KSV NIMA
Langmuir and Langmuir-Blodgett Deposition Troughs
KSV NIMA Langmuir and Langmuir-Blodgett Troughs are the leading and most widely used instruments for Langmuir film fabrication, Langmuir film characterisation (including microscopy) as well as Langmuir-Blodgett film deposition.

KSV NIMA Langmuir and Langmuir-Blodgett Troughs are used for the fabrication and characterisation of single molecule thick films that offer precision control over the lateral packing density of molecules.

Following characterisation studies of the unique properties of molecules in monolayers, the instruments can also be used to transfer these monolayers using a Langmuir-Blodgett or Langmuir-Schafer deposition technique. This enables you to create single and multilayer films with precise control of thickness, molecular orientation and packing density.

Applications

The fabrication of insoluble monolayers, at either the gas/liquid or liquid/liquid interface, with controlled packing densities (Langmuir films) and the creation and transfer of such well-ordered functional films to solid surfaces (Langmuir-Blodgett films) find use in a myriad of nanotechnology applications:

- Biomembranes and molecular interactions
  - Modelling of biological system (e.g. mimicking cell membranes)
  - Chemistry of biologically active molecules
  - Drug delivery and behaviour
  - Immunologic and enzyme-substrate reactions
  - Biosensors and surface immobilized catalysts

- Organic and inorganic coatings
  - Functional coatings with optical, thermal or conductive properties
  - Protective coatings (e.g. for semiconductors, optics...)
  - Novel coatings with nanotubes, nanowires, graphenes...
  - Smart surfaces

- Surfactants and colloids
  - Surfactant formulation
  - Colloid stability
  - Emulsions, dispersions, foams stabilization

- Rheology of thin films
  - Dilational rheology
  - Interfacial shear rheology
  (with the KSV NiMA Interfacial Shear Rheometer)

Technology

Langmuir Troughs

Langmuir Troughs are used to create, modify and study monolayers at either the gas-liquid or liquid-liquid interface (Langmuir films). A Langmuir film can be defined as an insoluble monolayer of functional molecules, nanoparticles, nanowires or microparticles that reside at the gas-liquid or liquid-liquid interface. The fact that these molecules can move freely at the interface provide great flexibility for the control of the packing density and the study of monolayer behaviour.

Once compressed, a monolayer film can be considered to be a two-dimensional solid film with a surface area to volume ratio far above that of bulk materials. At these conditions, materials often yield fascinating new properties. The Langmuir Trough allows you to infer how particular molecules pack together while confined in two dimensions. The surface pressure-area isotherm can also provide a measure of the average area per molecule and the compressibility of the monolayer.

In a typical isotherm measurement a monolayer is organized under compression, starting from a two dimensional gas phase moving through a liquid phase to a fully organised solid phase. In the gas phase the molecules are not interacting with each other. When the surface area is decreased the molecules become more closely packed and start to interact with each other. At the solid phase the molecules are completely organized and the surface pressure increases dramatically. At the maximum surface pressure the collapse point is reached after which the monolayer packing is no longer controlled.
KSV NIMA Langmuir troughs enable measurements of:

<table>
<thead>
<tr>
<th>MEASUREMENT</th>
<th>INFORMATION</th>
</tr>
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<tbody>
<tr>
<td>Isotherms</td>
<td>Structure, area, interactions, phase transitions, compressibility, hysteresis</td>
</tr>
<tr>
<td>Isobars/Isochors</td>
<td>Stability</td>
</tr>
<tr>
<td>Surface potential*</td>
<td>Dissociation, orientation, interactions</td>
</tr>
<tr>
<td>Dilational rheology</td>
<td>Film viscoelastic properties</td>
</tr>
<tr>
<td>Kinetics</td>
<td>Polymerisation and enzyme kinetics</td>
</tr>
<tr>
<td>Conductivity</td>
<td>Lateral conductivity</td>
</tr>
<tr>
<td>Environment monitoring</td>
<td>pH and temperature</td>
</tr>
</tbody>
</table>

* available as an option

**Langmuir-Blodgett Deposition Troughs**

A Langmuir-Blodgett Deposition Trough is very similar to a Langmuir Trough: it also enables Langmuir film fabrication at the gas-liquid interface. In addition, it is equipped with a dipping well and a dipper for Langmuir film deposition onto solid substrates at a desired packing density (typically in solid phase).

