Service Group Rheology

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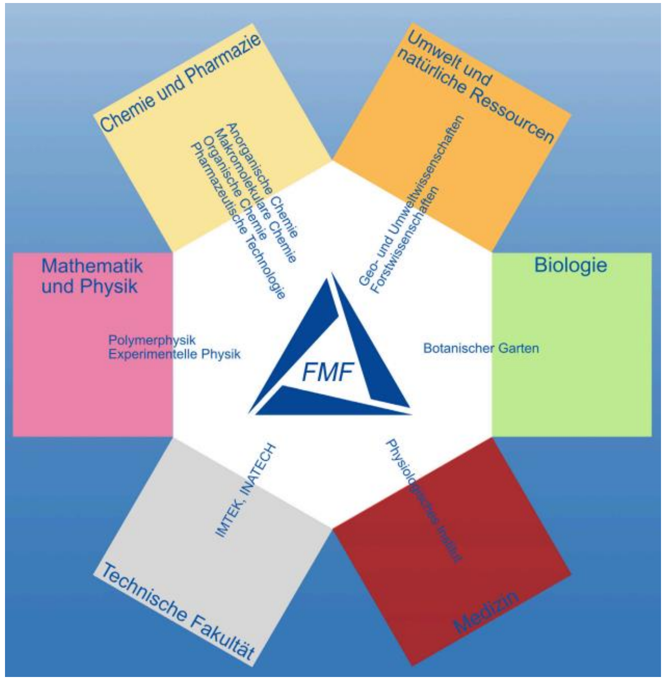
UNI FREIBURG

Who are we?

- FMF is a central institution of Albert-Ludwigs-University Freiburg
- In the field of new materials and materials-related technologies, it has been conducting basic application-oriented and target-oriented contract research for 32 years.
- Six faculties, Fraunhofer Institutes from Freiburg and the regional EUCOR universities are collaborating on this platform.



Bastian E. Rapp
Chair & Head

Ahmad Shakeel
Postdoc

Ulrich Matthes
Klaus Hasis
Technicians

List of processing equipment

- Extrusion
  - ZK 25T twin-screw extruder, Teach-Line (Collin)
  - 2 gravimetric feeders (Katron)
  - Xplore twin-screw micro-compounder
- Injection molding
  - Xplore mini-injection molding machine
  - Injection molding machine K40 E (Ferromatik)
- Film blowing line 180/400 (Collin)
- Hot melt press (Collin)

List of processing equipment

- Cutting and grinding
  - Rolling mill (Collin)
  - Rapid cutting mill
  - Table cutting mill (Hellweg)
  - Pin mill, ZM 200 (Retzsch)
  - Vibrating cup mill (Retzsch)
  - Hammer mill (IKA)

- Mixing
  - High-speed mixer (Henschel)
  - Aero wheel mixer (Engelsmann)


List of testing equipment

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- Rheometers
  - MCR702, MCR301 (Anton Paar)
  - MARS II (Thermo-Fisher)
  - UDS 200 (Paar Physika)
  - ARES (Rheometrics)
  - High-pressure capillary rheometer (Göttfert)
  - Melt index tester, MELTFLIXER LT (Coesfeld)

- Dynamic thermo-mechanical analysis
  - DMA Q800 (TA Instruments)
  - RSA3 (Rheometrics)
  - TMA 202 (Netzsch)

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List of testing equipment

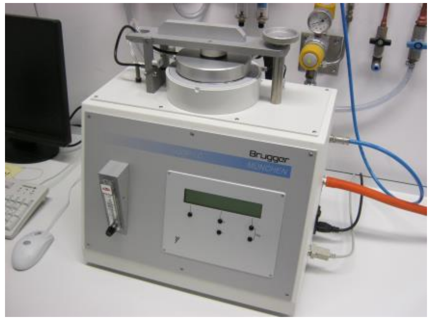
- Analysis of mechanical properties
  - Materials testing system Z005 (Zwick)
  - Impact strength analyzer 5102 (Zwick)

