ÖSTERREICHISCHE
GESELLSCHAFT
FÜR RHEOLOGIE

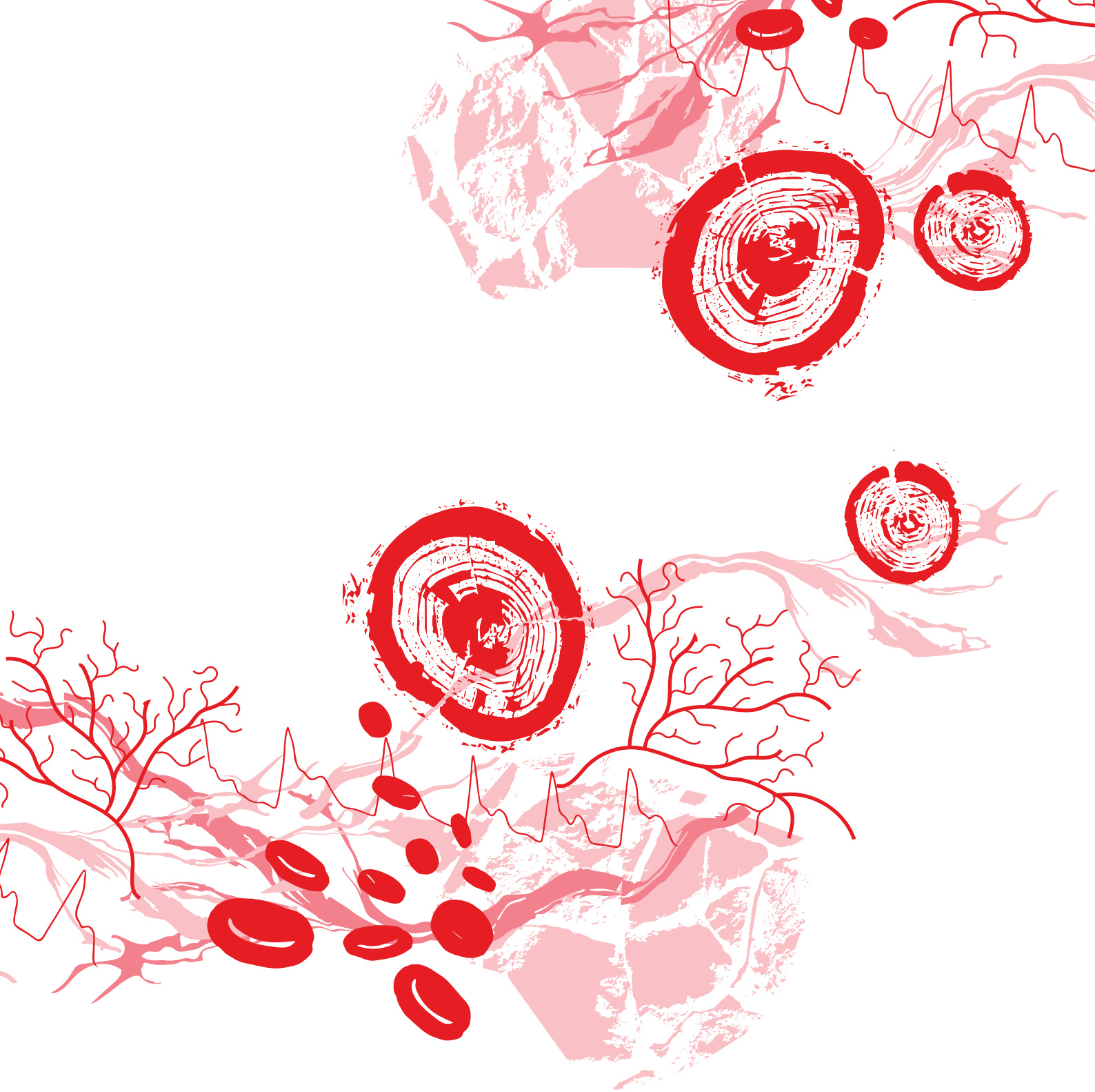
1ST ANNUAL CONFERENCE

OF THE AUSTRIAN SOCIETY FOR RHEOLOGY

18TH NOVEMBER 2022

VIENNA

Parkhotel Schönbrunn
Hietzinger Hauptstrasse 10-14
1130 Vienna



» The difficulty lies not so much in developing new ideas as in escaping from old ones «

(John Maynard Keynes)

Liebe Kollegen und an Rheologie Interessierte!

Im Namen des Vorstands der Österreichischen Gesellschaft für Rheologie möchte ich Sie herzlichst zu unserer ersten Jahrestagung in Wien begrüßen.

Ich freue mich sehr, dass wir uns schon so bald nach Gründung unserer Gesellschaft zusammenfinden können um unsere Arbeiten vorzustellen, uns mit anderen auszutauschen, und dabei mögliche Synergien zu entwickeln. Dabei können wir als junge Gesellschaft bereits erstaunlich viele Forschungsdisziplinen und Anwendungsbereiche abdecken. Danke, dass Sie mit Ihrem Beitrag den wissenschaftlichen und persönlichen Austausch vieler Rheologie-Spezialisten in Österreich fördern. Bereits jetzt blicken wir über unseren Tellerrand und dürfen auch Mitglieder aus anderen EU-Ländern in unserer Gesellschaft begrüßen. Es ist schön, dass Sie zu uns gefunden haben!

Ich wünsche Ihnen eine gute Veranstaltung und hoffe, dass Sie am Abend mit vielen neuen Ideen und Kooperationen nach Hause gehen werden.

