האגודה הישראלית לראולוגיה

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The Israel Rheology Meeting

ספר תקצירים

Book of Abstracts

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ליאונרדו סיטי טאואר, רמת גן

Leonardo City Tower, Ramat Gan

עמיתים יקרים,

אנו מתכבדים להזמינכם לקחת חלק בכינוס האגודה הישראלית לראולוגיה. מטרת הכינוס לאפשר מפגש בלתי אמצעי של חוקרים, סטודנטים, מהנדסים וטכנולוגים מהתעשייה, מכוני המחקר והאקדמיה. היסודות המדעיים של ראולוגיה מודרנית הונחו בשנות העשרים של המאה הקודמת. הולדתו של תחום זה נזקפת במידה רבה לפועלו המדעי של פרופ׳ מרקוס ריינר מהטכניון. במשך שנים רבות פעלה האגודה הישראלית לראולוגיה לטיפוח החידושים בתחום והנחלתם בקרב העוסקים והמתעניינים בו. בשנים האחרונות הננו עדים להתרחבות מרשימה של מספר הנדרשים לראולוגיה הן בתעשייה והן באקדמיה. העניין הגובר בראולוגיה והצורך של רבים מהעוסקים בה לחבור לעמיתיהם בקהילה הראולוגית עמם יוכלו לחלוק את ממצאיהם ולדון בבעיות בהן הם נתקלים, עומדים מאחורי הסיבות לקיום הכינוס.

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הפקולטה למדעי ההנדסה
אוניברסיטת בן גוריון

Göttfert

ISoR 2014
Nov. 24, 2014 Leonardo City Tower, Ramat Gan
Meeting Program

8:00	*Registration and get together*	
9:00	Moshe Gottlieb (BGU)	Opening remarks
9:15	Jan Vermant (ETH)	Interfacial rheology and its role in materials design
10:00	Daphne Weihs (Technion)	The microscopic nature of yield stress
10:25	Adar Sonn-Segev, Anne Bernheim-Groswasser, Yael Roichman, Haim Diamant (TAU,BGU)	Microrheology of in-vitro Acto-Myosin networks in steady-state
10:50	*Coffee Break*	
11:30	Joachim Sunder (Gottfert)	On-line testing of rheological parameters at laboratory and production plants
11:55	Inna Solomonov, Nir Kampf, Irit Sagi (WIS,TAU)	Rheology as a means of examining collagen-reached extra-cellular matrix degradation
12:20	Fritz Soergel (Thermo)	Comprehensive characterization of polymer-based formulations for Pharma Hot Melt Extrusion processing using rheometry and polarization light microscopy
12:45	*Posters and Lunch*	
14:00	Manfred Wilhelm (KIT)	Non-linear rheology and combined methods in rheology and processing
14:45	Massimo Baiardo (TA)	Cone & Partitioned Plate and Orthogonal Superposition for a better understanding of structure-properties relationships
15:10	Peter Forgacs (HP-Indigo)	Rheological fundamentals of HP-Indigo ElectroInk
15:35	Eyal Zussman (Technion)	Polymer network in a strong extensional flow: a study of the electro-spinning jet
16:00	*Coffee Break*	
16:30	Panel discussion	Troubleshooting in rheological measurements
17:15	Daphne Weihs	Closing remarks

Interfacial rheology and its role in materials design

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Many soft materials are characterized by the fact that they are interface dominated, such as for emulsions, foams or polymer blends. In biological systems, membranes and thin films (e.g. in the lungs) play an important role as well. Many of these materials can be engineered by tailoring the rheological properties particular to the interface.

In the present talk I will first try to address a few areas of relevance, before introducing the relevant material functions which control the functioning of the interface. Both soluble and insoluble systems will be addressed. Advances in measurement techniques for determining the interfacial rheological properties will be reviewed, before ending with some examples of materials with engineered surface rheology and some unusual applications.

