Competence in Rubber Materials

Deutsches Institut für Kautschuktechnologie e.V.

DIK - Research in the Service of Industry

As per its charter, the Deutsche Institut für Kautschuktechnologie e. V. (DIK) was founded in 1981 on the initiative of the German rubber industry and the Lower Saxony Ministry for Economics, Labor and Transport. Since commencement of its active engagement in the areas of processing technology and elastomer chemistry and physics in 1984, DIK has evolved into a respected research institution that now enjoys international renown.

Several factors paved the way to this success and to the development of the Institute into a competence center for rubber technology. For one thing, there is the unflagging service readiness of its staff and management. Then there is the support provided by the member companies, the Deutsche Kautschuk-Gesellschaft (DKG) [German Rubber Society], the Wirtschaftsverband der deutschen Kautschukindustrie (WDK) [≈ organization of the German manufacturers of tires and technical elastomers], the Lower Saxony Ministry for Economics, Labor and Transport and the Arbeitgeberverband der Deutschen Kautschukindustrie (ADK), (employers' federation of the German rubber industry).

This institute's success is, however, also the product of its unique underlying concept, which unites under one roof the various natural science and engineering disciplines having a bearing on rubber and polymer materials. This focus has enabled DIK to establish itself internationally as an institute of cross-sectional character unparalleled in its own way. We believe the combination of research and entrepreneurial focus to admirably position DIK as a know-how partner and service provider to the European rubber industry and its suppliers. In particular, the users of elastomer products themselves - the machinery construction or automobil industries together with their suppliers - stand to profit from DIK's competence.

Special priority is assigned the training and ongoing development of qualified employees for the rubber industry - whether at the entry level or in a specialist capacity. In cooperation with the Wirtschaftsverband der deutschen Kautschukindustrie (WDK) and Leibniz Universität Hannover, a continuing education and training course of studies in rubber technology („Weiterbildungsstudium Kautschuktechnologie (WBS)") has successfully been implemented since 1985. Here, rubber industry professionals can enroll in a decidedly job-related program of a high academic caliber. This unique offering gives those participating the wherewithal to become national and international rubber experts.

Organization of the Institute

Alongside the organs stipulated in the bylaws of the Institution - the General Assembly, the Board of Trustees, the Executive Board and the Academic Advisory Council - the key pillars on which the Institute rests are its six specialist Research Departments as well as its Quality Management and "Training and Education" units.

DIK particularly values promotion on the part of its members. By force of their membership, companies assist the Institute in maintaining and further developing the technical competence in the area of rubber that is needed to carry out research and, above all, to provide a wide range of services. The member companies include many renowned raw material suppliers, machinery manufacturers and firms in the rubber industry.

The Board of Trustees consists of one representative each from the Lower Saxony Ministry for Economics, Labor and Transport, the Wirtschaftsverband der Deutschen Kautschukindustrie e. V. (WDK), the Deutsche Kautschuk-Gesellschaft e. V. (DKG), and the Gottfried Wilhelm Leibniz Universität Hannover, as well as leading figures in the rubber industry and in scientific research.

The Executive Board is made up of the managing director of the Deutsches Institut für Kautschuktechnologie e. V. (Prof. Dr. Ulrich Giese, DIK), a representative of the Deutsche Kautschuk-Gesellschaft e. V. (Dr. Manfred Grothe, DKG), and a representative from industry (Helmut Heyne, ADK).

The task of the Academic Advisory Council is to provide the DIK Executive Board and the Board of Trustees consultation in all research matters as well as in all other matters bearing on the Institute's professional activities. It is composed of up to six members active in university and industrial research and instruction.

