produced an additional deposition of two molecular layers. This new depositing method giving Y-film resembles the horizontal lifting method[6] which gives X-film. The radioactivity of the L/B film was detected with a coaxial Ge (Li) detector (ORTEC Inc. Co., Oak Ridge, USA); a known amount of ^{109}Cd-sample was used for the calibration of the radioactivity.

Figure 2 shows the relationship between the radioactivity and the number of monolayers of ^{109}Cd-eicosanoate deposited on the resistive plate. A good

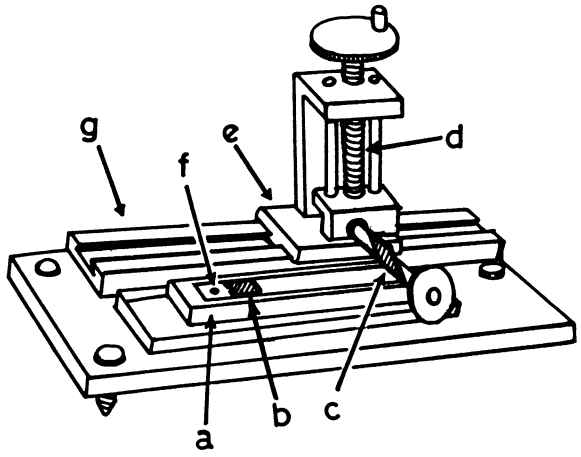

Fig. 1-a. Apparatus for the depostion of Langmuir-Blodgett film
a, Teflon trough whose inside is hydrophilic;
b, Floating barrier coated with paraffin;[7)]
c, Resistive plate for built-up film;
d, Lifting screw;
e, Slide unit;
f, 9-octadecenoic acid drop as a piston oil;
g, Track rail.

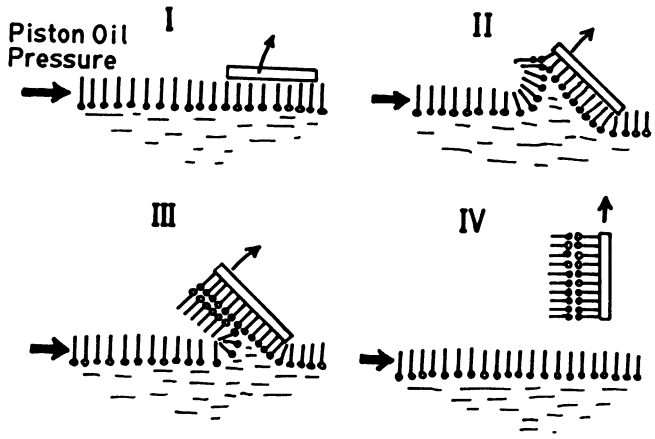

Fig. 1-b. Scheme of the deposition process of ^{109}Cd-eicosanoate monolayer on a resistive plate.

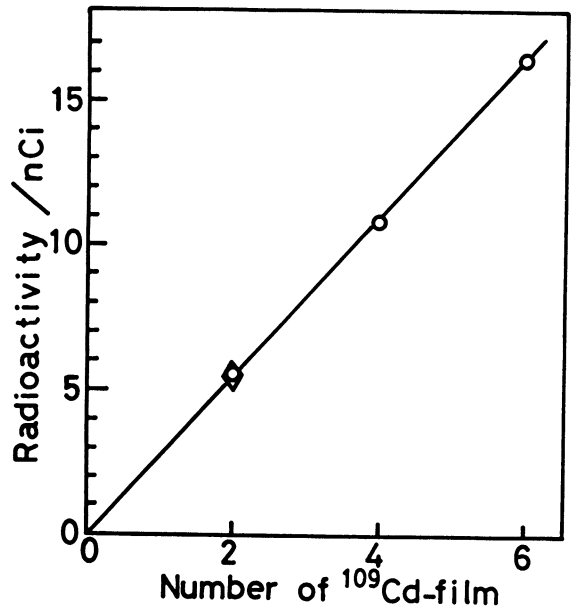

Fig. 2. Relationship between the radioactivity and the number of ^{109}Cd-eicosanoate monolayers deposited on resistive plate at 298 K.
A full diamond denotes the calculated value.

linearity was obtained. In this fugure the full diamond, whose value is calculated from the specific activity of the $^{109}CdCl_2$, the molecular area of the eicosanoic acid at the pressure of 30 mN/m and the number of layers, agrees exactly with the experimental result. These evidence suggests that the deposition of the ^{109}Cd-eicosanoate monolayer on the resistive plate was perfectly achieved by this method. This suggestion has been also confirmed by the fact that the transfer ratio of the ^{109}Cd-eicosanoate monolayer on the resistive plate was exactly unity. For the application of the L/B film of ^{109}Cd-eicosanoate as the radioactive source, its stability in vacuo is essential, because the radioactive sources are often used under high vacuum. An aluminium plate was fixed in front of the L/B film of the ^{109}Cd-eicosanoate with a 1 mm gap; the whole source, including the plate and the ^{109}Cd-film, was set in a vacuum chamber and evacuated to a pressure of 10^{-5}mmHg at room temperature for a week. After the experiment, the radioactivities of the L/B film and the Al plate were detected, respectively. Reduction of the radioactivity of the L/B film was not recognized, and the radioactivity was not detected from the Al plate. Furthermore, the contents in a liquid nitrogen trap did not show any radioactivity of ^{109}Cd. The stability of the L/B film in vacuo was thus confirmed. The new depositing method for the L/B film is, therefore, excellent for manufacturing the radioactive source and thought to be also applicable for the deposition of other valuable materials.

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