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IPA

Fraunhofer Institute for Manufacturing
Engineering and Automation IPA

Infrared spectroscopy in coating systems and painting technology

ATR unit (with a droplet of resin-based dispersion on the measuring point). Source: Fraunhofer IPA

Technology

Infrared spectroscopy (IR spectroscopy) is an analytical method for identifying chemical structural elements, ideally specific chemical compounds. When molecular groups/covalent bonds absorb energy from IR radiation, they become excited and vibrate at characteristic frequencies, which can be measured as a so-called IR spectrum (sum of all vibrations in the active spectral region with change in dipole moment, representation as a function of reciprocal wavelength = wavenumber). Modern infrared spectrometers use polychromatic IR radiation, whereas monochromatic IR radiation was used in the past. IR spectra are calculated by analyzing interferograms with Fourier transformation.

Measurement techniques and preparation methods for IR spectroscopy

The following measurement techniques and methods are commonly used at Fraunhofer IPA:

- **ATR (Attenuated Total Reflection):** IR absorption is detected directly at the surface of a sample to a depth of several μm (depending on the measuring crystal and wavenumber). Examples of use: identification of binders and fillers, detection of surface contamination (if coatings are thick enough), determination of resin/hardener ratios, evaluation of substance mixtures
- **IR microscopy:** examination of very small particles or areas (e.g. flaws on a sample)
- **Transmission measurements on foils**

Analysis of damage patterns using infrared spectroscopy based on examples of assignments

- Identification of binders and fillers
    - Changed properties of an anti-friction coating Result: modification in composition of coating or binder
    - Dispute regarding the identity of a wall coating (Specification: silicone resin) Deviation confirmed
- Classification of inclusion particles (substrate, coating, foreign particles)
    - Particles on the surface of a sol-gel coating consist of the same (dried) coating material
- Identification of impurities on coated surfaces
    - Identification of paint-wetting impairing (PWIS) or adhesion-inhibiting substances, e.g. silicones on substrate surfaces, in work gloves, etc.
    - Formation of white deposits on headlamp lenses due to release of substances from headlamp parts
- Identification of impurities in cathodic dip coating baths or cleaning baths
    - Flow problems on vehicle doors due to contamination of CDP by lubricant
- Liquid deposits in heat exchanger of a paint shop
    - Distinguishing of components of processed coatings from coolant
- Characterization of adhesion failure
    - Delamination phenomena on structures made of plastic support fleece structures due to contamination by silicones and fatty acid esters
    - Classification cohesion failure vs. adhesion failure
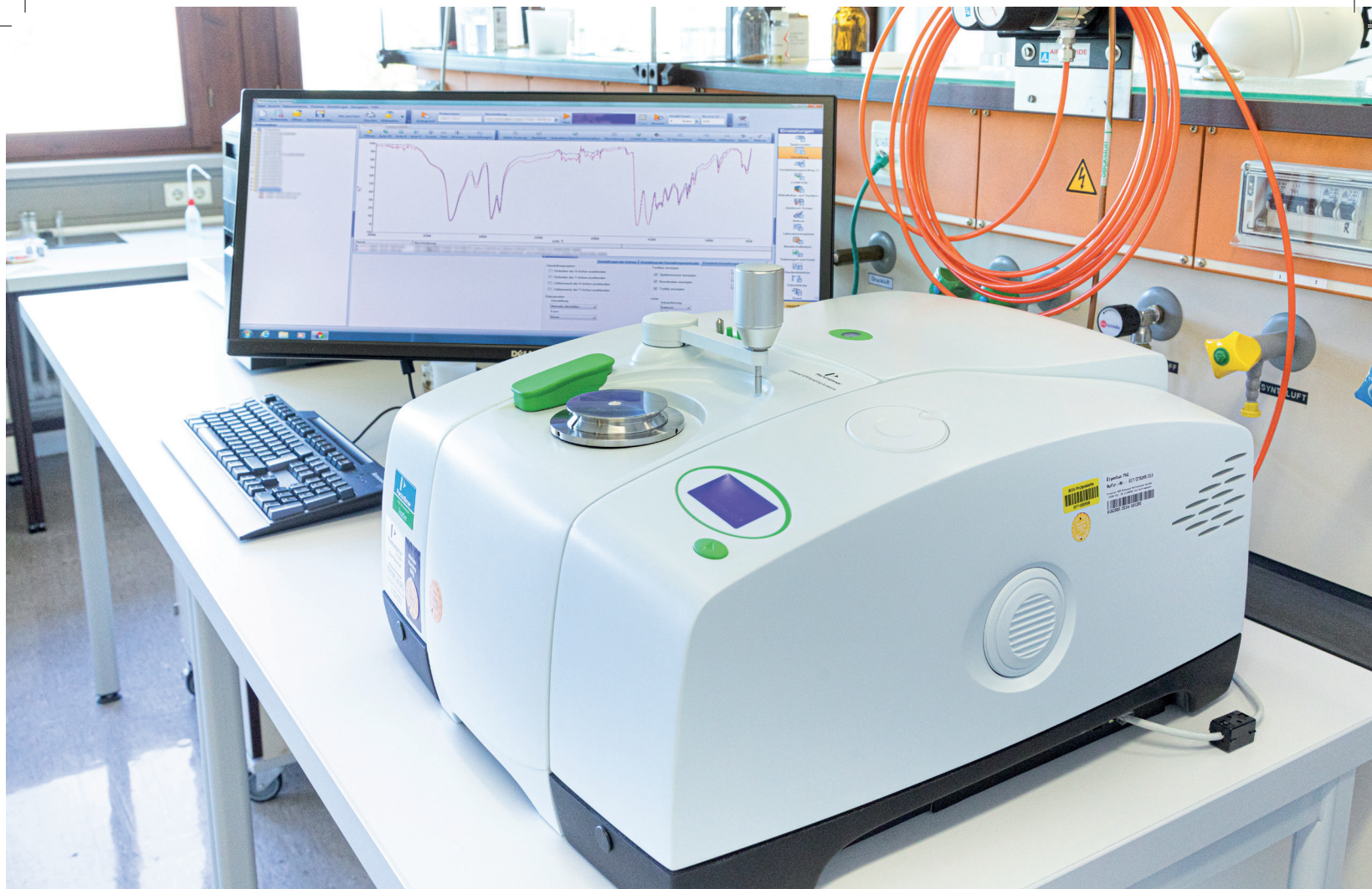
IR spectrometer with ATR unit.
Source: Fraunhofer IPA

- Determination of mixing ratio of 2-component coatings
- Characterization of changes in exterior automotive parts
  after years of use in tropical climate
  – Result: migration of plasticizer from adhesive into the
    load-bearing coating layer

Research projects with infrared spectroscopy

- Detection of decomposition products after activating the
  surface of polyolefins
- Degree of conversion of acrylic double bonds of UV coatings
  using different photoinitiators and irradiation sources
- Identification of migratable additives in plastic parts with the
  aid of rinse samples
- Capacity of specific types of an isocyanate hardener to diffuse
  from a clearcoat into the underlying basecoat layers
- Characterization of newly-synthesized or modified binders
  from R&D projects and of coatings made with them

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