NanoMAX

A compact, modern 2D Kratky system

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SAXS/WAXS experiments

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Rigaku's NanoMAX system

Small angle X-ray scattering (SAXS)

SAXS is a valuable non-destructive technique for reliably characterizing subjects concerning their size, shape, size distribution, and structural order/disorder. As the name implies, SAXS experiments study materials by looking at the X-ray scattering behavior at very small angles, usually less than 6°. SAXS techniques are used for a broad range of applications and technologies, including cosmetics, plastics, polymers, pharmaceuticals, food, energy, R&D and quality control. SAXS samples can come in a range of forms, including solids, liquids, liquid crystals and gels with characteristic dimensions ranging from 1 nm to 150 nm. The versatility of SAXS makes it a powerful tool to better understand materials that impact our daily activities.

A modern 2D Kratky system

SAXS systems generally fall into design categories that use either pinhole or Kraky collimations systems to reduce or eliminate parasitic scattering. The NanoMAX is a modernized 2D Kratky system that eliminates data corrections required of traditional Kratky systems with the added benefit of offering compactness and superb flux for samples when compared to standard pinhole systems.

A compact SAXS system

Laboratory space is a precious and expensive resource leaving researchers to favor high-quality compact systems where possible. The NanoMAX design satisfies this criterion well in that the system size is approximately 1 m long whereas traditional pinhole systems usually require > 3 m system lengths. NanoMAX system can be installed on a variety of X-ray sources, including the open port of a rotating anode, and has the advantage that higher flux is delivered to the sample in a much shorter camera length compared to pinhole SAXS systems. Most importantly, the NanoMAX incorporates features and hardware to support SAXS data collection for both isotropic and anisotropic scatterers with a very wide q-ranges of 0.0043 $Å^{-1} < q < 3.6 Å^{-1}$.

No need to compromise on intensity

The very nature of a SAXS experiment imposes limitations on the intensity of X-rays on the sample. Parasitic scattering may seriously impact data quality in a small angle region, especially for weakly scattering samples. Therefore the probe beam needs to be "cleaned" by pinholes, which mask a significant portion of the direct beam. The development of the "scatterless pinhole" drastically improved intensity by eliminating the need of "guard pinhole," but it cannot completely eliminate parasitic scattering. NanoMAX uses a "2D Kratky" design, which delivers high flux on the sample with totally eliminated parasitic scattering. SAXS systems can come in a variety of forms, each with advantages and disadvantages for supporting a variety of sample types, including weakly scattering samples or those whose experimental requirements require environmental variation, such as temperature, pressure or stress.

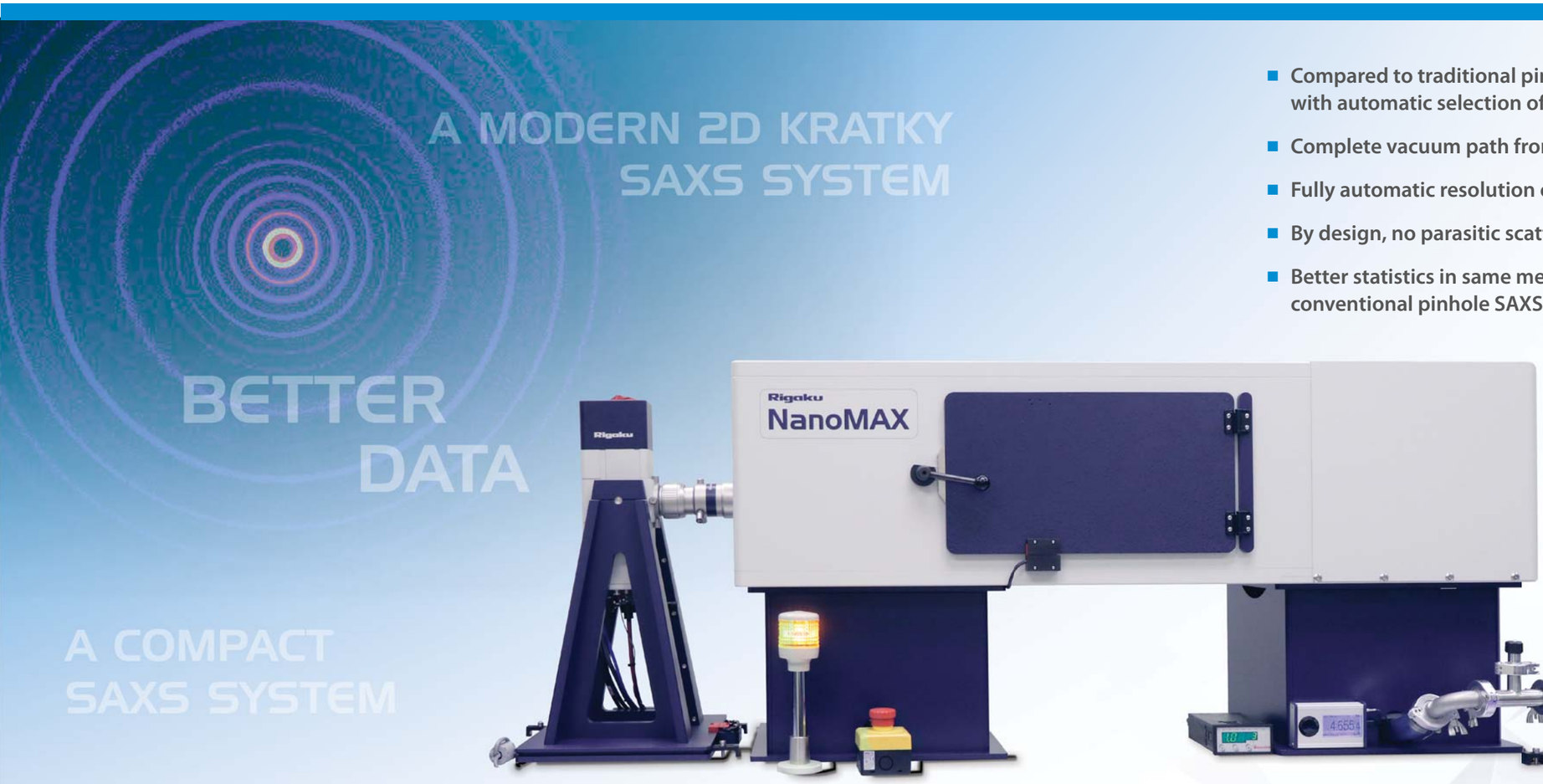
Universal sample holder with WAXS capability

