

## TGA-FT-IR for Damage Assessment of Polymers

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The application of coupled analysis techniques – using thermogravimetry coupled with infrared spectroscopy (TGA/FT-IR) as an example – is very beneficial when investigating damage cases in conjunction with polymer materials. The following damage cases from the areas of paints, adhesives, elastomers and (fiber-reinforced) plastics, for which it was possible to achieve clarification by means of TGA-FT-IR, will be explained in the presentation:

1. A high residual solvent content in a primer leading to blistering when used at high temperatures: TGA-FT-IR allows for quantitative determination of the residual content of butyl acetate that can be identified.
2. An anti-friction coating on cartridge cases exhibiting different sliding properties depending on the baking temperature: Various decomposition temperatures of a silicone modification of the epoxy resin binder and the content of residual solvents allow conclusions to be drawn about the cross-linking and sliding properties.
3. Plastic buffers in handguns made of polyester urethane which soften and discolor in the long-run: There is no incompatibility with the gun oil; rather, age-induced hydrolysis of the polyester urethane is the cause of damage. Hydrolysis can be determined thermogravimetrically on the basis of differing temperatures for the release of the diol and isocyanate components when comparing new and used buffers.
4. A “fiber optronic” device shows contamination of the fiber ends by amorphous SiO<sub>2</sub> due to the decomposition and migration of a silicone component. The silicone source can be identified by infrared spectroscopy and classified in terms of its migration properties based on the decomposition temperature.
5. Thermal damage to overheated carbon-fiber-reinforced plastics is quantified mainly in the form of residual strength by means of thermogravimetry and chemometric methods. In addition, the informative value of quantitative determination of the thermal decomposition products by means of TGA-IR for estimating the toxicity of combustion gas mixtures will be discussed.
6. Incompatibilities of nitrile butadiene rubber (NBR) with operating media can be traced back to a deviating amount of acrylonitrile in the copolymer. This can be quantitatively determined by means of the decomposition products, particularly in the form of hydrocyanic acid (HCN). In addition, a TGA-FT-IR experiment allows for conclusions to be drawn with regard to the additives contained and the operating materials absorbed.

Finally, the limitations of the methods, especially with regard to the identification of polymers and their additives, will be discussed. To this end, a brief comparison in terms of informative value will be made with pyrolysis gas chromatography/mass spectrometry (Py-GC/MS).