
THE BRITISH SOCIETY OF RHEOLOGY



BSR BULLETIN
incorporating the
6th Newsletter of the European Society of Rheology
2000, Vol. 43, No. 1
(Spring/Summer 2000)

CONTENTS

Officers & Members of BSR Council	ii
Editorial	2
BSR News	
Commentary on the 299 th Council Meeting	3
Conference Reports	
Fifth International Conference on Flow Processes in Composite Materials, Plymouth, UK	4
Materials Research Society Meeting, Spring 2000, San Francisco, USA	5
Nordic Rheology Conference 2000, Helsinki, FI	6
Rheological Papers	
The Hitch-Hiker's Guide to Polymer Rheology – <i>Tom McLeish</i>	8
BSR Announcements	16
NEWSLETTER OF THE EUROPEAN SOCIETY OF RHEOLOGY	
Announcements of the ESR	20
Local Society News	23
Membership News	
Obituary – <i>Prof Frank Leslie, JP, BSc, PhD, DSc, FIMA, FinstP, FRSE, FRS</i>	28
New Members	29
Lost Members	29
Recruitment Opportunities	30
Industry News	31
Conference Diary	32
Course Diary	34
Ones that got away...	34

Hon Editor:

Dr Paul Doody, Linx Printing Technologies plc
Burrell Road, St Ives, Cambridgeshire PE28 3LA

ISSN 1469-4999

EDITORIAL

Looking forward now to the imminent arrival of the XIIIth International Congress on Rheology (Rheology 2000) in Cambridge between 20-25 August 2000. With over 300 papers and nearly 400 posters, I would imagine there is something for everyone's rheological persuasions. Last minute information can be found on the website (<http://abbey4.swan.ac.uk/rheology2000/>).

A welcome (but alas too rare) event in this issue – a super paper from Tom McLeish on polymer rheology. Papers are always a welcome addition to the *Bulletin* and I encourage other authors, either in industry or in academia, to submit ideas.

More sad news this month with the passing away of another eminent rheologist – Prof Frank Leslie. Prof David Sloan has written an obituary on page 28.

I would like to solicit members' opinion on having a themed edition of the *Bulletin*. Whether this is a worthwhile thought, and suggestions for the theme would be most welcome.

Details of this years AGM are contained as a flyer in this issue.

Must go. Enjoy the rest of the summer, have a great time at the ICR (I hope to perhaps meet a few of you there) and may your constitutive models be non-convoluted!

Paul Doody

SUBMISSIONS TO THE BULLETIN

Submissions to the Bulletin may be made by any practical means – post, email, disk, fax, pigeon, donkey, *et cetera* but electronically is preferred (saves typing...). Most packages supported (Word, WordPerfect, ASCII, RTF, PDF) but always provide a contact name, address, eMail, or telephone number in case of problems.

Copy date for next bulletin is 15 September 2000. Copy date for next European edition is 15 November 2000. Please add these dates to your diaries! By the way, the intention (if not always the act...) is to publish in January, May, and September and, as always, all contributions gratefully received.

Late copy can sometimes be accommodated however the facilities of the BSR and ESR web sites may also be appropriate. Please contact Editor for details.



COVER ILLUSTRATION

I'd like to remind everyone that suggestions for Black & White or colour pictures (preferably of a rheological nature!) are welcomed by myself (Bulletin Editor) or Nick Hudson (Abstracts Editor). Suggestions are always welcome!

BSR NEWS

COMMENTARY ON THE 299TH COUNCIL MEETING

Where the rivers Ouse and Foss converge, there is a little known city called Erubacum where, between AD400 and 625, Paulinus was installed as the first Archbishop. Whilst walking from the train station to the hotel in which the Council Meeting was held, in the shadow of the imposing Minster, one gets a chance to soak up a little of the long history of this important northern city. On the west bank of the Ouse is the Multangular tower which is almost all that is left of the 2000-year old Roman colonia settled here.

In 867 the Danes captured the city and renamed it York (after Yorvick), and many of the street names date from this period. King Harold was here when the Normans invaded, trying to stop the Norwegian invaders, whom he eventually beat at the battle of Stamford Bridge in 1066. A little more recently, the whole of the BSR Council converged on the city by train to meet and decide the next phase of the Club's future.

The 299th Council Meeting of the BSR took place at the Dean Court Hotel within the sound of the great bells booming out on the hour, almost vibrating the very structure of the hotel building. Many momentous decisions were made as usual and the team departed during the late afternoon for another historic tour on the way back to the railway station, proving that on some occasions BR is the most efficient way to travel!

John Gearing

Gearing Scientific



- Contract Thermal Analysis: DSC, TGA, TMA, DMA, DETA, EGA (Evolved Gas Analysis by TGA-MS), Conductivity
- Relative Humidity & solvent options & Autosample on the world's most versatile DMTA – Gabo DMTS systems. Other new DMTAs from £17k! Spares / service for PL DMTA
- Thermal Conductivity apparatus for solids & foams. –150°C to 95°C with Autosample option
- Special polymers and standards

Gearing Scientific

1 Ashwell Street, Ashwell,
Herts, SG7 5QF, England
Tel: +44 1462 742 007
Fax: +44 1462 742 565
gearingsci@yahoo.com
www.rapra.net/gearing

We look forward to helping
you!

CONFERENCE REPORTS

FIFTH INTERNATIONAL CONFERENCE ON FLOW PROCESSES IN COMPOSITE MATERIALS

University of Plymouth, Plymouth, UK, 12-14 July 1999

The heat did wonders for the image of British weather in Plymouth for the Fifth International Conference on Flow Processes in Composite Materials (12-14 July 1999). Luckily for the 65 or so delegates, the heat was combated adequately by the situation of the conference. It was held in the Robbins Conference Centre at the University of Plymouth, the centre being underground with air conditioning.

For the delegates a drinks reception with Councillor Tom Savery, the Lord Mayor of Plymouth, and a boat trip was planned and complemented by a warm Summer's evening. The following evening's event was a dinner engagement at the Moorlands Links Hotel on Dartmoor which, I am sure, had lovely gardens to wander around. By this time, however, the weather had reverted to true type and I was not brave enough to endure the inevitable downpour.

The conference itself had representatives from more than a dozen countries and 32 papers were presented. The papers were split to make 11 sessions, 4 of which came under the title of Resin Transfer Moulding showing the interest in this field. Other sessions included Deformation Processes, Fabric Properties, Forming Sheet Materials and Rheology/Viscoelasticity. Keynote papers were given by the likes of Tony Spencer, Sureh Advani, Richard Parnas, Francois Trochu, Debes Bhattacharyya and Russell Dykes.

Tony Spencer presented a very interesting talk describing constitutive equations for fabric-reinforced viscous fluids despite losing his transparencies only hours earlier.

The lecture given by A D Kelker titled "Low cost manufacturing of composite integral armour sing resin transfer and resin infusion moulding processes" gave an opportunity to see a final product on film; the composite armoured vehicle shown demonstrated the advantages of the strength and lightness of the material. Fredrik Vahlund from the Swedish Institute of Composites gave a talk on squeeze flow rheology in large tools. He pointed out that performing squeeze flow measurements on a larger scale has advantages in that they closely mirror manufacturing conditions and having larger sample sizes makes it possible to consider a mix of fibres and matrix as a homogeneous material.

John Summerscales and his team are to be congratulated on the running of the conference and also for the completeness of the proceedings. It will be a hard act to follow but Debes Bhattacharyya will try to do just that in January 2002, Auckland, New Zealand.

Kim Fisher
Mathematics Department
Penglais Campus
University of Wales, Aberystwyth
Ceredigion SY23 3BZ

MATERIALS RESEARCH SOCIETY MEETING, SPRING 2000

San Francisco, USA

In San Francisco each spring, the Materials Research Society meets. The vast international conference covers the whole spectrum of research classed as “materials science”. With support from the British Society of Rheology, I attended this years’ meeting. Electronic properties, crystals, thin films and nanoscale structures were featured, along with research of more direct interest to rheologists. The MRS currently has a strong interest in soft materials, including processing and multiscale modelling. As well as promoting my own work on polymer rheology to the materials science community, I developed my interests further by gaining an overview of materials research.

My own talk, offering an improved fitting for the nonlinear rheology of LDPE, was well received at the session. The larger point of the work, from Tom McLeish’s group, is to reconstruct the approach to rheological modelling of branched polymers. The material-frame-invariant, memory- and damping-function approach is being replaced by a molecular theory with topology as the fundamental starting point. Many of the ideas originate from the physics community, so there was a real need to present the work by British rheologists to materials scientists. Questions indicated the level of interest in the work. Chris Macosko asked about our plans to test the theory further using model materials. Such testing is important because for model materials, with exact topology and low polydispersity, our theory has essentially no free parameters. Savvas Hatzikiriakos, from the University of British Columbia, asked if our constitutive equation could be written in closed form and included in a finite-element flow solver. I was pleased to inform him that this was indeed the case and that Oliver Harlen and Tim Nicholson are developing a viscoelastic flow solver in our research group.

Masao Doi introduced the “Doi Project”, to develop a software platform that will ultimately allow “seamless zooming” between polymer dynamics on multiple lengthscales. The goal is to understand and model polymeric materials on multiple lengthscales and know how the results interrelate. Bill Goddard of Caltech explained that, by linking multiple lengthscales, smaller lengthscale models fix parameters for the fast, coarse-level, models. In Goddard’s philosophy, quantum mechanics could ultimately fix all parameters. Julia Yeomans, from Oxford, discussed hydrodynamics in complex fluids within the context of mesoscale modelling. She gave an enlightening talk, including an explanation of how Rouse- and Zimm-like scaling emerge from mesoscopic models of polymer dynamics.

Boron nitride prevents sharkskin and gross melt fracture in polymer melt extrusion, according to Savvas Hatzikiriakos. Using fine particles of boron nitride as a processing additive can increase achievable processing rates by two orders of magnitude. Hatzikiriakos showed that using a crosshead die for wire coating extrusion gives the most pronounced effect. Rheological tests, such as small amplitude oscillatory shear, do not reveal the mechanism giving this effect. Only minor changes in the results were found with the addition of boron nitride. Recent flow visualisation experiments, indicate that the boron nitride eliminates the stick-slip phenomenon at the wall and also in the bulk, between layers observed in the polymer at the onset of gross melt fracture.

