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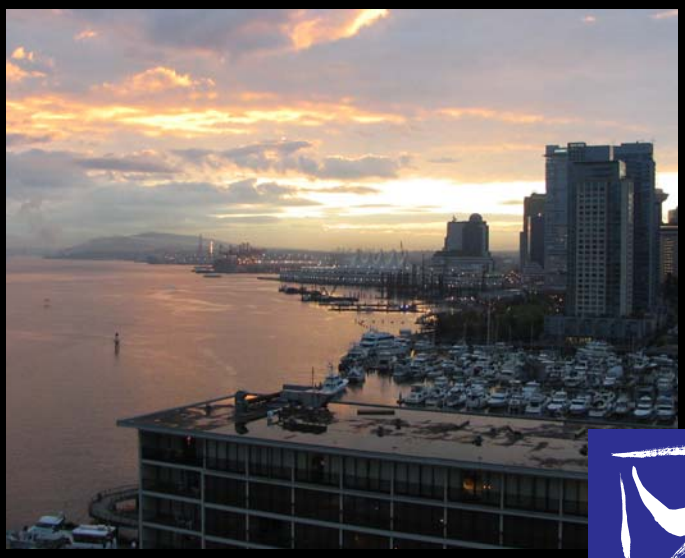
Vancouver Report

Rheology Bulletin



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The brush-stroke hourglass that serves as the logo of the *Rheology Bulletin* was designed for the *Bulletin* by Tomas B. Co in January 2004. Co is a faculty member in chemical engineering at Michigan Technological University USA; he is interested in painting and calligraphy.

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Change of address or letters to the editor: rheology@aip.org

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RHEOLOGY AND THE TRIPLE BOTTOM LINE

David V. Boger
Laureate Professor
The University of Melbourne

It was a great pleasure to be the lunchtime speaker at the 76th Annual Meeting in Lubbock where my presentation on 'Rheology and the Triple Bottom Line' was a contrast to the papers in the meeting. There has been a noticeable shift in the rheology community to smaller nano- and bio-systems.

It was surprising that so few people were aware of the triple bottom line. The three lines represent Society, the Economy and the Environment. Society depends on the economy, and the economy depends on the global ecosystem, whose ultimate health represents the ultimate bottom line. More precisely, the triple bottom line now focuses corporations, not just on the economic value that they add, but also the environmental and social value they add and/or destroy. At its narrowest it is a framework for measuring and reporting corporate performance against economic, social and environmental parameters. Sustainable development is linked to the triple bottom line in that it is about strengthening the business while reducing negative social and ecological consequences. Most major corporations now report relative to the triple bottom line.

How can rheology influence the triple bottom line? Rheological knowledge can be exploited by many industries to drastically reduce the volume of waste currently produced and stored and hence reduce the negative social and environmental impact of these industries. The minerals industry worldwide is an example, while the huge oil-sand mining activities in Canada is another, as is the disposal of human waste. For example, there are copper mines in the world that produce, on average, 250,000 tonnes on a dry basis of fine particle waste per day. Such waste is pumped to a disposal area at relatively low concentration when the material has Newtonian flow characteristics. This disposal area is invariably a very large dam; in fact, disposal areas approaching half the size of Singapore are present in the world. If the waste from such a mine, whether it be from minerals, coal, oil or human waste, is dewatered and the water is reused in the process, the footprint produced by the dam can be reduced dramatically. In fact, it is possible to go from wet to dry disposal. There are many incentives to do this ranging from conservation and reuse of water to reduction of the considerable risk involved in these dams. In the last twenty years there have been forty-four tailings dam failures. The probability of such a failure apparently ranges from one in seven to one in fifteen [www.wise-uranium.org/mdaf.html].

Figure 1: Failure of the Boliden lead-zinc tailings dam in 1998.

The consequence of a dam failure is dramatic and can be tragic. The photograph in Figure 1 shows the rupture in a tailings dam holding the waste from a lead-zinc mine in Spain in 1998. Five million cubic meters of water and particulates

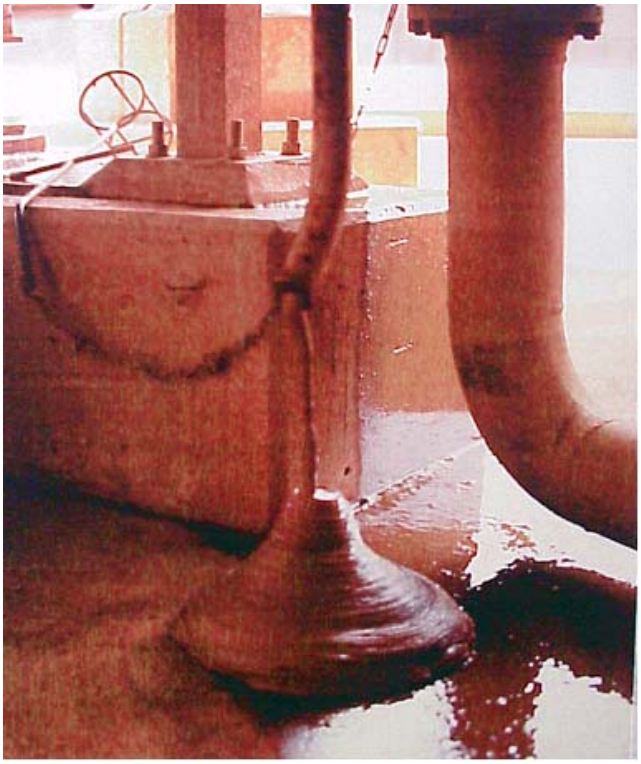

Figure 2: Mineral waste produced with a compression thickener.

containing high levels of heavy metals poisoned two rivers and flooded crops. The company was fined 45 million euros; the miner sued the company who built the dam for 101 million euros; regional authorities sued the company for 89.8 million euros; shareholders apparently are suing the company for their losses as the company shares plummeted. Cleanup costs exceeded 250 million euros. This is a graphic example of what happens when such a tailings dam bursts; in this case, no lives have been lost.

In another case, the Stava failure on 19 July 1985, 268 people lost their lives as a result of the tailings dam failure. Such failures can virtually be eliminated by moving from wet, Newtonian fluid suspension disposal to a highly concentrated, non-Newtonian fluid disposal simply by understanding and exploiting very basic shear and compression rheology. As the concentration is increased, the material becomes non-Newtonian, exhibiting, generally, pseudoplastic characteristics. Further increase in the concentration sees the beginning of a yield stress, and ultimately, one generates a very high yield-stress material which may be difficult, if not impossible, to pump. Materials with yield stresses up to 200 Pascals can now be pumped with centrifugal pumps, and it is technically feasible to dewater and pump at such concentrations and dry stack, as is the case in the alumina industry in Western Australia (see Figure 3). An application of very basic rheological principles, involving both compression and shear rheology, is all that is needed to reduce the risk, recover water, and reduce the footprint. Hence, consistent with the triple bottom line, exploiting the rheology will decrease the negative social impact and environmental impact of the particulate fluid waste, not only from the minerals industry, but also from the coal, oil and human waste disposal industries.

The photograph in Figure 2 shows the type of paste material that can be produced in compression thickeners and pumped, whilst the photograph in Figure 3 shows a dry disposal area, which contrasts markedly with a Newtonian, fluid dam which is often the current practice.

Figure 3: Alcoa Western Australia, bauxite waste dry stacking.

Model systems such as monodisperse polymers and suspensions of inert spheres were key to advances in rheology in the 20th century. In this article we receive an invitation from the hopelessly non-model world of food rheology, where, despite the complexities of nature, a determined rheologist can make satisfying contributions.

From Saulus to Paulus: Becoming a Food Rheologist

Peter Fischer, Michael Pollard, and Irene Marti

ETH Zurich, Institute of Food Science and Nutrition, 8092 Zurich, Switzerland

1. Welcome to the freak show (or "Dark shadow over planet Food Science")

Why do we consider most food sessions at rheology conferences to be "freak shows"? There are two reasons: First, standard food rheology often consists of little more than poorly executed case studies without any generic impact. Second, food is a multiscale, multiphase, and multistage complex material that we barely understand. Consider that most food products are made from natural materials, which means that the properties of most of our food material depends on environmental aspects such as soil quality, weather, and farming standards. In most cases such ingredients already have innate structural and textural properties with huge impact on the flow behavior of the final product, i.e. our food. Adding to the complexity, food or food ingredients are created or manufactured using a vast variety of processes to different quality standards and variable consumer expectations around the world [1].

An important goal of food research is therefore to develop and standardize desirable food properties - in our brave new food world this is called functionality. Most properties derive from the raw material, the manufacturing processes, and the joint interactions among the food's raw and processed components. If we knew the influence of specific ingredients on the flow behavior of complex fluids, it would in general be possible to design manufacturing processes to produce ingredients having tailor-made properties [2, 3]. In reality, food production nowadays is basically nothing more that a scaled-up version of your grandmother's kitchen. Trial and error dominates R & D in both industry and academics, as indicated by the vast number of case studies published in journals or presented in conferences.

