

THE BRITISH SOCIETY OF RHEOLOGY

BULLETIN



March 1992

1992, Vol. 35 No 1

CONTENTS

Officers and Members of Council	ii
Editorial	iii
Investigation of acacia, collagen and limulus amoebocyte lysate as standard film formers for use in surface rheometry: A. K. Nithiananthan	1
Fluid dynamics of drilling and completion	11
News of other Societies	13
Transparency in rheometer operation and computer software	14
Scholarships and grants 1992	16
North Midlands Group	17
Commentary: 268th Council Meeting	18
The Scott Blair Collection	21
Recently Published Books	27
Membership News	28
Obituary: Dr Robert Roscoe	29
Conference Announcements	30

Hon. Editor

Dr P. F. G. Banfill,

School of Architecture & Building Engineering,

University of Liverpool,

P. O. Box 147, Liverpool L69 3BX.

ISSN-0045-3145



THE BRITISH SOCIETY OF RHEOLOGY
OFFICERS AND MEMBERS OF COUNCIL
1991/92

- President:** Dr D. C-H. Cheng, 191, Icknield Way, Letchworth, Herts SG6 4TT.
Tel.: 0462-672146.
- Secretary:** Mrs C. A. Moules, Krüss UK Ltd., 5/6 Carrington House,
37 Upper King Street, Royston, Herts SG8 9AZ.
Tel.: 0763-244280 Fax: 0763-244298.
- Treasurer:** Mr P. C. Anderson, 32 Queensway, Feltham, Middlesex TW13 7NS
Tel.: 081-890-6586.
- Membership Secretary:** Dr D. J. Hourston, The Polymer Centre, University of Lancaster,
Bailrigg, Lancaster, Lancashire LA1 4YA.
Tel.: 0524-65201 Fax: 0524-63806 Telex: 65111 LANCUL G.
- Abstracts Editor:** Dr G. J. Brownsey, AFRC Institute of Food Research,
Norwich Laboratory, Colney Lane, Norwich, NR4 7UA.
Tel.: 0603-56122 Telex 975453 FRINOR G.
- Bulletin Editor:** Dr P. F. G. Banfill, School of Architecture & Building Engineering,
University of Liverpool, P. O. Box 147, Liverpool L69 3BX.
Tel.: 051-794-2619 Fax: 051-794-2605 Telex: 627095.
- Ordinary Members:** Dr R. Buscall, Imperial Chemicals Industries PLC,
Corporate Colloid Science Group P. O. Box 11, The Heath,
Runcorn, Cheshire WA7 4QE.
Tel.: 0928-513632 Fax: 0928-576675 Telex: 629655 ICIMOH G.
- Mr R. E. Carter, Polymer Laboratories Ltd, The Technology Centre,
Epinal Way, Loughborough, LE11 0QE.
Tel.: 0509-233300 Fax: 0509-234905 Telex: 341383
- Dr A. Evans, The Compression Chamber,
Royal Victoria Infirmary, Newcastle-upon-Tyne NE1 4LP.
Tel.: 091-281-2081.
- Dr N. E. Hudson, Department of Pure & Applied Chemistry,
University of Strathclyde, 245 Cathedral Street, Glasgow G1 1XL.
Tel.: 041-552-4400 Fax: 041-552-5664 Telex: 77472.
- Dr M. R. Mackley, Department of Chemical Engineering,
University of Cambridge, Pembroke Street, Cambridge CB2 3RA.
Tel.: 0223-334784 Fax: 0223-334748 Telex: 81240 CAMSPL G.
- Prof. P. Townsend, Department of Maths and Computer Science,
University College Swansea, Singleton Park, Swansea SA2 8PP.
Tel.: 0792-295398 Fax: 0792-295532 Telex: 48358 ULSWAN G

I am pleased to be able to include in this issue an article by Ahilan Nithiananthan, our Pergamon Biorheology Scholar. While the work was finished some time ago, publication has been delayed because of Patent procedures, but it is gratifying to see the fruits of the Society's efforts to encourage younger workers. However, applications for both of the Scholarships which we administer are slow to arrive. I cannot believe that there are no worthy candidates, so supervisors should prepare their nominations as invited by the notice in this issue.

The Society's working groups have been active. There is a request for specific information from Howard Barnes, the Chairman of the group dealing with transparency in rheometer operation and software, to which I hope all manufacturers will respond. Secondly there is an appeal from the Scott Blair Collection Working Group for members to donate copies of the Bulletins of the (American) Society of Rheology. The Scott Blair Collection is now well housed at Aberystwyth and will be actively acquiring new material.

The arrangements for the European School of Rheology to be held at Strathclyde University are well advanced. The programme is summarised in this issue and the School promises to be a splendid educational experience for those interested in rheology. Encourage your colleagues to register. The August-September period this year promises to be a busy time for those whose organisations can afford to send them to meetings and conferences: The International Congress in Brussels is followed by the European School, the Society's Autumn Conference and the Royal Society of Chemistry's Meeting on Colloids, to name just a few.

Finally, due to lack of interest, we have decided to abandon the competition as was foreshadowed in the last issue.

Copy date for next issue: June 15th.



