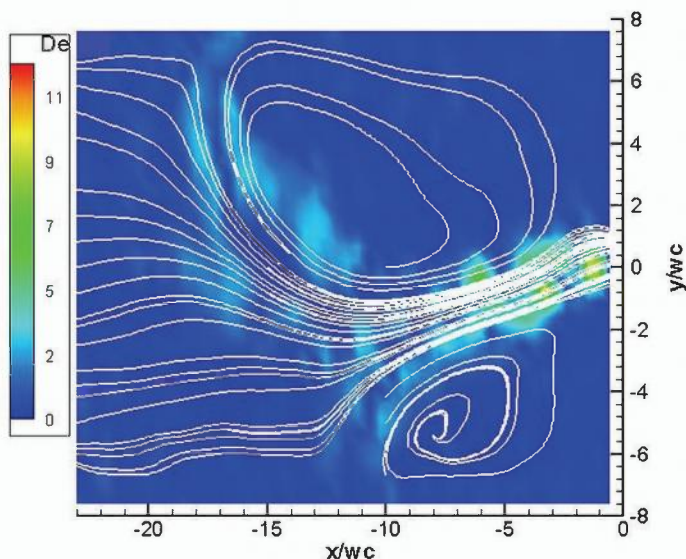


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EDITORIAL

SUBMISSIONS TO THE BULLETIN

Submissions to the Bulletin may be made by any practical means – post, email, disk, fax, pigeon, donkey, guide dog, *et cetera* but electronically is preferred (saves typing...). Most packages supported (Word, TeX, LaTeX, WordPerfect, ASCII, RTF) but always provide a contact name, address, e-mail, or telephone number in case of problems. The deadline for submission is Feb. 15th, June 15th and Oct. 15th, respectively, for three issues annually. As always, all contributions are gratefully received. Late copy can sometimes be accommodated, however the facilities of the BSR and ESR web sites may also be appropriate. Please contact the Editor (xue-feng.yuan@manchester.ac.uk) for details.

COVER ILLUSTRATION

Velocity field of an aqueous 0.5wt.% polyacrylamide solution ($M_w = 5 \times 10^6$ g/mol) through a 16:1 planar contraction microchannel with 400 μ m upstream width, 25 μ m downstream width and 50 μ m depth, at nominal *Weissenberg* and *Reynolds* numbers $Wi=96$ and $Re=0.22$, respectively. Elasticity number is $El=Wi/Re=436$. Local extensional deformation rates along streamlines are calculated from the velocity field. An image of Deborah number (De) map in a colour scale can be constructed as shown in the cover. It quantifies an instant pattern of starched polymer chains in complex flow. Courtesy from Alfredo Lanzaro (Alfredo.Lanzaro@postgrad.manchester.ac.uk), School of Chemical Engineering and Analytical Science, the University of Manchester, the UK.

We are always looking for appropriate images for the front cover of the Bulletin and Rheology Abstracts (preferably of a rheological nature!). Please contact either Xue-Feng Yuan (xue-feng.yuan@manchester.ac.uk) or Nick Hudson (n.e.hudson@strath.ac.uk). Contributions are always welcome!

AIMS OF THE SOCIETY

The way liquids flow and solids deform affects all aspects of life.

Extraction and processing of crude oil, moulding of plastics, use of toothpaste, spreading of margarine, painting and the lubrication of joints in the human body are all examples of processes depending upon rheological behaviour. Rheology is defined as the science of the deformation and flow of matter.

If your work is concerned with rheology in any way, then you have much to gain by joining the British Society of Rheology - publications, conferences and access to fellow members who, while working in a different discipline or industry, may be facing similar problems to yours. The Society is non-profit making and is registered as a charity.

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Different Experimental Methods in Stress and Strain Control to Characterise Non-linear Behaviour of Complex Fluids

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Abstract

The non-linear behaviour of complex fluids has been investigated by various experimental methods using different control modes. The results illustrate that such samples show a different response whether a periodic stress or a periodic strain is applied outside the linear visco-elastic region. A rheometer based on an air bearing supported electrically commutated synchronous motor with integrated torque measurement is shown to perform all tests in stress and strain control.

Various techniques have been proposed to characterize the cross over from linear to non-linear behaviour and the behaviour in the non-linear regime. A widely used method is the so-called Fourier Transform rheology in which not just the base wave but also the higher harmonics are measured in oscillatory testing. The rising of higher harmonics is associated with the onset of non-linear behaviour. However, no clear physical meaning can be attributed to the higher harmonics itself. A new theoretical framework as proposed recently by Ewoldt et al. [1] provides a quantitative analyzes of Lissajous figures during Large Amplitude Oscillatory Shear (LAOS). Their approach is based on the work of Cho et al. [2] in which a method is proposed to decompose the nonlinear response in LAOS conditions into elastic and viscous parts. Intra- and intercycle nonlinearities, strain-stiffening and -softening, and shear-thinning and -thickening are described and can be distinguished. The approach of Ewoldt et al. as most other published work on LAOS, both theoretical and experimental, is based on the assumption of a sinusoidal strain input $\gamma(t) = \gamma_0 \sin(\omega t)$. Experimental investigations following this assumption obviously require a rheometer, which is able to generate such an input function. Historically rheometers are used in which the strain input is applied to one side of the sample by a motor and the resulting stress is measured on the other side of the sample with a separate torque transducer.

With the paper from Ewoldt et al. as a starting point the following questions arise:

- Can the same formalism be used for a sinusoidal stress input as well?
- Can a rheometer with an EC-Motor and integrated torque measurement, i.e. without a separate transducer where the torque is a measure of the motor current, give the same results?

- Are the results the same for a sinusoidal strain and a sinusoidal stress input?
- Can the results be confirmed by data from other non-sinusoidal periodic functions?

In the linear regime an applied sinusoidal stress or a sinusoidal strain input reveal the same result and the same formalism can be used to calculate the relevant rheological properties. In the SAOS regime the elliptically shaped Lissajous diagrams have a strong symmetry, which is lost outside the linear visco-elastic range. The Lissajous diagrams for the LAOS regime still show point symmetry around the origin but the reflective or mirror symmetry is lost. This implies that in the LAOS regime it is not possible to calculate the properties for a sinusoidal stress input from the results of a sinusoidal strain input and vice versa. An extension of the existing framework to include sinusoidal stress input has been described in detail [3].

In the case of a sinusoidal strain input, Ewoldt et al. define minimum strain and maximum strain moduli and minimum rate and maximum rate viscosities. All four properties can be either calculated from the Fourier coefficients via Chebyshev polynomials or obtained as slopes in the respective Lissajous Figures. The ratio of the two newly defined strain moduli represents the intracycle strain stiffening ratio, whereas the ratio of the two viscosities is the intracycle shear thickening ratio. Similarly, small strain and large strain compliances as well as small rate and large rate fluidities are defined in the case of a sinusoidal stress input. The respective ratios are the intracycle stress softening and the intracycle shear thinning ratio [3].