- Dispersion analyzer, LumiSizer 611 (LUM)

- Micro-Pycnometer (Quantachrome)

- Morphological analysis, microscope G3SE (Malvern)

- Permeation measuring device (Brugger Feinmechanik)



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Research areas/fields

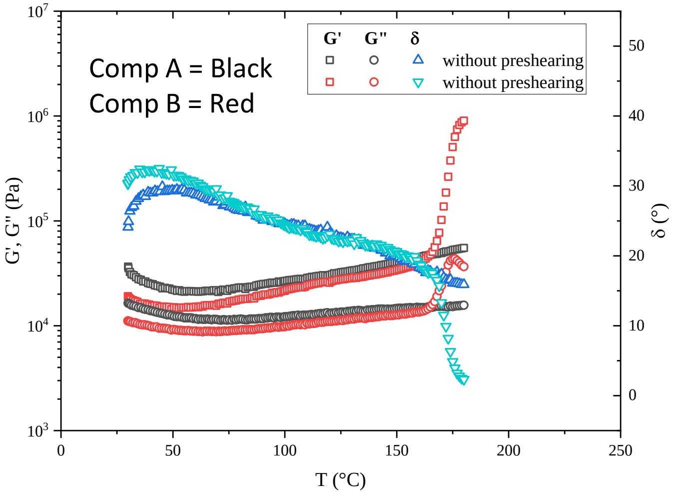
- Rheology of polymer blends, polymer solutions, particle dispersions, gels and polymeric ionic liquids
- Rheology of reactive resins and their processing
- Shear/strain induced crystallization of polymers
- Rheology combined with morphology detection

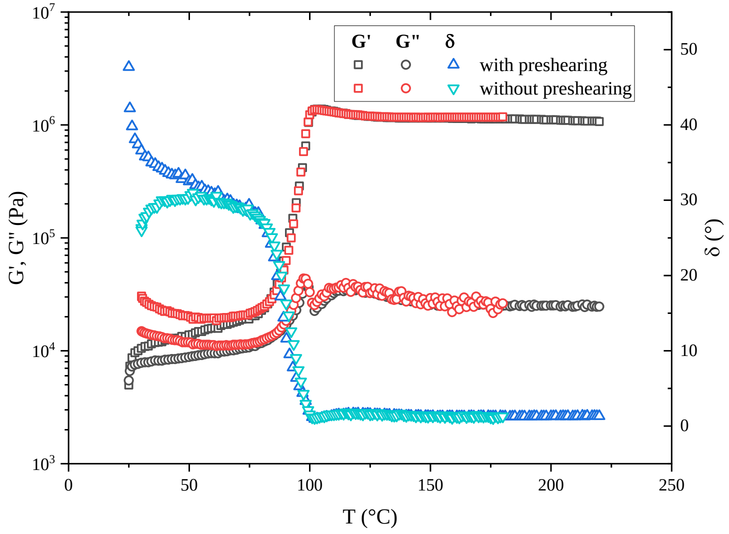
Research objectives

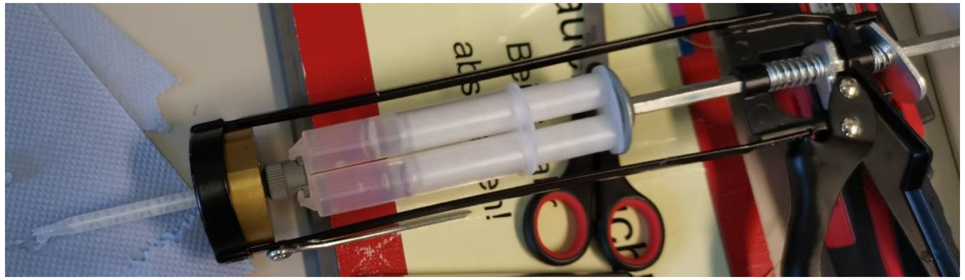
- To obtain rheological data as a function of shear or strain rate, stress, frequency and temperature
- To determine material functions, e.g. viscosity, moduli, creep, gel point and relaxation function
- To correlate rheological data with material properties, e.g. molecular weight, molecular weight distribution, short or long chain branching, polymer/solid content, etc.
- To obtain process relevant rheological properties under high temperature and high pressure using capillary rheometer
- To couple rheometry with morphology detection to understand shear orientation, elongation and crystallization of polymeric chains
- To optimize process and product development using rheological properties