Bitte genießen Sie auch die Umgebung des Tagungsortes. Das Weltkulturerbe Schloss Schönbrunn mit seinem Park lädt zu Spaziergängen ein, und vor dem Schloss hat schon der alljährliche Christkindlmarkt geöffnet. Und natürlich bietet die Wiener Innenstadt eine Fülle von Lokalitäten und Veranstaltungen, die es wert sind besucht zu werden.

Ich wünsche Ihnen eine gute Zeit bei und rund um unsere Tagung!

Dear colleagues and those interested in rheology!

On behalf of the Board of the Austrian Society for Rheology, I would like to warmly welcome you to our first annual conference in Vienna.

I am very pleased that we can get together so soon after the founding of our society to present our work, exchange ideas with others, and develop possible synergies. As a young company, we can already cover an amazing number of research disciplines and areas of application. Thank you for promoting the scientific and personal exchange of many rheology specialists in Austria with your contribution. We are already thinking outside the box and welcome members from other EU countries to our society. It's nice that you found us!

I wish you a good event and hope that you will return home with many new ideas and cooperations.

Please also enjoy the surroundings of the conference venue. The World Heritage Schönbrunn Palace with its park invites you to go out for a walk, and the annual Christmas market is already open in front of the palace. And of course Vienna's city center offers a wealth of venues and events that are worth visiting.

I wish you a good time at and around our conference!

Ihre Ursula Windberger
Tagungspräsidentin

PROGRAM

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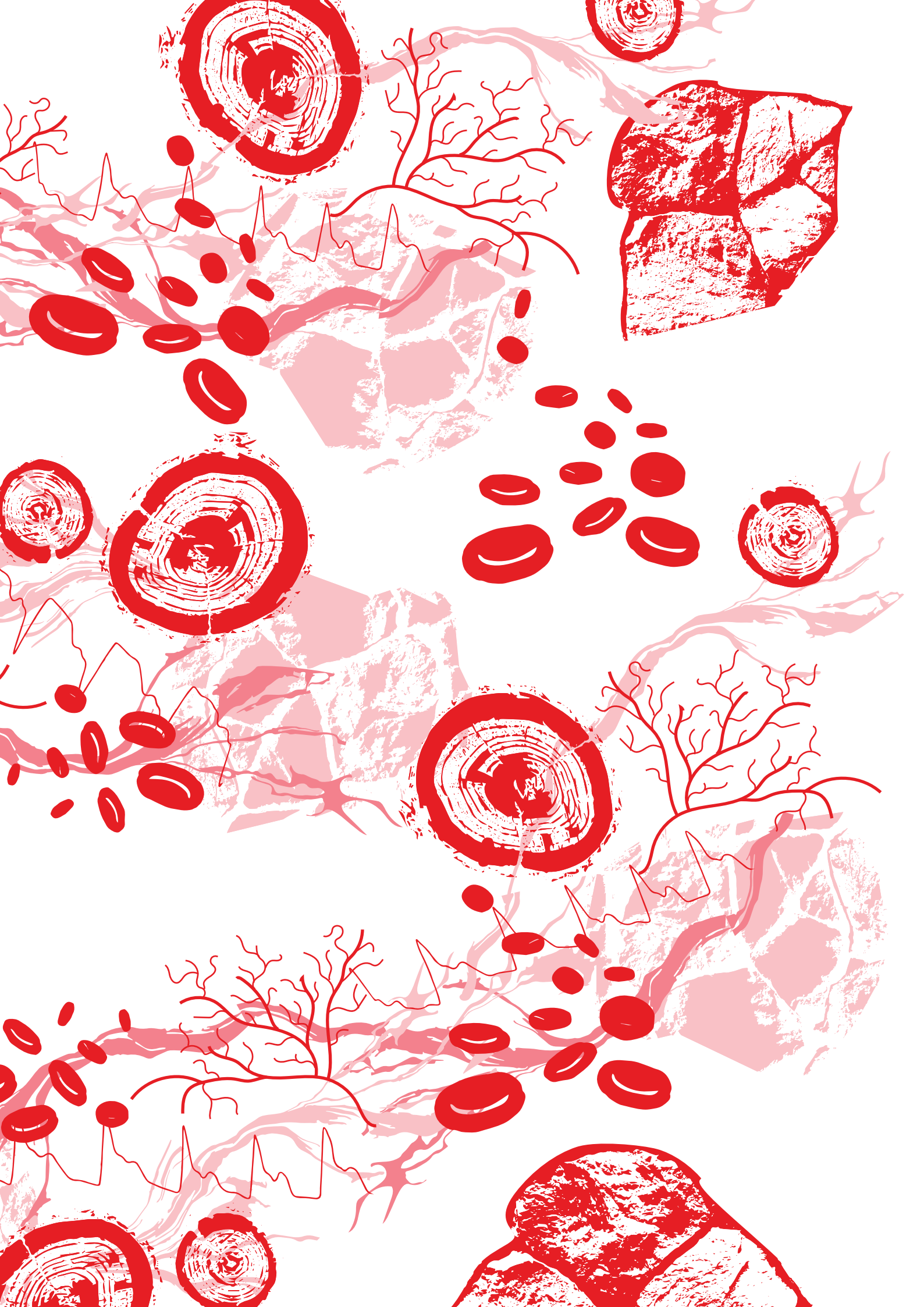
18TH NOVEMBER 2022