The effect of interfaces between different phases on processing was a recurring theme. Sharon Glotzer showed, using mesoscale simulations, how large filler particles can change the glass transition temperature in short chain polymers. Some polymer blends, e.g. PP-PS, have a lower zero shear viscosity than either of the two phases. One theory, by de Gennes and Fredrickson, is that the interface has fewer entanglements than the bulk, resulting in a lower viscosity and higher shear rate at the interface. Chris Macosko tested the theory using a simple layered structure and found that the theory over predicts this slip effect. Interestingly, polymer layered-silicate nanocomposites, now used in Toyota cars, exhibit unique rheology. Ramanan Krishnamoorti explained that a pseudo-solid behaviour can occur which is related to jamming of the silicate layers.

Overall, the MRS meeting was enjoyable and informative. Proceedings of the symposium on multiscale modelling will be published in Computational and Theoretical Polymer Science. The MRS will publish other symposia proceedings. I would like to thank the British Society of Rheology for financial support, which allowed me to attend the conference.

Richard Blackwell
University of Leeds

NORDIC RHEOLOGY CONFERENCE 2000

Helsinki, June 7th - 9th

The 9th annual conference of the Nordic Rheology Society was held at the University of Helsinki's chemistry department close to the city centre and was organised under the direction of Dr. Heikki Tenhu. As always, the conference was open to all aspects of rheology, which was reflected by the papers presented, but the special theme this year was the rheology of polymers. Consequently, the invited speakers this year are respected specialists in this field, Professor Helmut Münstedt of the Institute of Polymer Materials, University of Erlangen-Nuremberg and Professor Siegfried Hess of the Technical University of Berlin.

Before the conference proper, a three day course was held on polymer rheology. Indeed the holding of such pre-conference courses has become a feature of the Nordic Rheology Conferences of late, and are seen as hugely successful by those taking part. This year was no different with very positive feedback being the order of the day. The course covered all parts of polymer rheology with a very broad and comprehensive 'introduction' being given by Dr. Søren Hvidt of the University of Roskilde in Denmark. His series of lectures certainly gave the delegates the foundation to build upon the topics discussed by the invited speakers, namely laser-doppler velocimetry and non equilibrium molecular dynamics (NEMD).

The conference was launched by the first plenary lecture given by Professor Münstedt, with a title of, "Flow properties of polyolefin melts as investigated by laser-doppler velocimetry." The lecture contained a wealth of information and conveyed to the audience, some of whom were not polymer rheologists, the subtleties and nuances of the subject. The presence of slow moving vortices around the entrance to the capillary led him to conclude that secondary flow characteristics were apparent. When questioned if this could actually be thought of as the onset of turbulence at very low Reynolds numbers $\sim 10^{-5}$, known as elastic turbulence in the literature, he remained sceptical of this explanation.

The rest of the day was filled with submitted presentations that focused on either polymer rheology or instrumentation. A selection of the titles is given below; "Macroscopic volume, free volume and dynamic-mechanical properties of pressure densified polymer: polymer property predictions.", presented by Marcus Schmidt of the Department of Polymer Technology, Chalmers University of Technology, Gothenburg. "Transient extensional flow: Measurement in the filament stretching experience.", presented by Anders Bach of the Institute of Chemical Engineering, Technical University of Denmark. "Characterisation of long chain branching in metallocene catalysed polyethylene.", Anneli Malmberg, Borealis Polymers Porvoo, Finland.

The business part of the day was finished off with the Annual Meeting of the Nordic Rheology Society. 2000 represents an important year for the Society in that positions for the entire board were open for election. This took place without flaw and the names and addresses of the new board will be posted on the society's internet site, www.nordicrheologysociety.org once the positions take effect, typically in the later summer.

With business completed the new board and the rest of the delegates gathered for the conference dinner. Before settling down to eat the party were treated to a 45 minute sail from the harbour area of Helsinki to the island museum of Seurasaari. The site of the dinner, we were told, used

to be an old eating house from which until relatively recently alcohol was banned! Around the roof of the house were many sayings and inscriptions which told of the evils of the demon drink. This was all found highly amusing, after which the delegates were reassured that wine was most definitely on the menu! The conference dinner though is not all fun and frivolity, it is the traditional venue for the handing out of the society's awards and general recognition.

The society's main award, the Carl Klason Rheology Award, which is presented to a person who has endeavoured to promote rheology within the Nordic countries was, this year, awarded to a deserving recipient. Over the years not only has he promoted rheology within the Nordic countries but also wider afield. He has been involved in development of rheological equipment and well as teaching the subject to numerous students. For all of the above reasons and because he has been somewhat of a founding father and elder statesman of our society, the Carl Klason Rheology Award for 2000 was presented to Professor Ole Kramer of the University of Copenhagen.

The final day of the conference was opened by the second plenary lecture given by Professor Hess, "Computer simulations of polymer rheology and shear induced structural changes." Again the lecture contained a vast amount of information and placed the arcane world of non-equilibrium molecular dynamics (NEMD) at the disposal of the audience. From his simulations he showed a polymer molecule being coiled at low shear and opened or 'stretched' at high shear and viscosity decreasing. When questioned on the matter relating to the possible presence of extensional forces in predominantly shear flow regions, he agreed this was true. Under a pure or predominantly extensional flow such unwinding of the polymer molecule could result in strain thickening or increasing viscosity as strain rate increased. Here however, the predominant force was shear flow but the question of evaluating extensional components from conventional rotational rheometers was raised.

The remainder of the conference continued with the submitted papers and covered further topics than that of the special theme. Selected titles include, "Alginate gels and Ca-alginate gels; what's the difference?" presented by Kurt Draget of the Norwegian University of Science and Technology, Trondheim. "Measurement of extensional flow properties in contraction flow." Presented by Mats Stading of Chalmers University of Technology and SIK, The Swedish Institute for Food and Biotechnology, Gothenburg. A further interesting paper; "Molecular weight distribution and property computations by the energy model of viscoelasticity." was presented by Tommi Borg of TomCoat Oy, Kuopio-aho, Finland.

The conference then closed mid afternoon with the invitation to join the Nordic Rheology Conference 2001 at the University of Trondheim between the dates of June 13th - 15th. The special topic is to be on Mixed Systems and designed to cover synthetic and biopolymers, solutions and gels. Further details will be posted on the website throughout the coming year.

Niall W. G. Young. Secretary elect Nordic Rheology Society
Dansco Cultor
Edwin Rahrs Vej 38
DK-8220 Braband
Denmark

g8nwy@danisco.com

RHEOLOGICAL PAPERS

The Hitch-Hiker's Guide to Polymer Rheology

Tom McLeish

In which we remind ourselves about a few uncomfortable experimental facts concerning the rheological behaviour of polymer melts, and contemplate the very great diversity of possible constitutive behaviours. The case is made for the indispensability of molecular physical theory as guide in the vast mathematical space of constitutive equations, illustrated by recent progress in the case of long-chain branched polymers. Experiments are urged in which simultaneous measurements of molecular configuration are made alongside rheological data in non-linear flows of well-characterised model polymers. Panic is identified as an inappropriate reaction to the journey ahead.

In the celebrated *Hitch-Hiker's Guide to the Galaxy* by Douglas Adams [1], the reader meets at one point with a fiendish form of mental torture-chamber unknown in the parochial backwaters of our own solar system. The poor victim of this device is subjected to a fully-conscious vision of the true enormity of the Universe [2], and of himself in relation to it - then promptly expires under the mental impact of his overwhelming insignificance. Only the totally blind and the cosmically egotistical survive the experience.

Let the polymer rheologist beware! I heard only today of another expression of impatience by a Newtonian fluid mechanician at the failure of the Non-Newtonian community to come up with "the viscoelastic equivalent of the Navier-Stokes equations". I was once savagely criticised at a conference by a rheologist for failing to supply a simple constitutive equation from a theory. A starry night sky would shock them. The gentle and perfect orbits of Newtonian fluids provided us for two centuries with the comfortable worlds on which we learned the symmetry of stress, the covariance of continuity. The power of simple proportionality between the tensors of strain rate and stress beguiled mathematical travellers into the fluid universe that nature would continue to serve up such simplicity. She does not, but have we appreciated the enormity of her refusal? Recall Maxwell's one dimensional viscoelastic relationship between stress and strain - it seems at first sight almost as benign as Newton's:

$$\dot{\gamma} \sigma = G \dot{\gamma} \varepsilon - \frac{1}{\tau} \sigma \quad (1)$$

Immediate is the marvellous insight that viscosity is a composite phenomenon - the product of elasticity and relaxation time. But put the thing in a three-dimensional space and what happens to the simplest generalisation of Maxwell's toy model? The fluid foliates - where one object stood there now springs an infinite family of models, as law fails to contain the licence of higher dimension. Stress must rotate with the flow, as leaves on a river twist with the vorticity, but may choose how severely it shears, so

$$D_t \sigma = G(\mathbf{K} + \mathbf{K}^T) + \frac{1}{2}(\mathbf{K}\sigma - \sigma \cdot \mathbf{K}^T) + \frac{a}{2}(\mathbf{K}\sigma + \sigma \cdot \mathbf{K}^T) - \frac{1}{\tau} \frac{\sigma}{\dot{\gamma}} - \frac{1}{3} \frac{\dot{\sigma}}{\dot{\gamma}} \quad (2)$$

I still recall my bewilderment at first meeting with this behaviour. The simplest demand of monomodal relaxation and minimal non-linearity cannot prevent an immediate infinity of models. The familiar-sounding "upper" and "lower-convected" fixed points are just basis-vectors of the space.

But this is just a glimpse. I do not think we have appreciated anything approaching the full force of Coleman and Noll's subversive discussion in *The Archive for Rational Mechanics and*

Analysis [3]. The irony of their “Simple Fluid” still escapes us, the enormity of the space of “covariant functionals” ought to have the impact of Adams’ horror of hugeness. In the functional formality of

$$\sigma(t) = \dot{A} \left[K(t') \right] \quad (3)$$

their lurks a vast plurality of worlds. To call the dimension of the space infinite fails to do it justice. The mathematics itself rivals statistical mechanics in its multiplicity of states - and in the hopeless task of exploring them. If Galileo had hidden the implications of his cosmology with half the cunning of theirs, he would never have been asked to recant. If these formal mathematicians had the half of his hubris, I wonder at how a twentieth-century inquisition of rheologists might have sought to rival that of the seventeenth?