Current projects

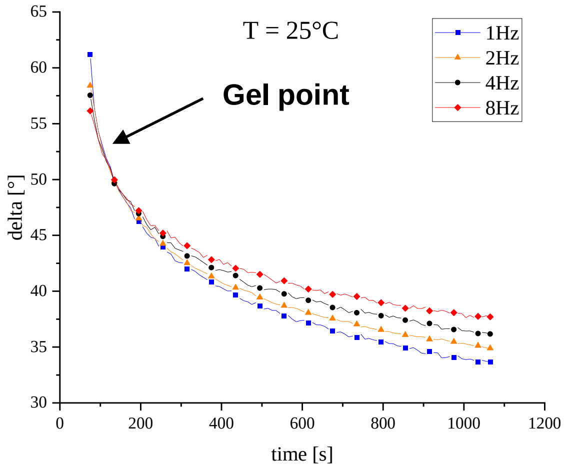
- To investigate the gel point and cross-linking point for two-component liquid silicon rubber (LSR) for injection molding application





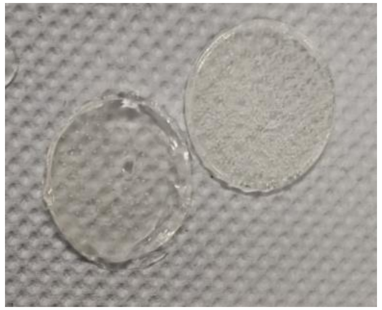


Cartridge press with 2-component syringe and static mixer



Research objectives

- Gel point investigation for different pre-shear rates and temperatures
- Cross-linking point investigation by performing frequency sweep tests at different temperatures without any pre-shear
- Effect of heating rate on the evolution of moduli
- Shear rate sweep test (flow curve) of mixture at different temperatures
- Comparison between DSC and Rheo- experiments