The Microscopic nature of Yield Stress

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Yield stress is a complex macroscopic phenomenon, which is still being heavily debated and not well-understood on any scale. Many cross-linked gels have been shown to exhibit a resistance to applied stresses up to a critical value, the yield stress, above which they exhibit flow. While the breakage of cross-links may explain the resistance, the exact microscopic origin of the yield stress is still unknown. In gels, and especially in biological gels, the local structure is heterogeneous and can vary with time, thus making localized measurements crucial. We explore the microscopic nature of yield stress in polymeric gels using microrheology to measure flow phenomena on a micron scale in polymeric gels.

We compare and contrast particle-tracking microrheology data with classical, macroscopic rheology of yield-stress gels. In addition, we use controlled on-microscope-stage perturbations to study the dynamics of yielding in gels. Transient gel disruption is achieved by applying using low-intensity ultrasound, which produces sample-wide effects. Those experiments provide enhanced time-resolution of the gel response and allow us to evaluate break-down and recovery of yielding structures, revealing not only local changes in structure but local gel dynamics as well. We present data showing Maxwell-like dynamics as well as sub-diffusion within a local trap in different gels. In addition, the response following perturbation provided an indication of local, structural dynamics

Microrheology of in-vitro Acto-Myosin networks in steady-state

Adar Sonn-Segev[1], Anne Bernheim-Groswasser[2], Yael Roichman[1], and Haim Diamant[1]

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We show that complex fluids such as actin networks respond differently to deformations at intermediate length scales than they do at large distances as a bulk material. This intermediate response regime is characterized by a $1/r^3$ decay with distance. When characterizing passive entangled F-actin networks, we observed this intermediate response at surprisingly large distances of 2-6 μm, which are comparable to the size of a cell, and are over ten times larger than the mesh size of the actin network. We generalize the framework of microrheology to include and characterize this intermediate response, which in turn allows extracting the material's structural properties.

We use this newfound understanding to extract structural information of active in-vitro reconstituted cytoskeleton networks, in which such analysis can be done in a controlled fashion.

On-line testing of rheological parameters at laboratory and production plants

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Laboratory rheometers and Melt Indexer perform measurements to determine the visco-elastic properties of polymeric materials with a time delay after the materials being processed. On-line rheometers deliver these data while the materials are still being processed. An overview of on-line capillary rheometers is presented. Important items of on-line measurement are reliability of the device and residence time behaviour. Automatic determination of melt index and of the visco-elastic properties from the flow curve becomes one element to control the polymer processing process.

Especially the elongation behaviour of polymer melts becomes more and more important. A new concept of on-line elongation testing based on the so called Rheotens is presented.

Rheology as a means of examining collagen-reached extra-cellular matrix degradation

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Uncontrolled extracellular matrix (ECM) degradation is a feature of many pathological events, including atheroma, arthritis, cancer and chronic tissue ulcers. Matrix metalloproteinases (MMPs) play a crucial role in ECM degradation, where only few of these enzymes are able to degrade fibrillar collagens. We have shown that enzymatic degradation of a collagen-rich native ECM by collagenases, MMP1 and MMP13, is an intricate process, not only in ECM biochemistry, but also by a change in its mechanical properties. By measuring the rheological storage (G') and loss (G'') moduli we demonstrate that both native and MMPs-degraded collagen has a gel-like structure. The G' value, attributed to the elastic component, of the native collagen was significantly higher than those of the MMP1 or MMP13 treated samples, indicating the softening of ECM during the MMPs' degradation. Importantly, collagen treated by MMP1 was weaker than that treated by MMP13, suggesting that MMP1 activity is highly correlated with collagen stiffness. Similarly, the viscous part, G'', values of collagen treated by MMPs were also significantly lower than those of native ECM. This reduction may be attributed to the reorganization of collagen packing from closely packed structures into loose networks. The native and MMPs-treated collagen morphology is also demonstrated by SEM and TEM microscopy. Our data show that the rheology technique may be used as a probe to distinguish between healthy and pathological tissue states.