The most general constitutive forms in currency are the integral expressions of K-BKZ form, which have the appeal of symbolic similarity to the general functional equation of Coleman and Noll:

$$\sigma(t) = \int_{-\infty}^t dt' m_1(t-t', I_1, I_2) B(t, t') - m_2(t-t', I_1, I_2) C(t, t') \quad (4)$$

Even these first-term truncations of a series expression in multiple-integrals over past time contain the flexibility of arbitrary kernel functions of time and of invariants, I_i , of past strain - the latter a tensor function of two variables. The possible structural variety which may be imported into such formulations is great, yet a moment’s reflection shows that this set of closed-form expressions for the stress inhabits a microscopic fraction of constitutive space. Allow for a moment that the stress be a composite product of two time-dependent functions, say a scalar and tensor, whose first-order time derivatives are non-linear functions of each other, and of the deformation gradient K (even this is a very special case):

$$\begin{aligned} \dot{\sigma}(t) &= v(t)S(t) \\ \dot{f}_1 v &= f_v(v, S, K) \\ \dot{f}_1 S &= f_S(v, S, K) \end{aligned} \quad (5)$$

Not even a formal representation of the integral-over-history kind is possible at such a short step from home, and stranger worlds than this exist. Even the comforting and common experimental observation of time-strain factorability may have lulled us into a false sense of security - in Larson’s book *Constitutive Equations for Polymer Melts and Solutions* [4], a little-noticed exercise shows that a sum over elements which themselves are non-separable may lead to an apparent recovery of separability in step-strain. The import of this demonstration is very great - it permits formulations of the product form (4) above, and higher-order descendants of them, to survive the objection of non-separability when a wide polydispersity in relaxation times demands a distribution of elements.

Clues that all is not contained in our present formulations lurk in the mass of data we have assembled on polymer melts. The most intriguing, because they strain the shackles of our phenomenology the strongest, flow from Low Density Polyethylene. This fascinating material, chemically indistinguishable from the rheologically-mild high-density form, has a similar shear-thinning response but is much more strain-hardening in uniaxial extension. The separable integral equation catches this disparate behaviour at the cost of ascribing a large proportion of the stress to the “Cauchy” tensor-function (C in eqn. 5 above) of strain rather than the “Finger” tensor (B in eqn. 5). Some awkwardness arises because of the natural geometric interpretation

of the Cauchy tensor, which describes the average deformation of embedded *surfaces* rather than of *line* elements. If molecules do not matter (though polymers are surely one-dimensional objects) then this is not serious, but a greater problem lies in another experiment. The geometry of *planar extension* is a severe test of mathematical models for it combines the flow-characteristics of extension (exponential separation of fluid points with time) with the invariant structure of shear (all two-dimensional flows demand equality of the first and second invariants of strain). For this reason any constitutive equation constructed around invariants will predict a response in planar extension akin to shear rather than to uniaxial extension. But after free-fitting an integral model for LDPE to these last two flows the case is stated- the jury is out until the evidence of planar response is measured. Naturally the decisive experiment turns out to be the hardest - only in the last year has the one data-set by Laun and Schuch [5] been complemented by a second from Meissner [6]. The verdict seems to be that nature has a higher regard for exponential kinetics than for invariants. The extensional flows are both hardening with strain, while only the special case of shear exhibits thinning. If this is true, even the appeal to “utility for practical purposes” fails to rescue the model integral equation; there could be few applications more practical than using rheological data in shear to predict a polymer’s film-blowing characteristics. Such a tempting possibility assured within the sphere of integral constitutive equations is denied to materials which belong on further-flung worlds. LDPE evades our calculational clutches.

Such phenomena that discomfort accepted polymer rheology tend to be marginalised - not forgotten, quite, but relegated to the status of curios. They might have an importance far more fundamental. The concerns over branched polyethylene above fall into this class, partly because they require difficult experiments to discern. Difficult experiments are not necessarily unimportant experiments, so it is therefore not surprising that when we turn from the narrow window of step and steady shear to more exotic rheological tests, other puzzles come into view. The essential requirement for extensional flows of both principal geometries has been illustrated, but three more classes of experiment await widespread application.

First we recall that the literature on polymer melts contains rare but regular warnings of dynamical processes with far longer time-scales than those of stress-relaxation. Apparent only in *interrupted* rheological experiments, they emerge as the unrepeatability of a non-linear measurement before a sufficient lapse-time in the rest-state. Variations on such techniques were discussed by Dealy and Tsang [7], who also point out the different time-scales on which shear and first normal stress difference decay in such experiments. The close approach of the time-scale for decay of the first normal stress difference to the anomalous rheological recovery time surely contains a clue.

Secondly, the technique of *reversing flows* has been developed to a high degree of sophistication by Wagner and co-workers [8]. It has long been known that almost no standard K-BKZ model survives these tests for any polymer - materials seem to make a special record of the highest strain in their recent past rather than their integrated history. The zeros in measured shear stress which may occur at finite time following a reversing step strain are indicative of the rich structure possessed by data from this technique.

Thirdly, we should not forget that important thermodynamic information is implicitly latent in even the most common rheological measurements as soon as temperature is varied. The first lesson of the polymer rheologist introduces her to time-temperature superposition, nature’s gift which in favourable cases permits the mechanical spectrum of a polymer to be recorded over 12 or more decades in frequency. It is often conveniently forgotten that such “thermorheological simplicity” is a special, not a general feature of polymer melts, and can be upset by the most unexpected modifications. The famous example takes us once more to the mysterious regions of rheological space inhabited by long-chain branched polyethylenes. A low-frequency activation energy in LDPE is found up to three times higher than the high-frequency value shared with the

linear material. Graessley and co-workers [9] have made a thorough study of this effect, which admits several other materials into this unorthodox class. Highly non-linear flows erase the anomaly in the same fashion as restriction to high-frequencies.

All these remarks are addressed to homogenous, single-phase fluids. No mention has yet been made of the remarkable and growing corpus of rheological data on textured polymeric materials. The best examples are provided by block co-polymers, recently reviewed by Fredrickson and Bates [10]. The linear rheology alone has, as would be expected, strong history and temperature dependence discernibly related to the mesoscopic structure of the materials. The causal connections between flow-induced structures in these materials and consequent mechanical properties are quite unresolved, although some approaches to the generic linear response of layered (or “smectic”) materials are at an early stage.

To summarise the argument to this point, the measure of success claimed in modelling the rheology of polymer melts is at best primitive and at worst illusory. It arises from self-imposed restrictions on the gamut of experimental windows onto these materials. This *experimental* narrowing of our field of view is a projection of the massive *mathematical* restrictions imposed by our phenomenology on the space of non-linear constitutive forms. The ironic class-name of “simple fluid” is indicative of the victory of unseeing eye over untroubled heart. *La silence de ces espaces éternelles m’effroit.*

It is time to turn to the back cover of our version of the *Hitch Hiker’s Guide to the Galaxy*, where we find the comforting words of the original spelled out in authoritative capitals - DON’T PANIC. We share with the possessor of this remarkable volume a similar predicament and a similar need. Those lost in silent spaces need a guide. Guide-books contain much that is unnecessary, misleading or wrong, but they are indispensable. Such will be the case with any molecular approach to polymer rheology, but without a hold of polymer structure at the molecular level we are lost the moment we leave the comfort of our familiar neighbourhood of mild materials and uncontroversial experiments.

Despite the glimpses of disturbing data above, there is good reason to suppose that, well-above the glass-transition temperature, the local stress is well-approximated by the “rubber-elastic” form driven by the configurational entropy of polymer chains [11]. In such a picture, the smallest necessary structural length b is the minimal flexible chain-segment of Kuhn. If polymer

chains at greater length scales are described by the continuous paths $R^\alpha(s)$ then the stress is just a local moment-average of chain configuration:

$$\sigma = \frac{3ckT}{b^2} \frac{1}{V} \hat{\mathbf{a}}_\sigma \left[\frac{1}{L} \int_0^L \frac{f R^\alpha(s)}{f s} \frac{f R^\alpha(s)}{f s} ds \right] \quad (6)$$

Here c is the concentration of Kuhn segments and L the contour length of the polymer chains. The extension to polydispersity is straightforward. In the entropy-dominated systems where this expression is valid, it represents a marvel of nature. The potential for this form of the stress in terms of a simple local average in chain configurations has certainly not been exhausted, nor has it been demonstrated that any of the troublesome rheological phenomena in melts lie outside its domain. Where it is a good approximation for the stress, it presents some hope of finding the realistic constitutive functionals of polymer melts by constraining the otherwise uncontrolled mathematics along physical pathways. There is no reason to suppose the constraint too severe - far more needs to be known before we can claim that. On the contrary, such a starting point easily leads to mathematical forms which have no phenomenological precedent, as we will see below in one brief example.

Two immediate guiding principles emerge, one for experiment and one for theory. The consequence for the rheological laboratory is that information on local molecular configuration in the melt is not a luxury but an essential complement to the mechanical response. In fact direct measures of the vital orientational average are possible via birefringence, dichroism and NMR methods. Janeschitz-Kriegel, Fuller and others [12] have first checked the assumption of (6), then explored the variation in orientation across molecules and parts of molecules. The information is rich: central regions of linear molecules relax their orientation slower than outer segments; smaller molecules retain orientation at long times when in the presence of larger ones; long-chain branch points greatly slow down material connected to them. The technique has yet to explore in depth the molecular response in large strains, and in particular could shed great light on the reversing step-strain experiments. Far less advanced in rheological application but equally valuable is the technique of neutron scattering. It is complementary to the local optical probes because it can measure structural correlations across entire molecules. Scattering from selectively-labelled melts under large strains [13] has shown directly how initial deformation at the molecular level, affine with the bulk, degenerates into highly non-affine configurations as the stress relaxes. Steady-flow measurements are difficult, but samples rapidly-quenched from the melt [14] show how anisotropy is a strong function of length-scale within the polymer molecule. Recent measurements in extension of a branched polymer [15] have been correlated with rheological data and exhibit both features of non-affine deformation and length-scale dependence of anisotropy.