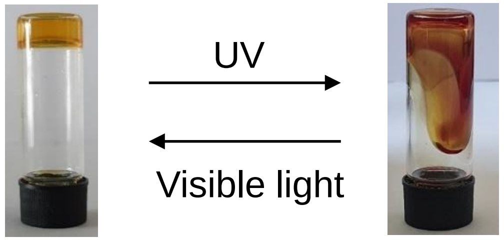


Cured silicone samples

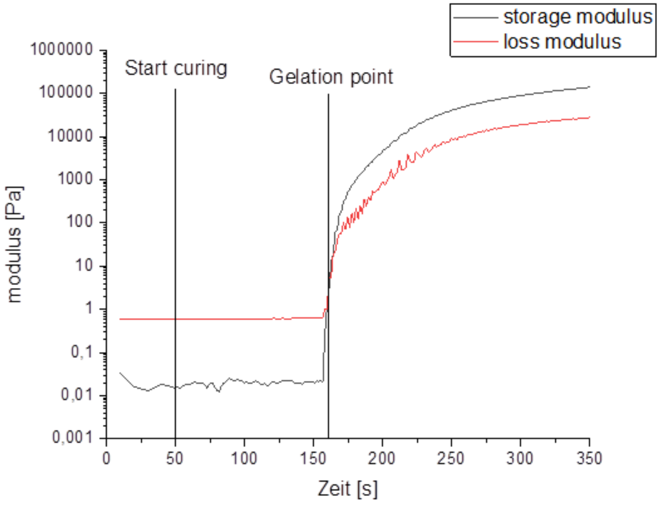
Current projects

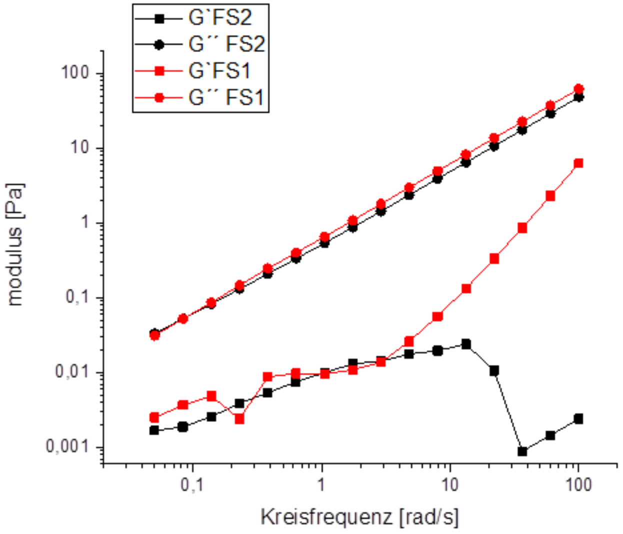
- To investigate the photo-switchable rheological behavior of gel-like material

Before UV



- To investigate the gel-point and gelation time of fluoropolymers for coating applications



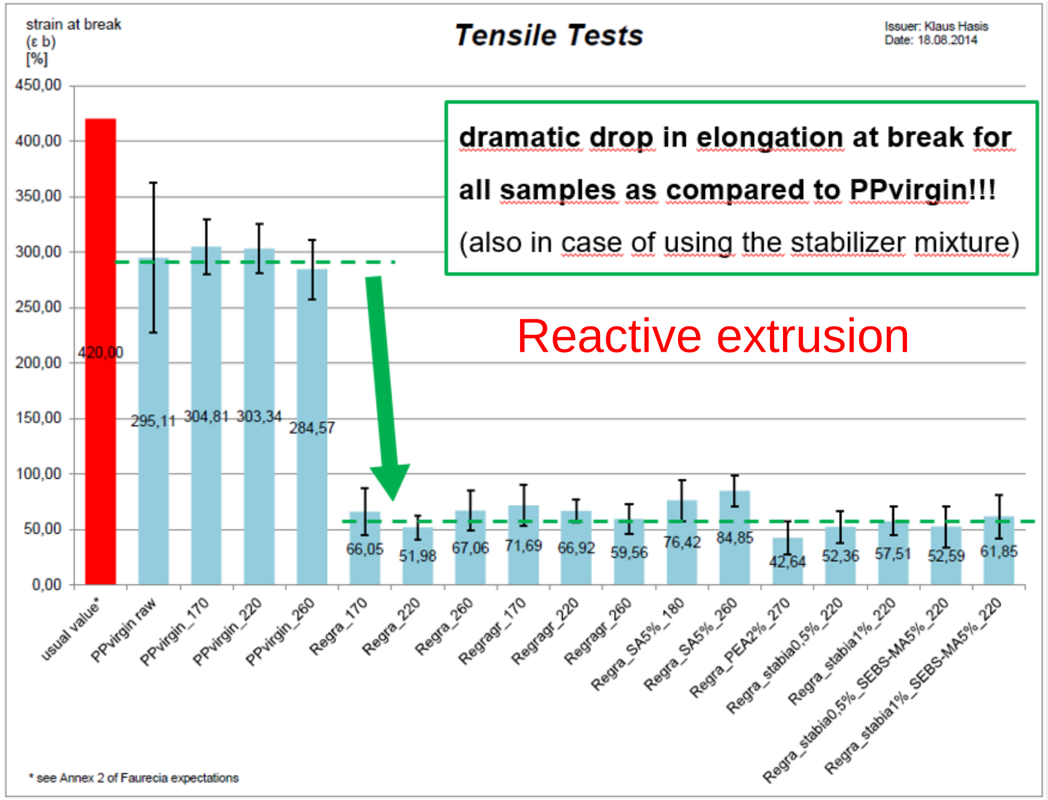


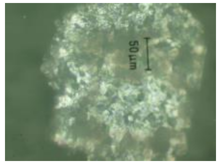
Past projects

- Recycling of painted PP bumpers by chemical decomposition of paint film followed by extrusion to obtain improved aesthetics and mechanical properties