Comprehensive characterization of polymer-based formulations for Pharma Hot Melt Extrusion (HME) processing using simultaneous rheometry and polarization light microscopy

Fritz Soergel

Thermo Fisher Scientific, Material Characterization, Karlsruhe, Germany

When newly developed Active Pharmaceutical Ingredients (APIs) are not soluble in water (or alcohol), Hot Melt Extrusion (HME) processing may be an alternative. In its formulation development, suitable polymers, plasticizers and processing additives need to be found. In the process development, a proper compounder/extruder layout as well as suitable processing parameters need to be determined. The goal is to achieve good processability, high bioavailability, long term stability as well as good drug release characteristics of the pharmaceutical product.

Compared to a rheometer, extruders (even small ones) require much more sample volume (which is expensive and rare) and much more time for a compounding/extrusion trial and subsequent cleaning. Before and after the compounding/extrusion process, analysis of size, distribution and morphology of the crystalline API is required. These parameters are affected by the processing configuration and parameters as well as by the heating and cooling rates applied.

Highly efficient for HME development is a rheometer, equipped with a polarization light microscope with well-defined heating and cooling rates, shear rate testing as well as oscillatory testing. This combined method requires only a small sample volume and delivers significant and well-correlated rheological data and microscopic images, allowing for investigation of the formation and the stability of solid solutions or crystalline dispersions. It provides an efficient screening tool for HME formulation development as well as rheological parameters for process development and process optimization (e.g. by modeling calculations of compounding and extrusion).

Non-linear rheology and combined methods in rheology and processing

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Rheology as a science of flow of matter is highly influenced by the topology and morphology and of the investigated polymer molecules and fillers. Within this presentation three current developments within our group will be presented. In the first part, the direct influence of molecular structure on the non-linear mechanical properties and the processing will be presented. Second the combination of rheological measurements with a second characterization method (NMR, X-ray, dielectric spectroscopy etc.) is described. These new developments gain unique information about molecular dynamic and structure of time and shear dependant phenomena within polymers.

Furthermore new ways to determine mechanical instabilities alike shark skin, stick-slip or gross melt fracture via the related pressure fluctuations in capillary rheology and slit dye extrusion is presented. This allows us to quantify pressure fluctuations in the mbar regime with several ms time resolution for optimized processing.

Lit.:

1) K. Hyun, C.O. Klein, M. Wilhelm, K.S. Cho, J.G. Nam, K.H. Ahn, S.J. Lee, R.H. Ewoldt, G.H. McKinley; A Review on Nonlinear Oscillatory Shear tests: Analysis and Application of Large Amplitude Oscillatory shear (LAOS); *Prog. Polym. Sci.* **36** 1697 (2011)
2) H. Palza, S. Filipe, I.F.C. Naue, M. Wilhelm; Correlation between Polyethylene Topology and its Melt Instabilities by Determining In-Situ Pressure Fluctuations and Using Advanced Data Analysis; *Polymer* **51** 522 (2010)
3) T. Meins, K. Hyun, K. Ratzsch, C. Friedrich, B. Struth, M. Wilhelm; Combined methods in Rheology: Rheo-SAXS, Rheo-NMR and Rheo-Dielectric to bridge length and time scales; Annual Transactions the Nordic Rheology Society, **19** 201 (2011), ISBN 978-952-15-2589-6

Rheological fundamentals of HP-Indigo ElectroInk

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ElectroInk is in the core technology of digital printing press machines developed and manufactured by HP Indigo Division the world leader in the field of digital press. Digital press machines at high speed have to produce high quality, immediately ready (with zero drying time) colored prints while each page can be different from the previous one. These demands require unique rheological properties; starting from the properties of highly viscous concentrated ink as it is supplied to the machines through visco-elastic fluids of decreasing and increasing viscosity during the consecutive transfer processes between the rollers of various functions in the machine to the end product of high modulus resilient solid film providing good abrasion resistance. Accordingly, ElectroInk is a complex fluid exhibiting non-linear rheological properties which change with concentration, temperature, shear and electrical field.

In the presentation some general findings of the unique rheological properties of ElectroInk will be given. It will be shown how these properties answer to the above outlined requirements. Simultaneously the instrumentation available at HP-Indigo will also be reviewed with the aim of pinpointing the topics where cooperation with other institutions can be fruitful.