SPEAKER	ABSTRACT TITLE
U. WINDBERGER	Blood clot phenotyping by LAOStress
K. SCHNEIDER	Rheological Characterization of Placental Extracellular Matrix Hydrogels
R. CERBINO	Quantitative rheo-microscopy of soft-matter
N. KALAFATAKIS	Unexpected stress relaxation of low functionality star-shaped polymers in the low frequency regime
S. BAUDIS	Photorheology: A Versatile Tool to Unravel Photopolymerization Processes
C. HASLINGER	Sonorheology: A Novel Set-Up for Investigation of Ultrasound-Triggered Reactions
D. BENDER	Food rheology and its importance in plant-based food processing
R.M. EDER	Potential of bio-based friction modifiers for safe use in food-grade lubrication
G. BRENN	The characteristic equation of oscillating viscoelastic drops
L. NOIREZ	Revisiting Rheology to Access Hidden Elasticity in Liquids and Complex Fluids
V. KLANG	Spruce balm-based dermal formulations: flow properties and storage stability
M. EDLER	Special Rheological Applications
K. ELSAYAD	All-optical measurements of blood plasma viscosity in COVID-19 patient samples
B. PICHLER	Hourly-Repeated Three-Minutes Creep Tests of Cementitious Materials at Early Ages
K. HOFER	Chemo-mechanical anaylsis of bitumen
A. ROBISSON	Heterogenous flows in sheared cement suspensions
L. NASSERI	Rheokinetic investigation on the thermal cure of adhesives

	SPEAKER	TIMELINE	CHAIR
9^{00}	WELCOME		
9^{15} – 10^{30}	U. Windberger K. Schneider R. Cerbino N. Kalafatakis	9^{15} – 9^{30} 9^{30} – 9^{50} 9^{50} – 10^{10} 10^{10} – 10^{30}	U. Windberger
10^{30} – 11^{00} COFFEE BREAK VISIT TO THE INDUSTRIAL EXHIBITION			
11^{00} – 12^{30}	S. Baudis C. Haslinger D. Bender R.M. Eder	11^{00} – 11^{20} 11^{20} – 11^{40} 11^{40} – 12^{00} 12^{00} – 12^{20}	Ph. Fuhrmann
12^{20} – 13^{20} LUNCH			
13^{20} – 15^{00}	G. Brenn L. Noirez V. Klang M. Edler K. Elsayad	13^{20} – 13^{40} 13^{40} – 14^{00} 14^{00} – 14^{20} 14^{20} – 14^{40} 14^{40} – 15^{00}	S. Berner
15^{00} – 15^{30} COFFEE BREAK VISIT TO THE INDUSTRIAL EXHIBITION			
15^{30} – 17^{00}	B. Pichler K. Hofer A. Robisson L. Nasseri	15^{30} – 15^{50} 15^{50} – 16^{10} 16^{10} – 16^{30} 16^{30} – 16^{50}	B. Hofko
16^{50} – 17^{00} CLOSING CEREMONY			
– 18^{30}	GENERAL ASSEMBLY		



ABSTRACTS

18TH NOVEMBER 2022

BLOOD CLOT PHENOTYPING BY LAOSTRESS

URSULA WINDBERGER , V. GEIMER
CORE UNIT LABORATORY ANIMAL BREEDING AND HUSBANDRY
MEDICAL UNIVERSITY OF VIENNA

Fibrin networks show strain hardening, Mullins effect, and nonlinear stress-relaxation. Due to the rich mechanical response, rheometry can provide important information on a blood clot´s phenotype. Viscoelastic tests together with treatment protocols based on cut-off values are already used for postoperative patient care, but since now only the linear behavior of clots is tested. Measuring at broader ranges of deformation will add important information because blood flow compels clots into a dynamic non-linear response that also alters clot remodeling. To characterize the influence of platelets and fibrinogen on clot behavior, a stress amplitude sweep test (LAOStress) was applied to clots from native plasma. Clots from animal species were used to validate the protocol. The oscillation cycle for each stress level was analyzed by using Lissajous plots. Cyclic shear stress loading generated a characteristic shear strain response that scaled with the platelet quantity at low stress, but that was independent from the platelet count at high shear stresses (> 200 Pa). At low shear stresses platelets augmented clot softening due to network alignment, whereas beyond a threshold macroscopic shear stiffening occurred, independent on platelet count. Quite differently, the fibrinogen concentration of the sample had a particular influence on shear stiffening of the aligned network. The more fibrinogen, the tighter the clot at high stretch-out. Cow and chicken clots showed double-yielding that became pronounced at higher fibrinogen concentrations. The new protocol proposed here provides several thresholds to connect the softening and stiffening behavior of clots from native blood plasma with the applied shear stress, points to the reversible part of deformation (residual strains were mostly removed), and thus opens a new route to describe a blood clot's phenotype. The protocol can be applied to other composite gels that contain semi-flexible fibers.

RHEOLOGICAL CHARACTERIZATION OF PLACENTAL EXTRACELLULAR MATRIX HYDROGELS

KARL H. SCHNEIDER[1,2], SABRINA ROHRINGER[1,2], MARVIN DÖTZLHOFER[1], FLORIAN LEISS[1], FELIX POINTER[1], BRUNO K PODESSER[1,2], HELGA BERGMEISTER[1,2], URSULA WINDBERGER[1]
[1] CENTER FOR BIOMEDICAL RESEARCH, MEDICAL UNIVERSITY OF VIENNA, AUSTRIA
[2] LUDWIG BOLTZMANN INSTITUTE FOR CARDIOVASCULAR RESEARCH, VIENNA AUSTRIA