The NanoMAX system includes a universal sample stage design with automated sample-to-detector distance change for a quick and automated change of q range to extend measurement for wide angle X-ray scattering (WAXS) experiments. Additionally, the universal sample stage provides options for additional stages that can quickly be swapped using a one-hand operation for installation. The sample stages are encoded and automatically recognized by the system software. Sample changing and analysis is almost effortless due to the new modular designed sample stages. Stages include:

- Solid sample stage
- Capillary sample stage
- A rotary stage
- Grazing Incidence stage
- Temperature stage
- Additional stages will be developed as needed

Simply plug, play and analyze your samples today!

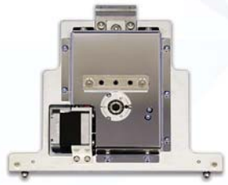
NanoMAX features and benefits



- Compared to traditional pinhole cameras, larger q range with automatic selection of q range
- Complete vacuum path from source to detector
- Fully automatic resolution change and beamstop alignment
- By design, no parasitic scatter data are observed during measurements
- Better statistics in same measurement time compared to conventional pinhole SAXS system

- Better data in less time than with conventional pinhole systems
- Small footprint, compact design
- System is radiation safe with interlocks, meaning that no additional radiation enclosure is required
- Beamstop with integrated pin diode provides continuous beam intensity measurement and transmission factor for samples
- Automated beamstop and beam size alignment
- 'Desmearing' of data for source width effects is *not* required
- Automated sample alignment
- Optional automatic sample changer and flow cell for solution samples

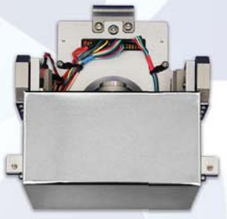
- Hot swappable sample stages with automatic stage identification



Rotating sample stage
Collect 360° of scattering data for anisotropic scatterers

Capillary sample stage
Support for solution samples with 3 sample positions for either static or flow cell use

Solid state sample stage
Collect data for multiple powder samples



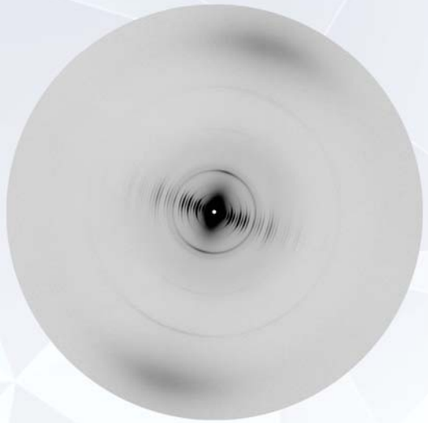
GI sample stage
Collect grazing incidence data for thin films and surfaces

The NanoMAX includes options for additional stages and configurations. Contact Rigaku with your application needs for more information.