In order to investigate the response of a complex fluid to either a sinusoidal strain or a sinusoidal stress input it is crucial that these input conditions are met. Otherwise the non-linearities are in both the stress and the strain and the outlined formalism is not applicable. It is therefore crucial to understand the working principle of modern rheometer.

The main components of a rotational rheometer are the motor with its supporting bearing system and the force measurement. Historically there are two principles used for research grade rotational drag flow rheometers [4]. In one a displacement or speed (strain or strain rate) is applied to the sample by the motor and the resulting torque (stress) is measured separately by an additional force sensor. In this type of instrument, which is commonly referred to as CR (controlled strain or controlled strain rate) rheometer or separate motor transducer system the electrical current used to generate the displacement or speed of the motor is not used as a measure of the electrical torque. With the other type of instruments, often called CS (controlled stress) rheometer or combined motor transducer system, a certain electrical current is applied onto the motor assembly. The current builds up a

magnetic field which produces an electrical torque resulting in a rotation of the drive shaft. In such a design there is no separate torque sensor needed, since the torque signal is directly calculated from the motor current. The movement of the motor shaft is measured by an angular displacement sensor, which in most types of CS rheometers is an optical encoder. Most CS rheometers are based on the so-called drag cup motor, which was already used in the first CS instrument, the Deer Rheometer build in 1968 [5].

In 1995 a rheometer based on a different motor system, an electrically commuted (EC) motor, sometimes also referred to as brushless DC-motor, was introduced [6]. In 2010 the fourth generation of rheometers employing this motor technology is now in use. From the principle of torque determination from the motor current this new rheometer resembles a classical control stress, or combined motor transducer system, but instead of a drag-cup motor it employs a fast and dynamic motor with a similar principle as is used in a classical strain or separate motor transducer system.

For a better understanding the motor principle is described in more detail.

An EC-motor is a direct current (DC) motor. In the EC-motor the rotor rotates synchronously with the rotating field on the stator, thus the name synchronous motor is often used to designate servo motors of this design. In the EC-motor the current is commutated electronically and there are no brushes or other mechanical contacts to excite the motor. Therefore, an EC motor is sometimes also called brushless DC-motor. The motor is excited by special permanent magnets with a high flux density located on the rotor. The permanent magnet poles on the rotor are attracted to the rotating poles of the stator by their opposite magnetic polarity. The magnetic poles of the stator are produced by an electric current flowing through a coil system located on the stator. The flux of the current carrying windings of the coil system rotates with respect to the stator. Like the DC motor, the current carrying flux remains in position with respect to the field flux rotating with the rotor. The major difference is that the synchronous EC motor maintains position by an electrical commutation, rather than mechanical commutation.

The torque is proportional to the strength of the permanent magnetic field and to the field created by the current carrying coils. The magnetic field in the stator rotates at a speed proportional to the frequency of the applied voltage. This is called a synchronous motor since the rotor rotates at the same speed, i.e. synchronously, with the stator field. The rotor field is produced by high energy permanent magnets, each one is mounted at a fixed position on the rotor disc. Since the positions, shapes and strengths of these permanent magnets are known, also the rotor field is well-known. The EC control makes use of this knowledge of the rotor field. Therefore, it is possible to adjust the electro-magnetical torque in such a way that it is linear to the total amount of the stator current, i.e. $M \sim I_s$. In this case a

change of the stator current will be followed by a change of the torque almost instantaneously. The strain or shear rate can be adjusted in a very fast way and without any overshoots. In combination with a high resolution optical encoder real strain and strain rate control is possible.

In a traditional strain rheometer a similar motor concept is used. In distinction to a traditional controlled strain rheometer no separate torque transducer is needed but the electrical current of the motor, I_s , is used as a measure of the torque. Like for CS rheometers both presetting and measuring of the corresponding properties are done from the same side of the rheometer. The described motor setup basically combines the advantage of both the traditional controlled strain rheometer with a fast motor control and the traditional controlled stress instrument with the ability to take the motor current as a measure of the torque.

In the case of a traditional CR-rheometer where the torque is measured separately from the motor the torque value is not influenced by the torque needed to accelerate the motor. In a setup which uses the motor current as a measure of the torque, the effect of accelerating the motor needs to be accounted for. The moment of inertia of a given mechanical system should be constant. However, effects like resonance, electro-magnetic couplings between stator and rotor, thermal expansion etc. can change the value of the moment of inertia. Using an EC-motor and its constant magnetic field on the rotor, the moment of inertia can be determined quite accurately for a given configuration. The actual value of the moment of inertia is considered by the electronics in the control mechanism. The set stresses in controlled stress mode or the measured stresses in controlled strain mode are the sample stresses and not like in a traditional controlled stress instrument the stresses calculated based on the total electrical torque the instrument applies. Using the actual moment of inertia value during the control mechanism also eliminates the resonance peak which often limits the frequency range of traditional controlled stress rheometers toward high frequencies. This was always integrated in the calculation of the rheological data points, i.e. for the full oscillation cycle information. However, it was not possible to access the real sample stress wave form but only the wave form of the total stress based on the electrical torque the rheometer applies. The capability of the rheometer has now been extended to provide the real sample stress wave form, which offers the possibility to do real intracycle LAOS investigations in strain and stress control.

Historically, CS rheometers are controlling the amplitude of the oscillation. In a controlled stress mode an instrument applies a sine wave with torque amplitude. However, when a strain controlled mode is used the instrument still applies a torque or stress sine wave.

Generally, a strain controlled oscillatory test in a CS rheometer consists of the following steps: applying one full oscillation cycle with an arbitrary stress amplitude, measuring the strain amplitude, adjusting the stress in the next oscillation cycle, and repeating this routine until the desired strain amplitude is reached. This method can be referred to as amplitude control. It has been shown earlier that rheometers with EC-motors are able to perform not just this traditional amplitude control, but they are able to carry out strain oscillation also with a real position or true strain control (Läuger et al. 2002). This oscillation technique was called Direct Strain Oscillation (DSO). DSO does not require a full (or even part of an) oscillation cycle but uses a real-time position control and adjusts to the desired strain directly on the sine wave. Therefore, the actual movement of the measuring system follows directly the required change in strain during each individual oscillation cycle. Since then the term DSO sometimes has been used also for the strain amplitude control methods. In this paper we use the expression DSO, as it was introduced, exclusively for the strain position control method.