Cone & Partitioned Plate (CPP) and orthogonal superposition for a better understanding of structure-property relationship

Massimo Baiardo
TA Instruments

When highly viscous elastic fluids are sheared in rotational rheometers, secondary flows develop when a critical deformation is exceeded. At this point sample fracturing occurs, the sample is ejected from the gap and the experiment has to be stopped. For many polymers, sample fracturing appears as the sample transitions from linear to nonlinear behavior. This severely limits the use of LAOS techniques on most polymer samples.

Sample fracturing starts at the sample rim with a sample contraction between the upper and lower plate (cone). This contraction develops into a fracture separating the sample into an upper and lower section and propagates to the center of the plate-plate or cone-plate geometry as the experiment proceeds. Sample fracturing goes along with a significant drop in the measured sample torque and at the same time sample is ejected out of the gap. Sample fracturing according to Keentok and Tanner occurs when the second normal stress difference exceeds the interfacial tension contribution at the sample rim. For non-elastic fluids, the interfacial tension at the curved surface prevents the sample crack to open and the sample heals itself. When N2 exceeds the critical value, however as soon as a crack opens, it continues to grow and the fracture propagates to the center of the plate.

Meissner in 1989 introduced a new type of geometry referred to as ’partitioned plate’ to measure second normal stress in a cone plate geometry. This geometry consists of a center plate measuring the sample torque and an outer ring to complete the cone plate geometry. Schweitzer in 2002 noticed that the partitioned plate could be used to delay the sample fracturing and as such allow viscosity and normal stress measurements at higher shear rates and up to larger total strains to be performed.

The new partitioned plate developed by TA Instruments was designed with two major requirements in mind: It has to fit into the existing ARES forced convection oven and installation must not require fine alignment each time the geometry is removed for cleaning.

The Partitioned plate requires no trimming for linear viscoelastic testing (=> improves reproducibility and facilitates testing), it delays sample fracturing and extends the shear strain range in oscillation up to 1 decade for an LDPE polymer melt and with the partitioned plate LAOS testing in the non-linear region becomes possible for lightly viscous elastic fluids.

Polymer network in a strong extensional flow - a study of the electrospinning jet

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The flow field in the electrospinning jet is typically governed by high strain rate extensional flow of a semi-dilute polymer solution that can cause substantial stretching and disentanglement of the polymer network. Modeling of the dynamic evolution of the entangled polymer network in an electrospinning jet predicted substantial longitudinal stretching and radial contraction of the network, a transformation from an equilibrium state to an almost fully-stretched state (Fig. 1). This prediction was verified by X-ray phase-contrast imaging of electrospinning jets, which revealed a noticeable increase in polymer concentration at the jet center, within a short distance from the jet start (Fig. 2). The model was expanded to semi-flexible conjugated polymer chains, and scanning near field optical microscopy (SNOM) of electrospun nanofibers revealed that the network's dense elongated conformation effectively remains after jet solidification. Furthermore, polymer entanglement loss in consequence of stretching was evidenced in jet fragmentation and appearance of short nanofibers (Fig. 3). It was found that short nanofibers are likely to appear when a combination of low entanglement of the polymer chains and high strain rate of the electrospinning jet exist.

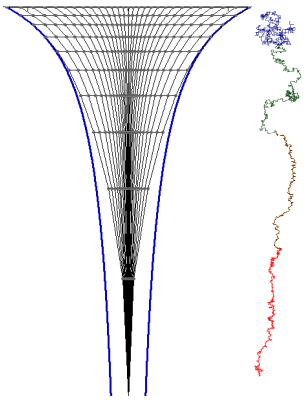

Figure 1. Simulated conformation of a polymer network during electrospinning (diluted x800).

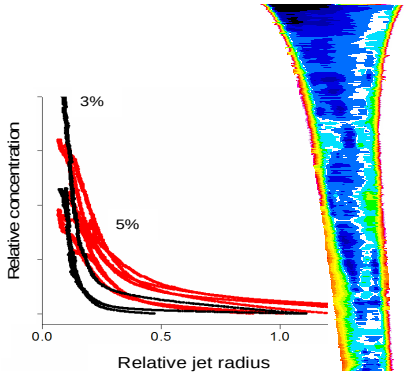

Figure 2. Absorption of electrospun jets, with nonuniform distribution (right) and a concentration rise at the jet center (left).