Applications

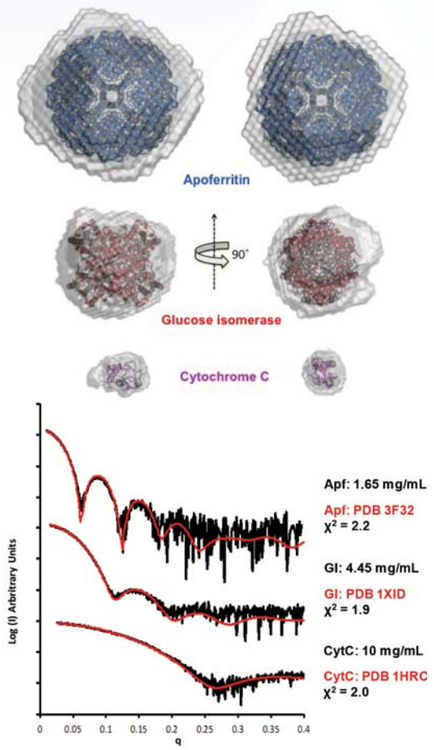
Rat tail tendon

SAXS is used to investigate higher order fiber structures and internal spacing.



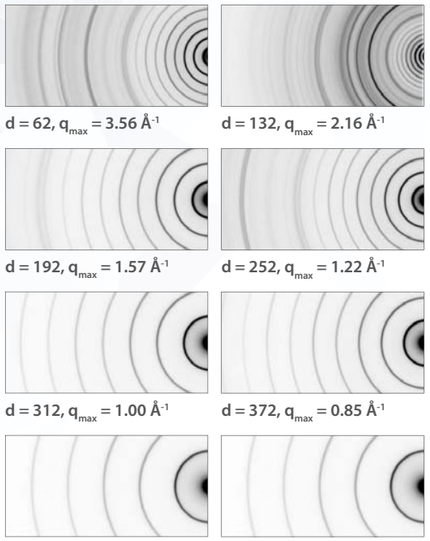
Biological solution SAXS

Fast, automated data collection for biological solution samples.



SAXS to WAXS – automated variable q

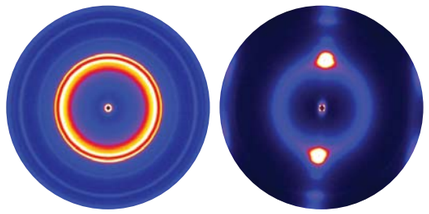
Data were collected for silver behenate powder (Kodak), a commonly used SAXS calibration standard, at various sample-to-detector distances using the NanoMAX. These data were then used to illustrate achievable q_{min} and q_{max}. At the maximum distance, ~490 mm, the measured q range is 0.004 $Å^{-1}$ – 0.68 $Å^{-1}$, whereas at the minimum distance, ~60 mm, q_{max} = ~3.5 $Å^{-1}$. For samples where middle angle scattering is required, no gantry system is required, whereas WAXS measurements require the gantry system to reach a higher scattering angle.



Variable sample-to-detector distance (d) allows both SAXS and WAXS measurements, as illustrated in the above silver behenate scattering images.

360° stage – anisotropic sample measurement

Data were collected for both unstretched and stretched LDPE photodegradable polymer to illustrate anisotropic data collection and processing of rotational SAXS data. A total of 16 images was collected at 22.5° increments about the beam using 10 minute exposure times. SAXSLab software was then used to stitch images to prepare a full 360° image.



Stitched images for both unstretched (left) and stretched (right) LDPE photodegradable plastic.

Specifications

Basic camera parameters	
q_{max} ($Å^{-1}$)	0.53 $Å^{-1}$
q_{min} when set for highest resolution	0.004$Å^{-1}$
Internal dimensions	333 mm X 300 mm X 903 mm, 90.2 L volume
Weight	Roughly 130 kg

Sample stages mount on a gantry system that transports the sample stage to change distance from the detector, thus changing the q range attained. The gantry motion has a resolution of 1 µm. The gantry also has motions for positioning the samples within the X-ray beam. This shared positioning minimizes complexity and cost, maintaining a fair value for customers. When running the motor with half steps, distances and resolutions for these motions are:

- Horizontal travel (X-axis): ± 40 mm, stage resolution: 1 µm
- Vertical travel (Y-axis): ± 25 mm, stage resolution: 1 µm
- Travel along the X-ray path (Z-axis, towards the detector): 429.95 mm, resolution: 1 µm

Sample stages

Stages	# of unknown sample positions	# of calibration sample positions	Maximum sample size (diameter)	Motion in addition to gantry	Other notes
Solid sample stage	25	2	5 mm	None	Supports capillary tubes or solid samples
Capillary stage	3	1	1.0, 1.5, 2.0 mm capilaries	None	Temperature control 5° to 90° (-10° possible with additives)
Rotary stage	1 rotating, 3 fixed	1 to 3 of fixed positions	Rotating: 6.35 mm Fixed: 4 mm	Full 360° rotation, 0.06° resolution	Fully measures anisotropic samples
Horizontal GI stage	1	0	Up to 100 mm	**Translation:** range: -4/+10 mm (14 mm total), resolution: 0.3175 µm **Rotation:** range full 360°, resolution: 0.0036° **Tilt:** range: From -3° to +7° (10° total), resolution (typical): 0.00015°	

Dimensions