Strategies

- Reactive extrusion of regra together with paint film decomposition agents and/or compatibilizers
- Chemical pretreatment of regra followed by ordinary extrusion
- Microcompounding of regra together with paint film decomposition agents and/or compatibilizers





Additives

- Stearylamine, pentaerythritol, Waradur-S (montan wax), maleated SEBS, Recycloblend 660

Processing stabilizers

- mixture of Irganox1010 and Irgafos168

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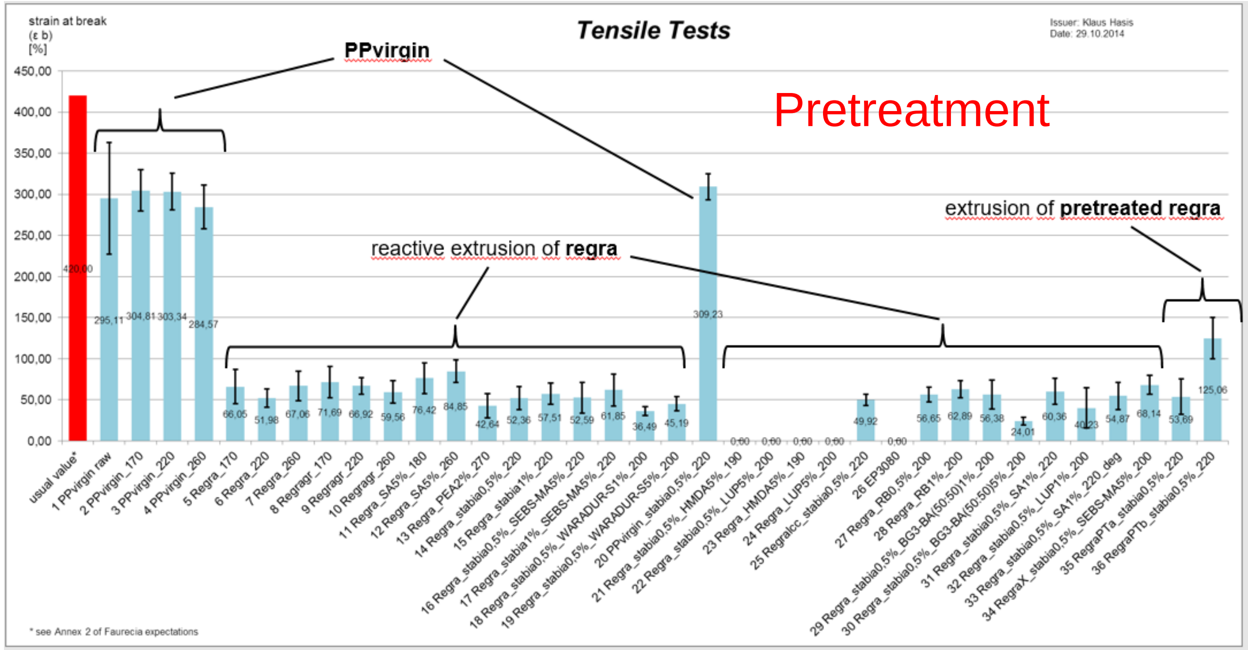

