

Rheonaut Module for HAAKE MARS Rheometer

Rheology combined with spectroscopy

The patented* Rheonaut® module for the Thermo Scientific™ HAAKE™ MARS™ rheometer simultaneously measures rheological properties and structural changes on the molecular level using FT-IR spectroscopy. This allows extensive investigations of structural changes under deformation/shear as well as thermally induced or UV-curing. The new level of understanding of rheological phenomena on the molecular level enables researchers to speed up formulation development and process optimization.

As a “macroscopic” analytical method, Rheology provides information on the bulk behaviour of a sample under specific conditions. However, viscoelastic properties of a material depend on its molecular structure.

*Resultec Analytic Equipment: DE 10140711, EP 02762251, US 6988393, JP 4028484



Modular rheometer platform Thermo Scientific HAAKE MARS III with Rheonaut module and Thermo Scientific Nicolet™ iS™10 FT-IR spectrometer

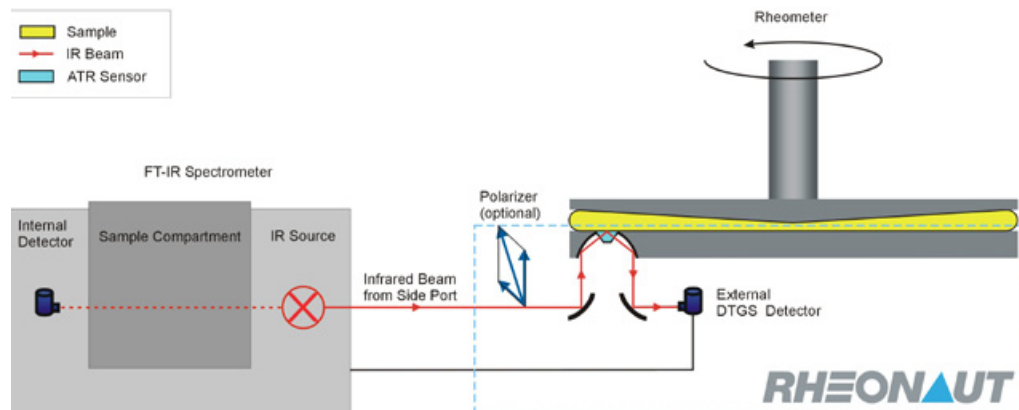
Coupling an FT-IR spectrometer with a rheometer allows the detection of changes in rheological properties on the molecular level, conformational changes and molecular orientation as a function of shear or due to chemical reactions.

Benefits of combined methods:

- Identical sample composition and history
- Simultaneous testing saves time
- Identical test conditions for both methods
- Reliable correlation of results

Benefits of the unique combination of rheology with FT-IR spectroscopy:

- Patented technique in a compact and fully integrated module
- ATR (attenuated total reflection) principle: sample thickness can be adjusted to the rheological needs and is independent from the infrared spectroscopy requirements
- Diamond ATR element absolutely inert against mechanical stress as well as chemical composition of the sample
- Compatible with standard spectrometers with a side port
- Thermo Scientific HAAKE RheoWin: one software to control rheometer and FT-IR spectrometer



Coupling an FT-IR spectrometer with a rheometer

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Applications

The Rheonaut module integrated into the HAAKE MARS rheometer can be used to investigate a material's rheological behaviour that strongly depends on its molecular structure. Applications include investigations of chemical reactions, inter- and intramolecular interactions such as stability testing as well as studying chain orientation in polymer melts and solutions.

Inter- and intramolecular interactions

Stability of emulsions

With the Rheonaut module, the shear induced changes in emulsion morphology can be monitored in-situ. The results can prove the ability of an emulsion to repair the damage caused by mechanical impact over time. The information on molecular organization and dynamics under deformation yields exact knowledge of interacting fundamental structuring mechanisms. This results in optimized tuning of technical properties, process engineering, and material parameters with respect to a functionally optimized structuring of emulsion systems, and therefore reduced time-to-market.