Even worse, food is much more than a material: it feeds us, it has emotional aspects, and we are insecure about it ("Do I eat the right foods?" "Is that cheese safe to eat unpasteurized?"). Dealing with food means that rheology and processing are not the only problems food scientists have to address [4].

So why don't we understand food material better, and what are possible escape routes? Copy-paste adaptation of physical, chemical and colloidal concepts and ideas to food material will not work, at least it will not work as fast and as well as one might expect. Here begins the dilemma faced by food rheologists that, in most cases, leads down the bitter path to the lamentable case study: All properties you might use to feed your model (model parameters related to structure or function) basically cannot be measured for food materials.

Why is this so? Because food material is produced by plants or animals, and we do not have control over their synthesis, and this prevents us from measuring the desired model properties. In the synthetic polymer world, your buddy polymer chemist might come to your office saying "Hey, I made this fancy twisty-twirly molecule, would you like to do rheology on it?" Or you might ask a polymer chemist: "Can you place a flag on this molecule? I would like to prove some aspect of my

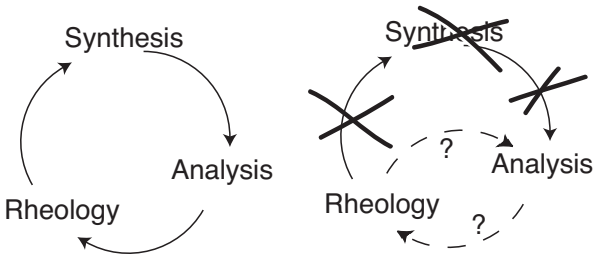

Figure 1: Feedback rheology - morphology - synthesis in polymers (left) and biomaterial (right).

model?" This approach is not possible in food rheology, unless you consider talking to a plant or cow as therapeutic counseling. The missing link is illustrated in Figure 1.

Three examples serve to illustrate the far different properties of food ingredients compared to synthetic molecules. Let's say that you want to attract more visitors to your polymer rheology lab during an open house at your university. Almost automatically you will think about using a food example, such as die swell of polymers explained by spaghetti extrusion. The only problem: dough is viscoelastic but exhibits a boringly tiny die swell. Here we have a problem where our standard polymer models and mindsets cannot be transferred to food.

Another example is that many people think of a protein as nothing more than a biopolymer with peptide building blocks instead of synthetic monomers. In this view, polymer models can describe protein rheology, and the main characteristic of a protein is its length. See the viscosity scaling exponent of around 12 in Figure 2 to grasp an idea that this might not be the case.

One final example is that plant biopolymers (polysaccharides) are sometimes described as block copolymers. After many fruitless attempts using a classical description of block copolymers, one can conclude that this picture is far too simple (see Section 3).

Having our classical polymer physics and chemical engineering background we might show up in the food business saying "Well, that problem's simple, it will be solved in a few weeks." After a few months of deep frustration in being Saulus, one has to admit that food is a bit more complex than expected, and after some more years you might become Paulus. So, "Welcome to food!"

To overcome this dilemma we certainly cannot propose a golden rule of food rheology. However, serious studies based on the multistage appearance of food properties and processing as well as generic food material characterization will help us to understand food better. Further, we have to work on our mindset towards food and have to accept that food is probably far more complex than we want to admit.

In the following we will focus on two subjects, fiber-reinforced chocolate and the phase behavior of polysaccharides. We hope the first case illustrates the multistage approach taken in food science while for the second example we would like to map a way to establish the link that we are used to having between molecular structure and rheology.

2. Fiber-reinforced chocolate

Chocolate is a confectionery product that is made from the fermented, roasted, and ground seeds of the tropical cacao tree. Cacao was first cultivated by the Aztecs of Mexico and the Mayas in Central America. The Mexicans associated the fruit with Xochiquetzal, the goddess of fertility, and the drink prepared from it was called xocoatl. Christopher Columbus brought some cocoa beans as a souvenir to Spain, and the first recorded shipment of cacao to the Old World for commercial purposes was in 1585. Some centuries later milk chocolate was invented and introduced to market by the Swiss candle maker Daniel Peter.

Milk chocolate is one of the most popular chocolate products. Its melt is a highly concentrated suspension and exhibits complex flow behavior. For

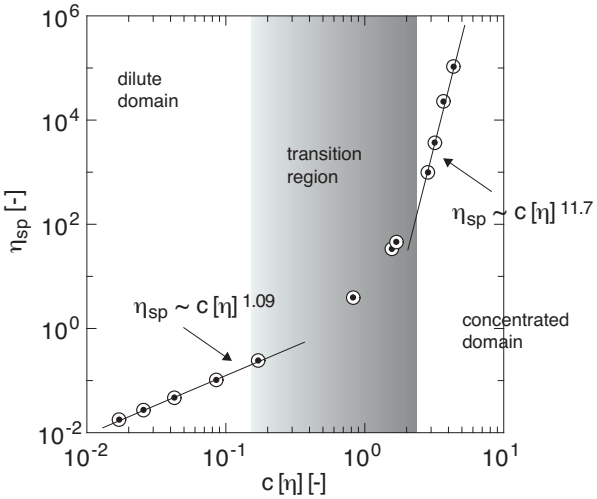

Figure 2: Specific viscosity as a function of dimensionless concentration for milk protein dispersion [6].

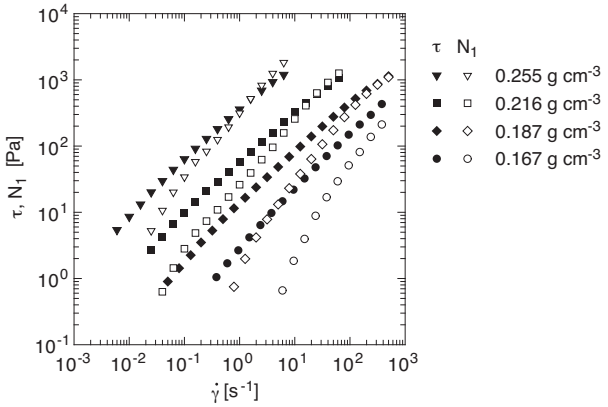

Figure 3: Shear stress and first normal stress difference as a function of shear rate for milk protein dispersion at various concentrations [6].

processing and consumer acceptance, low viscosity and low yield value are favorable characteristics. About 20 wt% of milk chocolate consists of milk powder, which influences taste, processing behavior, and rheological properties of the molten chocolate. In particular, milk fat content, particle size, porosity, moisture content, and lactose phase (amorphous/ crystalline) influence viscosity and yield-value of milk chocolate considerably. The aim of this study was to design a new milk drying process that allows for the production of dairy powders with favorable properties for their use in confectionary suspension systems (rheological modifiers). To reach this goal, the fiber dry-spinning technique was adapted. Dry-spinning was expected to facilitate the production of "fiber powders" with compact structure and well adjusted morphology. Resulting fiber diameters were aimed to be in the range of chocolate solids' particle size, i.e. 30 µm.

The chemical composition of proteins generally satisfies well the structural requirements of fiber-forming polymers if the tertiary or quaternary structures are properly unfolded [5]. Milk proteins are classified into two main fractions, the caseins and the whey proteins. The casein fraction naturally exists in large colloidal micelles. However, the stability of these micelles can be perturbed by chemical and thermal modifications of the environment. Casein micelles fully dissociate upon removal of colloidal calcium. Dispersions from milk proteins with dissociated casein micelles, such as sodium caseinates, generally exhibit viscoelastic properties and are potential fiber-forming materials.

With respect to the dry-spinning process, the shear viscosity and the first normal stress difference of milk protein dispersions were studied with capillary and rotational shear rheometry (Figures 2 and 3 [6]). The results obtained revealed that viscous and elastic properties increased with concentration and decreased with temperature. At shear rates accessible with rotational shear experiments, elastic properties dominated the viscous properties. Addition of lactose enhances intermolecular interactions, resulting in increased elastic and viscous response functions on shearing.

Filaments with compact structure, smooth surface, circular cross-section, and diameters in the range of 24 µm were obtained using milk protein. Increasing spinning fluid concentration, through addition of protein and/or lactose, triggered cohesive fracture of the filament, concomitantly the filament diameters increased, and the cross-sectional shape increasingly deviated from circularity. The effect of spinning fluid temperature depended on concentration.

Application studies were carried out on the basis of two groups of model systems mimicking confectionery suspensions. Non-colloidal suspensions consisting of glass spheres and glass fibers dispersed in silicon oil represented the first group. Total volume concentration and fiber fraction of the disperse phase were varied to study their influence on flow behavior. With increasing solids volume concentration, the dependency of fiber fraction on the relative viscosity changed from a monotonically increasing behavior to the occurrence of a minimum viscosity level, which was a function of shear rate. Based on separate contributions from the suspensions of each shape class, the upper Newtonian relative viscosities were accurately fitted using a model proposed by Farris [7] for mixtures of monodisperse hard spheres of different sizes. The results indicate the extended applicability of the model for suspensions with shape polydispersity and propose a mixing rule for such systems as shown in Figure 4 [6].

Three comparative test series were carried out with spin milk powder and skim milk powder as dairy ingredients in model chocolate melts. Rheometric results revealed that spin milk fiber in comparison to milk powder are viscosity reducers in confectionary suspension systems, leading to distinct reductions of viscosity and yield stress (Figure 5).