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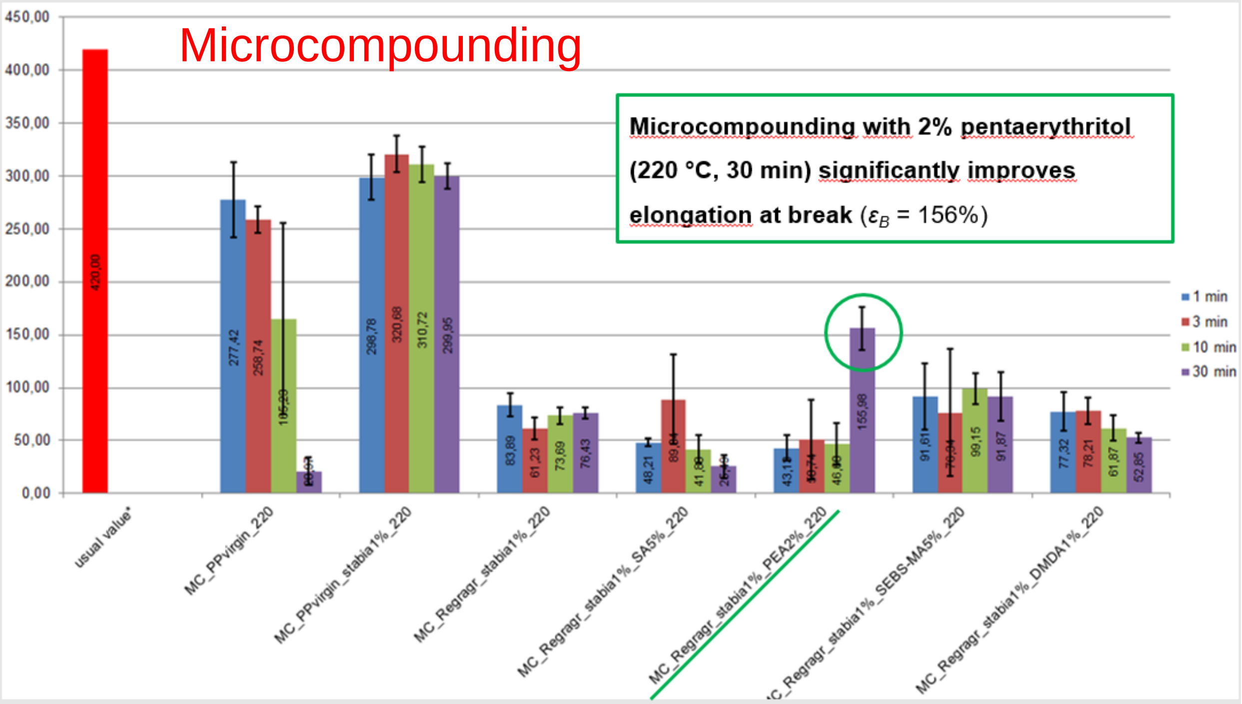

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Further processing experiments by using the microcompounder:

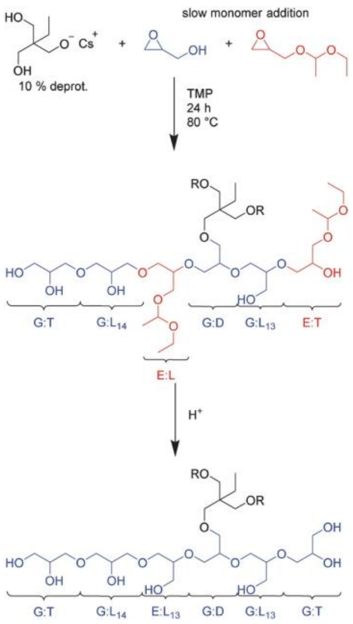
- examination of further paint film decomposition agents
- employing additional catalysts, e.g. in combination with alcohols such as pentaerythritol or trimethylolpropane
- admixing additional compatibilizers