Products and markets:

- Pharmaceuticals and Cosmetics
- Food

Network formation of gelatine

Gelatine is an irreversibly hydrolyzed form of collagen. The worldwide production amount of gelatine is about 300,000 tons per year. Gelatine is important in many applications, especially for pharmaceutical products. It typically constitutes the shells of pharmaceutical capsules. Via the backbone chemistry and/or specific additives, custom tailored network formation enables the adjustment of the controlled release pattern towards certain active pharmaceutical ingredients (API). The Rheonaut module enables to monitor temperature dependent steric hindrance, additive activity and network formation in-situ.

Products and markets:

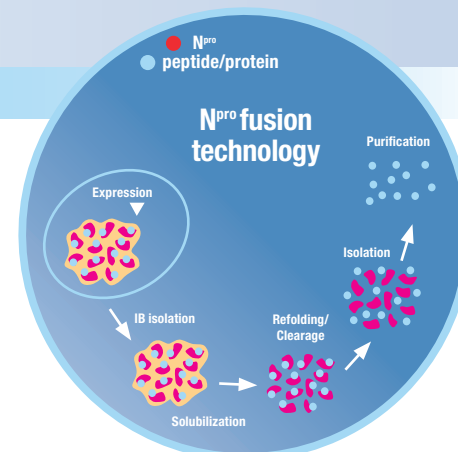
- Pharmaceuticals
- Food

Denaturation of proteins

Proteins are a fast growing market in the pharmaceutical industry. No matter which protein is synthesized in solution, it needs to be purified. One step of the purification process is usually filtering. During the filtering step, odds are high that the protein denaturates due to the high shear rates in the filter pores. Understanding the process is crucial for the manufacturer and the Rheonaut yields the answer by monitoring the shear dependent denaturation of protein solutions in a very sensitive way.

Products and markets:

- Pharmaceuticals
- Food



Extensive rheological investigations on chemical reactions

Thermal and UV-curing

Requirements and demands in the coatings and adhesives industry constantly increase with respect to eco-friendliness, product quality and production efficiency. A better understanding of kinetics of curing under specific conditions, e.g. temperature or UV-intensities as well as final mechanical properties of the cross-linked and cured coating product (G'/G'') are needed to choose the right formulation. This is essential for optimizing the process/application behaviour while minimizing energy footprint in production.

Combining rheology and FT-IR spectroscopy, rheological properties of a material can be correlated with ongoing (chemical) reactions, e.g. the degree of cross-linking as a function of time, temperature radiation, shear or deformation. The Thermo Scientific fast oscillation software tool monitors very fast curing reactions in the rheological data and FT-IR spectra on a millisecond timescale.

Products and markets:

- Adhesives
- Composites
- Coatings



Molecular orientation under shear

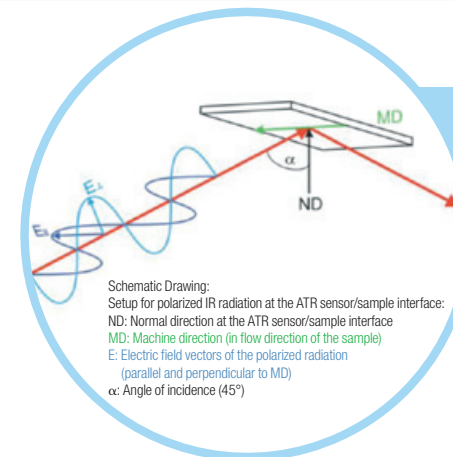
Properties of polymers

Mechanical properties of polymers are strongly influenced by the molecular orientation that happens during various processes, e.g. Extrusion or Pumping. Combining the Rheonaut module with a polarizer enables investigations on the mechanical properties and the molecular orientation under shear at the same time to get a complete description of their dependency.