All these tentative investigations are still representative of an approach to molecular rheology still in its infancy. They rely heavily on a second experimental thread - the careful synthesis of *model materials*. Although only available in quantities of grammes, truly monodisperse melts, perhaps with each molecule selectively labelled (usually with deuterium) for structural interrogation, have contributed incalculably to any understanding of molecular processes we may have. In spite of our remarks on structural probes, very well-characterised polymers can yield enormous amounts of information under even standard linear rheological examination. The monodisperse star-shaped polymers now made routinely by anionic polymerisation [16] provided a result of startling elegance: a melt of such material possesses a viscoelastic spectrum which is a function of the molecular weight of the dangling "arms" of the polymeric stars only, ignoring the total molecular weight. The power of this observation to eliminate any theory which fails to respect this strange independence of parts of the molecule divided by the branch point is very great.

At such crucial points of observation, the experiments lead directly into attempts to understand the rheology at the molecular level. Within the guiding paradigm of equation 6, it is clear that we need only supply a theory to couple the molecular contours to a fluid flow in order to calculate the stress. Now is not the appropriate place to detail the defence of any one approach, although a preference for *simplicity* at the level of molecular models would be a course recommended by the history of theoretical physics. A bias towards simple lines in a structural theory is quite a different matter from an insistence on simple mathematical form in a result. The former does not guarantee the latter. It would lose its power if it did.

The molecular coarse-grained approach via (6) does suggest rather immediately the lines on which a final constitutive theory would run. The most distinct feature is that the stress itself would not be a primary dynamical variable, but calculated from a set of structural variables which describe the molecular dynamics. The maximal set of such variables contains the

contours $\alpha R(s,t)$ themselves, but as it is only a very low order of orientational average which is required, there is some hope that a smaller set of variables would be adequate. Such a set would need to honour the established variance in behaviour of polymer segments at different topological points in the molecule (relative to free ends and branch points), as well as the dynamical constraints of the melt environment. The most successful approach of this kind has

been the “tube model” of Edwards and de Gennes (Doi and Edwards 1986). The applications of the basic model to viscoelasticity of monodisperse linear polymers, bimodal blends and star-shaped polymers are well-documented in the literature. The strength of the model has been in its ability to hold together a simplicity of assumption at a coarse-grained molecular level of how topological interactions couple to the orientation of bonds, with the retention of those molecular details which are known to matter. Here we draw on one of the recent developments on branched polymers within this programme to illustrate how a molecular theory, even when highly simplified, may produce a qualitatively new constitutive equation.

Both experiments and theory suggest that at least two branch points per molecule are needed in order to restrain the highly deformation-thinning behaviour seen in linear polymers. This is conceptually clear if the branch points act to immobilise the polymer locally within the temporary network of entanglements. If a linear polymer is stretched by a flow, it may rapidly contract again along its own contour, losing entanglements (and so reducing the bulk stress). However, all segments of chain between the branch points will remain in a stretched state for much longer. So suitable model polymer for which to attempt a full tube-model calculation consists of an entangled polymer strand connecting two branch points of functionality q . All dangling arms are also entangled and of identical length. Such a melt of “pom-pom” molecules has recently been treated by Larson and McLeish (1997). The full calculation is beyond the scope of this chapter, but a simplification of the theory is instructive because of the realisation in this case of our hope for a small set of structural dynamic and parametric variables from which a good approximation to the stress may be calculated. The two necessary dynamic variables are: (i) the ensemble-average second-moment orientation of the “connector piece” of the molecule, $S(t)$ and (ii) the ensemble-average stretch of this section $\lambda(t)$. In the absence of flow the first relaxes to the isotropic tensor, the second to unity, *but with different relaxation times* τ_b and τ_s respectively. The presence of entanglements is predicted to separate these two time-scales, which are identical for dilute polymers, so the ratio τ_b/τ_s increases with the molecular weight of the connector. This is the first of three essential but counterintuitive pieces of physics controlling the constitutive equation. The second is a separation of time-scales for orientational relaxation of the dangling arms and the connector - the latter is slower typically by two orders of magnitude. So even for rheological flows quite far into the non-linear range, the configuration of the arms is only mildly perturbed from equilibrium and may be ignored, or treated quite consistently as a Newtonian solvent. Thirdly, the tube concept points to a remarkable mechanism for limiting the stretch of the connector - above a critical stretch the “pom-pom” sections are partially withdrawn into tube previously occupied by the connector. The stretch relaxation time rapidly falls when this happens (the effective friction constant of the branch point is controlled by the entangled length of the dangling arms), permitting no further stretching. This could well be nature’s answer to the well-known infinities generated by “bead-spring” models of polymers in extensional flow. Usually circumvented by appealing to a diverging molecular stress, the withdrawal mechanism is gentler, with all molecular tensions remaining in the regime of Gaussian response! The full implementation of this physics leads to a constitutive algorithm of moderate complexity, but all the essential features are retained in a set of twin first-order differential equations for the auxiliary variables $S(t)$ and $\lambda(t)$ together with an expression for the stress. The result is a remarkably simple but hitherto unexplored form:

Expression for the stress:

$$\mathbf{s} = \frac{15}{4} G_0 \lambda^2(t) \mathbf{S}(t)$$

Evolution of orientation:

$$\frac{f}{ft} A(t) = K \cdot A + A \cdot K^T - \frac{1}{\tau_b} \frac{\partial}{\partial t} A - \frac{1}{3} \frac{\partial}{\partial t} I \quad \text{and} \quad S(t) = \frac{A(t)}{\text{trace}(A(t))}$$

Evolution of backbone stretch:

$$\frac{f}{ft} \lambda = \lambda (K : S) - \frac{1}{\tau_s} (\lambda - 1) \quad \text{strictly for } \lambda < q$$

The physics generates naturally one of the “product class” of constitutive forms proposed in equation (5). The choice of mathematical form at that point was of course not as arbitrary as it seemed, but there are plenty of more complex product-forms to write down!

The properties of the “pom-pom” equation-set are interesting [17] in a number of ways - here we just note that it generates naturally the “mysterious” strain-hardening response in both uniaxial and planar extension while retaining shear-thinning. The reason for this is the collusion of the separation of orientational and stretch times, together with the coupling of stretch to the mean orientation. The latter causes both extensional flows to orient the molecules into the direction in which they are stretched most, while in shear they are already rotated *out* of the stretch-direction at shear rates lower than τ_s^{-1} . The molecular picture recognises the role played by the rotational component of the flow, explicitly excluded from phenomenological constitutive equations built around invariants of the deformation. We can compare the (normalised) time-dependent viscosities in start-up of both extensional flows and shear flows calculated using the pom-pom model, and a comparison with the data of Laun and Schuch. In planar extension, a KBKZ equation would predict a response qualitatively similar to that in shear.

As we have noted, an attractive feature of molecular approaches to polymer rheology is that they are amenable to checking by other experiments which probe structure directly. If model branched structures such as the “pom-pom” molecule can be made (and simple versions are already documented in the literature [18]) then all of the physical ingredients of the strange constitutive formulation can be checked directly: the separation of time-scales of arm-relaxation, connector stretch and connector orientation by rheo-optical measurements on selectively labelled molecules, and the retraction mechanism by neutron-scattering. This chapter of the story is still in its opening paragraph; there is an enormous amount of careful work to do comparing theory, structure and rheological response, but more quantitative applications to real data look very promising [15, 19, 20, 21].

We have addressed just one of our selected list of “anomalies” in polymer rheology - and that at only a qualitative level. There is no guarantee that any of the others will prove amenable to the same theoretical framework - only time will tell, but there are signs of hope for constitutive hitchhikers. Highly branched polymers will contain deeply-buried sections with huge relaxation times, but which are very hard to detect in linear response, contributing significantly only at high strains [19]. Reversing flows produce strange conformations in entanglement theories. The unusual molecular states required to relax a long branch may carry an enthalpic energy cost unseen in linear materials [9].

These are very exciting times for travellers in constitutive space. But to avoid a miserable marooning on the wrong planet, they will certainly need their hitch-hikers’ guide, and for peace of mind should glance frequently at the back cover.

References

- [1] D. Adams, *The Hitch-Hiker’s Guide to the Galaxy*, Pan (1979)

- [2] Connoisseurs of the famous five-volume trilogy will recognise the horrific “Total Perspective Vortex”.
- [3] R. Coleman and W. Noll, *Arch. Rat. Mech. Anal.*, 1.
- [4] R. G. Larson, *Constitutive Equations for Polymer Melts and Solutions*, Butterworths, Boston, 1988.
- [5] H. M. Laun and H. Schuch, *J. Rheol.*, 33:119, 1989
- [6] J. Meissner, *Proc. of the XII Int. Conf. Rheol.*, Quebec, 1996.
- [7] J. M. Dealy and W. K.-W. Tsang, *J. Appl. Polym. Sci.*, 26, 1149-1158 (1981).
- [8] A. S. Lodge and J. Meissner, *Rheol. Acta*, 11, 351-352 (1972).
- [9] W. W. Graessley and V. R. Raju, *J. Polym. Sci.:Polym. Symp.*, 71, 77-93 (1984).
- [10] G. Fredrickson and F. S. Bates, Dynamics of Block Co-polymer Melts, *Adv. Polym. Sci.*, 26, 501-550 (1996).
- [11] M. Doi and S. F. Edwards, *The Theory of Polymer Dynamics*, Oxford (1986).
- [12] G. G. Fuller and J. A. Kornfield, *Macromolecules* 22: 1334 (1989).
- [13] A. Hakiki *et al.* *Rutherford Laboratory Reports* (1995).
- [14] R. Muller, J. J. Pesce and C. Picot, *Macromolecules*, 26, 4356, (1993).
- [15] T. C. B. McLeish, J. Allgaier, D. K. Bick, G. Bishko, P. Biswas, R. Blackwell, B. Blottière, N. Clarke, B. Gibbs, D. J. Groves, A. Hakiki, R. Heenan, J. M. Johnson, R. Kant, D.J. Read, R. N. Young “Dynamics of Entangled H-Polymers: Theory, Rheology and Neutron-Scattering” *Macromolecules*, 32, 6734-6758 (1999).
- [16] L. J. Fetters, A. D. Kiss, D. S. Pearson, G. F. Quack and F. J. Vitus, *Macromolecules*, 26, 647-654 (1993).
- [17] T. C. B. McLeish and R. G. Larson, *J. Rheol.*, 42, 1, 81-110, (1998).
- [18] J. Roovers, *Macromolecules*, 17, 1196 (1984); A. Hakiki, R. N. Young and T. C. B. McLeish, *Macromolecules*, 29, 3639-3641 (1996).
- [19] D. K. Bick and T. C. B. McLeish, *Phys. Rev. Lett.*, 76, 2587 (1996).
- [20] N. J. Inkson, T. C. B. McLeish, D. J. Groves and O. G. Harlen, *Journal of Rheology*, 43, 873-896(1999) .
- [21] R. J. Blackwell, T. C. B. McLeish and O. G. Harlen, *J. Rheol.*, 44, 121-136 (2000).