Including DSO there are three different ways to perform an oscillatory test:

1. Stress control by applying a sinusoidal stress input and controlling the stress amplitude (controlled shear stress or CSS).
2. Strain control by applying a sinusoidal stress input and controlling the strain amplitude (controlled shear deformation or CSD)
3. Strain control by controlling the strain position during an oscillation cycle (direct strain oscillation or DSO) and therefore applying a sinusoidal strain input. In the following we will only consider the DSO (sinusoidal strain) and CSD (sinusoidal stress) methods.

A gel like 4% Xanthan gum solution has been used as a sample. Various MCR301 and MCR501 rheometers from Anton Paar with Peltier temperature control at 25°C and cone-and-plate geometries with 50mm diameter and a 1° cone angle has been employed.

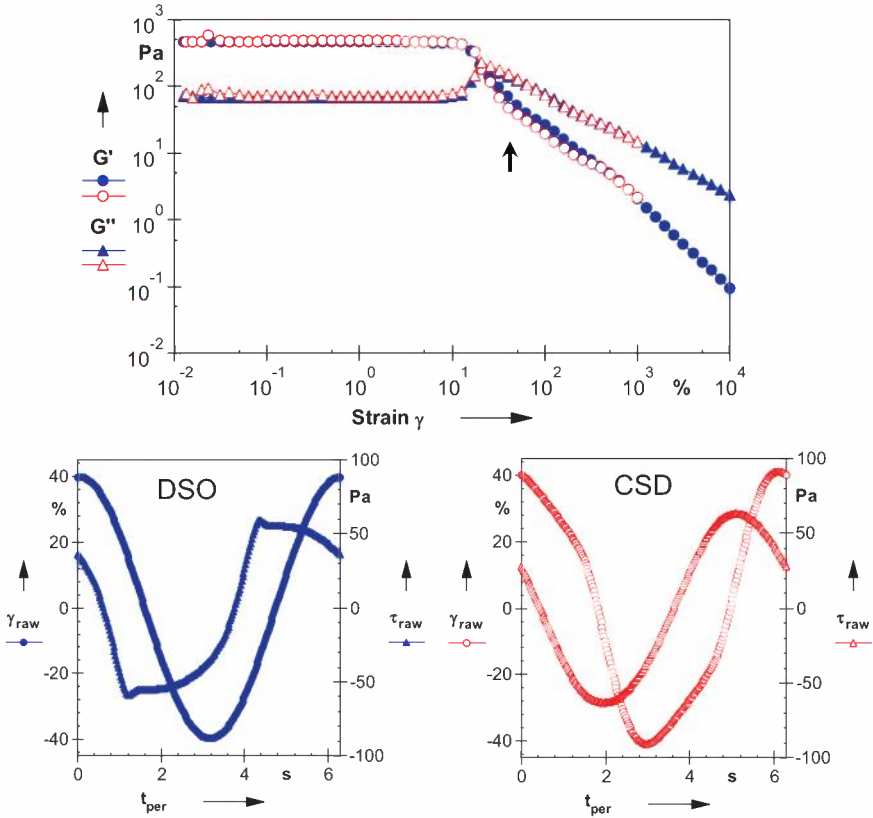


Figure 1. Top: Amplitude sweeps with DSO (closed symbols) and CSD (open symbols). Bottom: Strain and stress wave forms for DSO (left) and CSD (right) for the date point at 40% strain indicated by the arrow in the amplitude sweep diagram.

In Figure 1 amplitude sweeps with the DSO (sinusoidal strain) and the CSD (sinusoidal stress) methods are presented. In the linear region the results for both methods are the same. After leaving the linear region indicated by a decrease in G' a small but reproducible difference in the G' values can be observed. In the bottom of Figure 1 the wave forms of the strain and the stress at a strain of 40% are shown for the two oscillation methods. As can be seen the DSO method produces a perfect sinusoidal strain input wave and all non-linearities are in the stress response, whereas in the CSD method the input wave is a sinusoidal stress and the non-linearities are in the strain. Figure 1 therefore proves that the conditions of a perfect sinusoidal input functions in stress and strain are given.

The results also show that the response looks rather different when a sinusoidal stress or a sinusoidal strain is applied. In so-called Lissajous plots in which the stress is plotted versus the strain or versus the strain rate this finding can be further highlighted. In Figure 2 these plots are shown for both the DSO and the CSD method at a strain value of 40%. The plots for the two different input functions have significantly different shapes indicating a different response to a sinusoidal strain or a sinusoidal stress input.

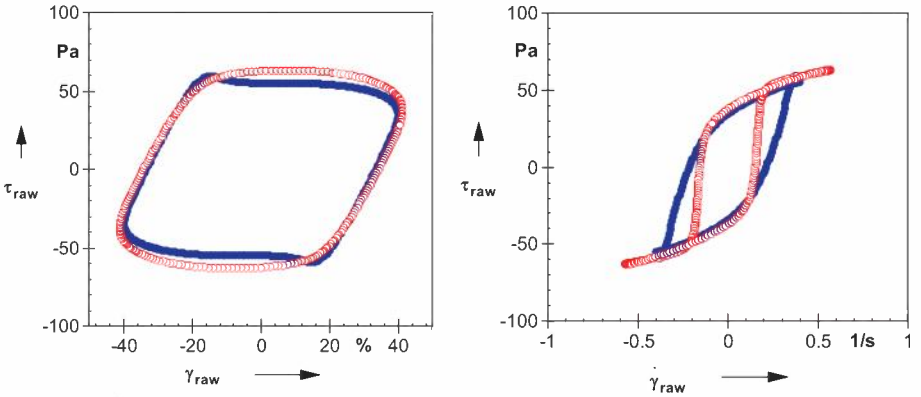


Figure 2. Lissajous-diagrams with stress versus strain (left) and stress versus strain rate (right) for DSO (filled symbols) and CSD (open symbols) methods at 40% strain.

The intra-cycle behaviour at various strains can be investigated by looking at Lissajous-plots with stress versus strain and stress versus strain rate as depicted in Figure 3. The data are normalized onto the base wave, i.e. the first harmonic. At small strains the sample behaves like a visco-elastic solid. The area within the ellipse of the stress/strain plot is small, i.e. the dissipated energy is small, whereas the area within the ellipse of the stress/strain rate plot is large, i.e. the stored energy is large. With increasing strain the area gets larger in the stress/strain plot (increasing dissipated energy) and the area in the stress/strain rate plots decreases (decreasing stored energy). With increasing strain the shape changes from an elliptical to a non-elliptical form indicating the cross-over from linear to non-linear behaviour.

