KSV NIMA

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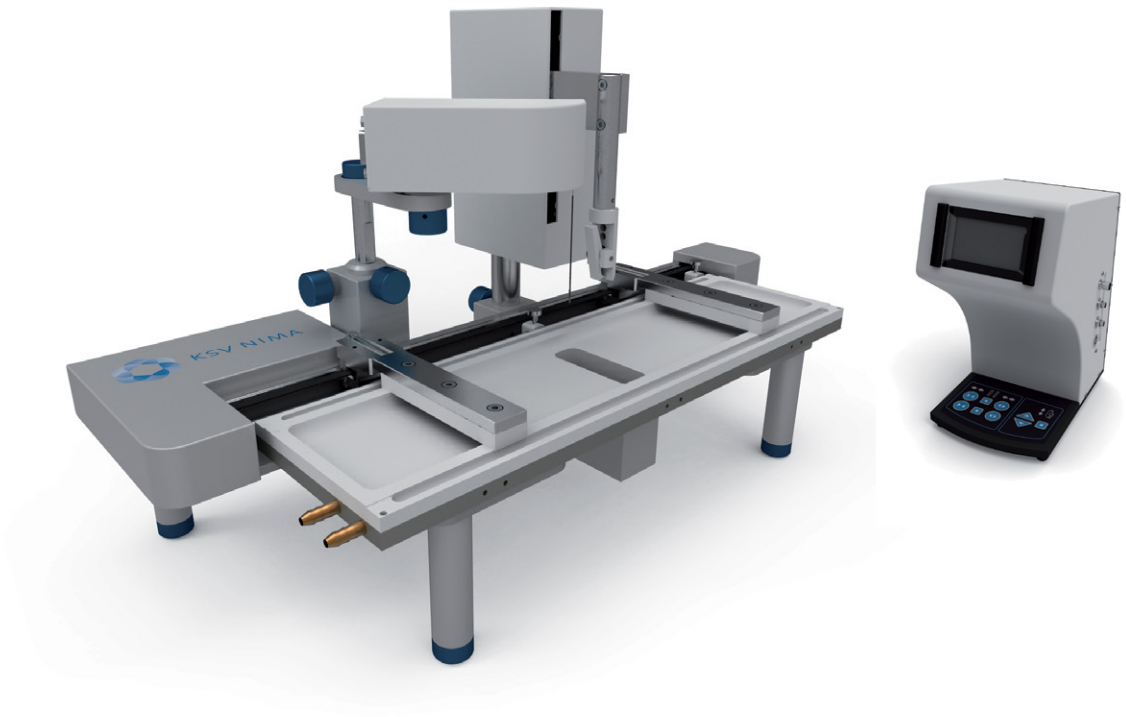
Langmuir and Langmuir-Blodgett Deposition Troughs



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 Deposition Troughs (KSV NIMA L & LB Troughs) are used for the fabrication and characterisation of single molecule thick films and offer the 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-Schaefer deposition technique. This enables the creation of 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 biomolecular interactions**
  - *Cell membrane model (e.g. protein and ion interactions)*
  - *Conformational changes and reactions*
  - *Drug delivery and behaviour*
- **Organic and inorganic coatings**
  - *Functional coatings with optical, electrical and structural properties*
  - *Novel coatings of nanotubes, nanowires, graphene etc.*
- **Surface reactions**
  - *Polymerisation*
  - *Immunological and enzyme-substrate reactions*
  - *Biosensors and surface immobilized catalysts*
  - *Surface adsorption and desorption*
- **Surfactants and colloids**
  - *Formulation*
  - *Colloid stability*
  - *Emulsion, dispersion, foam stability*
- **Rheology of thin films**
  - *Dilational rheology*
  - *Interfacial shear rheology (with the KSV NIMA ISR)*