BSR ANNOUNCEMENTS

The Rheological Aspects of Surfactant- Based Systems

ROYAL SOCIETY OF CHEMISTRY
Faraday Division – Colloid and Interface
Science Group

AND

BRITISH SOCIETY OF RHEOLOGY

Joint Research Conference Incorporating BSR AGM

18-19 September 2000 – University of Durham, UK

The conference is to address all rheological aspects of surfactant based systems, including those of emulsions, microemulsions, surfactant mesophases, interfacial rheology and influence of surfactant on rheological behavior of other solutions (e.g. polymeric solutions). Further offers of poster presentations, particularly from young research workers such as graduate students and post-doctoral assistants, are welcomed.

Accommodation will be on the campus of the University of Durham at Collingwood College. Those wishing to register should complete the attached registration form. A limited number of student bursaries is available through the Colloid and Interface Science Group and additional support from ICI plc. In all cases early booking is recommended.

A final programme, travel maps and details and acknowledgement of registration will be sent in August 2000.

PROGRAMME

Monday, 18th September

<i>From</i>	<i>Registration – Collingwood College</i>
10:00	
12:00	<i>Lunch</i>
14:00	Prof. S. J. Candau , Université Louis Pasteur, Strasbourg, FR Rheological properties of salt-free micellar solutions
14:30	Dr. P. D. Olmsted , University of Leeds, UK Metastability and Kinetics of shear -banding in wormlike micellar systems
15:00	Prof. H. Rehage , University of Essen, DE Quantitative description of the non-linear properties of dilute solutions of wormlike micelles
15:30	<i>Tea</i>
16:00	Prof. R. H. Colby , Pennsylvania State University, USA Rheology of polymer/surfactant aqueous mixtures
16:30	Prof. M. Gottlieb , Ben Gurion University, IL Rheological behaviour of a microemulsion/ABA copolymer system
17:00	Dr. D. Vlassopoulos , I.E.S.L., Crete, GR Structure and dynamics of micelles and supermolecular assemblies in solution and in the melt
17:30	<i>Poster session (Collingwood College) & BSR Annual General Meeting</i>
19:30	<i>Dinner – Collingwood College</i>

Tuesday, 19th September

9:00	Prof. M. E. Cates , University of Edinburgh, UK Title to be announced
9:30	Dr. A. R. Rennie , King's College, University of London, UK Title to be announced
10:00	Prof. P. Luckham , Imperial College, University of London, UK The rheology of surfactants in non-aqueous media
10:30	<i>Coffee</i>
11:00	Prof. P. V. Coveney , QMW College, University of London, UK Theory, modelling and simulation of amphiphilic fluid dynamics
11:30	Prof. G.J.T. Tiddy , UMIST, UK The relationship between rheological measurements and structure realignment under shear in surfactant liquid crystals
12:00	Prof. C. M. Care , Sheffield Hallam University, UK Lattice Boltzmann models of flow in anisotropic fluids
12:30	<i>Lunch – Collingwood College</i>
14:00	Prof. G. G. Fuller , Stanford University, USA Rheology in Two Dimensions
14:30	Prof. R. W. Richards , Durham University, UK Surface Visco-elastic properties of amphiphilic polymers at the air-water interface
15:00	Dr. B. S. Murray , University of Leeds, UK Interfacial rheology of biopolymer films
15:30	<i>Tea and Departure</i>

**FRC 2000 - COMPOSITES FOR THE MILLENNIUM
EIGHTH INTERNATIONAL CONFERENCE ON FIBRE REINFORCED
COMPOSITES**

*13th - 15th September 2000
University of Newcastle upon Tyne*



Co-sponsored by The Institution of Mechanical Engineers and The Institute of Materials

Following the considerable success of previous meetings, the eighth in this series of international conferences will be held at the University of Newcastle upon Tyne in September. The aim of the FRC meetings, which fulfill a unique slot in the composites calendar, is to bring together the latest developments in all areas of composite materials engineering, as well as to act as a forum for informed discussion. The FRC meetings have proved invaluable, not only to companies and research organisations wishing to keep abreast of the latest research in composites of all types, but also to those about to enter the field, and needing to gain an insight into the state of the art. Several European organisations now send delegates to FRC on a regular basis.

The conference will bring together senior personnel and key workers from all sectors of the composites field: end-users, manufacturers, designers, materials and equipment suppliers as well as research workers.

There will be sessions on Applications and New Developments, Composites Processing, Composite Properties, Materials Modelling and, for the first time, Green Composites. The meeting will contain presentations from industry and leading research universities.

The presentations will be supported by a bound volume of conference papers, published by Woodhead Publishing, and there will be Poster Sessions and an Exhibition. As with previous FRC Conferences, there will also be ample opportunity for discussion and interaction with colleagues.

Professor A G Gibson

**Director – Centre for Composite Materials Engineering,
University of Newcastle**

FRC 2000 Conference Chairman <http://www.ncl.ac.uk/ccme>



CALL FOR PAPERS
The University of Wales
Institute of Non-Newtonian Fluid Mechanics
supported by the
British Society of Rheology
will host a conference on

**Industrial Food Processing:
Experiments and Numerical Simulation**

at the University of Plymouth, UK.

Monday 9th April – Wednesday 11th April, 2001

The aim of this conference will be to advance the understanding of problems that occur within the food processing industry. The conference will bring together industrialists and academics with interests in experimental and numerical approaches to the various problems that arise. A particular theme will be food rheology but other relevant topics, such as the development of novel numerical methods or new experimental techniques, will be encouraged.

Accommodation will be provided at the Copthorne Hotel which is located very close to the conference venue.

Abstracts (not exceeding 300 words) will be required by 1st November, 2000.

Further information may be obtained from Professor T.E.R. Jones, Department of Mathematics and Statistics, University of Plymouth, Drake Circus, Plymouth, PL4 8AA, UK. (Tel: 01752 232735, email: ejones@plymouth.ac.uk)

ANNOUNCEMENTS OF THE EUROPEAN SOCIETY OF RHEOLOGY (ESR)

RHEOLOGIE ET INNOVATION

23–25 October 2000

Grenoble, France

In autumn 2000 the 35th Annual General Meeting of the "Groupe Francais de Rheologie" (GFR) will be held in Grenoble from 23 to 25 October in concert with the Greek and Italian Societies of Rheology. Nadia EL KISSI (Laboratoire de Rheologie) is coordinating the organization.

The topic is "Rheologie et innovation" with three sets of themes privileged right now:

-Assessments and Challenges

To give a progress report on the recent developments and to discuss the scientific stakes, in the field of rheology.

-New materials and techniques

To cross the techniques of characterization, recent or diverted of their first destination, and new materials, to obtain remarkable advances

-Rheology and society

To federate competences of the scientists working in different fields, since from health to environment, from car industry to cosmetics, every field of science and life is concerned.

Additional inquiries can be obtained through gfr2000@ujf-grenoble.fr

TDM 2000
3RD INTERNATIONAL CONFERENCE ON MECHANICS
OF TIME DEPENDENT MATERIALS

17-20 September 2000

Erlangen, Germany

Scientific program

The intention of this conference is to discuss time-dependent properties of different materials like ceramics, metals and polymers. The following speakers will present invited keynote lectures:

Prof. Dr. A. Argon (Massachusetts Institute of Technology, Cambridge, USA):
"Physics of the rate mechanism of plastic flow in crystalline and amorphous solids"

Prof. Dr. W. Pechhold (University Ulm, Germany):
"New methods for the measurement of the dynamic-mechanical behaviour of materials"

Prof. Dr. T. Sakuma (University of Tokyo, Japan):
"Grain boundary plasticity in oxide ceramics"

Dr. R.C. Stauber (BMW, Germany):
"Materials for automotive engineering – Current applications and trends"

Minisymposium

Part of the Conference will be a Minisymposium dedicated to Prof. Dr. F.R. Schwarzl on the occasion of his 75th birthday. The following lectures will be presented:

Prof. Dr. G. Hartwig (Forschungszentrum Karlsruhe, Germany):
"Time-dependent fracture processes"

Prof. Dr. L.C.E. Struik (DSM Research, The Netherlands):
"Glass transition and related phenomena in amorphous polymers"

Prof. Dr. F.R. Schwarzl (University Erlangen-Nürnberg, Germany):
"Technical mechanics of amorphous polymers under small stresses"

Papers and posters are welcome in the areas of:

- Experimental methods and techniques
- Comparison of time-dependent properties of different materials
- Dependence of time-dependent properties on molecular structure
- Influence of external parameters like stress, deformation and temperature on the time dependence of mechanical properties of materials
- Influence of the environment on time dependence of materials
- Time-dependence of materials in industrial applications
- Constitutive equations and mathematical modeling of time-dependent material properties

Registration

Students DM 350,-

Delegates DM 620,-

The reduced fees given above are valid for registrations before April 30, 2000.

After this date an additional amount of DM 50,- is charged.

BULLETIN OF THE EUROPEAN SOCIETY OF RHEOLOGY

Social program

The social program comprises a get-together on Sept. 17 and the conference dinner on Sept. 19 at the Atzelsberg castle near Erlangen. On the afternoon of Sept. 20 an optional excursion to the city of Bamberg, which has been selected as world cultural heritage, is being planned.

Location

The city of Erlangen is a lively University town in Central Frankonia (North Bavaria). It has about 100 000 inhabitants and is a center of important industry. Around Erlangen there are many places worthwhile visiting, for example:

- Rothenburg ob der Tauber
- Würzburg
- Munich (with the "Oktoberfest" at that time)

Accommodation

For accommodation registration cards will be enclosed to the confirmation of registration. Three categories of hotels will be offered.