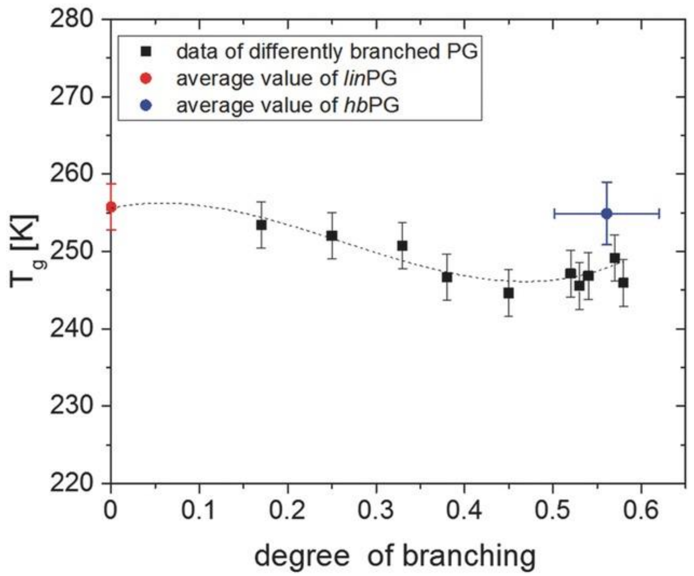
Past projects

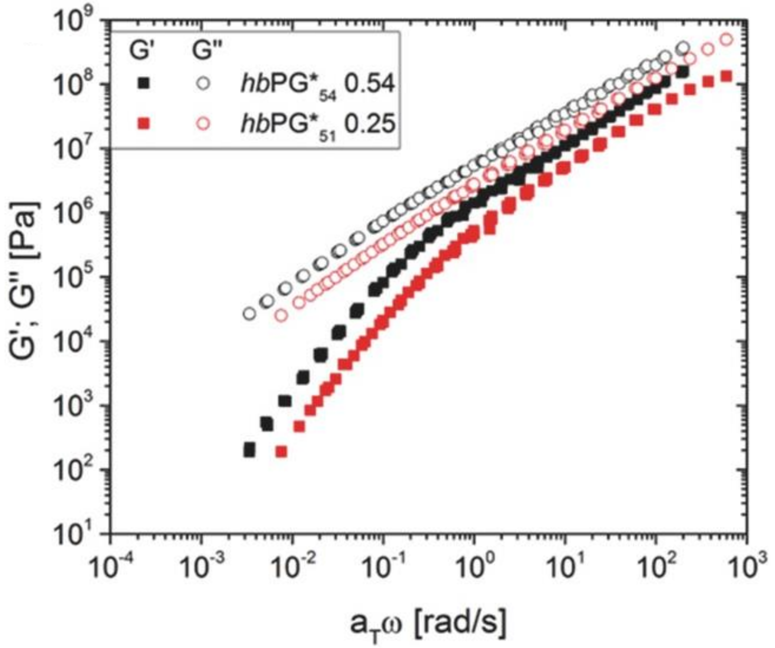
- Systematic variation of the Degree of Branching (DB) of polyglycerol and its impact on rheological properties

Strategy

- Random copolymerization of an AB_2 monomer (glycidol) with the linear AB monomer (ethoxy ethyl glycidyl ether) to generate hyperbranched polyglycerols with an adjustable degree of branching (DB) after deprotection



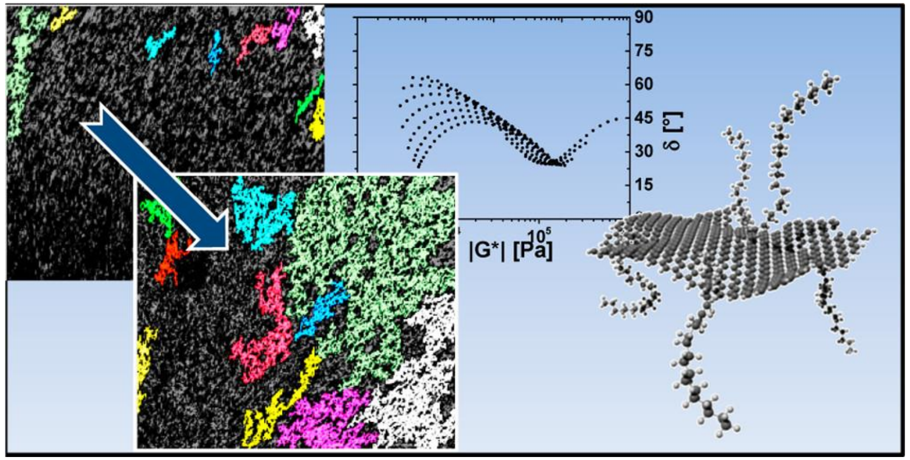




Polymers exhibit increasing intramolecular hydrogen bonds when increasing the DB, while the possibility of forming intermolecular hydrogen bonds is reduced