Technology

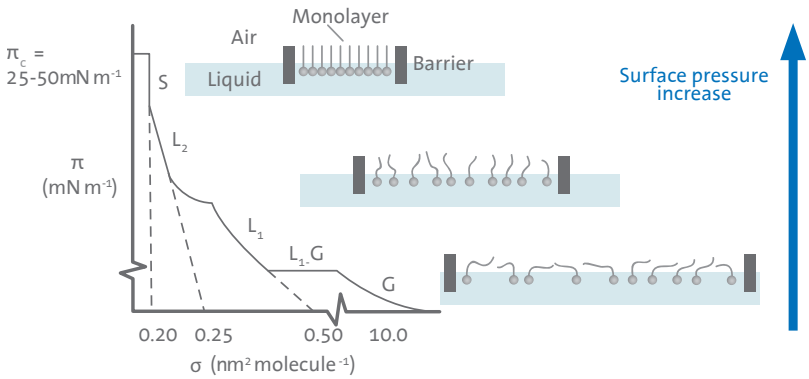
Langmuir Troughs

Langmuir Troughs are used to create, modify and study 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 controlling the packing density and studying monolayer behaviour.

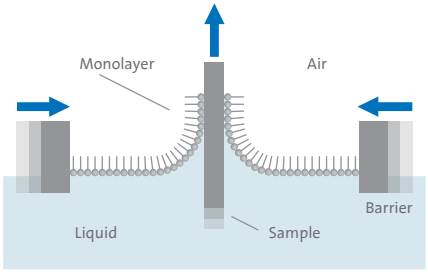
A Langmuir film is created by depositing material on an aqueous subphase confined in a shallow chamber called trough top (3). The monolayer can then be compressed with the help of a set of barriers (2). The surface presure thus the packing density is controlled *via* the pressure sensor (4) of the Langmuir Trough.

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.

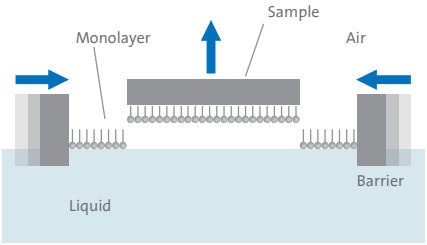
In a typical isotherm measurement a monolayer is organized under compression, starting from a two dimensional gas phase (G) moving through a liquid phase (L) to a fully organised solid phase (S). In the gas phase the molecules are not strongly interacting with each other. When the surface area is decreased 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.



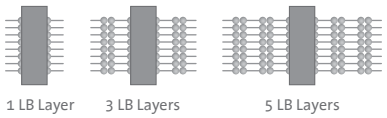
LANGMUIR-BLODGETT DEPOSITION



LANGMUIR-SCHAEFER DEPOSITION



MULTIPLE LANGMUIR-BLODGETT DEPOSITIONS



KSV NIMA Langmuir Troughs enable measurements of:

MEASUREMENT	INFORMATION
Isotherms	Structure, area, interactions, phase transitions, compressibility, hysteresis
Isobars/Isochores	Monolayer stability and relaxation
Surface potential	Monolayer electrical property characterization
Dilational rheology	Film viscoelastic properties
Kinetics	Enzyme kinetics of injection into subphase
Conductivity	Lateral conductivity
Environment monitoring	pH and temperature

Langmuir-Blodgett Deposition Troughs

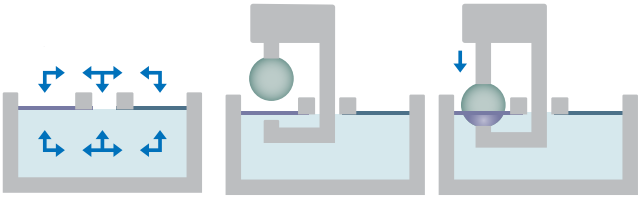
A Langmuir-Blodgett Deposition Trough (LB Trough) is very similar to a Langmuir Trough as it also enables Langmuir film fabrication and study. In addition, a LB Trough is equipped with a dipping well and a dipping mechanism. The dipping mechanism is used to transfer the Langmuir film onto a solid substrate at the desired packing density (typically in the solid phase). The well makes room for the solid sample below the Langmuir film.

In the case of Langmuir-Blodgett (LB) deposition the sample is moved vertically through the monolayer while in the case of the Langmuir-Schaefer (LS) method the sample is brought to the interface horizontally (i.e. no need for a trough top with a well).