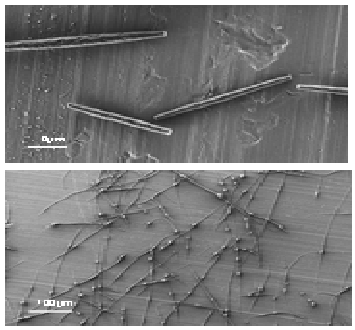

Figure 3. Electrospun short PMMA fibers, demonstrating jet fragmentation as a result of untangling of the polymer network.

1. I. Greenfeld, K. Fezzaa, M.H. Rafailovich, E. Zussman, “Fast X-ray phase-contrast imaging of electrospinning polymer jets: measurements of radius, velocity and concentration,” **Macromolecules**, 2012.
2. I. Greenfeld, E. Zussman, “Polymer entanglement loss in extensional flow – evidence from electrospun short nanofibers,” **Journal of Polymer Science Part B: Polymer Physics**, 2013.
3. A. Camposeo, I. Greenfeld, F. Tantussi, S. Pagliara, M. Moffa, F. Fuso, M. Allegrini, E. Zussman, and D. Pisignano, "Local mechanical properties of electrospun fibers correlate to their internal nanostructure", **Nano Letters**, 2013.

Poster List

1. Indications of phase transition of OMCTS nanometrically-thin films during Stick - Slip Friction, Irit Goldian, Nir Kampf, Arie Yeredor, and Jacob Klein – (Weizmann, Tel Aviv University)

2. Hierarchical structure of multicomponent polysaccharide-based ECM mimetics, Ortal Levi ,Guy Hochbaum and Ronit Bitton (Ben Gurion University)

3. Analysis of cocoa content in chocolate using tribo-rheometry and its correlation to mouth feel, Alina K. Higham and Massimo Baiardo (TA Instruments)

4. Orthogonal Superposition Measurements on Thermo reversible Gels, Madhu Namani and Massimo Baiardo (TA Instruments)

5. The Effects of Emulsifying Additives for Personal Care Products on Oil/Water Interfacial Rheology, Cotts and Massimo Baiardo (TA Instruments)

6. Rheological behavior of Nanofluid materials sensitive to external fields, Massimo Baiardo, (TA Instruments)

7. Simultaneous or subsequent thermal and UV curing detected with simultaneous rheometry and FT-IR spectroscopy, Jan Philip Plog, Fritz Soergel (Thermo Fisher Scientific)

8. Ink jet printing with suspensions – rheological characterization with Capillary Break-up Extensional Rheometry, Fabian Meyer and Fritz Soergel (Thermo Fisher Scientific)

9. Full structural recovery in thixotropic coatings investigated in CS mode with a robust mechanical bearing rheometer, Fabian Meyer and Fritz Soergel (Thermo Fisher Scientific)

10. Controlling Collagen Gel Stiffness and Pore Size through Gelation Conditions Noa Kirschner, Oshrit Poliker-Aharon, and Daphne Weihs (Technion)

Indications of phase transition of OMCTS nanometrically-thin films during Stick-Slip friction

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In this study, organic liquid Octamethylcyclotetrasiloxane (OMCTS) confined to molecularly thin layers is studied. It has been shown that when shear force is applied on a thin layer of OMCTS, the sliding is characterized by a stick-slip pattern. Surface force balance (SFB) experiments, supported by molecular dynamic simulations suggest that the stick-slip friction is a result of an abrupt phase transition between solid like and liquid like phases during sliding. This transition, in principle, should be expressed as the change in surface separation during shear because of density differences between the solid and liquid phase, which is expected to be in the order of 0.5 nm (for 5-6 molecular layers). Our aim is to find, for the first time, an experimental indication for this phase transition in OMCTS thin film during stick & slip friction, by video-recording the movement of the surfaces back and forth during the sliding (movement of an interference fringes) and looking for a movement at the same frequency as that of the stick & slip spikes. Preliminary results show that we have succeeded to conduct a clean SFB experiment with pure OMCTS confined between the surfaces, and these enable us to examine the nature of the phase transition during the stick-to-slip event.