Extracellular matrix (ECM) hydrogels are water-swollen 3D collagenous networks that provide bioactive protein structures to support cells and can be used for numerous applications in tissue engineering and regeneration. Their natural mixture of collagen, proteoglycans and glycoproteins gives these materials their value, but also makes them less controllable in terms of their biomechanical behavior. We produce and characterize human placenta ECM (hpECM) hydrogels to develop new materials which can be used as surface coating, injectable hydrogel, or as bioink for 3D bioprinting applications.
Rheology have become a useful tool for evaluating different hydrogel blends for their suitability as bioinks for 3D bioprinting. We investigated on gelation and stiffness of hpECM hydrogels and hydrogel blends. All rheological experiments were performed using a MCR 102 rheometer (Anton Paar) equipped with temperature controlling systems and using a 25 mm diameter parallel plate. Viscosity of pre-gel solutions, gelation kinetics, and compression tests were performed.
Our hpECM hydrogels showed reproducible results in terms of gelation kinetics. We observed a good controllability of the biomechanical properties using different gel concentrations as well as by applying additional crosslinking methods such as UV light. Also, the use of composite hydrogels such as the mixture of silk fibroin with hpECM hydrogel leads to gels with improved biomechanical properties. By means of rheology, the influence of certain factors such as the buffer system or certain chemicals on the gelation speed could be determined. We are striving to further optimize the testing strategy in order to learn even more about the biomechanical behavior of our hydrogels.

QUANTITATIVE RHEO-MICROSCOPY OF SOFT-MATTER

STEFANO VILLA [1,2], PAOLO EDERA [1,3], MATTEO BRIZIOLI [1], VERONIQUE TRAPPE [4], FABIO GIAVAZZI [1] AND **ROBERTO CERBINO** [5]

[1]DEPARTMENT OF MEDICAL BIOTECHNOLOGY AND TRANSLATIONAL MEDICINE, UNIVERSITY OF MILAN, MILAN, ITALY
[2]CURRENT ADDRESS: MAX PLANCK INSTITUTE FOR DYNAMICS AND SELF-ORGANIZATION, GOTTINGEN, GERMANY ¨
[3]CURRENT ADDRESS: ESPCI, PARIS, FRANCE
[4]DEPARTMENT OF PHYSICS, UNIVERSITY OF FRIBOURG, CHEMIN DU MUSEE 3, CH-1700, FRIBOURG, SWITZERLAND
[5]FACULTY OF PHYSICS, UNIVERSITY OF VIENNA, BOLTZMANNGASSE 5, VIENNA, AUSTRIA

Direct observation of the microscopic material structure and dynamics during rheological shear tests is the goal of rheo-microscopy experiments. Microscopically, they shed light on the many mechanisms and processes that determine the mechanical properties at the macroscopic scale. Moreover, they permit for the determination of the actual deformation field, which is particularly relevant to assess shear banding or wall slip. While microscopic observation of the sample during mechanical probing is achieved by a variety of custom and commercial instruments, the possibility of performing quantitative rheology is not commonly available. Here, we describe a flexible rheo-microscopy setup that is built around a parallel-sliding-plate, stress-controlled shear cell, optimized to be mounted horizontally on a commercial microscope. Mechanically, soft materials with moduli ranging from few tens of Pa up to tens of kPa can be subjected to a variety of waveforms, ranging from standard step stress and oscillatory stress to more peculiar signals, such as triangular waves or chirped signals. Optically, the shear cell is designed to be compatible with different imaging methods, (e.g. bright field or confocal microscopy). Most of the components of the shear cell are commercially available, and those that are not can be reproduced by a standard machine shop, easing the implementation of the rheo-microscopy setup in interested laboratories.

UNEXPECTED STRESS RELAXATION OF LOW FUNCTIONALITY STAR-SHAPED POLYMERS IN THE LOW FREQUENCY REGIME

NIKOLAOS KALAFATAKIS[1,2,4], GEORGIOS SAKELLARIOU[3], EMMANOUIL GLYNOS[1,2], AND DIMITRIS VLASSOPOULOS[1,2]

[1]INSTITUTE OF ELECTRONIC STRUCTURE AND LASER, FOUNDATION FOR RESEARCH AND TECHNOLOGY (FORTH), 70013 HERAKLION, CRETE, GREECE
[2]DEPARTMENT OF MATERIALS SCIENCE AND TECHNOLOGY, UNIVERSITY OF CRETE, 70013 HERAKLION, CRETE, GREECE
[3]DEPARTMENT OF CHEMISTRY, NATIONAL AND KAPODISTRIAN UNIVERSITY OF ATHENS, ATHENS 15784, GREECE
[4]CURRENT AFFILIATION: FACULTY OF PHYSICS, UNIVERSITY OF VIENNA, BOLTZMANNGASSE 5, VIENNA, AUSTRIA

Star-shaped polymers represent the lowest degree of branched polymers with one branching point and have attracted great interest in the last decades. They relax stresses via a mechanism known as arm retraction, characteristic of the their main difference compared to their linear counterparts, where both ends are free to relax. Their characteristic rheological behavior has been studied to a great extend, with their viscosity to be exponentially dependent on their molar masses, in contrast to their linear counterparts where a power-law dependence is found. In this study, we investigate the effect of bulky monomers in the synthesis of star polymers with low functionalities and we compare these dynamics with stars of non-bulky monomers of the same functionalities and number of monomers per arm. Using carefully selected rheological protocols, we study the center of mass relaxation of these bulky-monomer stars, that show an unexpected low frequency plateau in the storage modulus, reminiscent of colloidal-like dynamics.