3. Phase diagram of polysaccharides towards the "missing link"

Referring back to the synthesis-analysis-rheology loop (Figure 1), we must unfortunately accept that

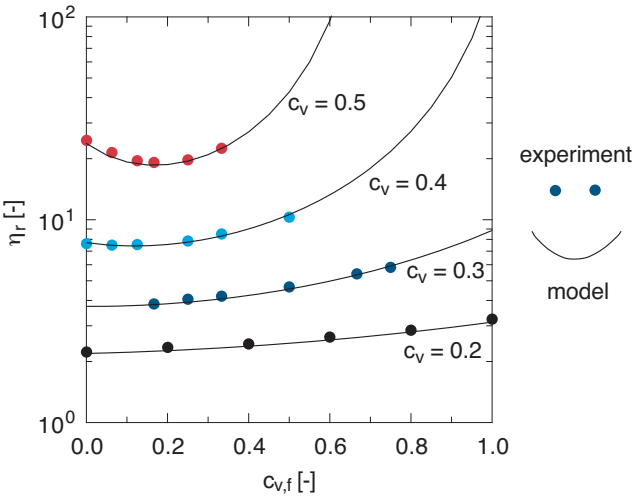

Figure 4: Relative viscosities as a function of fiber fraction for mixed sphere-fiber suspensions. Lines represent calculations from Farris model [6].

we cannot close this loop without control over the chemical composition of the material. For the time being, this is the major stumbling block to further improvements in understanding. Or, saying it in a different way, "Why we are still eating plants?" The answer is: because we are unable to synthesize biopolymers.

To illustrate some of the issues involved in linking this important molecular structure variable to the thermodynamic and flow behavior, consider the schematic in Figure 6. At least three types of distributions are shown here in an idealized way for a typical galactomannan polysaccharide: the molecular weight distribution (MWD), the chemical composition distribution (CCD), and the sequence distribution (SD). While most polymer scientists are comfortable dealing with two simultaneous distributions in their material, three or more are often present in polysaccharides.

The chemical structure of these very simple polysaccharides - the galactomannan storage polysaccharides found in the endosperm of Leguminosae plant seeds - always takes a general form, consisting of a linear backbone -D-mannose saccharide residues linked with a flexible (1-4)-glycosidic bond. The only major chemical decoration of these linear mannan chains are -D-galactose side groups, (1-6) linked. Without these side-groups, the linear mannan is an extremely hard, water-insoluble material, but when present at substitutions greater than 10 - 20%, the chains become soluble in water. Since ionizable groups are not present, aqueous solubility depends only on the presence of these side groups and the increased H-bonding density afforded by them. For details, see the reviews cited [8-10].

For this reason, it is the concentration and distribution of these side groups that provide much of the interest in these polysaccharides, as they control the solubility behavior [11]. The food and cosmetic industries exploit galactomannans primarily for their remarkable thickening power and water binding capacity at very low concentrations. In ice cream formulations, for example, galactomannan polymers help to stabilize the emulsion, act as a viscosfier, enhance texture, and help to slow ice crystal growth, and here often solubility effects come into play in unforeseen ways.

Currently, the literature is unclear on many aspects of the phase behavior of even this very simple system, a point that reflects both their complexity, and the need for better collaborative effort of biologists, polysaccharide chemists, and polymer scientists to put together a consistent picture out of widely differing viewpoints and methods. At what critical side-group substitution do we lose solubility, and how is this related to the native distribution present in the natural material? If we could isolate a narrow composition fraction, is it possible to identify a phase transition corresponding to liquid-liquid phase separation, which might be of interest

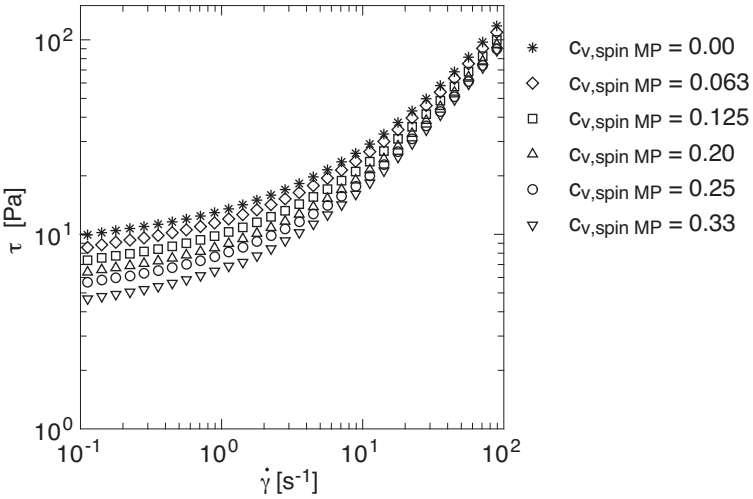

Figure 5: Shear stress as a function of shear rate from model chocolate with different fractions of spin milk fibers [6].

Innovations in rheological solutions

Malvern's rheological instruments have the unique ability to directly characterize material properties over 13 decades of shear rate. This means that physical material parameters can be measured, as well as their impact on process operation and end-use function.

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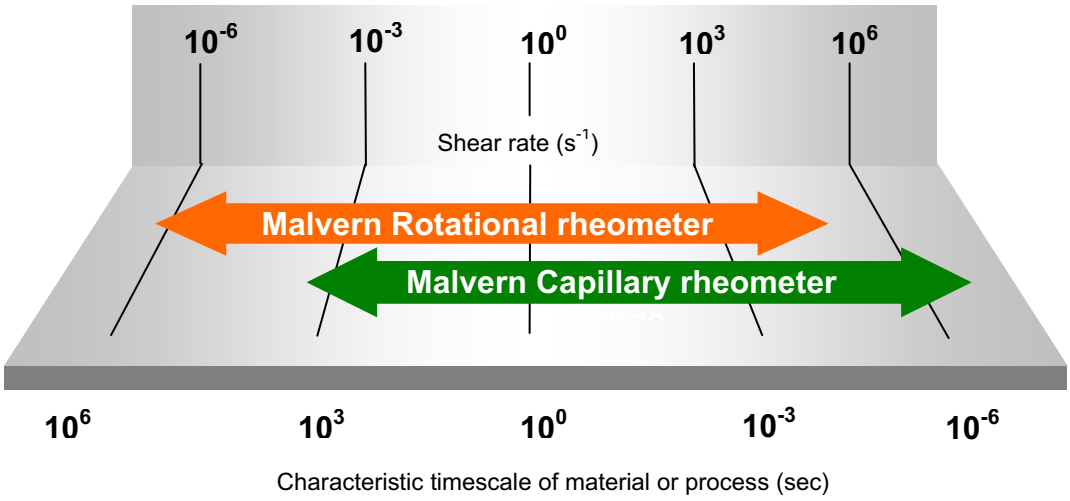

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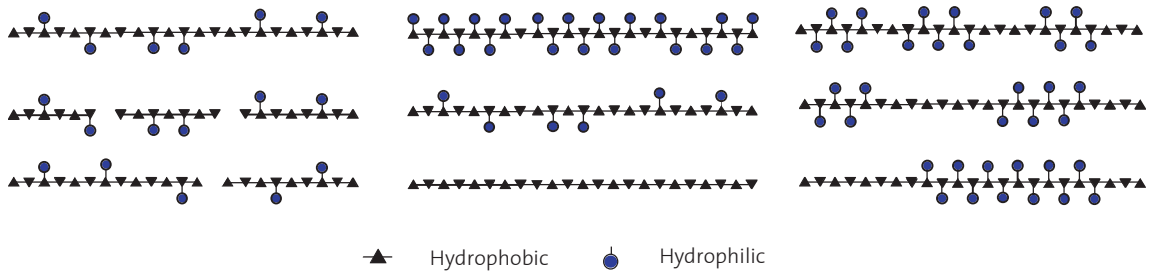

Figure 6: Galactomannan distributional characteristics such as (left) molecular weight, (center) degree of side-group substitution, and (right) associated statistical pattern are under biosynthetic control. Typically, only the averages of these distributions are known with certainty. Sorting the respective distributions and understanding their effects on solution and solid-state properties are standard-fare topics for investigation, but for galactomannans the problem is considerably more challenging than it is for a comparable synthetic polymer analog.

to extend the classical polymer solubility models? Could we take advantage of such a phase transition to extract selected fractions from the native materials? Such questions are only just being addressed in the literature and continue to be addressed with increasing complexity as we understand more about these systems [12].

It is clear that some thermodynamic and rheological criteria are needed to establish phase boundaries and to demarcate useful regions of the diagram in order to fully exploit the rheological properties of such biopolymers. A model system for a study of this type might consist of a homologous series of varying molecular weight, with fully characterized compositional analysis. We have attempted to address this problem by applying techniques of controlled depolymerization by ultrasonication, and compositional fractionation and analysis, with a view to providing better-defined raw materials as we look into the solubility behavior. While both techniques have been employed even for biopolymers, a wider acceptance of these methods might prove useful to examine in more detail the solid-state behavior as well.