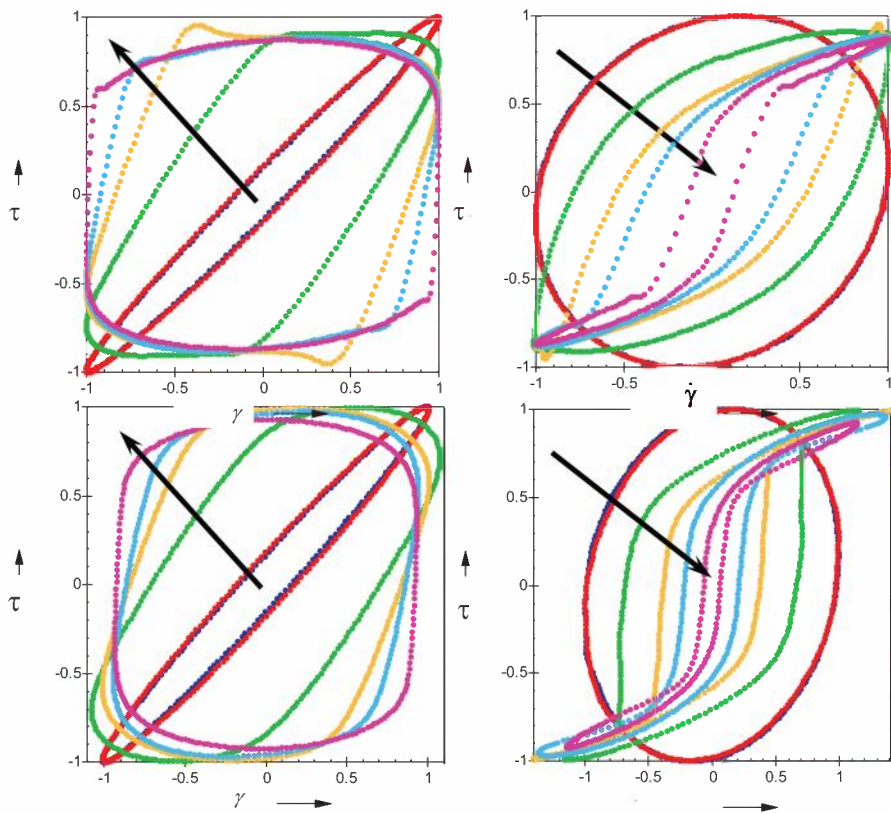


Figure 3. Normalized Lissajous-diagrams with stress versus strain (left) and stress versus strain rate (right). Sinusoidal strain (top) and sinusoidal stress (bottom) at 1, 10, 20, 40, 100, and 1000% strain. The arrows indicate the direction of increasing strain.

In the measurement with a sinusoidal strain input an extra peak occurs in the Lissajous presentation of stress versus strain for larger strains. This peak starts to evolve just after G'' reached its maximum at a strain of about 20%. The peak increases up to a strain of about 40%. The size of the peak is reduced at larger strains but still visible at strains up to 1000%. At strains for which the peak in the stress/strain plot is at or close to its maximum a kind of bow or loop is formed at the end of the elliptical figure in the stress/strain rate presentation. Both of these features the peak and the bow are not occurring in the measurements with a sinusoidal stress input.

As already discussed in Figure 1 the waveforms are also significantly different. In the sinusoidal stress input the stress shows a nice sinusoidal shape. All non-linearity is in the strain wave. The strain waveform is not sinusoidal but has a shoulder. On the other hand with a sinusoidal strain input, the non-linearity is in the stress response. The stress wave form shows the peak, which obviously is also present in the Lissajous figures. An interesting point now is that this peak is occurring with a sinusoidal strain input but not with a sinusoidal stress input. That means the structure forming (or structure destroying) process differs significantly depending whether a strain or stress input function is used.

In addition a quantitative analysis according to the formalisms for strain [1] and for stress [3] input reveals that at larger strain amplitudes the following intracycle behaviour occurs: strain stiffening and shear thickening for a sinusoidal strain input; also stress stiffening but shear thinning for a sinusoidal stress input.

This means that there are not just small quantitative differences, but the response of the sample to a sinusoidal strain input is qualitatively different compared to the response of a sinusoidal stress input. An possible explanation could be that in a situation with a strain input the sample has to follow exactly the commanded strain whereas in a stress input the sample can adapt its strain response to the stress by some sort of relaxation processes.

To further validate this finding and to be sure that the occurrence of this peak is not an artifact in the data treatment of the rheometer firmware during oscillatory measurements so-called cyclic loading tests with strain and stress input have been performed. The idea of the cyclic loading technique is to apply a periodic triangle function in strain or stress. Compared to the sinusoidal input functions, which are executed in the oscillatory mode of the rheometer, the triangle functions are programmed in the rotational mode. This means a strain (or stress) profile is applied and the responding stress (or strain) signal is recorded. There is no special analysis and in particular no Fourier transformation required to collect the data. Such cyclic loading tests in strain and stress confirm the results of the oscillatory tests for both the strain and the stress input, which means that the sample behaves differently whether a periodic strain or a periodic stress input function is applied.

Conclusions

The new LAOS framework from Ewoldt and coworkers has been extended to a sinusoidal stress input. The comparison of the samples response to stress and strain input functions shows significant differences. For a Xanthan sample the results differ significantly depending on the use of a sinusoidal stress or strain input. For a sinusoidal strain input the sample shows intracycle shear thickening, whereas a sinusoidal stress input leads to intracycle shear thinning. For both sinusoidal inputs

the results have been verified by cyclic stress and strain loading tests. This implies that complex fluids can behave differently whether periodic stress or periodic strain input functions outside the linear visco-elastic range are applied. For a strain input the sample has to follow the deformation control, whereas it can adapt its movement to a force input for a stress input. This will result in stronger nonlinearities for a strain input compared to a stress input.

A rheometer based on an air bearing supported electrically commutated (EC) synchronous motor offers true controlled strain and controlled stress in rotational and oscillatory testing. This is needed to quantitatively measure the different response of complex fluids to periodic strain and periodic stress inputs.

References

1. Ewoldt RH, Hosoi AE, McKinley GH; *J. Rheol.* **52**, (2008)1427-1458
2. Cho KS, Hyon K, Ahn KH, Lee SJ; (2005) *J. Rheol.* **49**, 747-758
3. Lauger J, Stettin H; *Rheo Acta* (2010) to be published
4. Macosko CW (1994) *Rheology: Principles, Measurements, and Applications*. (Wiley-VCH, New York, 1994)
5. Davis S, Deer JJ, Warburton B (1968); *Sci. Instrum. (J. Phys. E)* **1**, 933-936
6. Lauger, J, Huck S, (2000), *Proceedings of the XIIIth International Congress on Rheology*, Cambridge, UK, **3**: 10-13
7. Lauger J, Wollny K, Huck S; *Rheol. Acta*, **41**, (2002) 356-361

BSR NEWS

Report I on the 6th AERC 2010, Göteborg, Sweden

The 6th Annual European Rheology conference was held in the picturesque harbour city of Göteborg, on the west coast of Sweden. The AERC provides a meeting place where academic and industrial rheologists can share new science and technical developments, and discuss, develop and cooperate on common themes. This year's conference was the biggest yet, with over 430 participants and 7 parallel symposia. The conference was hosted at the Chalmers University of Technology and organised by the Nordic Rheology Society, with Mats Stading at the helm.

