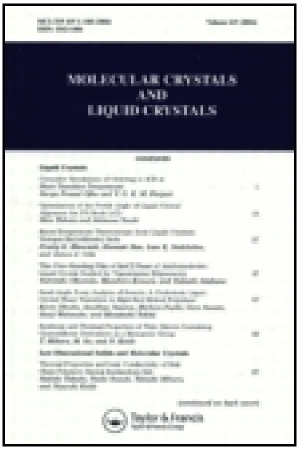

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A Novel Modular Langmuir-Blodgett/ Montal-Mueller Trough

L. S. Miller [a], A. L. Rhoden [a] & A. J. Cranston [a]
[a] Coventry University, Priory Street, Coventry, CV1 5FB, UK
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A NOVEL MODULAR LANGMUIR-BLODGETT/MONTAL-MUELLER TROUGH

L.S.MILLER, A.L.RHODEN and A.J.CRANSTON
Coventry University, Priory Street,Coventry CV1 5FB, UK.

Abstract

A modular trough has been designed to facilitate both classical LB techniques and those developed initially by Montal and Mueller for the study of biomolecular membranes. The trough is a development of the 'diamond design' previously reported. The barriers can vary the surface area between 115 cm^2 and 17.5 cm^2 in a design deliberately made small to achieve a low subphase volume of about 550 cm^3. The latter is important (because of cost) when working with biomolecules that are soluble in the subphase. In the Montal-Mueller mode the design facilitates control of surface pressure. The surface flow is channelled by shoulders to produce near-normal flow at an LB substrate, and high quality films are produced.

INTRODUCTION

Two key techniques in the study and application of organic surface films are first the Langmuir-Blodgett (LB) deposition technique[1] and the associated Langmuir film study, and secondly the Montal-Mueller[2] (MM) bilayer technique. The LB technique is concerned with the deposition of films onto a solid substrate (one monolayer at a time) and requires close control of surface pressures of the films on the water subphase before deposition. The MM technique has traditionally utilised natural biological materials (e.g. lipids) to form a bilayer stretched across a small hole which separates two aqueous subphases; this is done by raising the water surface on either side of the hole subsequent to the spreading of the lipid, and without close control of surface pressure. This is very similar to deposition of the first layer of an LB film on a hydrophobic surface (with a hole in it), except that in the MM technique the water is raised rather than the sample being lowered. The reason for this is that it is necessary to ensure complete electrical isolation between the two subphases to facilitate electrochemical measurements of the film properties. This can only be achieved effectively if two separate compartments are used so that the only possible path between the two is via the dry surfaces of the trough material (ideally PTFE).

Monolayers at the air-water interface can be formed or modified by direct application of material to that interface or by absorption of material from the subphase[3,4]. In the latter case in particular, the difficulty or cost of obtaining the active molecules gives an advantage to troughs having a low subphase volume.

The present design is primarily aimed at achieving Montal-Mueller deposition but with full control of surface pressure as utilised in LB work, and with a low working subphase volume.

CONSTRUCTIONAL DETAILS

Figure 1 shows the trough in use for Langmuir-Blodgett deposition. The two identical blocks (Figure 2) are bolted securely to aluminium bases and then clamped together on an optical table. PTFE tape is used to ensure a water-tight seal between the two halves.

Two transverse rods (which are PTFE covered stainless steel) are pulled outwards by position controlled motors using threads which are wrapped onto drums in the manner previously described[5,6]. Each rod is driven by only one motor via a long spindle to each of the drums, but is tensioned by two springs (one on either side of the trough) as shown. The rods rest in u-shaped cups fixed to the centre sections of the barriers, and so move the barriers. The latter are each constructed from a single piece of PTFE for maximum cleanliness. Thin regions act as hinges to allow for the necessary movement, and partly circular regions (as in a 'jig-saw puzzle') enable them to engage securely with the walls of the trough in a manner that inhibits leakage of the surface monolayers.

