Turnkey Solutions Featuring Cutting Edge Technology for Polymer Analysis

● Solutions for Industry

Bruker's comprehensive and versatile solution portfolio represents the best-in-class analytical landscape covering the full value chain of the ever-evolving global polymer industry. With 60 years of experience in magnetic resonance innovations, Bruker is continuing to push the boundaries of what is possible.

Time-Domain Nuclear Magnetic Resonance

Time-domain NMR (TD-NMR) instruments are widely used in product innovation and quality control environments. The technology provides push-button solutions for material properties like cross-linking or crystallinity and for individual quantification of multi-component products. As a direct derivative of NMR it offers method harmonization and result comparability capabilities. Only Bruker is offering both technologies, enabling its customers to maximize theses synergetic effects to stay ahead of the competition. Example applications of TD-NMR include:

- Rapid analysis of dip and elastomer coatings on multifilament or monofilament fibers; including polyester, polyamide, polypropylene, polyethylene, and polyacrylonitrile
- At line control and validation of polymerization processes
- Rapid, straightforward analysis of polyethylene density and crystallinity
- Crosslink density analysis in natural or synthetic rubbers
- Determination of hydrogen content in hydrocarbons
- Oil and water content analysis

Bruker's mq Series of standalone NMR systems can accommodate a wide temperature range from -100°C to + 200°C while maintaining low energy consumption of only ~35 W. These robust systems boast fully traceable data (GLP) and daily instrument validation, and can be supplied with optional sample automation add-ons.

Nuclear Magnetic Resonance

NMR is the single most important key technology for polymer analysis. Its unparalleled versatility in understanding dynamic interactions of any macromolecule makes it the perfect tool to investigate tacticity, branching, crosslinking, end-groups and morphology of mono- and polymers. Bruker's cutting edge technology like high sample temperature cryoprobes enables its customers and long-standing partners to obtain information on:

- Monomer purity, identity, and structure – important for identifying potential contaminants
- Polymer tacticity – including the purity of one form or the ratio of mixed tacticity polymers
- Sequence isomerization – including coupling details and chemical shifts
- Co-polymer composition and arrangement – including the ratios of different monomers
- Branching positions and frequency
- Crosslinking positions and density
- Endgroup characterization and quantitation
- Determination of chain lengths
- Detection of key elements such as ^{1}H, ^{13}C, ^{19}F, ^{11}B, ^{27}Al, ^{29}Si, and ^{31}P

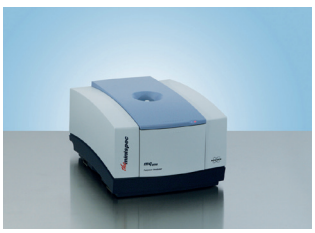
Bruker offers a number of NMR products specifically designed for the polymer industry.

The Fourier 80 benchtop can be used in monomer, block- or co-polymer analysis, while Bruker's range of high field NMR spectrometers boasts a ^{1}H resonance frequency of 400–700 MHz or higher field.

A multinuclear probe is well suited for acquiring measurements in all common polymer experiments, while polymer applications requiring high sensitivity at high temperatures benefit from the use of Bruker's range of specialist probes.

These include:

- **Cryogenically cooled large volume NMR probes** - able to handle 10 mm samples at temperatures up to 130°C
- **Cryogenically cooled multinuclear NMR probes** - ideal for measuring concentrated solutions of polymers in high boiling solvents
- **Ultra-high temperature liquid NMR probes** - water-cooled to deliver accurate measurements at temperatures up to 250°C

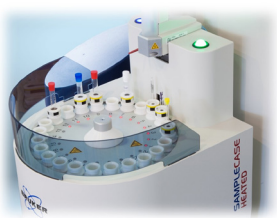


minispec Polymer analyzer

Offers NMR parameters related to crystallinity or cross link density. Applicable for QC or R&D applications, polymerization reaction kinetics, material properties and failure analysis studies

Fourier 80

Benchtop can be used in monomer and block- or co-polymer analysis



Sample Changer

The special challenges of working with samples at high temperatures and the need for very high sensitivity led to the development of special probes and accessories.

High field NMR spectrometers

with a ^{1}H resonance frequency of 400 – 700 MHz or higher field and a multinuclear probe is ready for the acquisition of all common experiments applied to polymers.

CryoProbe

The ideal tool for polymer NMR is the $^{1}H/^{13}C$ CryoProbe able to handle 10 mm samples and with a temperature range up to 130°C

Electron Paramagnetic Resonance

Electron Paramagnetic Resonance (EPR), or also referred to as Electron Spin Resonance (ESR) spectroscopy, is an indispensable analytical technology for polymer testing. It provides insights to polymerization and degradation processes, impurity profiling, reaction monitoring and various quality indicators via detecting paramagnetic species. Bruker offers dedicated solutions for:

- Detection and evaluation of photo, chemical and thermal degradation
- Optimization of stability and product shelf life
- Polymerization control
- Monitoring of post-sterilization effects
- Polymer quality control
- Paramagnetic impurity profiling

Bruker's comprehensive portfolio of EPR systems includes microESR, onlineESR, Magnettech ESR5000, and floor-standing models.