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

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.

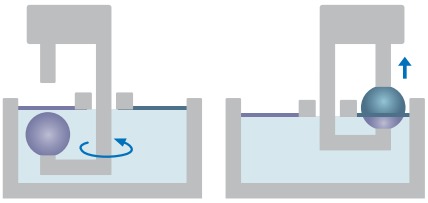
Alternate deposition is possible when using a system with two monolayer compression compartments and one empty compartment:



The dipping sequence can take any path between the 3 compartments for an unlimited number of cycles.

1. Sample in clip-holder
Two monolayers (violet and 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.

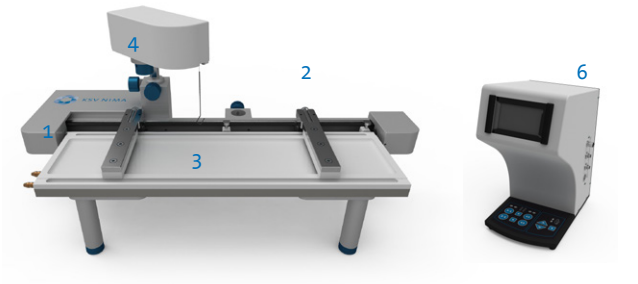
4. Second layer
The lower arm takes the sample up and passes it to the upper arm (the sample could go through any of the two monolayers, from any side).

Measurements on deposited surface

Further investigation of the deposited surface can be conducted using:

- Infrared reflection absorbance spectroscopy (KSV NIMA PM-IRRAS)
- Quartz crystal microbalance (Q-SENSE QCM-D)
- Surface plasmon resonance
- Electrical conductivity measurements
- UV-VIS absorption spectroscopy
- Atomic force microscopy
- X-ray reflectometry
- Transmission electron microscopy
- Ellipsometry
- X-ray photoelectron spectroscopy

KSV NIMA Langmuir Troughs



1 – Frame 2 – Barriers 3 – Trough top 4 – Surface pressure sensor

Conventional Langmuir System

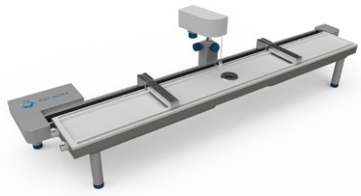
Langmuir troughs consist of a trough top to hold the subphase (typically water) and monolayer, barriers to adjust the area available to the monolayer and a balance to monitor surface pressure. The conventional KSV NIMA Langmuir Trough is available in several sizes: Extra Small, Small, Medium and Large. The Extra Small has the smallest volume but a larger surface area than the Small. The same frame is used for the three smaller trough tops, and one frame can use different sizes and types of trough tops. Larger frames used with for example Liquid-Liquid Troughs or High Compression Troughs also enable using smaller trough tops. Different trough top types are described below.

Liquid-Liquid Trough

A Liquid-Liquid Trough enables monolayer studies at the oil-water interface. When combined with an ISR, a Liquid-Liquid Trough enables the study of viscoelasticity at the oil-water interface.

High Compression Trough (ISR Trough)

A longer but narrower trough, the High Compression Trough provides a higher compression ratio. Specifically designed for use with the Interfacial Shear Rheometer (ISR), but the High Compression Trough can be used to increase performance with other characterization instruments.



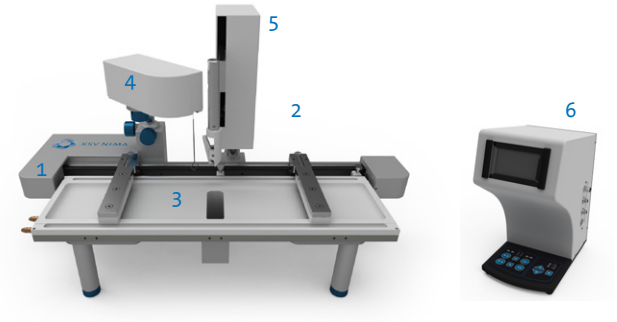
Microscopy Troughs

A Microscopy Trough has the same dimensions as a standard trough while featuring a sapphire window in the base of the trough top allowing high optical transmission down to a wavelength of 200 nm (suitable for visible light or UV microscopy). Inverted microscopy featuring a glass window is also possible with some trough sizes.