Following compression, Langmuir-Blodgett Troughs are used to transfer Langmuir films to solid substrates in a controlled environment. In the case of Langmuir-Blodgett (LB) deposition the sample is moved vertically through the monolayer while with the Langmuir-Schaefer (LS) method the sample is brought to the interface horizontally.

Nanoscale films of custom thickness can be built up by repeating the deposition techniques. When using the LB and LS techniques, both hydrophilic and hydrophobic samples can be coated with a monolayer from either the liquid phase or the gas phase.

Alternate deposition is possible when using a system with two monolayer compression compartments and one empty compartment:

The dipping sequence can take any path between the three compartments for an unlimited number of cycles. The movement of the sample is fully automated and programmable.

1. Sample in clip-holder. Two monolayers (violet and dark blue) on a common subphase (light blue).
2. First layer. The upper arm brings the sample down through the film. The lower arm receives the sample. The deposition cycle could also start from the subphase.
3. Change compartment. The lower arm can rotate to either the other monolayer compartment or the empty compartment if required.
4. Second layer. The lower arm takes the sample up and passes it to the upper arm (the sample could go through any of the two monolayers, from any side).

Density, thickness and homogeneity properties are preserved when transferring the Langmuir film onto the sample, giving the possibility to make organized multilayer structures with varying layer composition. Compared to other organic thin film deposition techniques, LB is much less limited by the molecular structure of the functional molecule. This means that it is often the only technique that can be used for bottom-up assembly.
Working principle

In brief, an aqueous subphase is confined in a shallow chamber in the trough top and the monolayer is compressed by the barriers. Surface pressure changes during compression are measured by the surface pressure sensor. The dipping mechanism is used to transfer the monolayer to a solid substrate. The Interface Unit and KSV NIMA LB software enable data transfer and recording.

Product range

KSV NIMA Langmuir Troughs

Conventional Langmuir trough
The conventional KSV NIMA Langmuir Trough is available in several sizes: Extra Small, Small, Medium and Large. It is important to stress that all systems can be easily switched between the Langmuir, Langmuir-Blodgett and Microscopy configurations. The three smaller troughs use the same frame providing the flexibility to change the trough top size at any time. The Large, Liquid-Liquid and High compression troughs (ISR trough) use larger frames but still allow the use of the smaller trough tops, Extra Small, Small and Medium. The Medium and Large systems can be used with Brewster Angle Microscopes (KSV NIMA BAM only fits on the Large systems) for monolayer imaging. The Small, Medium and Large systems allow the use of KSV NIMA SPOT [Surface Potential Sensor] for monolayer electrical property characterisation and KSV NIMA PM-IRRAS, an infrared technique for determination of molecular orientation and chemical composition.

High compression trough (ISR Trough)
A longer but narrower Langmuir trough enabling high compression ratio (up to 45:1). Specifically designed for the KSV NIMA Interfacial Shear Rheometer (ISR), the high compression trough can also be used for increased performance with Brewster Angle Microscope (MicroBAM), Surface Potential Sensor, PM-IRRAS and other characterisation instruments.

Liquid-liquid trough
A Liquid-Liquid Langmuir Trough is available for monolayer studies at the liquid-liquid interface (typically, oil-water). The liquid-liquid trough top is built on the same frame as the high compression trough.

Many experimental techniques can be used to further investigate monolayers at the gas-liquid interface even before deposition. These include:

- Kinetic measurements (subphase injection / vapour exposure adsorption dynamics)
- Electrical conductivity measurements
- Interfacial shear rheometry for 2D rheology (KSV NIMA ISR)
- Brewster angle microscopy (KSV NIMA BAM, KSV NIMA MicroBAM)
- Surface potential measurements (KSV NIMA SPOT)
- Infrared reflection absorbance spectroscopy (KSV NIMA PM-IRRAS)
- Other vibrational spectroscopies
- UV-VIS absorbance spectroscopy
- Optical and fluorescence microscopy
- X-ray reflectometry

KSV NIMA Langmuir-Blodgett Deposition Troughs

Conventional LB Deposition Trough
The KSV NIMA LB Deposition Trough is available in several sizes: Small, Medium and Large. It is important to stress that all systems can be easily switched between the Langmuir, Langmuir-Blodgett and Microscopy configurations. All Small and Medium troughs use the same frame providing the flexibility to change the trough top size at any time.