Hierarchical Structure of Multicomponent Polysaccharide-Based ECM Mimetics

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Polysaccharides such as alginate, hyaluronic acid and chitosan have been utilized in the fields of regenerative medicine and tissue engineering to allow cell growth in impaired regions, by providing an artificial bio-surrounding similar to the natural Extra Cellular Matrix (ECM). A common modification to improve survival and cell organization in these scaffolds is to covalently attach a peptide containing the cell adhesion ligand arginine–glycine–aspartate (RGD) to the polysaccharide's backbone.

Over the past decade the role of the mechanical properties and hierarchical structure of the cell surrounding in demining cells fate has been elucidated. Though the bioactivity of RGD-polysaccharides scaffolds has been well studied, little is known on the effect of peptide conjugation on the physical properties of the polymer.

The purpose of this research is to seek possible relationships between the structure on the nano-scale of modified polysaccharides in solution and the macroscopic properties of peptide-polysaccharides hydrogels.

A peptide containing the RGD sequence was covalently attached to three polysaccharides: alginate, HA and chitosan at two peptide/polymer ratios. Thorough Structural characterization of the polysaccharides (both natural and modified) in aqueous solutions using small angle X-ray scattering (SAXS) revealed that the modifications affect the structural features of the polymer chain and the spatial arrangement of the polymer networks. Rheology measurements of both solutions and gels suggest the conformational changes in the solutions are translated to changes in the polymer's mechanical properties.

Analysis of cocoa content in chocolate using tribo-rheometry and its correlation to mouthfeel

Alina K. Higham, Massimo Baiardo
TA Instruments, New Castle, DE

A large amount of resources in the food science industry are directed to understanding properties of food products such as texture and mouthfeel before, during, and after the consumption of food and beverages. These properties play a large role in consumer selection and acceptability, directly impacting the success of new formulations. Unfortunately, many sensory properties of food are difficult to characterize. Numerous studies have been shown to correlate some properties, such as firmness, fattiness, and creaminess with bulk rheological properties and recently, studies have begun to focus on thin-film tribological properties.

Tribology is defined as the study of friction, wear, and lubrication between two interacting substrates in relative motion. Within the mouth alone, the number of interacting substrates is quite plentiful: teeth-teeth, tongue-teeth, tongue-palette, tongue-food, just to name a few. It is believed that tribology can be used to analyze friction properties of substrates within the mouth and food surfaces to correlate with consumer perception and mouthfeel.

In this poster, the tribo-rheometry accessory in conjunction with a rotational rheometer will be described and the tribological properties of commercially-available chocolates. We will demonstrate how differences in chocolate composition, such as fat and cocoa content, affect the properties and behavior of chocolate thin films between two sliding surfaces. The coefficient of friction as a function of sliding velocity and load force will be given for the chocolate samples.

Simultaneous or subsequent thermal and UV curing detected with simultaneous rheometry and FT-IR spectroscopy

Jan Philip Plog, Fritz Soergel
Thermo Fisher Scientific, Material Characterization, Karlsruhe, Germany

Compared to thermal cross-linking and curing, UV cross-linking and curing is faster, better defined and processing plants have a smaller footprint and less energy consumption. For the production of sealing rings and other elastomer products, however, a simultaneous or subsequent application of thermal and UV curing is used. In general, controlled temperature conditions are contributing to a well-controlled UV curing production process, which can be optimized with lab measurements for higher processing speed and optimum product properties.

The oscillatory rheological characterization of the complex cross-linking and curing process reveals in detail the changes in the bulk properties. In order to understand and optimize cross-linking, curing and their kinetics on a molecular level, simultaneous FT-IR spectroscopy can be employed. The advantage of combining rheometry and FT-IR spectroscopy in one instrument is that the same sample with the same history is analyzed under exactly the same conditions.