The rheometer rotation causes an orientation of the sample molecules. Depending on the polarizer setup changes in the absorption bands can be monitored depending on the molecular orientation. By using linearly polarized infrared radiation, the orientation of the functional groups in a polymer can be measured either along the backbone or only the side chains. The difference in the band intensities between parallel and perpendicular polarized infrared radiation indicates the degree of molecular orientation for a polymer.

Products and markets:

- Polymers



Application Support

We provide comprehensive product and application solutions and our application specialist team is on hand to answer your questions.

Selected Product Information:

- P033 Spectroscopical insight into rheology
- P037 New UV module for UV curing measurements
- V246 Measuring of fast UV curing materials using oscillatory measurements
- V247 Detailed analysis of curing reactions of polyurethane resins
- V254 Curing of an Acrylate Glue – Rheology with Simultaneous FTIR-Spectroscopy
- V257 Monitoring Emulsions Morphology Under Shear
- V258 UV-induced curing reactions



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Specifications of the Rheonaut Module

Spectrometer:

Compatible with several standard FT-IR spectrometers

- Thermo Scientific Nicolet™ iS™10 compact spectrometer for basic measurements
- Thermo Scientific Nicolet iS50 flexible research-grade spectrometer for advanced measurements (learn more at www.thermoscientific.com/spectroscopy)

Measuring principle:

- ATR using a single reflection crystal (diamond with 1 mm² surface area)

Detectors (exchangeable):

- DTGS (Deuterated Triglycine Sulfate) as economical version (standard)
- MCT (Mercury, Cadmium, Telluride) for very fast spectra acquisitions
- Inert gas atmosphere to avoid absorption influences by H₂O or CO₂

Options:

- Manually controlled polarizer

Data acquisition and storage:

- “FT-IR spectroscopy module” for the Thermo Scientific HAAKE RheoWin software with integrated control of the FT-IR spectrometer (for selected spectrometer models e.g. Nicolet iS10, iS50), automatic synchronization of rheological data and FT-IR spectra

Temperature control units (exchangeable):

- Peltier unit: 0° – 120°C
 - Electrical unit: 30°C – 400°C*
- *For high temperatures sample hood required

Measuring geometries and accessories:

- Plates and cones with diameters up to 60 mm
- Sample hood to minimize temperature gradient within the measuring gap
- UV-curing module with exchangeable quartz glass plates with diameters up to 20 mm

Dimensions:

depending on spectrometer used W x D x H: 2000 x 600 x 890 mm
(Nicolet iS10 FT-IR incl. HAAKE MARS controller box and computer)



Spectrometers

The Thermo Scientific Nicolet iS50 and Nicolet iS10 FT-IR spectrometers are compatible with the Rheonaut module and add chemical information to your rheology studies.

Nicolet iS50

Research-grade FT-IR spectrometer upgradeable from basic spectroscopy to automated multi-range analysis.

- Flexible multi-ranging – manual or automatic
- Sample compartment for Thermo Scientific Smart™ and Standard accessories
- Multiple detectors on-board
- Built-in diamond ATR
- TGA-IR for deformation using Mercury TGA Software for rapid analysis
- Touch Point control for technique setup and operation
- iS50 Raman module offers motorized stage, USB camera, and total software solution
- Rapid scanning for fast kinetics, including ultrafast time-resolved capability
- Multiple emission ports
- Spectral range from visible to Far-IR

Nicolet iS10

Single range, validated spectrometer with mid-IR or near-IR capabilities designed for rugged, fast-paced operation.

- Mid-IR or Near-IR fixed range with manual source swap
- Sample compartment for Smart™ and Standard accessories
- Single detectors on-board
- ATR through accessories
- TGA-IR for deformation using Mercury TGA software for rapid analysis
- Integrated scan buttons for operations



Thermo Scientific Nicolet iS50 FT-IR spectrometer with ABX Automated Beamsplitter exchanger, built-in diamond ATR, and Raman module in the sample compartment.

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