As mentioned before, food rheology is not as pretty as some aspects of synthetic polymer rheology, but on the other hand we have to deal with highly heterogeneous materials. This difficulty cannot be avoided; the challenges await the willing.

P.S. Nano is not new to food, it was always colloidal.

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Vancouver 2005

Local Arrangements Chairs Savvas Hatzikiriakos (Vancouver 2005) and Albert Co (Portland 2006) enjoy the Society Reception.

Welcomed by Savvas Hatzikiriakos and the University of British Colombia, The Society of Rheology held its 77th Annual Meeting in Vancouver, BC Canada 16-20 October 2005.

The Monday evening banquet celebrated the achievements of Jan Mewis, the 2005 Bingham medalist. Paula Moldenaers introduced Mewis and his wife Ria Suy (shown below) and gave a brief tour of Mewis' journey from short pants to international awards. Mewis has had a distinguished career as a rheologist, specializing in suspensions, while maintaining a second "secret" life as a chemical safety expert. Mewis' collaborative style has taken him around the world (Delaware, Berkeley, Seoul) and back to Belgium.

Paula Moldenaers (above) roasts Mewis with vintage photos; Mewis receives the Bingham Medal and certificate from SOR president Susan Muller (right).

Five recipients of the SOR Distinguished Service Award: (standing) Andy Kraynik, John Dealy; (seated) Art Metzner, Mort Denn, Albert Co.

Also at the banquet, outgoing *JOR* editor Morton Denn was presented with The Society's Distinguished Service Award. Only the seventh recipient of the Award, Denn was recognized for 10 years of exceptional service to The Society as editor of the *Journal of Rheology*. The award was presented by Society president Susan Muller, who noted that Denn was appreciated for his thoroughness and high standards. Denn and his successor John Brady endured some good-natured ribbing from the president - it was noted that 10 years of hard work on the *Journal* had produced some changes in Denn's appearance; the audience was asked to speculate on what physical changes Brady would undergo as a result of his service as editor.

Mort Denn presented the 2004 Publication Award in Vancouver to Steven Meeker (ESPCI), Roger Bonnecaze (U. Texas, Austin), and Michel Cloitre (ESPCI) for their paper "Slip and flow in pastes of soft particles: Direct observation and rheology," *J. Rheol*., 48, 1295 (2004). All three authors were on hand to receive their award (photo at right with Denn).

The winner of the student poster contest, held Wednesday evening, was Randy H. Ewoldt from MIT (photo on the cover) for his paper, “Exploring the rheological properties required for adhesive locomotion in natural and robotic snails,” coauthored with Gareth McKinley.

There was a special symposium organized at the 77th meeting, honoring McGill professor John Dealy and his lifelong contributions in the area of molecular structure and rheology. The symposium consisted of nine invited papers presented on Tuesday afternoon. Those interested in honoring Dealy were invited to a reception that evening, which included a roast by Jeff Giacomin.

The official business of The Society was carried out on Sunday 16 and Tuesday 18 October; the minutes of the Executive Committee and Business Meetings are printed in this *Bulletin* beginning on page 22.

Bingham medalists in attendance in Vancouver: (standing) L.G. Leal, W.R. Schowalter, G. Marrucci, R.G. Larson, G.G. Fuller, C.W. Macosko, A. Acrivos, W.B. Russel; (seated) A.B. Metzner, J. Mewis, M.M. Denn, and J.M. Dealy.

Rheology News

Boger Honored in Australia

Rheologist David Boger from the University of Melbourne has received the *2005 Prime Minister's Prize for Science*, Australia's top award for excellence in science. Boger received the associated gold medallion and a prize grant of $300,000 AU at a ceremony in Canberra, Australia on 4 October 2005.

The *Prime Minister's Prize* is given for an outstanding specific achievement in any area of science advancing human welfare or benefiting society. Boger was cited for his contributions to understanding the dynamics of non-Newtonian fluids, particularly through the invention of Boger fluids, ideal elastic fluids with constant viscosity. Boger is also credited with making valuable contributions to the problem of addressing the management of the liquid waste produced by mining operations.

Boger is currently Laureate Professor of Chemical Engineering at the University of Melbourne.

Brown Honored in Cambridge U.S.

The Massachusetts Institute of Technology honored Robert A. Brown on 9 December 2005 with a symposium in Cambridge, MA USA featuring reflections by colleagues and former students. Brown's contributions to understanding crystal growth processes and viscoelastic fluid mechanics were highlighted. He is shown here (front, fourth from right) with former graduate students and his colleague and collaborator Robert C. Armstrong. Brown has recently left his post as Provost at MIT to become President of Boston University.

JOR has high Impact

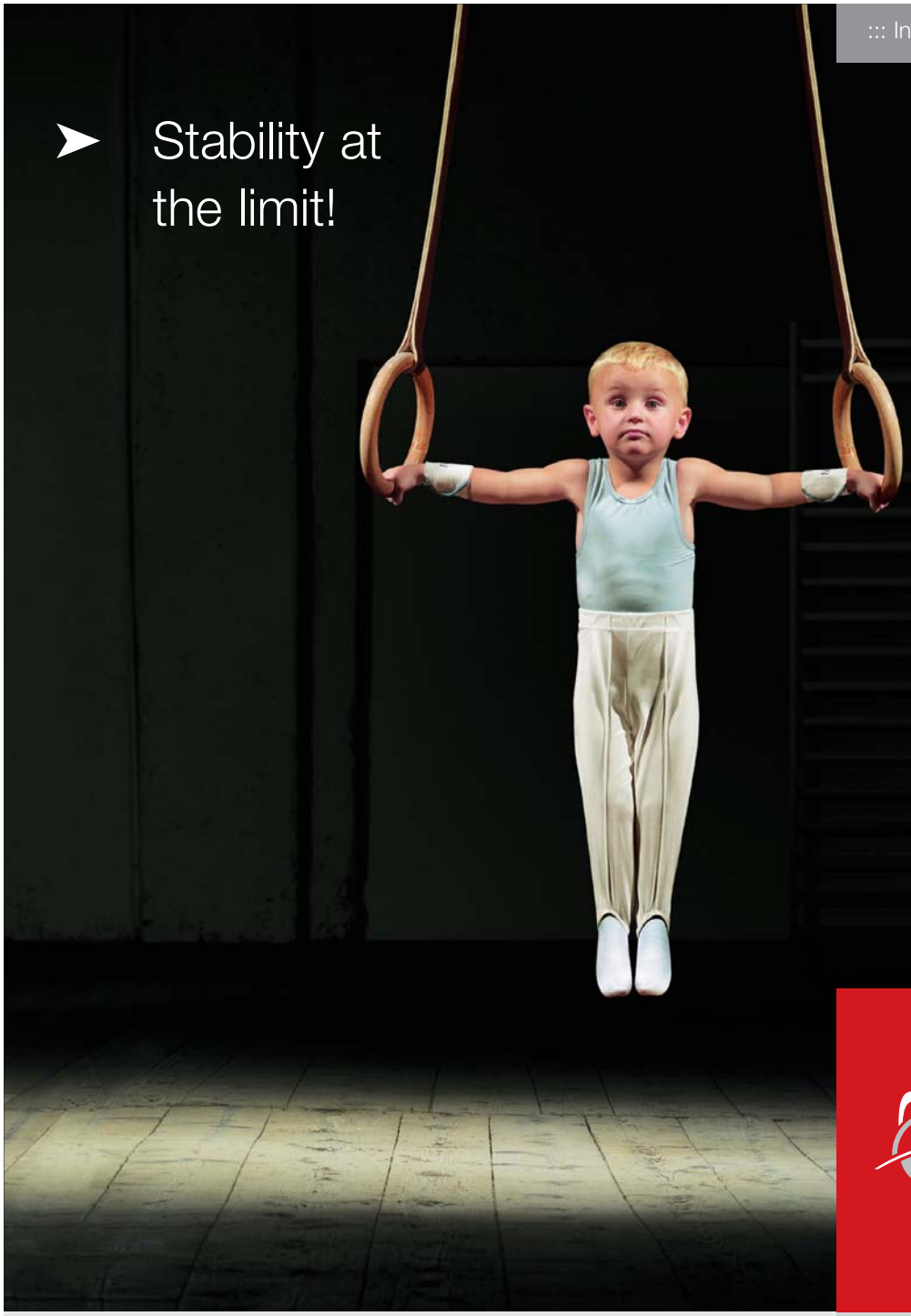
Outgoing editor of the *Journal of Rheology*, Mort Denn, reported to the SOR Executive Committee in Vancouver that *JOR* impact factors are strong and stable.

The journal impact factor was invented in the 1960s by the Institute for Scientific Information, now know as Thomson Scientific (www.isinet.com). The impact factor is a measure of the frequency with which an average article in a journal has been cited in a particular year. The 2004 impact factor of the JOR was 2.525, compared to 1.862 for the *Journal of Non-Newtonian Fluid Mechanics* and 1.558 for *Rheologica Acta*.

The impact factor of a journal is calculated by dividing the number of current-year citations to the number of source items published in that journal during the previous two years. The impact factor is used by librarians for collection management, and it is used increasingly in promotion and tenure evaluations at academic institutions as a reflection of the quality of journals in which researchers publish. Impact factor scores are released annually.