Simultaneous measurements on urethane acrylate composite coatings for glass fibers (used for fiber cable production) will be shown. Depending on the chemical nature of the components involved, the disappearance of the starting material's reactive groups and/or the appearance of the product's characteristic chemical groups can be seen and correlated with the development of the mechanical properties.

Ink jet printing with suspensions – rheological characterization with Capillary Break-up Extensional Rheometry (CaBER)

Fabian Meyer, Fritz Soergel
Thermo Fisher Scientific, Material Characterization, Karlsruhe, Germany

Recently, more and more applications are coming up using ink jet printing technology with suspensions e.g. for tiles, circuit boards, solar panels, adhesive application as well as 3D printing. In some of these printing processes, the suspensions inside the printer cartridges may even require temperature control as well as permanent stirring of the suspension to ensure a well-controlled printing process.

Comprehensive rheological characterization of the suspensions as well as optimization of the parameters in the ink jet printing process, include on the one hand testing in shear deformation, revealing the material's storage stability as well as its flow behavior and processability. On the other hand, extensional measurements are required to understand the atomization process as well as limitations in processing speed.

In Capillary Break-up Extensional Rheometry (CaBER) a small quantity of sample is placed between two circular plates. The top plate is rapidly separated from the bottom plate, causing the formation of a fluid filament. The mid diameter of this filament is recorded as a function of time. The filament life time of the ink jet printing suspensions mentioned above, can be as short as 20 ms. By using a high speed data acquisition card, even for such a short filament life time, a sufficient number of data points and a meaningful measuring curve can be obtained. These data reveal differences in formulations and processability and facilitate the calculation of curves of the apparent extensional viscosity.

Full structural recovery in thixotropic coatings investigated in CS mode (Controlled Stress) with a robust mechanical bearing rheometer

Fabian Meyer, Fritz Soergel
Thermo Fisher Scientific, Material Characterization, Karlsruhe, Germany

Measuring the thixotropic behavior (i.e. the shear-time dependent structural break down and recovery of a material) is an important method to evaluate the performance and applicability of paints and coatings and other materials.

The hysteresis area in a CR mode (controlled rate) thixotropy loop measurement reveals how thixotropic a material is. The exact time, which a material requires to recover after being exposed to higher shear rates, and the degree, to which it recovers in a certain period of time, can be determined from a shear recovery experiment. For measurement of full structural recovery, either rotational testing in CS mode or oscillatory testing in CS mode or CD mode (controlled deformation) is required. Rotational testing in CR mode, however, is only capable of revealing incomplete structural recovery, as the recovering structure is partly disaggregated by the continuous rotational motion in CR mode.

In a well-controlled lab environment, an air bearing rheometer would be the preferred instrumentation providing all required measuring modes. In a rough industrial environment with vibrations and dust, however, a sturdy and robust mechanical bearing rheometer may be more suitable, as long as it provides the required CS mode.

Full structural recovery has been investigated for 3 different kinds of commercially available thixotropic coatings: wall paint, primer paint and a lacquer for smooth surfaces.

Controlling Collagen Gel Stiffness and Pore Size through Gelation Conditions

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Metastatic cells have been known to apply forces on a non-degradable, impenetrable gel (PAA). Continued work in the lab includes evaluating if this ability exists in a physiological gel system. In this project, we have used collagen gels with modulated stiffness as the model system, chosen in the stiffness range determined for PAA gels. The gels were prepared by incubation at 37°C at various times. Cross-linking was done using glutaraldehyde (GA), and TRIS buffer was added to stop the cross-linking, as GA was found to be harmful to cells. We used rheometry to evaluate the elastic shear modulus of the gel. Gel stiffness was modulated by modifying gelation process conditions, focusing on gelation time, cross-linker concentration, and cross-linking time. The experiments showed that an increase in cross-linking time, cross-linker concentration, and gelation time will result in a larger elastic shear modulus. We have concluded that the optimal gelation period is 2.5 hours long. In addition, the optimal cross-linking time is 30 minutes and the GA concentration should be 0.4% w/v. Integrating these conditions provides control of gel stiffness, allowing flexible experiment design to simulate a physiological environment