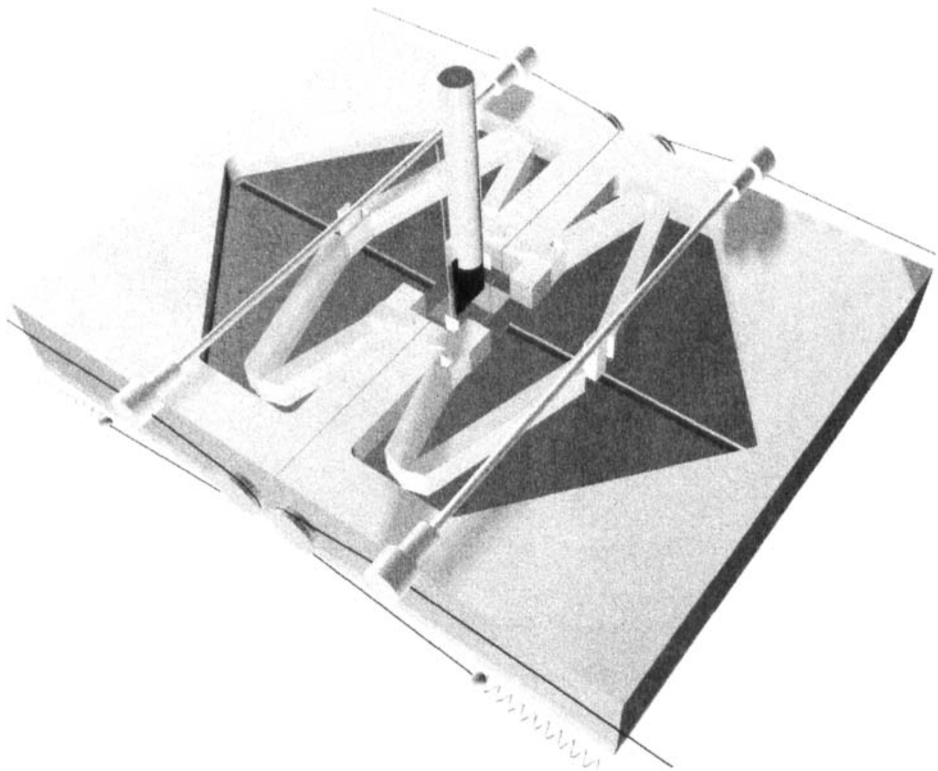

FIGURE 1. The overall form of the trough as an LB trough.

Two Whilhelmy plates are shown in Figure 1, but only one would be used for normal deposition in which the two barriers are controlled similarly to achieve symmetric deposition. The sample is dipped in the central well using a rod mounted on a linear translation stage which is pulled upwards via a thread and downwards by gravity.

By inserting an extra central region it will be possible to achieve a deeper dipping well or an alternating-layer geometry if required.

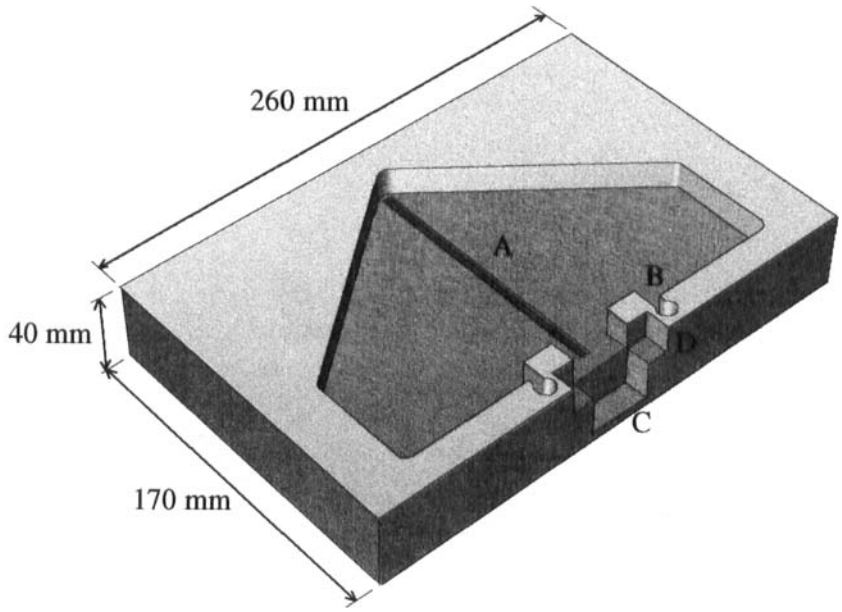

FIGURE 2 . The form of the main PTFE blocks used in the construction of the trough. A groove (A) guides the barrier, which locates in grooves of part-cylindrical form (B). A well (C) allows for LB dipping, and shallower wells (D) for the Whilhelmy plate(s).