Ribbon Barrier Trough

A Ribbon Barrier Trough can be used either in Langmuir or Langmuir-Blodgett deposition configurations. Specially designed for lung surfactant studies, the PTFE coated glass fiber ribbon enables higher packing densities (e.g. surface pressure of over 70 mN/m for DPPC) than the floating barriers used in conventional systems.

KSV NIMA Langmuir-Blodgett Deposition Troughs



5 – Dipping mechanism (LB option) 6 – Interface Unit

Conventional Langmuir-Blodgett System

The conventional KSV NIMA LB Trough is available in several sizes: Small, Medium and Large. The same frame as is used with the smaller Langmuir troughs is used with the Small and Medium LB Troughs, with the addition of a dipping mechanism. Different sizes and types of trough tops can be used with one frame.

LB films can be deposited on substrates ranging in size from a few square millimeters to many tens of square centimeters. Dipping well dimensions limit the size of the substrate. The LB dipping mechanism can also be fitted with a LS deposition kit for deposition on only one side of the substrate.

Alternate-Layer Deposition Trough

An Alternate trough used to deposit alternating layers of two materials, with a two compartment trough, two surface pressure sensors and two pairs of barriers. The substrate can be moved through any of the two monolayers or water in the desired order. Available in two sizes, standard and large.

KSV NIMA Characterization Instrumentation

PM-IRRAS

Infrared reflection absorbance spectroscopy with polarization modulation, for determination of molecular orientation and chemical composition.

Brewster Angle Microscope BAM

Monolayer imaging, optical observation of film homogeneity, phase behavior and film morphology. Available with different resolutions and features.

Surface Potential Sensor SPOT

Monolayer electrical property characterization by monitoring the potential difference over a film using a vibrating plate technique. Complements any Langmuir isotherm measurement with information on packing density and orientation.

Interfacial Shear Rheometer ISR

A unique shear rheometer for measurement of viscoelastic properties at the interface. For studies at air-water or oil-water interfaces, enabling analysis of viscoelasticity at the same time as controlling surface pressure.

Main technical specifications and compatibility chart

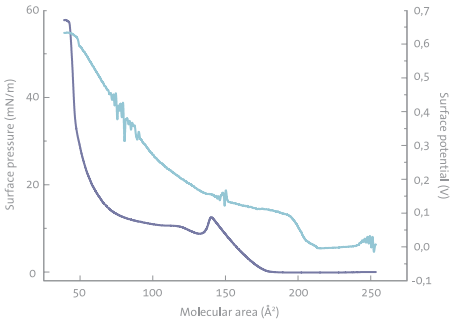
	Extra Small	Small	Medium	Large	Liquid-Liquid	(ISR) High Compression	Alternate Large	Alternate
General specifications								
Surface area (cm^2)	150	98	273	841	580 (423*)	587	930 (x2**)	586 (x2**)
Trough top inner dimensions (L x W x H mm)	300 x 50 x 1.2	195 x 50 x 4	364 x 75 x 4	580 x 145 x 4	784 x 74 x 7 (784 x 54 x 5*)	782 x 75 x 5	775 x 120 x 10 (x2**)	782 x 75 x 5 (x2**)
Maximum compression ratio	8.7	5.2	10.8	18	24.7	24.7	5.4	3,9
Barrier speed (mm/min)	0.1...270	0.1...270	0.1...270	0.1...270	0.1...270	0.1...270	0.1...200	0.1...270
Balance measuring range (mN/m)	0...150	0...150	0...150	0...150	0...150	0...150	0...150	0...150
Maximum balance load (g)	1	1	1	1	1	1	1	1
Balance resolution (µN/m)	4	4	4	4	4	4	4	4
Langmuir trough top	•	•	•	•	•	•	-	-
Total subphase volume (mL)	18	39	109	336	406 (212*)	293	-	-
Langmuir-Blodgett trough top	-	•	•	•	-	-	•	•
Total subphase volume (mL)	-	57	176	578	-	-	6000	1400
Dipping well dimensions (L x W x H mm)	-	20 x 30 x 30	20 x 56 x 60	20 x 110 x 110	-	-	Half circle, radius 133; depth 128	Half a circle, radius 75; depth 74
Maximum sample size (T x W x H mm)	-	3 x 26 x 26 (1 inch)	3 x52 x56 (2 inches)	3 x 106 x 106 (4 inches)	-	-	3 x 129 x 114 (4 inches)	3 x 30 x 50
Dipping speed (mm/min)	-	0.1...108	0.1...108	0.1...108	-	-	0.1...85	0.1...108
Upright microscopy trough top	-	•	•	-	-	•	-	•
Inverted microscopy trough top	-	-	•	-	-	•	-	•
Ribbon barrier trough top	-	-	•	-	-	-	-	•
Compatible with								
KSV NIMA PM-IRRAS	-	•	•	•	-	•	-	-
KSV NIMA ISR	-	-	-	-	•	•	-	-
KSV NIMA MicroBAM	-	-	•	•	-	•	-	•
KSV NIMA BAM	-	-	-	•	-	-	-	-
KSV NIMA SPOT	-	•	•	•	-	•	•	-