You can deposit LB films on samples ranging in size from a few square millimetres to many tens of square centimetres. Dipping well dimensions, and hence suitable substrate areas, are dependent on the model of trough and trough tops (see specification table). The LB dipping mechanism can also be fitted with a LS deposition kit for high optical transmission down to a wavelength of 200nm (suitable for visible light or UV microscopy). The Medium and the High compression troughs (ISR trough) use larger frames but still allow the use of the smaller trough tops, Extra Small, Small and Medium. The Medium and Large systems can be used with Brewster Angle Microscopes (KSV NIMA BAM only fits on the Large systems) for monolayer imaging. The Small, Medium and Large systems allow the use of KSV NIMA SPOT [Surface Potential Sensor] for monolayer electrical property characterisation and KSV NIMA PM-IRRAS, an infrared technique for determination of molecular orientation and chemical composition.

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- Surface potential measurements (KSV NIMA SPOT)
- Infrared reflection absorbance spectroscopy (KSV NIMA PM-IRRAS)
- Other vibrational spectroscopies
- UV-VIS absorbance spectroscopy
- Optical and fluorescence microscopy
- X-ray reflectometry

KSV NIMA Microscopy Troughs

The KSV NIMA Microscopy Trough is a special kind of Langmuir trough, which contains a sapphire window in the trough top base allowing high optical transmission down to a wavelength of 200nm (suitable for visible light or UV microscopy). The Medium and the High compression troughs are both suitable for upright and inverted microscopy. The Small trough can be used for upright microscopy.

| 1 – Frame | 4 – Surface pressure sensor |
| 2 – Barriers | 5 – Dipping mechanism (LB option) |
| 3 – Trough top | 6 – Interface Unit |
**Technical specifications and compatibility chart**

<table>
<thead>
<tr>
<th></th>
<th>Extra Small</th>
<th>Small</th>
<th>Medium</th>
<th>Large</th>
<th>Liquid-Liquid</th>
<th>(ISR) High compression</th>
<th>Alternate</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>General specifications</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Surface area (cm²)</td>
<td>150</td>
<td>98</td>
<td>273</td>
<td>841</td>
<td>580 (423*)</td>
<td>587</td>
<td>930 (627*)</td>
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<tr>
<td>Trough top inner dimensions (L x W x H mm)</td>
<td>300 x 50 x 1,2</td>
<td>195 x 50 x 4</td>
<td>364 x 75 x 4</td>
<td>580 x 145 x 4</td>
<td>784 x 74 x 7 (784 x 54 x 5&quot;)</td>
<td>782 x 75 x 5</td>
<td>775 x 120 x 10 (627&quot;)</td>
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<tr>
<td>Barrier speed (mm/min)</td>
<td>0.1...270</td>
<td>0.1...270</td>
<td>0.1...270</td>
<td>0.1...270</td>
<td>0.1...270</td>
<td>0.1...270</td>
<td>0.1...200</td>
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<tr>
<td>Balance measuring range (mN/m)</td>
<td>0...150</td>
<td>0...150</td>
<td>0...150</td>
<td>0...150</td>
<td>0...150</td>
<td>0...150</td>
<td>0...150</td>
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<td>Maximum balance load (g)</td>
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<td>1</td>
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<tr>
<td>Balance resolution (μN/m)</td>
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<td>4</td>
<td>4</td>
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<tr>
<td><strong>Langmuir trough top</strong></td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>-</td>
</tr>
<tr>
<td><strong>Total subphase volume (mL)</strong></td>
<td>18</td>
<td>39</td>
<td>109</td>
<td>336</td>
<td>406 (212&quot;)</td>
<td>293</td>
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</tr>
<tr>
<td><strong>Langmuir-Blodgett trough top</strong></td>
<td>-</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>-</td>
<td>-</td>
<td>•</td>
</tr>
<tr>
<td><strong>Total subphase volume (mL)</strong></td>
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<td>57</td>
<td>176</td>
<td>578</td>
<td>-</td>
<td>-</td>
<td>6000</td>
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<tr>
<td>Dipping well dimensions (L x W x H mm)</td>
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<td>20 x 30 x 30</td>
<td>20 x 56 x 60</td>
<td>20 x 110 x 110</td>
<td>-</td>
<td>-</td>
<td>133 x 133 x 128</td>
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<tr>
<td>Maximum sample size (T x W x H mm)</td>
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<td>3 x 26 x 26</td>
<td>3 x 52 x 56</td>
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<td>3 x 129 x 124</td>
</tr>
<tr>
<td>Dipping speed (mm/min)</td>
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<td>0.1...108</td>
<td>0.1...108</td>
<td>0.1...108</td>
<td>-</td>
<td>-</td>
<td>0.1...85</td>
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<tr>
<td><strong>Upright microscopy trough top</strong></td>
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<td>•</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>•</td>
</tr>
<tr>
<td><strong>Inverted microscopy trough top</strong></td>
<td>-</td>
<td>-</td>
<td>•</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>•</td>
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</table>