Core competencies

DIK engages in wide-ranging research and offers a broad spectrum of services. Over the years, the following have emerged as the Institute's key focal points:

- Physicochemical characterization of materials, raw materials and compounds
- Trace analysis (environmental aspects, industrial safety, leachability analysis)
- Materials development („new materials", compounding)
- Material concepts and modeling
- Functional reliability and service life predictions
- Processing methodology (compounding, two-component systems, extrusion)
- Simulation and continuum mechanics

DIK is organized into six departments that cover these various focal point areas. Taking an interdisciplinary approach, the departments engage in high-level research geared to issues of current relevance. The work carried out encompasses applied basic research, research commissioned by industry, pilot production runs, quality testing and failure analyses

Departments:

- Elastomer Chemistry
- Elastomer Physics
- Material Concepts and Modeling
- Materials Development
- Simulation und Continuum Mechanics
- Processing Methodology

Elastomer Chemistry

Prof. Dr. Ulrich Giese

In terms of content, Elastomer Chemistry (EC) covers three areas: materials and failure analysis, trace analysis, and microscopy. Because of the issues involved, microscopy collaborates closely with the other departments at DIK. Equipped with cutting-edge technology for spectroscopy, chromatography, thermoanalysis, and electron microscopy, the department is able to guarantee thorough execution of the numerous commissioned assignments and research projects entrusted to it on the most diverse issues. The unit's more than 25 highly qualified and experienced technicians and researchers provide work of the highest level. Also worth noting is the department's activities in the area of nitrosamine analysis, which is conducted on the basis of many years of experience with a dedicated testing facility to TRGS 552 and current accreditation standards to EN 17025.

Topically, the overall range of research focal points is quite diverse. It includes the development of new materials, studies of aging mechanisms, crosslinking, methods development, characterization of multiphase systems (morphology) and of rubber/filler interaction, analysis of leachables and extractables out of polymer materials, elastomer emissions and environmental exposure, processes for transporting gases and fluids in elastomers, and recycling. Special environmentally relevant aspects like emissions, nitrosamines, polycyclic aromatic compounds, and the environmental exposition of elastomer products are additionally covered, with consideration given to the comprehensive experience gathered to date.

Research focal points

- *Characterization of multiphase systems (morphology)*
- *Polymeric fillers*
- *Rubber/filler interaction*
- *Crosslinking*
- *Aging mechanisms*
- *Modification of fillers and polymers*
- *Nanomaterials (synthetic and bio-based)*
- *Leachables and extractables out of polymer materials*
- *Elastomer emissions and environmental exposure*
- *Transport processes in polymers for gases and fluids in elastomers*

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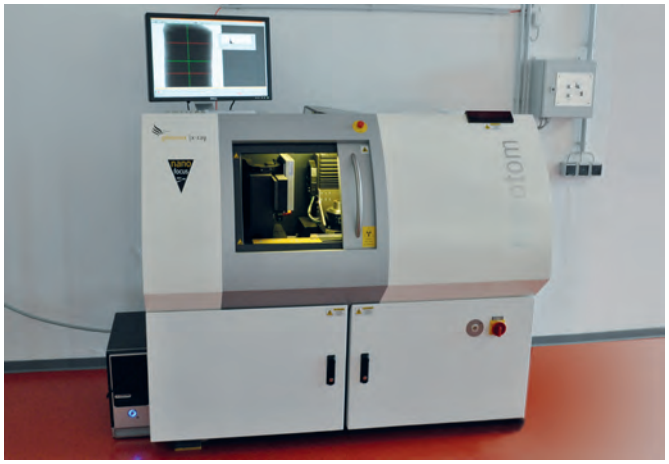
Elastomer Physics

Dr. Jens Meier

Elastomer Physics focuses on both the characterization and the targeted control and predictability of property profiles of elastomer materials and components under service conditions. DIK's partners and customers stand to profit from the Institute's many years of experience in the areas of viscoelasticity and elastomer relaxation behavior as well as from the Institute's high degree of competence in conducting tests on damping, even in the high-frequency range. Another departmental focal point is predicting the service life of elastomer materials on the basis of special dynamic analyses. The application of material laws and the determination of key characteristics - via Wöhler curves, for example - is just as much within EP's scope of competence as is the physical characterization of „new materials" - materials based on magnetorheological elastomers, for instance.