* The Liquid-Liquid Trough is deeper than a standard trough as this allows for the two liquid phases. The value in the brackets corresponds to confinement of the lower phase (other value for the upper phase).

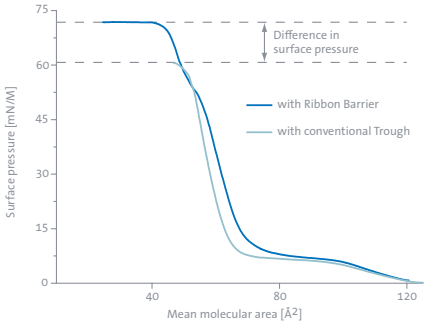
** The Alternate-Layer Deposition Trough is made of two separated compartments for creation of two monolayers simultaneously.

Each of these four colours used in the table correspond to one frame.
All trough tops labelled with the same colour can be placed on the same frame, for modularity.

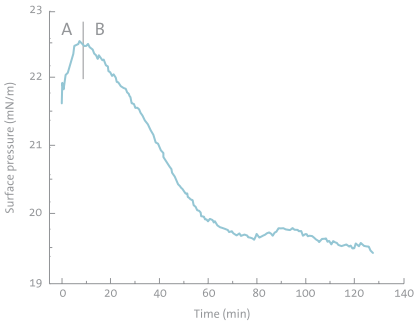
GRAPH 1



GRAPH 2



GRAPH 3



KSV NIMA LB Software

The KSV NIMA LB 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 can be recorded and the desired data can be easily plotted. 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, polymerisation, or any other zeroth-order reactions).
- Analysis of monolayer penetration, solubility and binding of biomolecules (enzymes, proteins, peptides etc.).
- Isochores and Isobars: increase or decrease of surface pressure/temperature, surface pressure/time, or surface pressure/any desired measurable parameter can be plotted.
- Dilational rheology: oscillating barriers for monitoring viscoelastic properties at desired surface pressure.
- Dipping: both Langmuir-Blodgett and Langmuir-Schaefer modes allow the control and monitoring of surface pressure, dipping speed, stroke length, deposition profiles and transfer ratio.

After an experiment has been performed the user 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, dimerisation or conformational change at this mean molecular area.

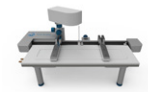
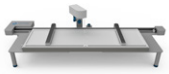
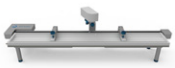
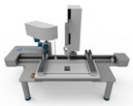
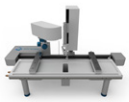
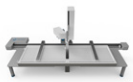
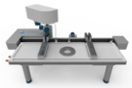
Graph 2: High monolayer compression

The graph shows the surface pressure - area isotherms of a DPPC monolayer obtained with a conventional KSV NIMA Langmuir Trough Medium (light blue) and with the KSV NIMA Langmuir Ribbon Barrier Trough (dark blue). The difference in the maximum surface pressure observed between the two curves demonstrates the ability of the KSV NIMA Ribbon Barrier to compress (and maintain) monolayers at higher packing densities.