**Compatible with**

<table>
<thead>
<tr>
<th></th>
<th>Extra Small</th>
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<th>(ISR) High compression</th>
<th>Alternate</th>
</tr>
</thead>
<tbody>
<tr>
<td>KSV NIMA PM-IRRAS</td>
<td>-</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
<td>KSV NIMA ISR</td>
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<td>•</td>
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<td>-</td>
</tr>
<tr>
<td>KSV NIMA MicroBAM</td>
<td>-</td>
<td>-</td>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>KSV NIMA BAM</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>•</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>KSV NIMA SPOT</td>
<td>-</td>
<td>•</td>
<td>•</td>
<td>-</td>
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<td>•</td>
</tr>
</tbody>
</table>

* The liquid-liquid trough is made of two compartments for the two liquid phases. The values into brackets correspond to the lower compartment, the other value is for the upper one.
** The Alternate-layer Deposition Trough is made of two separated compartments for creation of two monolayers simultaneously.

Each of these four colours used in the table correspond to one frame.
It means all trough tops labelled with the same color can be placed on the same frame, for modularity.
The KSV NIMA software is very intuitive and easy to use. It allows the user to perform a variety of pre-programmed methods which cover the best known L and LB film experiments. These pre-programs can be modified further for particular needs. A wide range of data and parameters are recorded to the database depending on which type of measurement and options have been chosen. The recordable parameters are: data point number, time, barrier position, barrier speed, trough top area, molecular area, dipper position, dipper speed, layer number, transfer ratio, cumulative transfer, temperature, pH and surface potential.

Standard programs include:

- Compression/relaxation isotherms: measuring surface pressure as a function of mean molecular area, remaining area, time or any other measured parameter.

- Analysis of monolayer kinetics (enzyme kinetics, monolayer hydrolysis, polymerization, or any other zero-order reactions).

- Analysis of monolayer penetration, solubility and binding of biomolecules (enzymes, proteins, peptides etc.).

- Isochores and isobars: increase/decrease of surface pressure/temperature, surface pressure/time, or surface pressure/any desired measurable parameter.

- Dilational rheology: oscillating barriers for monitoring viscoelastic properties at desired surface pressure.

- Dipping: allowing the control and monitoring of surface pressure, speed, stroke length, deposition profiles and transfer ratio.

After an experiment has been performed you can return to the data for further analysis in the data reduction and analysis section. After selecting an experiment the data for that experiment will be displayed. Different experimental data can be displayed on the same graph for comparison. Calculation of additional results and export of data can be done. There is an option of viewing and editing the experimental setup which can be very helpful if the data produced should be recalculated based on new information about the materials.

**Measurement examples**

**Graph 1: Drug development**

The figure displays surface pressure-area (violet) and surface potential-area (light blue) isotherms of an antiparasitic drug monolayer on an air-buffer solution interface. An unusual surface pressure-area transition was observed at mean molecular area of 140 Å², but no transition was shown in the surface potential-area isotherm. This suggests that the transition is not a phase transition but instead the drug could undergo aggregation, dimerization or conformational change at this mean molecular area.

**Graph 2: Coatings**

Langmuir-Blodgett deposition of stearic acid was performed on a QCM crystal from 0.1 mM MnCl₂ subphase at a surface pressure of 30 mN/m. The graphs shows the dependency of QCM signal as a function of Langmuir-Blodgett deposition layer number. The deposition shows excellent correspondence between theoretical and measured change in the QCM frequency, proving an excellent transfer of the monolayer to the sample.

**Graph 3: Food technology**

The graph displays the time dependent change of surface pressure after injecting β-lactoglobulin to a DMPA (dimyristoyl phosphatidic acid) monolayer at an air-buffer interface, when there is chitosan present in the subphase. First the β-lactoglobulin absorbed to the monolayer (section A), after which the β-lactoglobulin is removed from the monolayer by the chitosan (section B). PM-IRRAS studies of the system confirmed the chitosan-protein complex formation and complete removal of the protein from the monolayer.
Product benefits

Full control over your experiment

- Powerful and intuitive software satisfying novice and experienced user’s needs. It is the core of KSV NIMA L and LB instrumentation, enabling complete control and real time display of:
  - Surface pressure
  - Barrier position
  - Barrier Speed
  - Substrate position during deposition (LB)
  - Dipper Speed (LB)
  - Temperature
  - pH (option)
  - Surface potential (option)

- Additional digital display and manual control keypad allowing measurement preparation right next to the instrument (Interface unit).