Following a welcome address by Mats and the vice chancellor of Chalmers, the packed lecture hall was treated to an inspiring talk by one of the greats of the field, Prof. David V. Boger FRS. Entitled "Environmental Rheology", Prof. Boger's talk highlighted the importance of rheology in the treatment of mining waste, and the environmental travesties that result from poor waste management. It was an eye-opening and evocative talk, and was passionately delivered, leaving delegates with much to think about.

Prof. Ole Hassager gave the second AERC plenary lecture the following day. This was his second in a row, after speaking at the AERC in Cardiff the year before, where he received the prestigious Weissenberg award. Prof. Hassager discussed the use of the mean span dimension in measuring polymer size. Inspired by Buffon's needle problem, we were reminded that thoughtful application of simple mathematics can provide remarkable insight.

There was a wide range of talks on a number of different topics in rheology, highlighting the all-encompassing scope and the importance of rheology to society. As a computational rheologist, my interest was slightly skewed towards the modelling and simulation side. Manfred Wagner gave an extremely interesting keynote lecture on the recent progress in the modelling of polymer melts. The introduction of an inter-chain tube pressure has allowed the development of tube models which better model the experimental data of linear polymer melts. The current president of the BSR, Oliver Harlen, also presented some impressive results in his keynote lecture on jet break up of polymer solutions in inkjet printing. Simulations showed that the character of jet break up is significantly affected by the presence of polymers, and his results showed good agreement with experiment. I also particularly enjoyed a talk by Y. J. Choi, a student of Martien Hulsen, on simulating two-particle interactions in viscoelastic fluid and Rob Poole's talk on the appearance of elastic instabilities in lid-driven cavities.

The atmosphere throughout the conference was enthusiastic and friendly. I had the opportunity to meet rheologists from many different backgrounds and to discuss their and my own research. The poster sessions (to which I contributed) contained many high quality posters on a range of topics, and were also a source of discussion and debate.

Throughout the conference, delegates were treated to the very best in Scandinavian hospitality. A welcome reception in Göteborg's splendid town hall was held on the first night and an excellent conference dinner at the Park Avenue Hotel the following night. The after dinner speeches were particularly enjoyable; the image of David Boger sporting a fez and Ole Hassager holding a giant red balloon will stand out in my mind for some time. The after dinner salsa lessons were also a memorable, and quite surreal, conclusion to the evening!

The AERC 2010 was a fantastic opportunity to meet and discuss research with fellow rheologists and to learn of the latest advances in the field. It was well organised and the lovely city of Göteborg proved an excellent host. I wish to thank the British Society of Rheology for awarding me a student travel grant, making the visit possible.

Steven Lind
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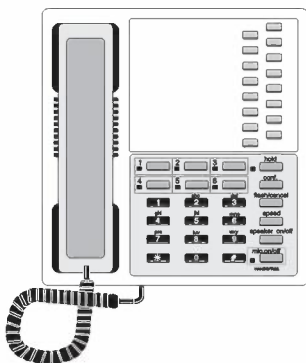
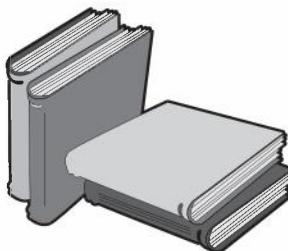
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If you do not wish to be an Abstractor, but find an interesting article which contains some rheology, please pass it on to me, so that it can be included in Rheology Abstracts.



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Report II on the 6th AERC 2010, Göteborg, Sweden

The 6th Annual European Rheology Conference was held on 7th-9th, April, 2010 in the beautiful city of Göteborg (Sweden). AERC 2010 provided a fabulous opportunity for nearly 450 rheologists both in academia and industry to share new scientific and technical developments, and to discuss, develop and cooperate on common themes.

The conference covered a wide range of research activities, including complex fluids (polymer melts and solutions, food, bio-fluids), emulsions, foams and solid rheology, dispersion rheology, interfacial rheology, complex fluid flow dynamics, microrheology and microfluidics and a wide range of practical applications. The program consisted of two plenary lectures, twelve keynote lectures, numerous oral presentations and two poster sessions.

David Boger (University of Melbourne) opened proceedings with an impressive plenary lecture on environmental rheology, concentrating on the management of mine waste (tailings) that can result in severe and long term environmental and social consequences if poorly managed. The dewatered waste, exhibits non-Newtonian behaviour, such as shear-thinning, a yield stress and thixotropic behaviour. These properties allow the dewatered waste to flow in a pipe and can be exploited to improve waste disposal techniques. The volume of waste is minimized and the chances of toxic run off and floods reduced.

In the applied rheology session, Norbert Willenbacher (Karlsruhe Institute of Technology) gave a keynote lecture with the title “Capillary breakup elongational rheology (CaBER): beyond the cylindrical filament case”. For example, concentrated suspensions or emulsions form concave filaments and the elongation rate varies in time and position along the filament. Yield stress fluids in particular exhibit strong necking and filament thinning. He addressed the interpretation of these CaBER results by using a full three-dimensional simulation and a sophisticated optical experimental system. The transient neck diameter, transient curvature at the neck and the region of deformation were correlated with the shear rheological data. In addition, he proposed approaches to determine the elongational yield stress.

In the session on modelling, simulation and computational rheology, I particularly enjoyed the keynote lecture entitled “Jet break-up of polymer solutions in inkjet printing”, given by Dr. Oliver Harlen (University of Leeds). By using the FENE dumbbell constitutive equation, the parameter values controlling the break-up length and character of jet break-up can be established. The numerical results successfully show the production process of small satellite droplets, which are detrimental to practical ink-jet applications. Furthermore, by using Zimm theory to

predict the parameter values in the FENE model, the numerical results quantitatively agree with experimental results. This work is significant to our understanding of how solutions of high molecular weight polymers affect the ink-jet process.

There were only a few presentations on microrheology and microfluidics in this conference. Manlio Tassieri (University of Glasgow) presented an experimental procedure demonstrating broadband microrheological measurements with optical tweezers. Monica Oliveira (Faculdade de Engenharia da Universidade do Porto) gave a talk on elastic-driven instabilities in microfluidic flow-focusing devices, in which two types of instability were observed. Christopher J. Pipe (Chinese Academy of Science) utilized the microfluidics with solutions of wormlike micelles to investigate viscoelastic flow near two stagnation points (one is compressive and one extensional) on a cylindrical obstacle. The measured velocity data demonstrated that the flow is governed by a characteristic deformation rate and illustrated the formation of the long-tail-like wakes.