(Continues page 27)

➤ Stability at the limit!



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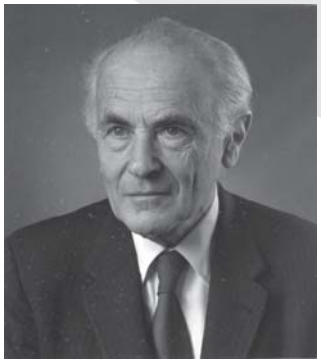

AIP Emilio Segrè Visual Archives,
Physics Today Collection

Frederick R. Eirich

(1905-2005)

by Robert Simha, Case Western Reserve Univ.

With the passing of Fred Eirich, one of the last in the circle of young researchers attracted to Herman Mark's Vienna Institute in the early thirties is gone. One of Fred's strengths was versatility and breadth in his research. With his background as a colloid chemist it was natural for him to assume the responsibility for the experimental side in the rheology of suspensions and polymer solutions. The former were of interest per se and as models for the latter. Specific issues were the dependence of viscosity on particle concentration as the result of hydrodynamic interactions, on particle shape, and on particle size. Rigid, swollen and porous spheres served as early models for flexible and solvent-penetrable coils, as did flexible threads. This work formed the basis for Fred's obtaining the formal habilitation as a Docent. Another direction during that period concerned pure liquids. Here he contributed an application of Eyring's transition state theory of transport to an analysis of homologous series of esters with an outlook on correlations between viscosity and surface tension.

The rheological direction was continued in subsequent years at Brooklyn Polytechnic Institute (now Polytechnic University) with such issues as the influence of solute aggregation, molar mass dependence of hydrodynamic interactions, and adsorption of polymers from solution.

Fred's service extended from research to educational matters in a general sense by review articles and editorial activities. We acknowledge in particular the five volumes of *Rheology: Theory and Applications*, which deal with a wide range of systems and methods. The Society of Rheology recognized Fred Eirich's contributions by awarding him the Bingham Medal in 1983.

Finally I should mention that much of the Vienna work was carried out at a time when Fred had to assume administrative activities in the firm after his father's passing. As a personal note: these circumstances contributed to my cultural education by providing free theater and concert tickets.

An outstanding scientist and good friend of many has left us.

Arthur S. Lodge

(1922-2005)

Rheology lost a great friend in Arthur Lodge early on 24 June 2005.

Arthur Scott Lodge was born on 20 November 1922, in Liverpool, England, and received his baccalaureate (1945) and doctoral degrees (1948) from Oxford University in mathematics and physics, respectively. In 1949, he took a position at the British Rayon Research Association, where his supervisor was Karl Weissenberg, inventor of the Weissenberg rheogoniometer. In 1961 Lodge joined the faculty of the University of Manchester Institute of Science and Technology (UMIST). In 1964 Lodge authored the text *Elastic Liquids* (Academic Press), which the *Journal of Physical Chemistry* sent to Professor Bob Bird at the University of Wisconsin-Madison for review. Bird was impressed. "It was the first book on rheology that showed clearly the structure of the subject. It

also pointed out how various rheological measurements could be interrelated," says Bird. To give his research group the opportunity to get better acquainted with Lodge's work, Bird arranged for Lodge to be in Madison as a visiting professor for the academic year 1965-1966; in 1968 the Lodge family moved to Madison permanently. On his arrival at UW-Madison, Lodge and colleagues Bird, John Ferry, John Schrag, and Millard Johnson founded the Rheology Research Center (RRC). Lodge chaired the RRC Executive Committee for 23 years until his retirement in 1991.

Elastic Liquids introduced the Lodge rubberlike liquid constitutive equation, the foundation for contemporary nonlinear viscoelasticity. The Lodge rubberlike liquid managed to explain most of what could be reliably measured at the time (other than non-constant shear viscosity) and also anticipated nonlinear behavior not reliably measured until years later, such as the Lodge-Meissner relation. In 1974 Lodge followed up *Elastic Liquids* with his second text, *Body Tensor Fields in Continuum Mechanics* (Academic Press, 1974). Lodge was an inventor and entrepreneur, designing and marketing the on-line *Lodge Stressmeter*, a device for making accurate measurements of shear normal stress differences using pressure-driven slit flow. Lodge was awarded the SOR Bingham Medal in 1971 and the Gold Medal of the British Society of Rheology in 1983. In 1992, he was elected to membership in the U.S. National Academy of Engineering.

Lehigh University, courtesy AIP Emilio

Ronald S. Rivlin

(1915-2005)

Ronald Samuel Rivlin died on 4 October 2005 at the age of 90. Rivlin was a prominent rheologist involved in placing early rheological modeling on firm mathematical footing.

December 5, 2005
Dear Faith-
Ronald Rivlin is one of my heroes. A few years ago IUTAM (International Union on Theoretical and Applied Mechanics) ran a survey of its Congress Committee members to nominate the most influential papers in Mechanics in the 20th century. Probably the most popular was the paper by Ronald where he showed how to solve certain problems for ANY ARBITRARY energy function in rubber elasticity (*Phil Trans Roy Soc London* A241 (1948) 379-397). This kick-started the drive to study complex nonlinear material behaviour (rheology) and is, I believe, a watershed in our subject. We shall miss his humour and his capability.
Best Wishes-Roger Tanner FRS

Rivlin was born in London, and he received his BA degree in physics and mathematics from St. John's College at Cambridge in (1937) and a doctorate (ScD) from Cambridge in 1952.

Rivlin first worked for the General Electric Company (1937-1942), where he came into contact with the prominent rubber expert L. R. G. Treloar. From 1942-1944 Rivlin worked at Telecommunications Research Establishment and subsequently moved to the British Rubber Producers Research Association (1944-1952). Rivlin is believed to have become interested in viscoelastic liquids through his contact with Treloar, who influenced his decision to move to BRPRA, and as a result of seeing the normal-force-driven rod-climbing experiments of Karl Weissenberg during his time at BRPRA. In 1953 Rivlin moved into academia, becoming professor of applied mathematics at Brown University, where he taught until 1967. In 1963 he co-hosted the 4th International Congress on Rheology in Providence, RI with R. S. Marvin. Rivlin moved to Lehigh University in 1967 and retired from that institution in 1980.

Rivlin's work figured prominently in the history of the development of constitutive equations for non-Newtonian fluids. The Reiner-Rivlin equation (stress is a quadratic function of the rate-of-strain tensor) was an early non-Newtonian constitutive equation, perhaps the first nonlinear constitutive equation to be properly frame-invariant. This inelastic constitutive equation was proposed by

(*continues* page 27)

Portland 2006

78th Annual Meeting of The Society of Rheology will be held in Portland, Maine USA from 8-12 October 2006; the associated short course on "Interfacial Rheology and Applications" by Gerald G. Fuller, Andy Kraynik, and Jan Vermant will be offered on 7 and 8 October. Plan to attend. All sessions will be held at the Holiday Inn By the Bay Hotel and Convention Center in downtown Portland, located within walking distance of the Old Port, Portland's working waterfront, and Arts District.

As usual, the meeting will begin with a Welcome Reception in the hotel on Sunday evening. The Society reception will be held on Monday evening. The Bingham Award will be presented at a dinner on Tuesday evening. We will hold the poster session on Wednesday evening.

Located on the coast of Maine, Portland sits on a peninsula that juts out into Casco Bay. It nestles between Maine's forest-covered mountains and spectacular rugged coast. In the Casco Bay region of Greater Portland to Freeport you will find unspoiled landscapes, beautiful vistas, succulent lobster, stately lighthouses, outdoor adventures, and exceptional shopping. Ambling through downtown, you will notice the Victorian architecture and cobblestone streets residing graciously beside modern office buildings. In the Old Port, great brick buildings, once warehouses for local merchants, now hold a myriad of original shops, galleries and restaurants.

The Holiday Inn By the Bay is approximately 10 minutes from the Portland International Jetport, which is served by Continental Airlines, Delta, Northwest, United Express, U.S. Airways, and Independence Air. Within walking distance of the hotel, you can stroll along the working waterfront, enjoy a boat cruise on the bay, and taste the charm of Old Port's cozy restaurants, shops, and galleries. Also nearby are the Children's Museum, Portland Museum of Art, L.L. Bean Factory Outlet Store, Civic Center, and Merrill Auditorium. The famous Portland Headlight and Freeport outlet shopping are only a short drive away.

A block of rooms will be available at the Holiday Inn By the Bay for the participants in the meeting. High-speed wireless Internet access is available in all rooms and conference areas of the hotel. Additional information on the Greater Portland and Casco Bay area can be found at www.visitportland.com. More information on the meeting can be found at the SOR web site www.rheology.org/sor/.