EMXplus
Supreme Resolution and Sensitvity for EPR Spectroscopy

Magnettech ESR5000
Benchtop EPR

MicroESR
General Purpose ESR

Software

Bruker analytical solutions support research of monomers for use in the plastics industry, petroleum additives, combi-chem libraries, novel organometallic catalysts, chiral building blocks for biomolecules, or other myriads of chemicals.

A molecule-centric workflow that interprets structures accurately and securely is essential for an organization to unlock the full value of its compounds. Scientists from the bench to the pilot plant, from R&D to development, require ease-of-use for data entry as well as experimental searchability and scalability to track milligrams to kilogram quantities. The Bruker Arxspan Electronic Lab Notebook, together with the Registration and Inventory systems work seamlessly from a convenient web-interface to provide efficient laboratory data management.

The cloud-based Arxspan platform provides

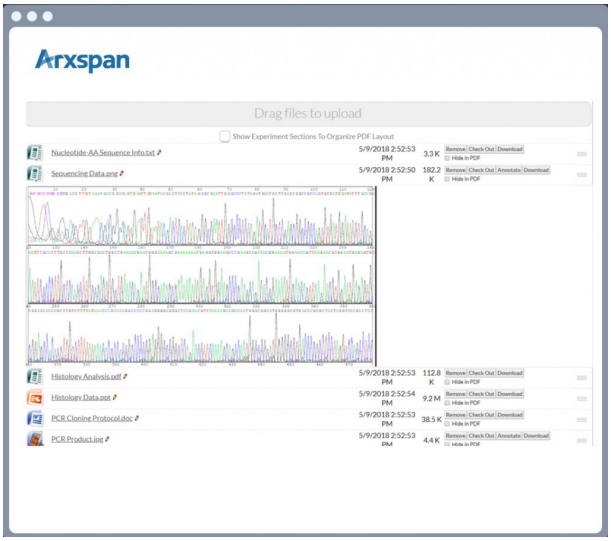
Compliance: Data standards, security and compliance with 21 CFR Part 11 are included in the software

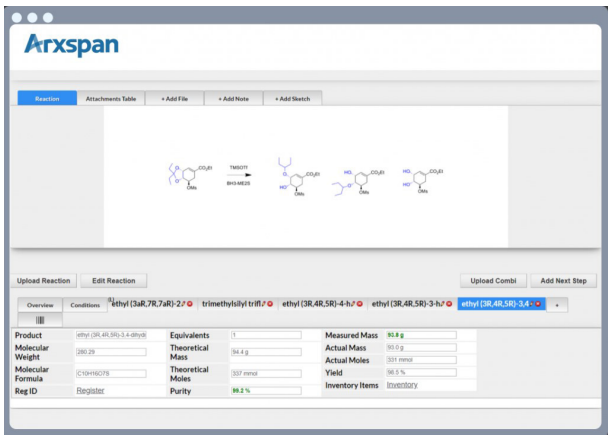
Transparency: all data produced during a research life cycle is available through instant searchable access, analysis and insight to IP

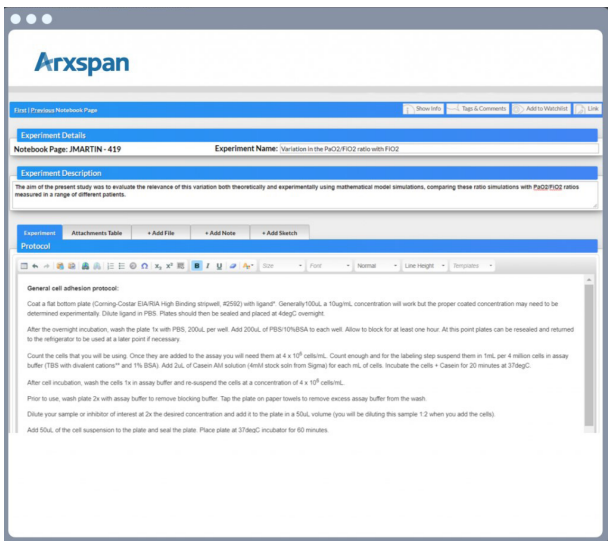
Data Security: Clear management of permissions leads to internal and external data security

Flexibility: The user environment is accessible from any device. Modules can be purchased as a suite or as standalone modules

Efficiency: streamlined workflows, reduced manual processes and information exchange lead to more efficiency







Bruker BioSpin

www.bruker.com