PHOTORHEOLOGY: A VERSATILE TOOL TO UNRAVEL PHOTOPOLYMERIZATION PROCESSES

C.GORSCHE[2,3] , R.HARIKRISHNA[2], **STEFAN BAUDIS[1,2]**, P.KNAACK[2], B. HUSAR[2], J.LÄUGER[4], H.HOFFMANN[2], R.LISKA[2]

[1]CHRISTIAN DOPPLER LABORATORY FOR ADVANCED POLYMERS FOR BIOMATERIALS AND 3D PRINTING

[2]INSTITUTE OF APPLIED SYNTHETIC CHEMISTRY, TU WIEN

[3]CUBICURE GMBH

[4]ANTON PAAR GERMANY GMBH

Photopolymerizations most frequently are very fast reactions of multifunctional monomers. Hence, deducing the effects of different components and conditions on final properties of formed insoluble networks is challenging. Together with Anton Paar GmbH, an infrared spectrometer was coupled to a photorheometer[1]. With this tool, a broad spectrum of different photopolymerizable formulations was characterized thoroughly by combination of the rheological with the chemical information.
These formulations include classical (meth)acrylic[2] and epoxy system[3] but also other ring-opening[4] and thiol-ene[5] click systems up to highly complex systems of, e.g., modified biopolymers used as precursors for hydrogels6 for biofabrication applications[7].

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SONORHEOLOGY: A NOVEL SET-UP FOR INVESTIGATION OF ULTRASOUND-TRIGGERED REACTIONS

CAROLA HASLINGER[1,2] , ANNA ZAHORANOVÁ[2] , GEORG KRENN[3], STEFAN HOLLER[3], STEFAN BAUDIS[1,2]

[1]CHRISTIAN DOPPLER LABORATORY FOR ADVANCED POLYMERS FOR BIOMATERIALS AND 3D PRINTING, GETREIDEMARKT 9, 1060 VIENNA, AUSTRIA

[2]INSTITUTE OF APPLIED SYNTHETIC CHEMISTRY, TECHNISCHE UNIVERSITÄT WIEN, GETREIDEMARKT 9, 1060 VIENNA, AUSTRIA

[3]ANTON PAAR AUSTRIA GMBH, ANKERSTRASSE 6, 8054 GRAZ, AUSTRIA

Ultrasound (US) are mechanical waves with the frequency higher than 20 kHz, above the human audible region. US is frequently used in material science and medicine as diagnostic method, However, it can also trigger changes in material properties, or induce chemical reactions within materials.
To study ultrasound-triggered changes in mechanical properties of studied materials, we here introduce a rheometer combined with an US unit built into the bottom plate to stimulate the sample during rheology measurements. The US unit consists of a US transducer that is connected with a waveform generator and a power amplifier. Additionally, a special PMMA-based stamp is used during ultrasonication to minimize US wave reflexion. This custom-made set-up was developed in cooperation with Anton Paar GmbH.
The used US unit mimics conditions relevant for medical applications. More specifically, pulsed US with a frequency of 1 MHz, an amplitude up to 200 mV_{RMS} and a duty cycle of around 20 % were selected in our case. These conditions were picked as they are not harmful to the human body. This is important for research that focuses on medical applications, as harsh US conditions would damage affected tissue.

Different sample types were tested, from liquid formulations with low viscosity to relatively stiff hydrogels. Depending on the type of interaction with US, stiffening or softening of the material can be observed during US triggering. These changes can be permanent, or the material returns to its original state. In both cases the in-situ rheological measurements during ultrasonication are a suitable tool for monitoring of the mechanical changes in the material.

FOOD RHEOLOGY AND ITS IMPORTANCE IN PLANT-BASED FOOD PROCESSING

DENISSE BENDER
DEPARTMENT OF FOOD SCIENCE AND TECHNOLOGY, INSTITUTE OF FOOD SCIENCE, UNIVERSITY OF NATURAL RESOURCES AND LIFE SCIENCES VIENNA, MUTHGASSE 18, 1190, VIENNA, AUSTRIA.

Food is a complex anisotropic material which behavior and structure depends on its main biological components (proteins, carbohydrates, fats, fibers, water). To make food suitable for consumption, it usually undergoes processing, subjecting the material to diverse thermal, chemical and/or mechanical loads. As a result, the rheological behavior of food will be affected and significantly influence the sensory perception, as well as the end-product quality. Thus, information about the rheological behavior of food is essential, as it may be useful for the development, optimization and quality control of end-products, as well as the selection of appropriate processing approaches. Several case studies focusing on plant-based food, mainly bread, will show how ancient, modern and emerging processing technologies are selected according to rheological food properties to tailor mid- and end product qualities.

POTENTIAL OF BIO-BASED FRICTION MODIFIERS FOR SAFE USE IN FOOD-GRADE LUBRICATION

EDER ROSA MARIA, FRAUSCHER M., FRANZ R., BOIDI G.
AC2T RESEARCH GMBH, VIKTOR-KAPLAN-STRASSE 2/C, 2700 WIENER NEUSTADT, AUSTRIA

Bio-based lubricants, such as olive oil meant for skin contact, have been available on the market for decades. However, no wide application for machines in industry is yet used for such bio-based lubricants, applications might reach from the automotive industry to devices used for e.g., food or pharmaceutical production. Thereby, conventionally used lubricants were compared with bio-based lubricants, using the tribological set-up (ball-on-three-plates) on the rheometer MCR302. As a first step, friction modifiers, being one type of lubricant additive, were compared. Film-forming friction modifier additives are used to control friction in thin film boundary and mixed lubrication conditions, to decrease wear appearances and to consequently reduce the energy consumption. For sample selection, a literature toxicological assessment comparing conventionally used friction modifiers with a petro-chemical origin was performed. Essentially, the bio-based friction modifiers were lubricated in water, whereas the conventionally used friction modifiers were lubricated in a conventionally used oil. The defined conventionally used friction modifiers, were further compared with the bio-based, green alternative friction modifiers. The method development for the rheometer MCR302 was designed under variation of normal force [N], temperature [°C] and sliding speed [m/s]. Further, repeatability tests and accuracy determinations enclose the method development. The performed tests indicate the advantages and disadvantages of both bio-based and conventionally used friction modifiers. Comparing the conventional FM in polyalphaolefin (PAO8) to the bio-based FM in PAO8 at 80 °C and in distilled water at 30 °C, revealed that bio-based FM, namely rapeseed oil and salmon oil, can perform at least as good as the best performing conventional FM, namely tallow amine. Concluding, this study presents an essential step towards developing innovative sustainable technological solutions in lubricant research.