My poster entitled “How geometric conditions affect the non-linear dynamics of semi-dilute polymer solutions in micro-fluidics” concentrated on quantitatively analyzing the flow transitions in various geometric conditions. Both the upstream and downstream geometric conditions are significant in governing the elongational deformation of polymer solution in entry flow. My work attracted considerable interests among academic researchers.

My attendance at AERC 2010 was a special opportunity for me to exchange ideas and expertise with other researchers and experts from around the world. I would like to thank the BSR and TA Rheometric for awarding me the poster prize in last year BSR mid-Winter meeting, which made my attendance at AERC possible.

Zhuo Li
Manchester Interdisciplinary Biocentre
School of Chemical Engineering and Analytical Science
University of Manchester, the UK
16th April 2010

Commentary on the 329th Council Meeting of the BSR The Lake Vyrnwy Hotel, March 31st 2010

The 329th meeting of BSR Council was held at the Lake Vyrnwy Hotel immediately following the INNFM Easter meeting - so starting at lunchtime on 31st March. There was initial confusion (there often is!): the meeting started with most of Council but no lunch, and about 10 minutes later the rest of Council turned up to tell us that lunch was in the other building. Hasty removals ensued.

Another regular feature of Council meetings at the moment was an instant rejigging of the order of the agenda. This time, Mike Webster (who's stepped down from Council proper but still liaises between us and the ESR, of which he is the Treasurer) had been invited to attend the meeting just for a couple of items: so they were bumped to the top of the agenda. The major item was the relationship between the BSR and ESR. There are strong and healthy links between the two organisations, but working out where we stand in relation to one another is a constant dance. The ESR has a new president, Chris Gallegos, which means its emphasis will be shifting slightly. Mike was keen for us to show our commitment to the ESR by looking at ways we could work more closely together, in particular through our web presence. There was a lot of discussion of various options, some being discarded as too expensive in the current climate, and others as too much work for now but possible later; in the end we agreed that we ought to be linking the two websites much more. The ESR has a very good listing of conferences, for example, which we should link to instead of struggling to produce our own version; and the ESR website should link directly to ours (rather than having its own BSR page).

Once Mike had departed, we settled down to the rest of the agenda at breakneck speed because we could see the snow coming in over the lake and no-one fancied an extra unscheduled night in mid-Wales! We spent a while discussing possible candidates to be the next President of the BSR (discussions which must obviously remain confidential); and rather longer talking about Rheology Reviews, and the articles in hand for the 2009 issue. Once the Royal Society of Chemistry takes over the production and publication of Rheology Reviews, it won't be an annual publication; instead issues will come out when the reviews are in. But in the meantime, RR2009 needs to appear, and this is occupying a lot of our President's time right now.

The mildly amusing moment of the meeting came from the previous day's AGM, at which Chris Petrie had revealed a windfall of around £5,000 in a supposedly dormant bank account. David Binding (as outgoing Treasurer) explained what had happened. The account had been opened for the International Congress of Rheology in Cambridge in 2000; at the end of that meeting the balance had been

transferred into our normal accounts and the account ignored. It turns out that some organisations, once they have bank details on file headed "BSR", simply re-use them regardless of any details printed on the invoice they're supposed to be paying. So various payments for meeting attendance and advertising had magically appeared in this account over the last 10 years: we will now reclaim it but we won't close the account (who knows what might appear there in the next 10 years!).

We did have time to discuss a few other things - mostly regular items like invoicing manufacturers for their advertising (pretty dull if you're not on Council), and forthcoming scientific meetings (covered elsewhere in the Bulletin) but we managed to finish the meeting in a record 2 hours and I think we all got home without getting stuck anywhere. Next time we'll meet in Oxford in September, and because the September meeting is not attached to a scientific meeting, we should be able to cover the agenda in the approved order and at a saner speed.

Honorary Secretary:

Dr H. J. Wilson (secretary@bsr.org.uk)



An excellent conference dinner speech given by Professor A. Jeffrey Giacomini in the INNFM/BSR Easter meeting at the Lake Vyrnwy Hotel on the 30th of March 2010 was enjoyed by all participants.



More photos taken in UWINNFM Easter Meeting at the Lake Vyrnwy Hotel
in March 29-31, 2010.



The Non-Newtonian Club (NNC) is an informal rheology discussion group which provides low-cost, informal, one-day meetings which provide an excellent forum for industrial and academic rheologists to meet together informally to present work in progress, raising key needs and concerns, and discussing unresolved practical and modelling issues that may be inhibited at more formal conferences. The agenda of the most recent BSR NNC meeting and the corresponding abstracts can be found at <http://innfm.swan.ac.uk/bsr/frontend/nonnewtonianclub.asp>.

The Non-Newtonian Club Meetings are held 2 - 3 times a year and provide a forum for those practicing rheology to meet. Presentations (typically 20-30 minutes) are made by academic and industry-based scientists, as well as young scientists, presenting on a range of topics that involve rheology in a relatively informal and friendly environment. To encourage phd students and 'young' scientists to present, we offer an award for the best presentation from phd students or 'young' scientists. We endeavour to keep these meetings free. Should you wish to host, sponsor, or participate in such an event, please let me know.

The next NNC meeting will take place in Imperial College sometime this year. We are still looking for speakers from anyone involved with rheology as long as their material relates to the subject. Attendance is free of charge and includes tea/coffee and lunch. The best young speaker will receive a prize sponsored by Anton Paar. For further information visit the BSR website or contact Dr Bettina Wolf at bettina.wolf@nottingham.ac.uk.

Dr Bettina Wolf
BSR Industry and Non-Newtonian Club Coordinator

BSR 2010 Midwinter Meeting
Food, Pharma, Health Care and Biological Systems
December 13 and 14, 2010
The University of Nottingham

Organising committee:

- Bettina Wolf (Food Sciences, University of Nottingham)
- Oliver Jensen (Applied Mathematics, University of Nottingham)
- John Mitchell (Biopolymer Solutions, Sutton Bonington)
- Steve Goodyer (Anton Paar)
- Mrs Val Street (meeting secretary)

Invited speakers:

- **Tim Foster**, Cellulose based materials
- **Chris Holland**, Spinning silk
- **Oliver Jensen**, Rheological aspects of plant cell expansion
- **Malcolm Mackley**, The rheology of starch based swallowing fluids and the way these fluids behave in a model mechanical "Cambridge Throat"
- **Pete Wilde**, Interfacial rheology of food materials
- **Ian Wilson**, Rheology and Marmite™
- **Gleb Yakubov**, Surface architecture, lubrication and nanorheological properties of mucins and mucosal bio fluids

Invitation for contributions:

This BSR Midwinter Meeting will shortly open for abstract submission for oral and poster contributions. Applicants for poster contributions will be allocated a short slot on day 1 to introduce their poster. The traditional poster prize will be awarded and the winner will have the opportunity to give a brief talk on day 2.