Local Arrangements:
Albert Co
Dept. of Chem. and Bio. Eng.
University of Maine
Orono, ME 04469-5737
207-581-2282
albertco@maine.edu
and
Douglas W. Bousfield
Dept. of Chem. and Bio. Eng.
University of Maine
Orono, ME 04469-5737
207-581-2300
bousfld@maine.edu

Technical Program SOR Portland, ME USA

Program Co-Chairs

Antony Beris
Dept. of Chem. Engineering
University of Delaware
Newark, DE 19716 USA
(302) 831-8018
beris@che.udel.edu
and
Eric Furst
Dept. of Chem. Engineering
University of Delaware
Newark, DE 19716 USA
(302) 831-8018
furst@udel.edu

The Portland meeting will have 10 thematic sessions, a general papers session, and a poster session. In addition to the Bingham medal lecture, there will be two plenary lectures:

Paul Janmey
Univ. of Pennsylvania USA
Departments of Physiology, Physics and Bioengineering

Hans Christian Öttinger
ETH Zurich Switzerland
Department of Materials

Technical Symposia

Suspensions, Colloids and Granular Materials
Robert Butera
DuPont Marshall Laboratory
3500 Grays Ferry Avenue
Philadelphia, PA 19146 USA
(215) 539-6521
robert.j.butera@usa.dupont.com
and
John Bender
Univ. of South Carolina
Dept. Chemical Engineering
Swearingen Engr. Center
Columbia, SC 29208 USA
(803) 777-5025
benderjw@engr.sc.edu

Microfluidics, Confined Systems and Thin Films
Todd Squires
U.C. Santa Barbara
Dept. of Chem. Engineering
Santa Barbara, CA 93106 USA
(805) 893-7383
squires@engineering.ucsb.edu
and
Nicos Martys
Natl. Inst. of Standards & Tech.
Bldg. & Fire Research
Mail Stop 8615
100 Bureau Drive
Gaithersburg, MD 20899 USA
(301) 975-5915
nicos.martys@nist.gov

Blends, Emulsions and Multiphase Flows
Shelley Anna
Carnegie Mellon University
Dept. of Mechanical Eng.
Scaife Hall 310
5000 Forbes Avenue
Pittsburgh, PA 15213 USA
(412) 268-6492
sanna@cmu.edu
and
Andy Kraynik
Sandia National Laboratories
Dept. 1514 MS0834
Albuquerque, NM 87185 USA
(505) 844-9696

Non-Newtonian Fluid Mechanics, Instabilities and Turbulence
Lance R. Collins
Dept. of Mech. & Aero. Eng.
Cornell University
246 Upson Hall
Ithaca, NY 14853 USA
(607) 255-0379
LC246@cornell.edu
and
R. Sureshkumar
One Brooking Drive
St. Louis, MO 63130 USA
(314) 935-4988
suresh@wuche.wustl.edu

Microrheology
Patrick Spicer
Procter & Gamble
8256 Union Centre Blvd.
West Chester, OH 45069 USA
(513) 634-9628
spicer.pt@pg.com
and
Victor Breedveld
Georgia Institute of Tech.
Sch. of Chem. & Biomolec. Eng.
311 Ferst Drive NW
Atlanta, GA 30332 USA
(404) 894-5134
victor.breedveld@chbe.gatech.edu

Biomaterials, Biological Systems and Self-assembly
Srini Raghavan
University of Maryland
Dept. of Chemical Engineering
College Park, MD 20742 USA
(301) 405-8164
sraghava@eng.umd.edu
and
Surita Bhatia
University of Massachusetts
Dept. of Chemical Engineering
686 N Pleasant Street
Amherst, MA 01003 USA
(413) 545-0096
sbhatia@ecs.umass.edu

Viscoelasticity of Solids, Thixotropy and Glasses
Jan Mewis
Katholieke Univ. Leuven
Chemical Engineering Dept.
De Croylaan 46
B-3001 Leuven BELGIUM
32-16-322361
jan.mewis@cit.kuleuven.ac.be
and
Gregory McKenna
Dept. of Chemical Engineering
Texas Tech University
Lubbock, TX 79409 USA
806-742-3553
greg.mckenna@ttu.edu

Paper, Pulp and Industrial Processes
Douglas Bousfield
University of Maine
Chem. and Biological Eng.
Orono, ME 04469 USA
207-581-2300
bousfld@maine.edu
and
Albert Co
University of Maine
Chem. and Biological Eng.
5737 Jenness Hall
Orono, ME 04469 USA
(207) 581-2282
albertco@maine.edu

Photos courtesy of Convention and Visitors Bureau of Greater

Polymer Solution Rheology: Molecular-scale Modeling and Experiments
Ron Larson
University of Michigan
Dept. of Chem. Engineering
2300 Hayward Street
Ann Arbor, MI 48109 USA
(734) 936-0772
rlarson@umich.edu
and
Jimmy Feng
University of British Columbia
Chemical & Biological Engr.
Vancouver, BC V6T 1Z4 CANADA
(604) 822-8875
jfeng@chml.ubc.ca

Rheology and Structure of Entangled Polymer Systems
Monty Shaw
University of Connecticut
Dept. of Chemical Engineering
IMS U 3136
97 N Eagleville Road
Storrs, CT 06269 USA
(860) 486-3980
montgomery.shaw@uconn.edu
and
David Venerus
Illinois Institute of Technology
Dept. of Chemical Eng.
Chicago, IL 60616 USA
312-567-5177
venerus@iit.edu

General papers
Jason Butler
431 Chemical Engineering Building
Chemical Engineering Dept.
University of Florida
Gainesville, FL 32611 USA
(352) 392-2591
butler@che.ufl.edu
and
Phil Sullivan
Schlumberger Tech Corp.
Oilfield Chemical Products
110 Schlumberger Drive
Sugar Land, TX 77478 USA
psullivan@slb.com

Poster session
Matthew Liberatore
Chemical Engineering Dept.
Colorado School of Mines
Golden, CO 80401 USA
(303) 273-3720
liberato@che.udel.edu

Portland 2006

Society Business

NEWS

New Officers Installed

At the close of the SOR Business Meeting on Tuesday 18 October 2005, Andy Kraynik (photo) assumed the presidency of The Society, taking over from outgoing president Susan Muller. Other newly elected officers include Vice President Bob Prud'homme, Editor John Brady, and Member-at-Large Dan Klingenberg. Continuing as officers are Susan Muller (Past President), Jeff Giacomin (Secretary), Monty Shaw (Treasurer), and Tim Lodge and Lynn Walker (Members at Large).

SOR Logo Discussed

The SOR is considering changes to its logo. In discussions in the ExCom and Business meetings in Vancouver (see minutes below), SOR Secretary Jeff Giacomin presented the history of the SOR logo and outlined some problems with the diacritical marks both present and missing from the current Greek logo. Possible remedies to these inconsistencies were discussed as outlined in the minutes. No changes were adopted, and discussions are ongoing.

Interested members weigh in on logo issues raised by Jeff Giacomin: (l-r) Savvas Hatzikiriakos, Giacomin, Andreas Alexandrou, Georgios Georgiou, Evan Mitsoulis, and Bob Mendelson.

Minutes of the ExCom Meeting

Sunday 16 October 2005
Vancouver, BC Canada

Susan Muller called the meeting to order at 8:45 a.m. in the Oak Room One of the Westin Bayshore Resort and Marina in downtown Vancouver. Committee members in attendance were Susan Muller, Andy Kraynik, Bill Russel, Monty Shaw, Lynn Walker, Jeff Giacomin, Timothy Lodge, and Mort Denn. Invited guests were John Brady (Editor), Art Metzner (Representative to AIP), Janis Bennett (AIP Liaison), Albert Co (SOR Webmaster), Eric Shaqfeh (Technical Program Chair), Savvas Hatzikiriakos (Local Arrangements Chair), Gerry Fuller (Chair, Local Arrangements, ICR Monterey), Pat Mather (Chair, Membership Committee), Eric Furst (Technical Program Co-Chair, Portland Meeting), Antony Beris (Technical Program Co-Chair, Portland Meeting), Mike Solomon (Chair, Education Committee), and Faith Morrison (Editor, *Rheology Bulletin*). The minutes of the previous meeting were read and approved.

Faith Morrison reported on her activities as Editor of the *Rheology Bulletin*. Though we now have strong advertising support from four rheometer manufacturers, the *Bulletin* Editor continues to solicit new advertisers.

Monty Shaw presented the Treasurer's report. A motion was passed to approve the report that includes raising (1) the Technical Program Chairman's Discretionary Fund from $2,000 to $3,000, (2) the *Rheology Bulletin* budget from $7,000 to $9,000, and our budget for Annual Meeting Reserve from $100,000 to $200,000 to cover our meeting liabilities. Over 14% of our *Journal* revenues now come from consortium agreements (thus significantly supplementing print subscription income). The Society is in good shape.

Janis Bennett reported on AIP business. A motion

Secretary's Report

was passed to have the Past-President police the use of the SOR email list. We have yet to have a submitting *JOR* author opt for the new open access publishing ($2,500 fee), whereby the *JOR* article becomes freely available to everyone.

Art Metzner, as Representative of The Society to the Executive Committee Meeting of the AIP, reported on the September 2005 meeting. Metzner led a discussion about the AIP publishing business, which is expanding, now serving as publisher for such large organizations as ASME and ASCE. This increased publishing volume lowers AIP costs per journal, and thus our *JOR* costs. Metzner will represent the President at the March 2006 meeting of the corporation of the AIP. Such representation is stipulated by our constitution.