- Comprehensive instruction manual on how to set up the instrument and how to make basic experiments.

- KSV NIMA also provides extensive knowledge and application support enabling you to get the most out of your instrument.

Optimal performance thanks to unique choices in design

- Ultra-sensitive surface pressure sensor for extremely precise measurements.

- Compression barriers are made from Delrin (hydrophilic), for enhanced monolayer stability. PTFE (hydrophobic) compression barriers can also be supplied upon request.

- Open design enables easy placement of trough tops into the frame allowing substitution with another trough top within seconds and easy cleaning of the trough top surface.

- Langmuir and Langmuir Blodgett trough tops are made from single pieces of pure PTFE for optimized cleanliness and reliability. This unique design prevents any leakage in any part of the trough top including dipping well. It avoids the use of potentially contaminating glue or other seals.

- Thin frame design allowing combination of optical characterisation techniques such as PM-IRRAS, Brewster Angle Microscopy, fluorescence microscopy etc.

- Symmetric barrier compression as a standard for homogenous packing. Single barrier compression is also available with every instrument.

- Centred dipping well allowing uniform monolayer LB deposition.

- Instrument design with durable components.

- Subphase temperature control facilitated by aluminium heat/cool base plate operated by external circulating water bath (the water bath sold separately).

Your lifetime partner

- Highly modular thanks to a unique exchangeable trough top mechanism which allows combining all Extra Small, Small and Medium trough tops from KSV NIMA Langmuir and Langmuir-Blodgett selection. You can change functionality of your system, at any time: for instance, exchanging a Langmuir trough top to a LB trough top, or selecting a different size of trough top.

- All systems except the Alternate are compatible (directly of after upgrade with a new trough top) with KSV NIMA Surface Potential Sensor, Brewster Angle Microscopes (KSV NIMA BAM and/or KSV NIMA MicroBAM) and PM-IRRAS characterisation instruments.

- Wide range of accessories (Horizontal dipping clamps, Surface Potential Meter, pH probe, etc.)

At KSV NIMA we understand that the requirements of molecular research experiments can be extremely varied and that our standard products may not offer the exact specifications that you desire. Please contact us to discuss your project.

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From Benjamin Franklin to KSV NIMA: A history of LB

In 1774, Benjamin Franklin reported the following to the British Royal Society:

“At length at Clapham where there is, on the common, a large pond, which I observed to be one day very rough with the wind, I fetched out a cruet of oil, and dropped a little of it on the water. I saw it spread itself with surprising swiftness upon the surface the oil, though not more than a teaspoonful, produced an instant calm over a space several yards square, which spread amazingly and extended itself gradually until it reached the leeside, making all that quarter of the pond, perhaps half an acre, as smooth as a looking glass.”

Had Franklin known that the maximum extension of an oil film on water represents a layer one molecule thick (2 nm), he would have found out that a teaspoonful (2 ml) would cover an area of 2000 m², that’s half an acre as he suspected. Benjamin Franklin had created a “thin film”, more precisely a monolayer at the air-water interface.

In the late 19th century Agnes Pockles, a German pioneer in chemistry, discovered the influence of impurities on the surface tension of water by using a rudimentary surface balance in her kitchen sink. This system was a precursor to the Langmuir trough.

In the early 20th century Irving Langmuir, an American chemist and physicist, was the first to perform systematic studies on floating monolayers on water. He was the first to give the modern understanding of monolayer structure at the molecular level, in particular the fact that the molecules show a preferential orientation. The systems to study floating monolayers on water are now named after him. In 1932 he was awarded the Nobel Prize for his work on surface chemistry.

Langmuir was also the first to show that monolayers can be transferred from the air-water interface to solid substrates for further study. Together with his assistant, Katherine Blodgett, he showed that it was possible to go further and to deposit many monolayers onto the same substrate, thus building up a multilayer film of any required thickness. Deposited monolayers of any thickness are now known as Langmuir-Blodgett (LB) films.

Since the late 20th century KSV NIMA has made a number of innovations which dramatically improved the Langmuir and Langmuir-Blodgett troughs. KSV NIMA continues to develop innovative products that can give the next generation of researchers the tools they need to push the boundaries of thin film research.