FLOW PATTERNS

Figure 3 shows flow patterns measured[7] with the trough configured as in figure 1. The starting point (darker barrier) corresponds to the presence of a compressed monolayer. Small PTFE discs were placed on this and an LB deposition undertaken. The lines show the motion of the discs as the deposition occurred. The flow is essentially normal to the substrate due to being channelled by the shoulders (B). This has been shown to give deposition of high-quality films, but clearly would not be suitable for certain applications where possible ordering of the films by the flow is required to be avoided or the surface monolayer is very rigid.

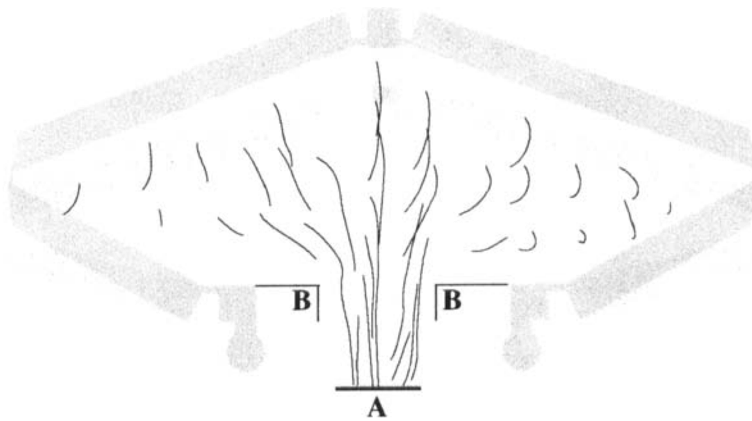

FIGURE 3. The flow pattern measured during symmetric LB deposition (trough configured as in Figure 1).

THE MONTAL-MUELLER TECHNIQUE

Figure 4 shows the central region of the trough when it is configured for the MM technique. A thin sheet of PTFE with a small hole in it is clamped between the two main blocks. The only possible electrical connections between the two (now separated) subphases are through the small hole (over which the bilayer will be formed) or via external (dry) PTFE surfaces. The two Whilhelmy plates are now in separate compartments, each also with its own barrier. Thus the surface pressure in each compartment may be separately controlled. In operation, the barriers are used to set the desired surface pressures before raising the water levels to form the MM bilayer. This gives additional control compared to most designs of MM trough; it is possible because of the use of continuous barriers which accommodate the differing levels as the water is raised by raising reservoirs connected by tubes to the two subphases.

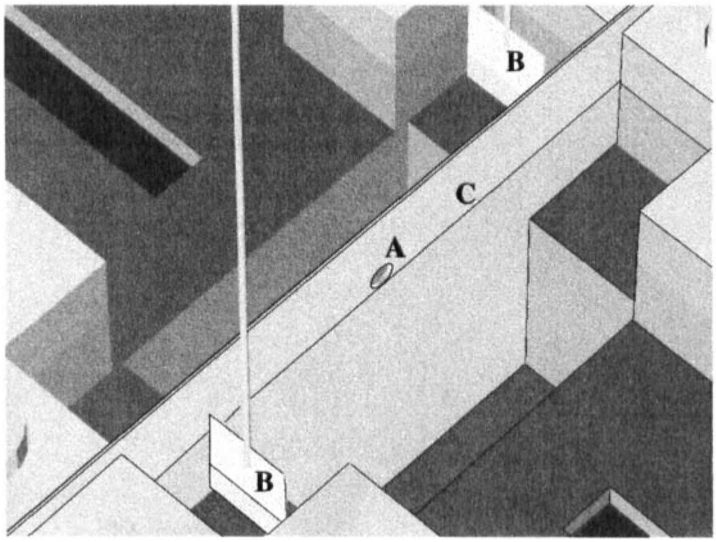

FIGURE 4. The Montal-Mueller barrier, with hole (A), in position dividing the two halves of the trough each with its own Whilhelmy plate (B). The water level is at (C).

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