For more information please contact:

Claus Gabriel or
Tel: ++49 9131 8528709
Institute of Polymer Materials
Fax: ++49 9131 8528321
TDM2000@www.uni-erlangen.de

Stefan Rettenberger
Tel: ++49 9131 8527746

International Scientific Committee

Prof Dr H Altenbach (DE)	Dr B von Bernstorff (DE)	Prof Dr AH Cardon (BE)
Prof Dr GW Ehrenstein (DE)	Prof Dr JD Kaplunov (RU)	Prof Dr HH Kausch (CH)
Prof Dr P Greil (DE)	Prof Dr H Mughrabi (DE)	Dr G B McKenna (US)
Prof Dr K Ravi-Chandar (US)		

International Organizing Committee

Prof. Dr. H. Münstedt, Chair (DE)	Prof. Dr. I. Emri, Vice-Chair (SI)
Prof. Dr. W.G. Knauss, Vice-Chair (US)	Prof. Dr. M. Takashi, Vice-Chair (JP)
Prof. Dr. O. Vöhringer (DE)	Dr. J. Kaschta (DE)



President

Prof. Manfred H. Wagner

Institut für Kunststofftechnologie

Universität Stuttgart

Böblinger Str. 70

D-70199 Stuttgart, Germany

Tel: +49-711-641-2330

Fax: +49-711-641-2335

E-mail:

wagner@ceylon.verfahrenstechnik.uni-

stuttgart.de

Vice-President and European Delegate

Prof. Dr. H. Münstedt

Lehrstuhl für Polymerwerkstoffe

Universität Erlangen-Nürnberg

Martensstr. 7

D-91058 Erlangen, Germany

Tel: +49-9131/85-7604

Fax: +49-9131/85-8321

E-mail: polymer@ww.uni-erlangen.de

Secretary

Dr. Werner Mielke

Bundesanstalt für Materialforschung und -
prüfung (BAM)

Unter den Eichen 87

D-12205 Berlin

Tel: +49-30-8104-1610

Fax: +49-30-8104-1617

E-mail: drg@bam.de

GERMAN SOCIETY OF RHEOLOGY (DRG)

The Golden Jubilee Meeting of the German Society of Rheology (DRG) will take place from May 14 to 16, 2001, at the Bundesanstalt fuer Materialprüfung (BAM), Berlin, where the DRG was founded in 1951. The DRG is the fourth-oldest rheological society (after SoR, BSR, and NRV).

The programme will include plenary lectures with historical reflections on experimental and theoretical aspects of rheology, contributed papers, an exhibition, and a jubilee banquet.

M.H. Wagner



President

D. Vlassopoulos

FORTH-IESL

P.O. Box 1527

71110 Heraklion, Crete, Greece

Tel: +30-81-391469

Fax: +30-81-391305

E-mail: dvlasso@iesl.forth.gr

Vice-President

J. Tsamopoulos

Univ. of Patras, Chem. Eng.

FORTH-ICE/HT

26500 Patras, Greece

Tel.: +30-61-997203

Fax: +30-61-993255

E-mail: tsamo@zeus.chemeng.upatras.gr

Secretary

G. Georgiou

University of Cyprus

Dept. of Mathem. & Statistics

P.O. Box 537

1678 Nicosia, Cyprus

Tel: +357-2-338701

Fax: +357-2-339061

E-mail: georgios@pythagoras.mas.ucy.ac.cy

Past-President

E. Mitsoulis

N.T.U.A.-Mining Eng. & Metal.

Heroon Polytechniou 9

15780 Zografou, Athens, Greece

Tel: +30-1-7722163

Fax: +30-1-7722173

E-mail: mitsouli@metal.ntua.gr

Members-at-Large

S.G. Hatzikiriakos

Univ. of British Columbia

Dept. of Chemical Engineering

2216 Main Hall, Vancouver,

BC V6T 1Z4, Canada

Tel: +1-604-8223107

Fax: +1-604-8226003

E-mail: hatzikir@unixg.ubc.ca

V.G. Mavrantzas

FORTH-ICE/HT

P.O. Box 1414

26500 Patras, Greece

Tel: +30-61-997225

Fax: +30-61-993255

E-mail: vlasia@sequoia.iceht.forth.gr

HELLENIC SOCIETY OF RHEOLOGY (HSR)

HSR is co-organizing with the French and Italian Societies the 35th Annual Colloquium of the French Group of Rheology, in Grenoble, France, October 23-25, 2000. The main theme is 'Rheology and Innovation'.

The 3rd International Meeting of the HSR is going to be held in Patras, Greece, June 10-14, 2001.

This meeting is dedicated to Professor Andreas Acrivos on the occasion of his retirement from the Levich Institute and CUNY.

Deadline for submission of abstracts is December 15, 2000.

For information please contact:

Professor John Tsamopoulos,

Dept. of Chemical Engineering, University of Patras, 26500 Patras,

Greece. Tel:30-61-997203, Fax:30-61-993255.

Email: tsamo@chemeng.upatras.gr

GROUPE FRANÇAIS DE RHEOLOGIE (GFR)



President

Prof. Rémi Gaudu

MASTER - E.N.S.C.P.B.

Avenue Pey-Berland

BP 108 F-33402 TALENCE CEDEX

Tel.: +33 (0)5 56 84 66 88

Fax: +33 (0)5 56 84 66 68

E-mail: gaudu@lmaster.u-bordeaux.fr

Secretary

M. Jacques Bouton

RHEO S.A.

99 Route de Versailles

F-91160 CHAMPLAN

Tel.: +33 (0)1 64 54 01 01

Fax: +33 (0)1 64 54 01 87

Treasurer

Prof. Jean-François Tassin

Université du Maine Laboratoire de

Physico-chimie macromoléculaire

Avenue Olivier Messiaen

F-72017 LE MANS CEDEX

Tel.: +33 (0)2 43 83 33 61

Fax: +33 (0)2 43 83 35 58

International Delegate

Prof. Madeleine Djabourov

ESPCI

URA 857

10 Rue Vauquelin

F-75231 PARIS CEDEX 5

Tel.: +33 (0)1 40 79 45 58

Fax: +33 (0)1 40 79 47 95

E-mail: Madeleine.Djabourov@espci.fr

The 34th annual general meeting of the French Group of Rheology (GFR) has been held in Paris on October 18-20 1999 (CONSERVATOIRE NATIONAL DES ARTS ET METIERS 292 rue Saint Martin PARIS). Its main scientific subjects were related to the **Rheology in life sciences and technologies (Rhéologie des Matériaux du Vivant)**. The Scientific Committee chaired by P.G. de Gennes included M. Baquet, L. Dubertret, G. Couarraze, B. Launay, J-L. Morancais, C. Oddou, D. Quemada, J-F Stoltz. Bringing together 168 academic and industrial scientists this meeting included 47 communications and four plenary sessions. It is really difficult to select some papers among the various quite interesting ones which illustrate both the diversity and the quality of the presentations. The first inaugural conference given by Professor P. G. DeGennes (Collège de France) was devoted to molecular biology and unsolved fundamental problems encountered in genetics. Numerous papers were devoted to the study of polymers or biopolymers. The second invited lecture was given by Professor P. Bongrand (INSERM Marseille) and concerned another fundamental question in cell physiology related to the process of mechanotransduction. In the following session, the rheological behaviour of rheological materials was studied both on a microscopic (cellular) scale and a macroscopic one. In the third invited lecture, D.P. de Rossi (University of Pisa) gave a talk about the research in biomimetics, and examined some analogues of living matter in term of actuators and sensors. In the field of biomimeticism, a particular attention has to be paid to the conference presented by G. Jeronimidis (University of Reading) as the fourth invited lecture which focused on plant physiology, recent and potentially interesting field for biorheologists. The following sessions were devoted to the field of rheology of powders and dispersed systems and of rheology of controlled release systems. In the field of biofluid rheology, the fifth invited conference given by P. Snabre was very exciting from an experimental viewpoint; the emphasis has been put on rheo optical and rheo acoustical techniques. The complete proceeding of this meeting have been published as a special 400 pages issue of « *Les Cahiers de Rhéologie* » (Volume XVI N°3)

After the annual general meeting of the GFR, Pr Patrice Flaud who was coordinating the organization committee has been elected new president of the GFR. More information on the new board of the GFR and on our activities can be obtained from our newly opened internet site : <http://www.univ-lemans.fr/sciences/wgfr>.



President

Prof. Rémi Gaudu

MASTER - E.N.S.C.P.B.

Avenue Pey-Berland

BP 108 F-33402 TALENCE CEDEX

Tel.: +33 (0)5 56 84 66 88

Fax: +33 (0)5 56 84 66 68

E-mail: gaudu@lmaster.u-bordeaux.fr

Secretary

M. Jacques Bouton

RHEO S.A.

99 Route de Versailles

F-91160 CHAMPLAN

Tel.: +33 (0)1 64 54 01 01

Fax: +33 (0)1 64 54 01 87

Treasurer

Prof. Jean-François Tassin

Université du Maine Laboratoire de

Physico-chimie macromoléculaire

Avenue Olivier Messiaen

F-72017 LE MANS CEDEX

Tel.: +33 (0)2 43 83 33 61

Fax: +33 (0)2 43 83 35 58

International Delegate

Prof. Madeleine Djabourov

ESPCI

URA 857

10 Rue Vauquelin

F-75231 PARIS CEDEX 5

Tel.: +33 (0)1 40 79 45 58

Fax: +33 (0)1 40 79 47 95

E-mail: Madeleine.Djabourov@espci.fr

The next GFR annual conference will be held in Grenoble 23-25 October 2000. It is organised in association with the Italian and the Hellenic societies of rheology around the topic "**Rheology and Innovation**". Three themes are privileged:

Assessments and challenges. New materials and techniques. Rheology and society.

The limiting date of the inscriptions is September 15.

Any further information can be obtained from:

e-mail

: gfr2000@ujf-grenoble.fr

Web

: <http://rheologie.ujf-grenoble.fr>

The third edition of the « Meeting of Young Rheologists » has taken place in La Colle sur Loup , close to Nice, from May 22nd to 24th , 2000. During these 2 days, 18 participants coming from the main French rheology laboratories, had the opportunity to exchange on their work in a friendly atmosphere, also with 3 "senior rheologists" (Lionel Choplin-GEMICO, Jean Pierre Montfort- PAU University, and Jean-François Tranchant- PARFUMS CHRISTIAN DIOR) as well as with the organizing team: the CEMEF laboratory. Half a day was dedicated to visit TOURNAIRE, a local company which produces containers for the chemical and pharmaceutical industries. The participants could during this visit have several direct illustrations of the impact of rheology on polymer processing and aluminium forming.