THE CHARACTERISTIC EQUATION OF OSCILLATING VISCOELASTIC DROPS

DINO ZRNIĆ, **GÜNTER BRENN**
INSTITUTE OF FLUID MECHANICS AND HEAT TRANSFER, GRAZ UNIVERSITY OF TECHNOLOGY, GRAZ, AUSTRIA

Drop surface deformations due to shape oscillations influence the area of the drop interface with its environment and induce fluid motion inside and outside the drop. This influences transport rates of mass, momentum and energy across the interface. An accurate analysis of the drop shape oscillations is important for accurately predicting the transport rates. A first step may be a linear analysis involving the so-called characteristic equation of the drop, which emerges from the normal-stress boundary condition on the drop surface. The equation determines the complex angular frequency of the oscillation. As a transcendental, nonlinear equation, its solution is quite involved. The equation includes the oscillation mode, an integer number counting the deformation lobes along the polar circumference of the drop, and a modified Ohnesorge number, representing the capillary and viscous material parameters, as well as, for a viscoelastic liquid, the time scales of the liquid. In the present work, we investigate the characteristic equation of drops of Oldroyd-B viscoelastic liquids. Solving the equation shows that, for a given oscillation mode of a given drop, there exists a large manifold of complex angular frequencies, which require proper account in a nonlinear analysis of the shape oscillations. We show the method used for solving the characteristic equation and results for drops of aqueous polyacrylamide solutions. A comparison of the solutions to frequency and decay rate data from individual drop oscillation experiments is the key to identifying the right solutions of the equation, showing that, in the nonlinear analysis, sets of two initial conditions are sufficient. The way through the subsequent nonlinear analysis is outlined in brief at the end.

REVISITING RHEOLOGY TO ACCESS HIDDEN ELASTICITY IN LIQUIDS AND COMPLEX FLUIDS

LAURENCE NOIREZ, P. BARONI
LABORATOIRE LÉON BRILLOUIN (CEA-CNRS), CEA-SACLAY, 91191 GIF-SUR-YVETTE CEDEX, FRANCE

By reinforcing the interaction energy of the liquid with respect to the surface, the response of liquids to mechanical shear stress is stronger and exhibits at sub-millimeter scale elastic properties. It is thus possible to measure solid-like properties such as non-zero low-frequency shear elasticity in various liquids[1]. The observation of elastic properties at the sub-millimeter scale in liquids generally reputed viscous-like away from any phase transition and the absence of structuring confirm the relevance of considering elastic interactions as an intrinsic liquid property and that flow mechanisms are not determined at the molecular level. We will present an extended viscoelastic study of these elastic properties applied to fluids containing electrostatic interactions such as ionic liquids, paramagnetic liquids or, blood plasma[2]. We will also highlight the corollary of the existence of elastic correlations by identifying for the first time a thermo-mechanical coupling in liquids. Thermo-elasticity is a solid-like property. It requires long-range collective interactions that are not considered in current liquid or viscoelastic descriptions. We present pioneering studies providing evidence for such thermo-coupling. We will show that ordinary liquids (glycerol, polypropylene glycol...) emit a modulated thermal hot and cold signal when applying a low frequency (Hz) mechanical shear stress [3]. As consequence, the liquid converts the energy of shear waves in non-uniform thermodynamic states. These dynamic thermal changes support the hypothesis of the excitation of macroscopic shear elasticity, in accordance with recent non-extensive experimental observations [2] and theoretical models [4].

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SPRUCE BALM-BASED DERMAL FORMULATIONS: FLOW PROPERTIES AND STORAGE STABILITY

VICTORIA KLANG, MARTINA JOZIĆ, ELISABETH EICHENAUER, SABINE GLASL
DEPARTMENT OF PHARMACEUTICAL SCIENCES, UNIVERSITY OF VIENNA, JOSEF-HOLAUBEK-PLATZ 2,
1090 VIENNA, AUSTRIA

Treatment of chronic wounds, an important issue with a growing elderly population, is increasingly hindered by antibiotic resistance. Alternative wound care approaches involve the use of traditional plant-derived remedies such as purified spruce balm (PSB) with antimicrobial effects and promotion of wound healing. However, spruce balm is difficult to formulate due to its stickiness and high viscosity; dermal products with satisfying technological properties and scientific literature on this topic are scarce. Thus, the aim of the present work was to develop and rheologically characterize a range of dermal formulations with different hydrophilic/lipophilic composition to deliver spruce balm to the skin for wound healing applications. To this end, semi-solid formulations based on different compounds (petrolatum, paraffin oil, cera lanae, castor oil, water) were developed. As first step of this project, flow curves were recorded after production and in regular intervals over six months at 23°C (MCR 302, Anton Paar GmbH, Austria, CP25-2, Ø: 25 mm, 2°). Two separate batches of each formulation (n=4) were prepared and analyzed during storage over 6 months at 23°C or 8°C.

Results showed that the semi-solid formulations exhibited shear-thinning flow behaviour with dynamic viscosity around 35 Pas (monophasic apolar ointments), 70 Pas (biphasic water-in-oil creams based on cera lanae) and 10 Pas (biphasic water-in-oil creams based on a commercial cream base) at a shear rate of 10/s. The most stable system was an apolar ointment based on cera lanae, which showed a decrease in viscosity of below 10% after six months of storage at 8°C. In contrast, biphasic creams showed optical and/or rheological signs of destabilization.