Mike Solomon, Chair, reported on the Education Committee. A motion was passed to offer a short course titled "Interfacial Rheology and Applications," by Gerry Fuller, Andy Kraynik and Jan Vermant at the 2006 meeting in Portland. The Education Committee is actively soliciting proposals for the 2007 meeting in Salt Lake City.

Morton Denn, as outgoing Editor, reported on *JOR* editorial matters. A paper published in *JOR* has at least a 30% higher chance of being cited than if it were published in any other journal on rheology or polymer processing. A clean transfer of Editorship to John Brady, Editor-Elect, is expected, with just one paper pending with overlapping editorship. John Brady discussed future plans for the *Journal of Rheology*.

Albert Co provided his report as Webmaster. Co reports that in the 2005 election 574 ballots were cast (35.6% of Society membership), up from 564 in 2003 (33.8%), and just 301 in 2001. The Chair of the Meetings Policy Committee (by convention, this committee is chaired by the Vice President) is responsible for collecting information from the Local Arrangements Chair on exhibitor contact information and on hotel room block patterns for future meetings.

SOR ExCom at work in Vancouver.

Savvas Hatzikiriakos reported on the Vancouver meeting. There were 317 registrants (as of the morning of this Executive Committee meeting), 16 booths (13 exhibitors), and 36 registered in the short course. Loss of CDN$12,410 projected. Unused drink tickets could save thousands ($8.50/ticket), and the loss could come down to CDN$5,000. The Executive Committee thanked Hatzikiriakos for his hard work.

Eric Shaqfeh reported on the technical program. 207 talks are normally scheduled in the 4 track system; a fifth track was added to accommodate a large oversubscription (30%), with some papers shifted to the poster session. 266 papers were scheduled. There were 12 last minute cancellations; these have been filled in by volunteers from the poster session for a final total of 263 papers. Quality was very high. 700 authors are represented.

Jeffrey Giacomin, *JOR* Editor for Business, presented usage statistics for the *JOR Online*. Brady recommended that we invite consortium sites heavily using the *JOR Online*, if not already subscribing to the print edition, to subscribe. He also recommended that we inform the membership of the new Scitation alerts system, which is now freely available at www.scitation.com. Once set up, an account at this site will alert you by email when articles emerge in a specified narrow subfield, of rheology for example.

Albert Co reported on the 78th Annual Meeting of The Society to be held 8-12 October 2006 in Portland, Maine. Everything is going swimmingly. Antony Beris and Eric Furst outlined their plans for the Portland technical program.

Jeffrey Giacomin led a discussion on correcting the SOR logo (hourglass inscribed with παντα ρει). The inscription on the hourglass παντα ρει ought to be παντα ρει as it once correctly appeared on Volume 1 of the *Journal of Rheology* in 1929. Whereas "παντα ρει" means "always flowing," Heraclitus is believed to have said "everything flows" or "τα παντα ρει." A motion was passed to

correct the logo. Since ancient Greek uses only the upper case, a motion was also passed to convert the logo to "TA ΠANTA PEI," (2 spaces) circumventing diacritical markings, making our logo more easily typed and truer to its ancient Greek roots.

Andy Kraynik proposed to have the 2010 meeting in Santa Fe, New Mexico, Monty Shaw, to have it in Hartford, Connecticut in 2011, and Pat Mather proposed Cleveland, Ohio for 2011 too.

Pat Mather, Chair of the Membership Committee, reported on activities of the Membership Committee. As of 30 September 2005, The Society had 1619 members, already up from our 2004 year-end total of 1542.

Member-At-Large Tim Lodge reported on the student travel grants program. All of the 22 applications for the Vancouver meeting were awarded. Each award consists of 4 nights at the conference hotel.

At 4:55 p.m., Muller moved the meeting into Executive Session. Kraynik and Shaw recused themselves from the meeting. With enthusiasm, the Executive Committee unanimously approved Kraynik's proposal to host the 82nd Annual Meeting in Santa Fe, New Mexico 24-28 October 2010. Mather was encouraged to prepare a budget for 2011 in Cleveland.

The meeting was adjourned at 5:06 p.m.

Minutes of the Business Meeting

Tuesday 18 October 2005
Vancouver, BC Canada

Susan Muller called the meeting to order at 5:48 p.m. in the Seymour Room of the Westin Bayshore Resort and Marina in Vancouver. Read by the Secretary, a motion was passed to accept the minutes of the previous business meeting in Lubbock.

Susan Muller announced that, as of the start of this business meeting, there were 325 registrants to the Vancouver meeting.

Each officer report and each committee report presented at the Executive Committee meeting (see above) was presented and accepted at the business meeting.

Giacomin led a discussion on correcting The Society logo, moving to change it to "TAΠANTAPEI." On behalf of Beris, Georgiou, Alexandriou, Tsamopoulos, Hatzikiriakos, Collias, and Vlassopoulos, Evan Mitsoulis raised an important objection. Though modern Greek requires the article "TA" for the motto to mean "everything flows," in ancient Greek "ΠANTAPEI" means "everything flows." They propose simply restoring the logo to "πάντα ῥεῖ," the one appearing on the first issue of the *Journal of Rheology* in 1929. This would distinguish our motto from that of the Greek Society of Rheology that in 1996 adopted "Τὰ πάντα ῥεῖ" for its motto and logo. A further objection was raised to block capitals. Though ancient Greek did use block capitals exclusively, our modern version of these, "TAΠANTAPEI" is no truer to the ancient font than "πάντα ῥεῖ." A motion to correct The Society logo to "TAΠANTAPEI" (no spaces) was tabled.

The meeting was adjourned at 6:32 p.m.

Treasurer's Report

To the membership,

Once again I am pleased to report that the finances of The Society of Rheology are in good condition. Our projection for year end 2005 is comfortably positive, and there seem to be few major concerns for the near future. Transient costs of implementing the PEER-X paper-handling system for the *Journal of Rheology* have started to appear, and we have budgeted for additional charges in 2006. Income for the online *Journal* (*JORO*) continues to climb as more consortia for electronic access are formed. This aspect of modern publishing might become a burden in the future as the consortia seek to reduce costs upon contract renewal. Thanks to the diligence of AIP, the *Journal* production costs have stayed low. In fact a recent change of printer has reduced printing costs even further.

As for other Society financial activities, the membership dues income remains level, and our recent meetings continue to make modest profits. For example, the Lubbock meeting and short course

Treasurer's Report

netted $8412.57 (not all appearing in 2005). While the accounting is not in for the Vancouver meeting, we do expect a moderate loss. The large income reported for August 2006 is due to receipts for meeting registration and does not include meeting costs. Based on preliminary reports, the costs have been estimated and included in the column "2005 Projection." Please note that this projection includes a credit for "Student member travel," which is a separate line item.

For those who examine the report carefully, you will note that the 2006 budget, approved by the membership at The Society meeting in Vancouver, features several significant changes relative to the 2005 budget. One is increased interest income, due to higher interest rates on our account at AIP. The second item is *Bulletin* advertising revenue, thanks to the successful efforts of *Bulletin* Editor Faith Morrison to increase the appeal of the *Bulletin* to advertisers. The third item is an increase in the discretionary fund for the Program Chair of the Annual Meeting with the idea that additional travel funds will help maintain the quality of the plenary presentations.

Treasurer's

Respectfully submitted,
Montgomery Shaw, Treasurer

The Society of Rheology
Receipts and Disbursements

	2006 Budget	2005 Projection	2005 August	2005 Budget	2004 Year End
RECEIPTS					
Dues	55,000	56,193	55,655	55,000	54,885
Interest	35,000	32,953	17,862	10,000	10,958
Journal of Rheology	259,500	268,110	248,601	256,000	253,126
Mailing List Sales	1,000	0	0	1,000	0
Bulletin Advertising	7,000	7,560	7,560	3,000	3,504
Annual Meeting (net)	0	12,787	38,247	0	36,586
Short Course (net)	0	6,565	6,565	0	8,915
TOTAL RECEIPTS	357,500	384,168	374,490	325,000	367,974
DISBURSEMENTS					
AIP Dues Bill & Collect.	12,000	9,277	6,711	12,000	12,715
AIP Adm. Services	9,500	9,491	6,334	9,500	9,553
AIP Mem. Soc. Dues	7,600	7,706	5,137	7,600	8,343
Contributions and Prizes	1,900	1,967	1,767	1,900	1,700
Journal of Rheology	191,420	209,002	138,100	234,349	232,262
Bulletin	9,000	8,745	8,745	7,000	6,930
Bingham Award	7,000	10,000	5,000	14,000	0
Executive Cmt. Meetings	13,000	3,584	2,384	13,000	7,486
Pres. Discretionary Fund	1,500	0	0	1,500	0
Treas. Discr. Fund	1,500	400	0	1,500	286
Progr. Chm. Discr. Fund	3,000	4,000	1,928	4,000	0
Webmaster Discr. Fund	3,000	1,800	503	3,000	0
Office Expenses	4,000	2,293	1,268	3,000	3,755
Banking Services	300	39	39	100	333
Liability Insurance	7,500	6,000	512	7,500	3,330
Membership Broch. & Appl.	500	0	0	1,500	422
Accountant	2,200	1,925	1,925	2,200	1,910
Student member travel	12,000	21,428	3,566	24,000	13,100
Annual meetings, future	7,000	2,050	2,050	7,000	7,532
Website	1,000	300	120	1,000	3,936
Miscellaneous	1,000	0	0	1,000	0
TOTAL DISBURSEMENTS	295,920	300,005	186,088	356,649	313,594
Net	61,580	84,163	188,403	-31,649	54,380