Bruno VERGNES who was co-ordinating this meeting, got an enthusiastic feed back . The series of the « Meeting of Young Rheologists » will be continued with a 4th edition in 2002.

The GFR and the Canadian Rheology Group are organizing jointly a Symposium on Rheology within the 50th Canadian Chemical Engineering Conference to be held in Montreal, October 15-18, 2000. Sessions on Fundamental and Applied Rheology, Polymer Solutions, Polymer Blends and Composites, Emulsions, Suspensions, Instrumentation, Numerical Simulations are organized. More informations available on the website of the Conference (<http://csche2000.ca>).

VINOGRADOV SOCIETY OF RHEOLOGY (VOR)



President

Prof. Valery Kulichikhin

Institute of Petrochemical
Synthesis
Russian Academy of Sciences
29 Leninsky Pr.,
Moscow 117912
Russia
Tel +7 (095) 9524145
Fax: +7 (095) 2302224
e-mail: klch@ips.ac.ru

Secretary

Dr. Ernst Frenkin

Institute of Petrochemical
Synthesis
Russian Academy of Sciences
29 Leninsky Pr.,
Moscow 117912
Russia
Tel. +7 (095) 9554336
e-mail: fre@ips.ac.ru

Treasurer

Dr. L.Ivanova

Institute of Petrochemical
Synthesis
Russian Academy of Sciences
29 Leninsky Pr.,
Moscow 117912
Russia
Tel. +7(095) 9554388

Delegate to the ICR

Prof. Alex Malkin

Tel. +7 (095) 1878122
e-mail: alex@malkin.msk.ru

The 20th Symposium of the Vinogradov Society of Rheology, dedicated to 90th Anniversary of Prof. G.V.Vinogradov's birthday was held on May 22-27, 2000 in Karacharovo (Russia).

More than 120 members of Society from Russia, Ukraine, Belorussia, Latvia, Kazakhstan participated in this Symposium. Ten rheologists from USA, Canada, Germany, Czech Republic, Portugal and Poland were been invited as guests of the Symposium.

The Program consisted of 8 plenary lectures, 56 oral presentations and 60 posters. All aspects of rheology were discussed, including rheology of biomedical systems.

Two panel discussions devoted to "Rheology of complex polymer liquids" and "Metodological problems of rheology of blood" took place during Symposium.

Professor A.Isayev (University of Akron, USA) and Professor V. Kulichikhin (Insitute of Petrochemical Synthesis, Russian Academy of Sciences) were awarded at the General Meeting of members of the Vinogradov Society of Rheology with the Vinogradov prize for 1999.

Professor Kulichikhin was elected as the President of the Society for next four years.

Valery Kulichikhin

BSR MEMBERSHIP NEWS

OBITUARY

Professor Frank M Leslie, JP, BSc, PhD, DSc, FIMA, FInstP, FRSE, FRS
Born 8 March 1935, died 15 June 2000

The department was devastated to hear of the untimely death of Professor Frank Leslie, following what should have been a routine hip replacement operation. He was a distinguished applied mathematician, a good friend and a respected colleague, and will be greatly missed.

Frank was born in Dundee in 1935 and was educated at Harris Academy and Queen's College, Dundee (now the University of Dundee), where he gained a First Class Honours degree in Mathematics in 1957. He completed his PhD in 1961 at the University of Manchester, under the joint supervision of Prof M J Lighthill and Dr B Morton, while he held a post as Assistant Lecturer in the Department of Mathematics. His PhD project dealt with flow in the open thermal siphon and viscoelasticity in fluids.

He spent the following year as a Research Associate at MIT, and it was there that he first came across the work of Jerry Ericksen on anisotropic liquids. This discovery shaped his subsequent research career. Frank returned to the UK as a lecturer at Newcastle University in 1962, where he stayed until 1968, apart from a sabbatical year in 1966-67 spent as a Visiting Professor at Johns Hopkins University in Baltimore. It was there where he first met Ericksen, who encouraged Frank to focus his attention on mathematical models for liquid crystals. This encouragement led Frank into an exciting and distinguished career. He accepted the position of Senior Lecturer in Mathematics at the University of Strathclyde in 1968, becoming a Reader in 1971 and a Professor in 1979.

The development of all liquid crystal display devices owes a great deal to Frank. Liquid crystals describe a state of matter that lies between the familiar solid and liquid states. The name arises from the fact that, although liquid, the material retains some crystalline properties that are associated with an elongated molecular structure. Their interesting properties - in display devices, for example - arise from the possibilities of aligning molecules with electric or magnetic fields. Frank's early work on nematic liquid crystals led to theoretical developments in nematic modelling, and his work on nematics since 1966 influenced every theoretical and experimental group in the world. His most influential papers (out of a total of well over 50) are undoubtedly "*Some constitutive equations for anisotropic fluids*", Quarterly Journal of Mechanics and Applied Mathematics, **19**, 357-370 (1966), and "*Some constitutive equations for liquid crystals*", Archive for Rational Mechanics and Analysis, **28**, 265-283 (1968).

In recent years he had also been involved with liquid crystal modelling through European Network programmes. He always sustained a general interest and activity in a broader sense by being on the editorial boards of many prestigious liquid crystal and mathematical journals and remained an enthusiastic supporter of the British Liquid Crystal Society, being elected its Chairman from 1987 to 1991.

It is impossible to estimate the profound impact that Frank Leslie's ideas have had on the world-wide activities in nematic and smectic liquid crystals. He gained many honours and awards for his research. Frank was elected a Fellow of the Royal Society of Edinburgh and a Member of the Johns Hopkins Society of Scholars in 1980. He received the Annual Award of the British Society of Rheology in 1982. In 1995 he was elected a Fellow of the Royal Society of London, and, in the following year he was awarded the prestigious Sykes

Gold Medal by the University of St Andrews for his DSc degree. The FRS award was a tremendous honour for Frank and his family, and for the Department of Mathematics and the University. In 1997 he was the proud recipient of the George W Gray Medal of the British Liquid Crystal Society.

It is difficult to describe how stunned we are at the loss of such a distinguished and friendly colleague. Our thoughts are with Ellen and his family. Frank was intensely proud of his Scottish heritage, and this epitaph, written by the Scottish bard Robert Burns for a family friend, seems most appropriate.

*An honest man here lies at rest,
As e'er God with his image blest:
The friend of man, the friend of truth,
The friend of age, and guide of youth:
Few hearts like his - with virtue warm'd,
Few heads with knowledge so inform'd:
If there's another world, he lives in bliss;
If there's none, he made the best of this.*

**Professor David Sloan,
Head of Department of Mathematics, University of Strathclyde**

NEW MEMBERS

UNITED KINGDOM	
Mr Andrew Hoggan Alpha-Fry Ltd Tandem House Marlowe Way Croydon, Surrey, CR0 4XS	Dr Alan Wheatley Global Development Manager Axel Christiernsson Bury, UK
David Elliot ICI Paints Wexham Road Slough, Berkshire	
OVERSEAS	
Haifa El-sadi 26 Papillon Pointe Claire, Quebec, Canada	

LOST MEMBERS

Council is anxiously attempting to trace the following members, whose address details are no longer valid. If you can supply information, please contact the Membership Secretary (contact details inside front cover):

Cassidy M. Mr.	Kothari D.C. Mr	Pitman S.J. Mr
Crook S. J. Mr.	Mathanj R.K. Miss	Power F. Ms
Finch M. Mr.	Moran P. J. Mr.	Sinha S.K. Mr.
Keeley A.M. Dr.	Mulji N. Miss	Whelan I.P. Mr.
Kim Young Sik Professor		

RECRUITMENT OPPORTUNITIES

Job Seekers are advised to check the "eurorheo" archives at <http://www.mailbase.ac.uk/lists/eurorheo/archive.html> for other employment opportunities.

For example:

The Dow Chemical Company is a global science and technology based company that develops and manufactures a portfolio of chemical, plastic and agricultural products and services for customers in 168 countries around the world. With annual sales of more than \$19 billion, Dow conducts its operations through 8 global businesses employing 39,000 people. The company has 121 manufacturing sites in 32 countries and supplies more than 2,400 products.

For our Corporate R&D department we are looking for a (m/f):

Computer Modelling Specialist

with international ambitions. The job will be based in Terneuzen, The Netherlands, at the coastline of Zeeland and close to cities like Antwerp, Brugge, and Ghent.

For Dow to be successful long term, an infrastructure must be maintained, enhanced and expanded in the field of New Products and Math Modelling. It is in this role that we have a great opportunity. The successful candidate will be able to use his/her technical skills in both chemistry/physics and mathematical models. The goal is to implement and expand PC based databases and simulation software for rheology and formulation design. These developments will occur in close collaboration with internal customers. He/she will interact with top specialists in Dow all over the globe. The successful candidate will receive a thorough training for which travelling abroad may be acquired.

Applicants should have a university degree in Chemical Engineering, Computer Sciences, Mathematics, Physics or Chemistry with good knowledge of computational tools. A good knowledge of Delphi and Unix/Linux is an advantage. The willingness to communicate across multiple disciplines and functional areas is essential. They must be fluent in English. Candidates will be expected to have a self-starting attitude, implying a large degree of autonomy and responsibility towards their customer and team. They must demonstrate a talent for interpersonal effectiveness. Dow offers the chance to develop a career and not just a job, in combination with a highly competitive salary & benefits package. To find out more about Dow, visit our web site at:

www.dow.com

If you are ready for these challenges please send your application, in English by July 27, to: Dow Benelux, for the attention of Agnes Van den Berg, PO Box 48, 4530 AA Terneuzen, The Netherlands or e-mail to "BusinessServices@Dow.com" and list "Job 006149LNLD (space)your last name" on the Subject line. You will receive an autoreply.

INDUSTRY NEWS

RHEOLOGY ANALYSIS SOFTWARE

A user-friendly analysis software - RHEA - has been specifically developed for engineers working in rheology needing a rapid analysis procedure. Master-curves of stiffness or compliance information in either time or frequency domain are generated from dynamic or creep data. The RHEA software allows users to rapidly inspect the quality of data and to develop the interrelationships with ease. RHEA converts dynamic mechanical data (G' , G'' vs. frequency) from the frequency domain to the time domain, $G(t)$ and $J(t)$ and vice-versa.