SPECIAL RHEOLOGICAL APPLICATIONS

MICHAEL EDLER
ANTON PAAR GMBH
GRAZ, AUSTRIA

The Modular Compact Rheometer (MCR) from Anton Paar offers you one thing first and foremost: an open range of possibilities. Beside “classic” rheology many additional special rheological applications can be realized using an MCR. In this connection, recently measured data ranging from high temperature rheology of low viscous metal melts to rheological analysis of especially conditioned powders up to determination of the mechanical properties of precision engineering components are shared. Among other things it can be shown that rotational rheometers with normal force control and CC measuring geometry can be used to measure not only the viscosity but also the density of liquids up to highest temperatures.

ALL-OPTICAL MEASUREMENTS OF BLOOD PLASMA VISCOSITY IN COVID-19 PATIENT SAMPLES

J. ILLIBAUER[1], T. SEITZ[2], J. ABERLE[1], M. FOEDINGER[2], A. ZOUFALY[2], **KAREEM ELSAYAD[1]**
[1]MEDICAL UNIVERSITY OF VIENNA,
[2]KLINIK FAVORITEN - WIENER GESUNDHEITSVERBUND

The viscosity of blood plasma is important for physiological function. It has been shown during the course of the COVID-19 pandemic that it can be significantly elevated in severely ill COVID-19 patients, and linked to mortality, with fatality a direct consequence thereof. This can be attributed in part to coagulation agents being prominent during infection, especially in early COVID-19 strains. Understanding the physical-chemical details resulting in this, identifying associated risk factors, along with possible mitigation strategies can prove to be lifesaving in many of these cases. In addition, the realization of techniques to rapidly identify criticality (i.e. prognostics) can also provide valuable time for early medical intervention and improved outcomes. Here we apply shear rheology and Brillouin Light Scattering spectroscopy to study the rheological properties of healthy plasma and plasma from COVID-19 patients with different degrees of severity. While the former technique measures the familiar dynamic shear viscosity, the latter measures the acoustic damping properties at picosecond time scales (the longitudinal viscosity) which will depend on both the shear and bulk viscosities. These are typically relevant for modeling the propagation of shock waves, and acutely sensitive to the nature of intermolecular interactions. We find that they can also provide unique insight into disease severity, and may allow for the identification of risk groups and treatment/mitigation strategies. Our results show Brillouin Light Scattering spectroscopy can be used to rapidly measure and extract medically useful complimentary rheological and viscoelastic information of biofluids, an approach we term *Brillouin Scattering Rheology*.

HOURLY-REPEATED THREE-MINUTES CREEP TESTS OF CEMENTITIOUS MATERIALS AT EARLY AGES

BERNHARD PICHLER
INSTITUTE FOR MECHANICS OF MATERIALS AND STRUCTURES, TU WIEN, KARLSPLATZ 13/202,
1040 VIENNA, AUSTRIA

Cementitious materials used in construction exhibit increasing deformation under constant loading (“creep”) and decreasing material resistance under constant deformation (“relaxation”). This rheological behavior is particularly challenging at early material ages, during which hydration (= the chemical reaction between water and cement) leads to an evolution of the microstructure. Long-term creep tests started at early material ages are difficult to interpret, because of the hydration-driven evolution of the microstructure during the experiment, hence the expression “aging” creep tests. In order to decouple creep testing from hydration, an innovative creep testing protocol was developed [http://doi.org/f8hgjp]. It consists of hourly-repeated three-minutes creep tests. Clearly, hydration continues also during a three-minutes creep test, but it cannot make a significant progress. Therefore, every ultrashort test delivers creep properties of one specific “non-aging” microstructure. During one hour, in turn, hydration does make a significant progress, particularly so at early material ages. Therefore, two successive creep tests refer to different microstructures. Performing hourly-repeated three-minutes creep tests from one day after production to material ages of eight days, allows for a detailed characterization of the early age evolution of the macroscopic viscoelastic stiffness properties of cementitious materials. Corresponding experimental results were used for the development of multiscale models for creep of cement paste [http://doi.org/f9cxv4] and concrete [http://doi.org/cqq9], as well as of code-inspired correlation and evolution formulae describing the early-age evolution of creep properties of concretes as a function of the uniaxial compressive strength of the material reached 28 days after production [http://doi.org/czmn].

CHEMO-MECHANICAL ANAYLSIS OF BITUMEN

KRISTINA HOFER, JOHANNES MIRWALD, BERNHARD HOFKO
CHRISTIAN DOPPLER LABORATORY FOR CHEMO-MECHANICAL ANALYSIS OF BITUMINOUS MATERIALS, INSTITUTE OF TRANSPORTATION, TU WIEN

Bitumen is a visco-elastic, organic material, which primarily consists of hydrocarbons and small amounts of oxygen, nitrogen and sulfur. It is used as a binder in asphalt mixtures and as a sealing material in the roofing industry. Over the course of its life-span bitumen is susceptible to aging due to contact with oxygen and other environmental factors, which results in the stiffening of the material. To ensure the quality and durability of the material accurate and comprehensive analysis methods have to be applied. For the characterization of the visco-elastic behaviour of bitumen the dynamic shear rheometer (DSR) can be used, whereby the complex shear modulus represents the stiffness and the phase angle gives information about the degree of viscous response to stress. For the analysis of the chemical composition Fourier-Transformation Infrared (FTIR) spectroscopy is applied, whereby certain spectroscopic bands can be assigned to chemical structures formed during the aging process. The combination of mechanical and chemical information is a crucial step in understanding the properties and the aging behavior of the material. Therefore, the chemo-mechanical correlation was developed, which illustrates the link between the mechanical properties and the chemical composition of the respective bitumen sample. The FTIR aging index, which represents the formation of carbonyls and sulfoxides, is plotted on the X-axis and the norm of the complex modulus |G*| or the phase angle δ is plotted on the Y-axis. This gives visual and graphical information about how an increase in stiffness is correlated to an increase in incorporated oxygen and vice versa.