Registration: Will open shortly.

Directions: Information will follow shortly.

Accommodation: Main conference hotel will be in Kegworth, public transport to the campus is available. Details will be made available when registration opens.

Please check <http://www.bsr.org.uk/> for further news.

UNIVERSITY OF WALES
INSTITUTE OF NON-NEWTONIAN FLUID MECHANICS
Portmeirion Hotel, Gwynedd, U.K.

April 18 - 20, 2011

Programme

In 2011, the UWINNFM will be celebrating its 20th birthday. To mark the occasion, we have booked all the accommodation at the Portmeirion Village and Castle complex (www.portmeirion-village.com) from April 18–20.

The meeting will commence at 12 noon on Monday April 18th and finish at lunchtime on Wednesday April 20th. The theme of the meeting will be “**Non-Newtonian Fluid Mechanics – Progress and Challenges**”.

In normal circumstances, costs at the Portmeirion complex are very high. However, we have been able to negotiate a reasonable financial arrangement with the hotel and, on this special occasion, the UWINNFM will supplement the costs so that they are kept to those for the 2010 Lake Vyrnwy meeting, i.e. £400 for participants and £150 for accompanying persons.

Two of the three speakers at the inaugural 1991 meeting in Swansea, Professors Marcel Crochet and Anthony Pearson, have agreed to lecture at the Anniversary Meeting. The background and history of the UWINNFM will be outlined in a lecture by Professor Peter Townsend (Swansea).

Other speakers who have agreed to give Plenary Lectures include:

D. Baird (Virginia), A. Burbidge (Nestle), R. Buscall, S. Cox(Aberystwyth), I. Emri (Slovenia), G. Fuller (Stanford), C. Gallegos (Spain), J. Giacomini (Madison), O. Harlen (Leeds), J. Hyun (Korea), D. James (Toronto), R. Keunings (Belgium), J. Maia (Cleveland), G.Maitland (Imperial College), O. Manero (Mexico), G. McKinley (MIT), J. Mewis (Belgium), P. Moldenaers (Belgium), S. Muller (Berkeley), T. Phillips (Cardiff), P. Slatter (Melbourne), R. Tanner (Sydney) and M. Wagner (Germany).

Venue: Portmeirion is an Italianate village, the creation of architect Sir Clough Williams-Ellis, which stands on its own private peninsula overlooking the Snowdon mountain range and the sea. It can be reached from London, Liverpool and Birmingham by road and from London and Birmingham by rail. (Portmeirion is about 1.5 km. from Minffordd, which is a station on the British Rail network).

Costs: The total cost of £400 includes the registration fee and full-board accommodation from Monday lunch to Wednesday breakfast. An accompanying person, sharing a room with a conference delegate, will be required to pay £150.

UNIVERSITY OF WALES
INSTITUTE OF NON-NEWTONIAN FLUID MECHANICS
Portmeirion Hotel, Gwynedd, UK.

April 18 – 20, 2011.

Prospective speakers should return this form, together with appropriate payment and a 200 word Abstract, no later than February 1st, 2011.

Block letters throughout please

Title.....

Surname

Forename(s)

Organization

Full address.....

.....

Tel Fax Email

- ☐ I wish to attend the conference and I enclose a cheque for £400 made payable to the University of Wales Institute of Non-Newtonian Fluid Mechanics.
- ☐ I shall be accompanied by and I enclose a cheque for £150 made payable to the University of Wales Institute of Non-Newtonian Fluid Mechanics.
- ☐ I wish to present a paper and I enclose an Abstract.

Please return this form to Mrs Nerys Humphries, Vice-Chancellor's Office, University of Wales Registry, King Edward VII Avenue, Cathays Park, Cardiff CF10 3NS, UK. Full information can also be obtained from Prof. Ken Walters (kew@aber.ac.uk) or Prof. Peter Townsend (P.Townsend@swansea.ac.uk).

INDUSTRY NEWS

Thermo Fisher Scientific Inc

Thermo Fisher Scientific Launches New Suite of Micro-Conical Twin-Screw Compounders

Thermo Fisher Scientific Inc. has launched the Thermo Scientific HAAKE MiniCTW, the latest model in a suite of micro-conical twin-screw compounders. These machines feature several models that serve a variety of markets, including polymer, bioscience, nanotechnology and pharmaceutical.

All models use as little as 5 grams or 7 milliliters (ml) of material for compounding, which is especially beneficial for industries that compound expensive or small-scale materials such as nano-composites, bio-polymers or pharmaceuticals. By using the optional force feeder, customers can continuously extrude very small material volumes. The instrument is based on proven, conical twin-screw technology with co-rotating and counter-rotating screws, and works as a standalone unit with data export. The residence time is well-defined due to the channel and a bypass valve.

The Thermo Scientific HAAKE MiniCTW is ideal for the precisely controlled reactive extrusion of high-viscous melts. By running the instrument in circulation mode, the required reaction time for the reactive mixture can be easily controlled. At the end of the test, the bypass valve can be opened and the sample extruded as a strand. By measuring the torque of the drive motor, the reaction process can be monitored effectively.

Features and benefits of the new suite of micro-conical twin-screw compounders include:

- Requires only 7 ml of material for compounding
- Removable top barrel for easy and quick cleaning
- New software for user-friendly process monitoring
- Various models serving a breadth of applications (from polymers to pharmaceuticals)

Thermo Fisher Scientific Collaborates with the Institute for Fluid Mechanics at the Dresden University of Technology

Thermo Fisher Scientific Inc. works closely with the Institute for Fluid Mechanics at the Dresden University of Technology to provide rheology training for its students. As a result of this collaboration, various practical experiments based on

the Thermo Scientific HAAKE Viscotester 550 viscometer are now available to all interested rheology customers.

Rheological investigations are becoming increasingly important for the development and quality control of new products ranging from low-viscosity eye drops to solid polymer bodies. This makes early training all the more important to gain an understanding of rheological phenomena. Thermo Fisher's "introduction to rheology" training package offers a special configuration of the HAAKE Viscotester 550 viscometer as well as instructions for two practical experiments. The package is focused on schools, vocational schools, universities and companies that provide training. In addition, advice and examples of results are provided for instructors. A day of training for an instructor as part of the Thermo Fisher Scientific seminar program rounds out the training package.