Alongside a comprehensive range of state-of-the-art equipment, use is also made of unique and specifically developed methods - e.g. high-frequency ultrasound measurements or analysis of material behavior under conditions of multiaxial stress. Another field of activity is rheology of polymers and mixtures all the way to mold filling simulation.

Research focal points

- *Dynamic-mechanical properties up to high frequencies*
- *Customized acoustic, damping and friction characteristics*
- *Long-range predictions of relaxation and creep by means of accelerated testing*
- *Prediction of the service life of dynamically stressed components*
- *Fracture mechanics and damage calculations*
- *Magnetorheological elastomers for sensors and adaptronics*
- *Special investigations into material homogeneity by means of X-ray tomography (CT)*
- *Processing rheology and mold filling simulation*

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Prof. Dr. Manfred Klüppel

Material Concepts and Modeling

Material Concepts and Modeling was established in 2002 under the direction of PD Dr. Manfred Klüppel. Its purpose is that of enabling DIK to better address the growing challenges facing industry with regard to the physical modeling of elastomers. A key object of research in this department is elucidation of the connection between the microscopic structure and the macroscopic properties of flowable as well as crosslinked, reinforced elastomer systems. Special importance is attached to applied basic research aimed at throwing light on the physical properties of elastomers and implementation of the knowledge so acquired in microstructure-based models

Research focal points

Contact mechanics and friction

- *Theory of rubber friction, traction characteristics of tires*
- *Contact mechanics at rough (fractal) interfaces*

Aging and wear

- *Aging phenomena of polymer and filler networks*
- *Crack propagation and fatigue, friction and wear mechanisms*

Fillers and reinforcement

- *Characterization of fillers and filler networks*
- *Theory of filler-induced reinforcement*
- *Dynamics of filler flocculation*
- *Material models for FE simulation*
- *Molecular-dynamic simulation for interphase dynamics*
- *Elastomer nanocomposites*

Dielectric and dynamic-mechanical spectroscopy

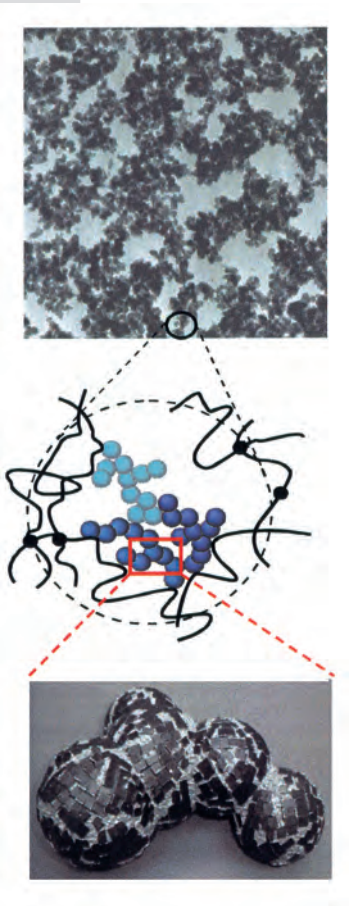
- *High-frequency characteristics*
- *Charge transport mechanisms*
- *Microwave heating*

Rheology of rubber melts

- *Molecular rheology of entangled polymer melts*
- *High-pressure capillary viscosimetry, elastic turbulences, wall slip phenomena*
- *Combined rheological and dielectric analysis*

Polymer networks and polymer blends

- *Theory of rubber elasticity, determination of polymer network parameters*
- *Characterization of blend morphology, filler distribution in blends*



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Materials Development and Testing

Dr. Harald Geisler

Materials Development and Testing forms the link between elastomer research and Industry. Materials development implements the insights gained with respect to focal-point characterization of raw materials, compounds and elastomers as well as processing methods. Making maximum use of numerous physical testing methods, the department is able to develop new materials with specific property profiles.