HETEROGENOUS FLOWS IN SHEARED CEMENT SUSPENSIONS

SUBHRANSU DHAR, TERESA LIBERTO AND **AGATHE ROBISSON**
RESEARCH UNIT OF BUILDING MATERIALS - INSTITUTE OF MATERIAL TECHNOLOGY, BUILDING PHYSICS AND BUILDING ECOLOGY - FACULTY OF CIVIL AND ENVIRONMENTAL ENGINEERING - TU WIEN, KARLSPLATZ 13/207-01, A-1040 VIENNA, AUSTRIA.

Fresh cement pastes are complex suspensions, with a yield stress that depends upon the material recipe (cement-to-water ratio and additives) and increases with time in the paste at rest. The yield stress is linked to the formation of a multiscale network composed by the equally highly charged ground clinker particles containing calcium silicates and the precipitating calcium silicate nano-hydrates (C-S-H). High yield stress concretes typically need to be vibrated to flow and be placed, while low yield stress ones flow easily under their own weight. The measurement of the yield stress is therefore crucial both for practice and to estimate the early cohesion between hydrating cement particles.

In this study, we measure the yield stress of various cement pastes using a stress-controlled rheometer with different geometries, namely serrated parallel plates, vane, concentric cylinders, and helix. Results show discrepancies, with a yield stress lower by a factor of 5 to 18 in the parallel plate geometry compared to the vane/helix one, depending on the cement recipe. To explain this inconsistency, we image the flow in the parallel plate geometry along the external diameter, using a fast rate camera, and treat the data using particle image velocimetry (PIV). Results show shear banding, with a stationary band near the static plate and a sheared band near the upper rotating plate. Using the width of the stationary band, the shear stress is recalculated from the applied torque, but the moderate value increase cannot explain the above discrepancy. We hypothesize that material heterogeneities develop during flow, and a band of less concentrated cement paste is formed.

RHEOKINETIC INVESTIGATION ON THE THERMAL CURE OF ADHESIVES

LATIFEH NASSERI[1,2], CATHERINE ROSENFELD[1,2], PIA SOLT-RINDLER[1,2], HENDRIKUS W.G. VAN HERWIJNEN[1,2]

[1] KOMPETENZZENTRUM HOLZ GMBH – WOOD K PLUS, ALTENBERGER STR. 69, 4040 LINZ, AUSTRIA
[2] INSTITUTE OF WOOD TECHNOLOGY AND RENEWABLE MATERIALS, BOKU UNIVERSITY, KONRAD-LORENZ STRASSE 24, 3430 TULLN, AUSTRIA

Oscillatory rheological measurements can be used to study the temperature-induced curing process of wood adhesives. A high curing reactivity is an essential characteristic of an adhesive for wood applications. The degree of curing and the cure kinetics determine the manufacturing parameters as well as the performance of the wood-bonded product.

The formation of high molecular weight molecules reflects on the rheological behavior, as the adhesive changes from a low-viscosity liquid to a stiff solid during the curing process. An important kinetic characteristic is the sol-gel transition point, which is defined as the first appearance of a macromolecule with an infinitely large molecular weight in a reactive system. It is typically measured in so-called rheological, multiwave experiments.

A frequently applied kinetic analysis in wood science is the so-called one-point model free approach, also known as Arrhenius plots. These Arrhenius plots can be used for example to determine the activation energy in the sol-gel transition point in oscillatory, rheological measurements.
In recent years, multi-point model free methods have also been applied to rheological data. These isoconversional methods are a useful tool for gaining insight into the complex multi-step curing processes without making assumption about the reaction mechanism. This enables practitioners to model the curing process without knowing the curing chemistry. For example, this can be applied in the qualitative analysis of the influence of additives or additional reactants on the polymerization process.

NOTES

SPEAKERS CONTACT

STEFAN BAUDIS
stefan.baudis@tuwien.ac.at

DENISSE BENDER
denisse.bender@boku.ac.at

ROBERTO CERBINO
roberto.cerbino@univie.ac.at

MICHAEL EDLER
michael.edler@anton-paar.com

KAREEM ELSAYAD
kareem.elsayad@meduniwien.ac.at

CAROLA HASLINGER
carola.haslinger@tuwien.ac.at

NIKOLAOS KALAFATAKIS
nikolaos.kalafatakis@univie.ac.at

VICTORIA KLANG
victoria.klang@univie.ac.at

LATIFEH NASSERI
l.nasseri@wood-kplus.at

BERNHARD PICHLER
bernhard.pichler@tuwien.ac.at

AGATHE ROBISSON
agathe.robisson@tuwien.ac.at

KARL H. SCHNEIDER
karl.schneider@meduniwien.ac.at

URSULA WINDBERGER
ursula.windberger@meduniwien.ac.at

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SARA HABIAK
Illustration and Editorial Design
mailto@sarahabiak.com

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» Necessity is the mother of taking chances«

(Mark Twain)

ÖSTERREICHISCHE GESELLSCHAFT FÜR RHEOLOGIE

Institut für Lebensmittelwissenschaften
Universität für Bodenkultur | Muthgasse 18
1090 Wien | Österreich
E-Mail: oegr@boku.ac.at