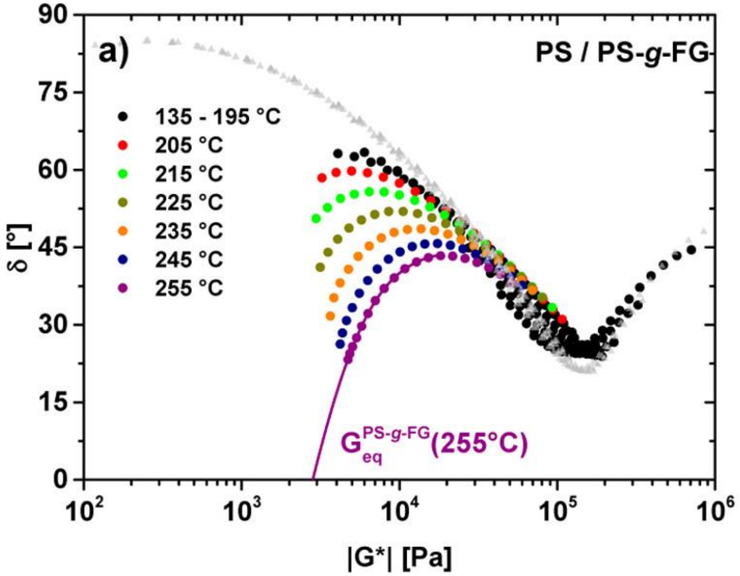
Past projects

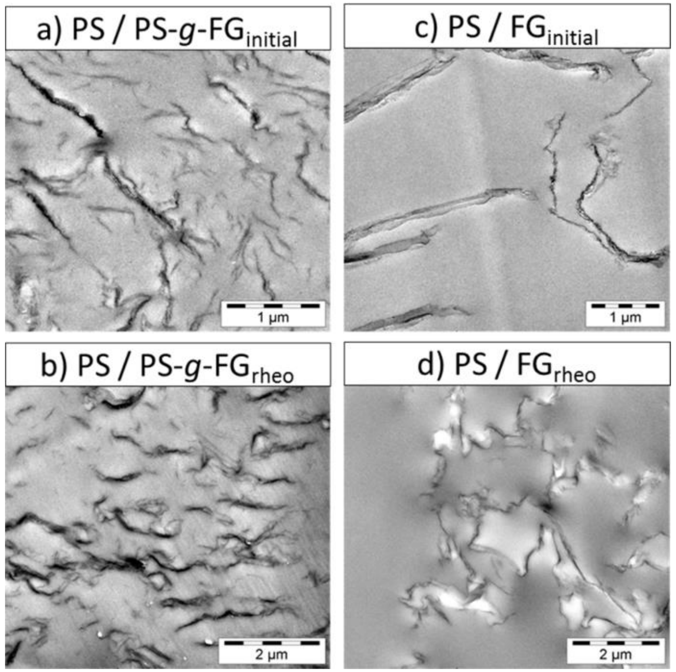
- Shear- and Temperature-Induced Graphene Network Evolution in Graphene/Polystyrene Nanocomposites and Its Influence on Rheological, Electrical, and Morphological Properties



Strategy

- Hydrophobic modified graphite oxide was grafted with polystyrene chains (PS-g-FG), thus enabling a high degree of compatibility with the polystyrene matrix





Extensive shear (large amplitude oscillatory shear) led to a destruction of the network while small shear impact (small amplitude oscillatory shear) in combination with elevated temperature was crucial for an effective buildup of the graphene particle network