Proceeding on the basis of the physicochemical properties of raw materials, the department investigates the interaction of these in application-relevant formulas. The functioning of newly developed or modified raw materials is examined on rubber compounds best exemplifying the relevant field systems. This involves, among other things, systematic analysis of the effect on the dispersion behavior of fillers as well as on crosslinking behavior, processibility and storage stability. The insights serve as direct feedback on field-related basic research by making it possible to determine how the micro- and macrostructure of raw materials affect processing and application properties.

A focal point that has emerged in recent years is material modification by means of atmospheric-pressure plasma treatment aimed at improving permeation density and modifying friction and wetting properties as well as bondability and adhesion

Research focal points

- *Development of new materials*
- *Development of measuring methods*
- *Physical testing as per standardized methods*
- *Characterization of the distribution of fillers in rubber compounds*
- *Vulcanization kinetics*
- *Influence of polymer and filler structure on processing*
- *Definition of quality characteristics of new raw materials*
- *Determination of aging behavior of elastomers under thermal and medial as well as dynamic load, with particular attention given requirements specific to the automotive industry*

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Processing Methodology

Dr.-Ing. Benjamin Klie

Processing Methodology at DIK focuses on continuous and discontinuous compounding technology - including extrusion, calendering and injection molding - as well as researching and developing new types of elastomers based on nanocomposites. The wide range of laboratory and technical equipment at its disposal enables the department to engage in basic research, while also allowing for the analysis and optimization of manufacturing processes in close alliance with industry.

Projects are carried out in tight cooperation with industrial partners. All told, the spectrum extends from short-term orders for individual business partners all the way through to comprehensive bilateral or multilateral projects funded by industry and long-term projects supported by public institutions. In rubber technology, it is frequently hard to draw a distinction between process and material issues. For this reason, the activities of Processing Methodology tie in closely with the scope of activity of DIK's remaining material-oriented departments. This creates ideal conditions for successfully accomplishing the respective tasks.

Research focal points

- *Analysis of flow characteristics and the processing behavior of compounds*
- *Discontinuous and continuous compounding processes*
- *Manufacture of thermoplastic vulcanizates*
- *Extruding, calendering and injection molding, especially 2-component injection molding processes*
- *Process development and -optimization for industrial customers*
- *Contract manufacturing of rubber compounds*

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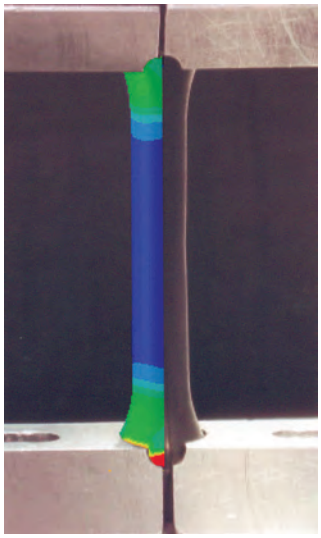
Dr. Nils Hendrik Kröger

Simulation and Continuum Mechanics

Simulation and Continuum Mechanics is DIK's youngest department. Its core competence is the multiscale simulation of the material behavior of elastomers and their application in component optimization and service life predictions. Computer simulation amounts to „doing as if". In other words, an attempt is made to replicate the real behavior of systems on the computer. Simulation offers a number of advantages over classical experiments:

It makes it possible to already study the behavior of complex components on the computer, even before prototypes of the components have been made.

Simulation also allows for the kind of insights into processes that cannot be obtained by means of real-life measurements. In other words, it makes it possible to „take a look inside".



Many experiments are extremely costly, take much too long, or are over much too quickly. For this reason, the results are hardly or only partially satisfying. Simulation helps here as well.

Simulation methods are extremely helpful where the aim is one of testing different variants of a product - something that is particularly important in achieving optimization. In many cases, simulations are less costly than experiments and take less time to run.

It goes without saying that even the best simulations cannot completely replace experiments. They serve much more to reasonably reduce the number of trials required and can also provide attendant support for product development further down the line.