"During student training, rheological measurements in studies are conducted using rotating viscometers such as the HAAKE Viscotester 550. The device is ideally suited to practical experiments, and its easy operation using predefined internal routines or software makes it possible to train multiple users quickly," said Prof. Odenbach, head of the Department of Magneto-Fluid Dynamics at the Dresden University of Technology's Institute for Fluid Mechanics, who developed the practical experiments used in the training. "We use instruments such as the Thermo Scientific HAAKE MARS for more complex rheological measurements. It is a modular rheometer platform with numerous attachments that offers the advantage of being able to make individual adjustments to a wide range of applications."

Advantages of the training package at a glance:

- A robust and reliable rotating viscometer with predefined, internal routines
- Cylinder measuring geometry for medium-viscosity tests, expandable with optional measuring geometry (e.g. plates, cones, rotary or hanging cylindrical bodies)
- User-friendly Thermo Scientific HAAKE RheoWin measurement and evaluation software for beginners or experts and free updates at www.thermoscientific.com/mc
- Documentation consisting of an introduction to the basics of rheology and the description of two practical experiments, including advice for instructors
- Optional participation in further training for an instructor to provide a basic understanding of rheology or refresh existing knowledge

Anton Paar

New Furnace Rheometer System (1600°C)

Anton Paar have launched the FRS1600 rheometer which is capable of rheological measurements at temperatures up to 1600°C. This is a specialized instrument which will be useful in measuring the flow of metals, glasses and ceramics as well as more unusual materials such as lava. As with all systems from Anton Paar the system is extremely modular and comes with a range of heads incorporating both mechanical and air bearings. Standard measuring systems are made from aluminium oxide but can also be custom made to user requirements. The integrated furnace is controlled from the rheometer software and is housed inside a safety cage.



Minature Mixing Device for MCR series of Rheometers

Working in collaboration with Expansion Instruments Anton Paar are pleased to offer customers of the MCR series the XIM mixer. This accessory enables the study of mixing effectiveness with sample volumes of less than 5ml. As well as being used to evaluate polymeric blends the XIM will also be utilised for nanocomposites and foodstuffs such as dough. Rheological results on materials mixed with the XIM superpose with data for materials mixed on much larger scale mixing devices. The accessory has been thoroughly tested using MCR rheometers.

For further information on the FRS1600, XIM mixer or LAOS discussed in Joerg Laugers article please contact steve.goodyer@anton-paar.com, or telephone Anton Paar on (01992) 514730 or visit www.anton-paar.com.

Malvern Instruments

Malvern Instruments acquires assets of Reologica Instruments AB

Malvern Instruments Limited (Malvern, UK) has acquired certain assets of Swedish rheology company Reologica Instruments AB (Lund, Sweden), which went into administration on 23rd March 2010. Financial terms have not been disclosed.

Paul Walker, Managing Director of Malvern Instruments, said: “This purchase gives Malvern access to additional technologies and intellectual property that will support the continued development of our own rheology business.”

“Reologica Instruments has been involved in the design and manufacture of rheometers and associated accessories for more than 20 years and there is a wealth of knowledge in the business. We anticipate that key members of the Reologica team will transfer as a result of the deal.”

“Malvern has a global reputation not only as a manufacturer of world-class materials characterization systems, but also for the support that we provide to our customers. We will endeavour to support existing users of Reologica systems wherever we can.”

Existing Reologica customers should contact:

Phone: +44 (0) 1684 891800

E-mail: helpdesk.reologica@malvern.com

Malvern speaker takes ‘Extreme Rheometry’ theme at MACRO 2010

Polymer scientists and engineers attending the 43rd IUPAC World Polymer Congress; Macro 2010, on 11-16 July at the SECC in Glasgow, Scotland will have the chance to hear Dr Samiul Amin from Malvern Instruments present: ‘Extreme Rheometry of Entangled and Network Forming Polymers: An Optical Microrheology and LAOS (Large Amplitude Oscillatory Shear) Study’. His presentation discusses the characterization of links between non-linear rheological response and underlying microstructure and dynamics in complex fluids.

A highly effective analytical tool, rheology provides insights into the underlying structure of materials such as polymers and can uncover links between structure and aspects of performance, such as processing, lubrication, adhesion, product dispersibility, and drug release profiles. However, proper application of rheology to expose structure-performance links is often limited by the highly specialised knowledge and expertise needed to relate experimental data to a material’s microstructural characteristics through theoretical models. By adopting an Expert System Rheometry approach when designing its Kinexus rheometer, Malvern is addressing these issues. Conference attendees will have the opportunity to examine a poster entitled: ‘Engineering The Next Generation of Nanostructured Complex Fluids Through Expert System Rheometry’ outlining the novel solution that lies at the heart of Kinexus.

CONFERENCE DIARY

2010	CONFERENCES & MEETINGS
11-16 July Glasgow	IUPAC 2010 World Polymer Congress (Macro2010) Contact: Professor Peter A. Lovell, School of Materials, the University of Manchester, email: pete.lovell@manchester.ac.uk ; Tel: +44(0)161 306 3568; Fax: +44(0)161 306 3586.
1-6 August Sapporo Japan	5th Pacific Rim Conference on Rheology Hokkaido University, Sapporo, Hokkaido, Japan Conference Website: http://prcr2010.com
5-11 Sept Porotoro □ Slovenia	MTDM'2010 - 7-th International Conference on Mechanics of Time-Dependent Materials Petra Jakovac cem@fs.uni-lj.si or http://www.mtdm10.si/
8-10 Sept Cape Town South Africa	SASOR 2010 3rd Rheology Conference Dr Veruscha Fester festerv@cput.ac.za ; http://www.sasor.co.za
18-22 Oct. New Mexico USA	82nd Annual Meeting of the Society of Rheology Conference Website: http://www.rheology.org
13-14 Dec University of Nottingham	BSR Midwinter Meeting 2010 Dr Bettina Wolf (Food Sciences, University of Nottingham) Bettina.Wolf@nott.ac.uk or http://www.bsr.org.uk/

2010	COURSES & WORKSHOPS
14 - 15 July Loughborough UK	RHEOLOGY WORKSHOP Steve Goodyer, Anton Paar Ltd, 13, Harforde Court, John Tate Road, Hertford, SG13 7Q T: +44 (0)1992 514730; F: +44 (0)1992 514739 E: steve.goodyer@anton-paar.com
1 - 2 Dec Bradford UK	RHEOLOGY WORKSHOP Steve Goodyer, Anton Paar Ltd, 13, Harforde Court, John Tate Road, Hertford, SG13 7Q T: +44 (0)1992 514730; F: +44 (0)1992 514739 E: steve.goodyer@anton-paar.com
2011	
17-20 May Glasgow Scotland	PROCESS RHEOLOGY: For further information, contact Dr N E Hudson, Dept of Pure & Applied Chemistry, University of Strathclyde, 295 Cathedral Street, Glasgow G1 1XL. Tel: +44 141 5482162; Fax: +44 141 5484822; e-mail: n.e.hudson@strath.ac.uk



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