For more information please visit <http://www.abatech.com/Rhea.htm> or contact me at the numbers below.

Geoff Rowe
Abatech, Inc.
73 Old Dublin Pike, #312
Doylestown, PA 18901

Tel: 1(267) 880-1295
Fax: 1(561) 679-2464
Mobile: 1(267) 251-1976
e-mail: growe@abatech.com

For more Abatech news --> <http://www.abatech.com>

BOOK RELEASE

Engineering Rheology - Second Edition

*Roger I. Tanner,
P.N. Russell Professor of Mechanical Engineering,
University of Sydney, Australia*

* Discussion of computational rheology not available elsewhere in book form

* Provides a comprehensive summary of the field

This book sets out to provide a guide, with examples, for those who wish to make predictions about the mechanical and thermal behaviour of non-Newtonian materials in engineering and processing technology. After an introductory survey of the field and a review of basic continuum mechanics, the radical differences between elongational and shear behaviour are shown. Two chapters, one based on a continuum approach and the other using microstructural approaches, lead to useful mathematical descriptions of materials for engineering applications.

As examples of nearly-viscometric and nearly-elongational flows, there is a discussion of lubrication and related shearing flows, and fibre-spinning and film-blowing respectively.

A long chapter is devoted to the important new field of computational rheology, and this is followed by chapters on stability and turbulence and the all-important temperature effects in flow. This new edition contains much new material not available in book form elsewhere-for example wall slip, suspension rheology, computational rheology and new results in stability theory.

Oxford Engineering Science Series No. 52
0-19-856473-2, Hardback, GBP 55.00
480 pp, 134 line figures, March 2000

Debra Gooley
Marketing Manager - Physical Sciences
Oxford University Press, Great Clarendon
Street, Oxford, OX2 6DP, UK

Direct line telephone: 01865 267250
Fax: 01865 267782
E-mail: gooleyd@oup.co.uk
Website: www.oup.co.uk

CONFERENCES

You are also advised to visit the BSR home pages where an extensive list of conferences is maintained by Chris Petrie:

<http://www.ncl.ac.uk/rheology/conferences/index.html>

2000	
21-26 Aug Cambridge GB	RHEOLOGY 2000 - XIIITH INTERNATIONAL CONGRESS ON RHEOLOGY Organised by the BSR with the assistance of the European Society of Rheology. Chairman of the Executive Committee: Prof K Walters FRS, University of Wales, Dept of Mathematics, Penglais, Aberystwyth, Dyfed, SY23 3BZ, Wales, UK T: +44 (0)1970 622750 F: +44 (0)1970 622777 Info: http://abbey4.swan.ac.uk/rheology2000/
11-14 Sep Sofia BG	9TH INTERNATIONAL CONFERENCE ON MECHANICS AND TECHNOLOGY OF COMPOSITE MATERIALS Central Laboratory of PhysicoChemical Mechanics - BAS, Acad. G. Bonchev Str, Block 1, 1113 Sofia, Bulgaria F: +3592 70 34 33 E: clphchm@bgcict.acad.bg
13-15 Sep Newcastle GB	FRC 2000 - COMPOSITES FOR THE MILLENNIUM: EIGHTH INTERNATIONAL CONFERENCE ON FIBRE REINFORCED COMPOSITES Louise Blackburn, Conference Organiser, Conference Design Consultants T: +44 (0)191 284 7590 F: +44 (0)191 285 6993 Info: www.ncl.ac.uk/~nccme
17-20 Sep Erlangen DE	TDM 2000 – 3RD INTERNATIONAL CONFERENCE ON MECHANICS OF TIME DEPENDENT MATERIALS Claus Gabriel / Stefan Rettenberger, Institute of Polymer Materials, University of Erlangen-Nürnberg, Martensstraße 7, D-91058 Erlangen, Germany T: +49 9131 852 8709 / 7746 F: +49 9131 852 8321 E: TDM2000@www.uni-erlangen.de
18-19 Sep Durham GB	THE RHEOLOGICAL ASPECTS OF SURFACTANT BASED SYSTEMS (INCORPORATING BSR AGM) Dr R Ettelaie, Colloid, Interface & Rheology Group, ICI Wilton Centre, PO Box 90, Wilton, Middlesborough, Cleveland, TS90 8JE T: +44 (0)1642 437882 F: +44 (0)1642 437344 E: rammile_ettelaie@ici.com
4-6 Oct Monash AU	IMPLAST 2000 – 7TH INTERNATIONAL SYMPOSIUM ON STRUCTURAL FAILURE & PLASTICITY Irene Thavarajah, Monash University, Clayton, Australia T: +61 3 9905 1344 F: +61 3 9905 1343 E: Implast@adm.monash.edu.au Info: www.monash.edu.au/oce/implast
15-18 Oct Montreal CA	50TH CANADIAN CHEMICAL ENGINEERING CONFERENCE (SYMPOSIUM ON RHEOLOGY) Prof A Ait-Kadi, Dept de genie chimique, Universite Laval – Pav. Pouliquet,

2000	
	Ste-Foy, Quebec, Canada, G1K 7P4 E: aitekadi@gch.ulaval.ca J Bouton, RHEO SA, 99 route de Versailles, 91160 Champlain, France E: bouton@rheo.fr Info: http://csche2000.ca
23-25 Oct Grenoble FR	35TH ANNUAL MEETING OF THE GROUPE FRANCAIS DE RHEOLOGIE (GFR) – “RHEOLOGIE ET INNOVATION” (RHEOLOGY & INNOVATION) E: gfr2000@ujf-grenoble.fr Info: http://rheologie.ujf-grenoble.fr
30 Nov London GB	INORGANICS IN RHEOLOGY CONTROL Mario Moustras, Inorganics in Rheology Control, RSC, Burlington House, Piccadilly, London W1V 0BN T: +44 (0)20 7440 3388 F: +44 (0)20 7437 8883 E: moustrasm@rsc.org Info: www.rsc.org/lap/rsccom/dab/ind011.htm
2001	
14-15 Feb Hilton Head, SC US	72ND ANNUAL MEETING OF THE SOCIETY OF RHEOLOGY (SOR) Details will be added when available
2-3 Apr Bristol GB	STRUCTURE AND DYNAMICS IN SHEAR FIELDS - CALL FOR PAPERS Organised on behalf of the Colloid & Interface Science group of The Royal Society of Chemistry Dr I D Robb, North East Wales Institute, Mold Rd, Wrexham, UK T: +44 (0)1978 293133 F: +44 (0)1978 290008 E: robbi@newi.ac.uk
14-16 May Berlin DE	GOLDEN JUBILEE MEETING OF THE DEUTSCHEN RHEOLOGISCHEN GESELLSCHAFT (DRG) E: drg@bam.de
10-14 Jun Patras GR	3RD INTERNATIONAL MEETING OF THE HELLENIC SOCIETY OF RHEOLOGY – CALL FOR PAPERS Dedicated to the retirement of Prof Andreas Acrivos Deadline for submission of abstracts is 15 December 2000 Details will be added when available
23-27 Sep Melbourne AU	6TH WORLD CONGRESS OF CHEMICAL ENGINEERING Meeting Planners, 108 Church Street, Hawthorn, Victoria 3122, Australia T: +61 (0)3 9819 3700 F: +61 (0)3 9819 5978 E: chemeng@meetingplanners.co.au Info: http://www.meetingplanners.com.au/chemeng
21-25 Oct Bethesda, ML US	73RD ANNUAL MEETING OF THE SOCIETY OF RHEOLOGY Details will be added when available.
T: Telephone; F: Facsimile; E: Email; Info: WWW URL	

COURSES

2000	
6-10 Nov Glasgow UK	PROCESS RHEOLOGY Dr N E Hudson, Dept of Pure & Applied Chemistry, University of Strathclyde, 295 Cathedral St, Glasgow G1 1XL, UK T: +44 141 548 2162 F: +44 141 548 4822 E: n.e.hudson@strath.ac.uk
2001	
29 May – 1 Jun Loch Lomond UK	THEORETICAL, EXPERIMENTAL AND INDUSTRIAL ASPECTS OF RHEOLOGY Dr N E Hudson, Dept of Pure & Applied Chemistry, University of Strathclyde, 295 Cathedral St, Glasgow G1 1XL, UK T: +44 141 548 2162 F: +44 141 548 4822 E: n.e.hudson@strath.ac.uk
4-8 Jun Minneapolis, MN USA	26TH ANNUAL SHORT COURSE ON RHEOLOGICAL MEASUREMENTS: APPLICATION TO POLYMERS, SUSPENSIONS, AND PROCESSING Directed by Chris Macosko. Contact David Giles, University of Minnesota, Department of Chemical Engineering and Materials Science, 421 Washington Avenue SE, Minneapolis, MN 55455, USA T: +612 625 0880 F: +612 626 1686 E: giles002@tc.umn.edu
T: Telephone; F: Facsimile; E: Email; Info: WWW URL	

ONES THAT GOT AWAY...

2000	
Apr-May Odessa UA	SENSIBLE EXPERIMENT IN MATERIALS SCIENCE Chairman: Prof V Voznesensky DSc, PO Box 76, Main Post Office, Odessa, 65000, Ukraine E: vav@paco.net
7-12 May Orlando, FL US	SPE-ANNUAL TECHNICAL CONFERENCE (ANTEC 2000) SPE Conference Department T: +1 203 775 0471 F: +1 203 775 8490 Info: http://www.4spe.org/
9 May London GB	POLYMERS IN COLLOIDAL SYSTEMS SCI Conference Office, 14/15 Belgrave Square, London, SW1X 8PS T: +44 (0)171 598 1563 E: deborahn@chemind.demon.co.uk
22-26 May Minsk BY	4TH MINSK INTERNATIONAL HEAT AND MASS TRANSFER FORUM E: igur@hmti.ac.by
11-13 Jun Bath GB	SPECIALITY CHEMICALS IN INDUSTRIAL MINERAL PROCESSING Dr D Greenhill, ECC International Ltd, Par Moor Rd, St Austell, Cornwall, UK T: +44 (0)1726 818139 F: +44 (0)1726 818031 E: dave.greenhill@ecc.co.uk
T: Telephone; F: Facsimile; E: Email; Info: WWW URL	