Research focal points

- *Problem-matched material models for elastomers, thermoplasts, thermoplastic vulcanizates (TPVs), foamed materials and the like (taking into account the Mullins effect and the Payne effect, material damping and anisotropy)*
- *Implementation of new concepts and material laws in commercial FE programs like Abaqus and MSC.Marc*
- *Parameter identification on the basis of homogeneous and in-homogeneous states of load distribution*
- *Simulation of fatigue and aging processes*
- *Replication of self-organizing processes within materials*

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Quality Management and Accreditation

Dr. Kelim Vano Herrera

The Deutsche Institut für Kautschuktechnologie e. V. (DIK) has a modern quality management system at its disposal. As a laboratory accredited to DIN EN ISO/IEC 17025, DIK is qualified to conduct chemical testing as well as application and materials technology testing in accordance with various test procedures. Continuous quality records document and verify the binding nature of procedural and job instructions. Reliability, environmental compatibility and transparency are the hallmarks of the test procedures applied. They guarantee cost-efficiency and protection of confidential information. At DIK, only trained and regularly schooled professionals exhibiting reliable judgment and a marked awareness for quality are assigned to render quality-relevant services. Detailed checklists and follow-up controls oblige those carrying out and supervising an order to exercise the greatest degree of diligence and self-accountability at every stage in the implementation of an order. Systematic quality requirements and acceptance criteria for the product and the supplier govern in-house procurement of equipment and services.

With the benefits to the customer uppermost in mind, the quality management system at DIK governs and verifies all quality-related activities in the following areas

- *Acquisition, customer care,*
- *Contract review and accounting*
- *Preparation of samples and reporting of results*
- *Test specifications*
- *Test devices, measuring techniques and data processing*
- *Physicochemical testing of elastomers*
- *Chemical trace analysis (e.g. migratable materials, nitrosamines, etc.)*
- *Storage and transport of samples*
- *Auditing and assessment of the quality management system.*

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Collaboration in research projects and commissioned work

There are numerous attractive possibilities for collaborating with DIK on research and commissioned projects:

Projects in alliance with industry

Bilateral projects

Partnership in publicly sponsored projects, e.g. with funding from the Federal Ministry of Education and Research (BMBF), the EU, the German Federation of Industrial Research Associations (AiF), etc.

Dissertations, thesis projects for graduate, bachelor and masters degree

Ongoing discussion of project results and project planning with those commissioning the projects

Confidentiality

Membership in DIK

In accordance with the Institute's bylaws, an interested company is kindly requested to file a written application for membership with the Executive Board of DIK. Membership dues are scaled to accord with the size or sales of the company applying. The advantages of membership include, for example, the exchange of information (networking), consultation, information on publicly sponsored projects at DIK, gratis literature service in the form of doctoral dissertations from DIK, cost reductions for continuing education events and conferences run by DIK, recruiting of young qualified staff and professionals.

Training and Education

Qualified employees are a crucial factor in ensuring a company's standing in national and international competition. Nowadays, it is more important than ever before to have employees whose product and quality awareness is in sync with market developments. DIK offers qualified, up-to-date training and continuing education for rubber industry employees, suppliers to the rubber industry, and users of elastomer materials.

We guarantee small class sizes that ensure the success of training and education offerings. The courses are conceived to best serve operational needs. Those successfully completing our courses and technical seminars receive an official certificate for their records. The course system rests on three pillars: a continuing education course of study entitled „Rubber technology for entry-level employees", courses in the modular continuing education system, and subject-related seminars. In collaboration with the Deutsche Kautschuk Gesellschaft (DKG), DIK offers special seminars in the „Machine-Material-Process" series. The lecturers - respected specialists in industry and research as well as experienced employees at DIK - guarantee the high caliber of the events

Advanced study program in rubber technology. In collaboration with Leibniz University Hannover and Wirtschaftsverband der Deutschen Kautschukindustrie e. V. (wdk) and Deutsches Institut für Kautschuktechnologie e. V. (DIK) runs an extra-occupational continuing education and training course of studies in rubber technology (WBS). This training course is held in German only.

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