Graph 3: Surface reactions

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.

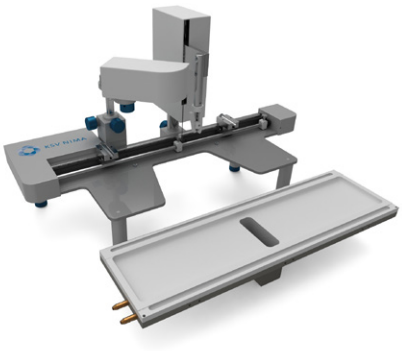
OVERVIEW OF THE READY-MADE KSV NIMA TROUGH SYSTEMS. PLEASE NOTE OTHER COMBINATION ARE ALSO POSSIBLE.

Extra small	Small	Medium	Large	Liquid-Liquid	High Compression (ISR)	Alternate
Langmuir Troughs						
 KN 1001	 KN 1002	 KN 1003	 KN 1006	 KN 1004	 KN 1005	
Langmuir-Blodgett Deposition Troughs (A = Alternate, L = Alternate Large)						
	 KN 2001	 KN 2002	 KN 2003			 A = KN 2006 L = KN 2004
Microscopy Troughs (U = upright, I = inverted)						
	 U = KN 3001 (no inverted)	 U = KN 3005 I = KN 3003			 U = KN 3002 I = KN 3004	
Ribbon Barrier Troughs (L = Langmuir, LB = Langmuir-Blodgett)						
		 L = KN 1007 LB = KN 2005				
STANDARD FRAME			LARGE FRAME	HIGH COMPRESSION FRAME		ALTERNATE FRAME

Product benefits

Optimal performance thanks to unique choices in design

- Ultra-sensitive surface pressure sensor for extremely precise measurements. Platinum plates, platinum rod and paper plates can be used as probe to meet all needs.
- 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.



Easy removal/placement of trough top on the instrument frame for cleaning or exchange to another trough top.

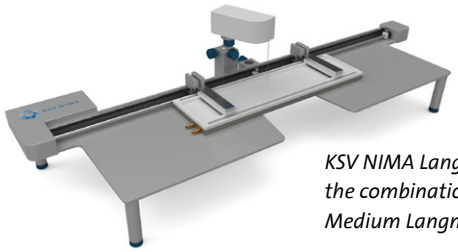
- Langmuir and Langmuir Blodgett trough tops are made from single pieces of pure PTFE for optimized cleanliness and reliability. This unique design prevents any leakage in any part of the trough top including the dipping well. It avoids the use of potentially contaminating glues or other seals.
- Compression barriers are made from Delrin (hydrophilic), for enhanced monolayer stability. PTFE (hydrophobic) compression barriers can also be supplied upon request. A robust metal frame prevents barriers from deforming over time.
- Thin frame design allowing combination of optical characterisation techniques such as PM-IRRAS (infrared spectroscopy), Brewster Angle Microscopy, fluorescence microscopy, X-ray 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.
- Subphase temperature control facilitated by aluminium heat/cool base plate operated by external circulating water bath (the water bath is sold separately).
- Adjustable legs enable fast and accurate levelling of the trough. The legs can be removed easily for trough placement on a microscope.

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)
- Manual control keypad with digital display 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.

Your lifetime partner

- Highly modular thanks to a unique exchangeable trough top mechanism which allows using diffrent sizes of trough tops without purchasing a new frame. You can change the 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.



KSV NIMA Langmuir Trough made from the combination of a Large Frame and a Medium Langmuir trough top

- All systems except the Alternate are compatible (directly or 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.
- Instruments made of durable components. Some of our instruments from 20 years ago are still being utilised!
- Wide range of accessories (Horizontal dipping clamps, Surface Potential Meter, pH probe, etc.)

Flexibility

- 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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Contact information

KSV NIMA
Biolin Scientific
Tietäjäntie 2
FIN–02130 Espoo, Finland

Tel +358 9 5497 3300
Fax +358 9 5497 3333

info@ksvnima.com
www.ksvnima.com

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