Journal of Rheology

(All amounts: USD)

	2006 Budget	2005 Projection	2005 August	2005 Budget	2004 Year End
RECEIPTS					
Subscriptions	181,500	180,045	179,977	187,000	184,797
Reprint Sales	7,000	10,306	6,108	7,000	9,606
Ad Sales	35,000	36,694	25,309	33,000	32,177
CD sales (net)	0	0	0	0	0
JORO revenue	35,000	37,758	34,670	27,000	25,447
Miscellaneous	1,000	3,308	2,538	2,000	1,100
TOTAL RECEIPTS	259,500	268,110	248,601	256,000	253,126
DISBURSEMENTS					
Ads	9,000	9,451	6,135	9,000	7,991
Reprints, Single Copy	5,400	4,572	3,659	5,400	5,025
Paper, Printing	24,500	31,635	19,989	30,529	31,547
SOR Editorial	42,000	51,328	32,034	49,000	49,217
Production	43,500	48,262	32,445	52,500	63,552
Fulfillment	7,600	6,483	4,216	7,600	6,676
Distribution	17,020	17,928	11,861	16,920	17,123
Electronic publishing	35,000	32,795	22,543	48,000	42,489
Miscellaneous	7,400	6,547	5,218	15,400	8,642
TOTAL DISBURSEMENTS	191,420	209,002	138,100	234,349	232,262
Net	68,080	59,108	110,501	21,651	20,864

The Society of Rheology, Inc.

Balance Sheet

(all amounts, USD)

	2005 August	2004 Year End	2003 Year End	2002 Year End	2001 Year End
Assets					
Cash in checking account	46,161	29,012	2,047	466	9,374
Securities	0	0	0	0	0
Balance in AIP account	982,525	976,655	938,047	915,334	843,151
Total Assets	1,028,686	1,005,667	940,094	915,800	852,525
Liabilities and Net Assets					
Liabilities					
Deferred revenue	0	155,969	143,603	162,363	137,468
Total Liabilities	0	155,969	143,603	162,363	137,468
Net Assets					
Publication reserve	450,000	450,000	450,000	450,000	450,000
Student travel grant reserve	10,000	10,000	10,000	10,000	10,000
Annual Meeting reserve	100,000	100,000	100,000	70,000	70,000
Operating reserve	100,000	100,000	70,000	70,000	70,000
Unrestricted	368,686	189,698	166,491	153,437	115,057
Total Net Assets	1,028,686	849,698	796,491	753,437	715,057
Total liabilities and net assets	1,028,686	1,005,667	940,094	915,800	852,525

the end

(*Rivlin* continued from page 19)

Markus Reiner from phenomenological arguments, while Rivlin deduced the same equation as the mathematical form that is consistent both with the stress being a function only of the rate-of-deformation tensor and independence of the calculation from superposed rigid rotation (frame-invariance). Rivlin's name stands with those of Oldroyd, Ericksen, Green, Coleman, and Noll as fundamental to the development of modern constitutive theories for elastic liquids.

Rivlin received the SOR Bingham Medal in 1958 and was a member of the U.S. National Academy of Engineering and the American Academy of Arts and Sciences.

A personal remembrance of Rivlin written by Alan Gent of the University of Akron will appear in the *Journal of Elasticity*.

(*JOR Impact Factors* continued from page 16)

Denn presented the ExCom with a table of impact factors for the past four years for *JOR* and for several mechanics journals where *JOR* authors might choose to publish. Only *Physical Review Letters* (impact factor = 7.218) and *Macromolecules* (impact factor = 3.898) had higher impact factors. Both of these journals serve much wider audiences than *JOR* or other fluids-based journals. The strength of *JOR* within its field (mechanics) and the stability of its impact factor numbers are testimony to the high quality of research conducted by *JOR* authors, according to Denn.

Three generations of *Journal of Rheology* editor were present in Vancouver: Art Metzner (1985-1995), John Brady (2005-present), and Morton Denn (1995-2005).

CALENDAR OF RHEOLOGY CONFERENCES AND COURSES

2006

19-22 September 2006
IUTAM Symposium on Flow Control with MEMS, London, UK, J.F. (Jonathan) Morrison

19-23 February 2006
4th International Symposium on Food Rheology and Structure - ISFRS 2006, Zurich Switzerland (www.isfrs.ethz.ch/)

13-17 March 2006
Short Course on *The Basic Composition of Coatings*, by University of Missouri-Rolla Coatings Institute, Michael R. Van De Mark, Director, Rolla, Missouri USA

26-31 March 2006
IUTAM Symposium on Interactions for Dispersed Systems in Newtonian and Viscoelastic Fluids, Guanajuato, Mexico, George Homsy, Roberto Zenit (mecmat.iimatercu.unam.mx/~iutam/)

10-13 April 2006
13th International Conference on Deformation, Yield and Fracture of Polymers, Rolduc Abbey, Kerkrade Netherlands, Han E. H. Meijer

25-26 April 2006
AERC Short Courses, *Multiscale modelling methodologies* by Kurt Kremer, Manuel Laso, Hans Christian Öttinger, and Doros N. Theodorou, and *Interfacial Rheology and Applications*, by Gerry Fuller, Jan Vermant, and Andy Kraynik, Hersonisos, Crete, Greece

27-29 April 2006
3rd Annual European Rheology Conference AERC 2006, Hersonisos, Crete, Greece, Dimitris Vlassopoulos and George Georgiou (www.rheology-esr.org/AERC/2006)

15-19 May 2006
Short Course on *Introduction to Paint Formulation*, by University of Missouri-Rolla Coatings Institute,

(continues next page)

Michael R. Van De Mark, Director, Rolla, MO USA
17-18 May 2006
Short Course on *Applications of Nanotechnology in Coatings*, by Jamil Baghdachi, Eastern Michigan University Coatings Research Institute, Ypsilanti, MI USA

23-25 May 2006
Short Course on *Polymers for Coatings Technologists*, by Jamil Baghdachi, Eastern Michigan University Coatings Research Institute, Ypsilanti, MI USA

11-16 June 2006
Short Course on 's *Rheological Measurements* directed by Chris Macosko, University of Minnesota, Minneapolis, MN USA (www.cems.umn.edu/rheology)

5-8 July 2006
International Workshop on Mesoscale and Multiscale Description of Complex Fluids, Prato, Italy, Ravi Jagadeeshan and Eric Shaqfeh (users.monash.edu.au/~rprakash/Workshop/prato.htm)

17-21 July 2006
Symposium on Flows in Manufacturing Processes, ASME Joint U.S.-European Fluids Engineering Conference, Miami, FL USA (www.asmeconferences.org/FEDSM06)

7-8 October 2006
SOR Short Course on *Interfacial Rheology and Applications,*" by Gerry Fuller, Andy Kraynik, and Jan Vermant, Portland, ME USA

8-12 October 2006
78th Annual Meeting of The Society of Rheology, Portland, Maine USA, Albert Co

2007
12-14 April 2007
4th Annual European Rheology Conference AERC 2007, Naples Italy, Nino Grizzuti

11-14 June 2007
IUTAM Symposium on Recent Advances in Multiphase Flows: Numerical and Experimental, Istanbul, Turkey, Andreas Acrivos and Can Delale

6-8 September 2007
IUTAM Symposium on Advances in Micro- and Nanofluidics, Dresden, Germany, N.A. (Nikolaus) Adams
6-7 October 2007
SOR Short Course on Rheology (topic TBA), Salt Lake City, UT USA

7-11 October 2007
79th Annual Meeting of The Society of Rheology, Salt Lake City, UT USA, Jaye Magda

2008
2-3 August 2008
SOR Short Course on Rheology (topic TBA), Monterey, CA USA

3-8 August 2008
XVth International Congress on Rheology and 80th Annual Meeting of The Society of Rheology, Monterey, CA USA, Gerry Fuller

Summer 2008
13th International Congress of Biorheology, location TBA (held every three years, www.coe.ou.edu/isb).

2009
Spring 2009
5th Annual European Rheology Conference AERC 2009, location TBA

17-18 October 2009
SOR Short Course on Rheology (topic TBA), Madison, WI USA

18-22 October 2009
81st Annual Meeting of The Society of Rheology, Madison, WI USA, Jeff Giacomin

2010
Spring 2010
6th Annual European Rheology Conference AERC 2010, location TBA

23-24 October 2010
SOR Short Course on Rheology (topic TBA), Santa Fe, NM USA

24-28 October 2010
82nd Annual Meeting of The Society of Rheology, Santa Fe, New Mexico USA, Andy Kraynik

See also www.rheology.org/sor/info/Other_Meetings.htm

Rheology Conferences and Courses