INVESTIGATION OF ACACIA, COLLAGEN AND LIMULUS AMOEBOCYTE LYSATE AS STANDARD FILM FORMERS FOR USE IN SURFACE RHEOMETRY

Ahilan K Nithiananthan
Dept. of Pharmaceutics
The School of Pharmacy
University of London
29-39, Brunswick Square
London WC1N 1AX.

ABSTRACT

The suitability of the materials acacia, collagen and *Limulus* amoebocyte lysate as standard surface film formers for the Oscillating Ring Surface Shear Rheometer is investigated. The effect of (1) different concentrations of acacia and collagen on surface film formation, (2) bulk hydrogen ion concentration on collagen surface film formation and (3) different concentrations of endotoxin on the surface elasticity of the film formed by *Limulus* amoebocyte lysate (LAL) is reported. The findings show the common variability in the proteinaceous components of acacia and collagen to be a possible cause of poorly reproducible surface films. The reaction of LAL and endotoxin produces satisfactorily reproducible surface films but its use as a standard has considerable disadvantages.

INTRODUCTION

A common problem for scientists studying the rheological properties of materials is the calibration of the rheometer and as a result the question of whether or not the data obtained is correct in an absolute sense often lies unanswered. In order to overcome these basic flaws in the rheometric technique much effort has been expended in finding well characterized materials or formulating materials as standards for rheometers. The Oscillating Ring Surface Shear Rheometer (ORSSR) was designed to enable the study of the dynamic rheological properties of thin films formed at the gas/liquid or liquid/liquid interfaces. In order to demonstrate the ORSSR's ability to measure surface viscosity and surface elasticity it has been necessary to investigate various materials for their film forming properties, and in each case consider their suitability as an improved standard. This paper investigates the films formed by gum acacia, collagen and the *Limulus* amoebocyte lysate.

Acacia is a complex proteinaceous polysaccharide obtained as a dried powdered gum. Aqueous solutions of Acacia are known to exhibit viscoelastic film forming properties (Shotton and Wibberley, 1959) which are time dependent (Sherriff and Warburton, 1974). Higher concentrations of the aqueous solution (between 2% and 10% W/V) are known to effect increases in both the rate of film formation and the final strength of the film, measured in terms of surface elasticity (Kerr, 1985).

Collagen, a principal protein in mammals, is essential in providing connective tissue matrices with their stability and physicochemical properties. The distinctive property of collagen *in vivo* is that it forms insoluble fibres that have high tensile strength. Collagen in a soluble form is extracted from the tissues of young animals. The absence of covalent cross-links in immature collagen makes it feasible to extract the basic structural unit, called tropocollagen. Tropocollagen has a molecular weight of 285,000 and consists of three polypeptide chains of the same size (Traub and Piez, 1971).

The *Limulus* amoebocyte lysate (LAL) is a lyophilized preparation obtained from the blood of the marine horseshoe crab (*Limulus polyphemus*). The blood's *in vivo* property of forming a gel in the presence of contaminating toxins (endotoxins) is exploited commercially by the preparation of a highly refined extract for the *in vitro* testing of pharmaceutical injections for unwanted endotoxins. Although the LAL is produced to a crude (non-quantitative) rheological standard it is sufficient for producing a reproducible bulk gel-clot in the presence of a specific concentration of endotoxin with a specific activity. The ability of highly diluted solutions of LAL to form a reproducible surface elastic film in the presence of various concentrations of endotoxin was investigated.

The rheological properties of thin films range from Newtonian to visco-elastic and are often defined by measurements of viscosity and elasticity.

THEORY

Thin films are formed in one of two ways: (1) Materials which are insoluble in the bulk distribute themselves at the surface to form a layer, or (2) molecules are concentrated at the surface via the thermodynamic adsorption of molecules that are normally soluble in the bulk. Depending on the concentration of the material the film formed may be a molecular monolayer or a molecular multilayer whose concentration fades exponentially into the bulk. It is necessary in such work to minimize rheological contributions from the bulk especially

when measuring viscosity. This is done by keeping the ratio of surface viscosity (η_s) to bulk viscosity (η_b) as high as possible. Dilute aqueous solutions which form networks tend to form strongly elastic films at the surface when compared to the bulk, and therefore there is likely to be little interference from the bulk.

The most complex systems are those where solute macromolecules form a surface film by diffusion from the bulk. Initially the solute molecules are in a state of random motion throughout the solvent, equally distributed in the surface as in the bulk. In the absence of overt solvent motion the achievement of an equilibrium adsorption of macromolecules (Silberberg, 1968) is categorized into three essential steps each characterized by their own time scale (Warburton, 1972):

(1) *Subsurface to Surface Diffusion* — this is governed by the surface barrier effect and is thought to take place within seconds or minutes. During the diffusion process the net forces acting on the molecule change causing a change in its conformation. Once at the surface the molecules tend to have a lower free energy than in the subsurface which favours their presence there (Scheraga, 1964). However once an equilibrium concentration has been achieved a state of flux exists whereby back diffusion from surface to subsurface may occur by solute molecules in the surface with sufficient energy being replaced by solute molecules from the subsurface. Further thermodynamic stability of the solute molecules at the surface is achieved by the displacement of solvent molecules associated with it, resulting in a further lowering of the entropy of the solute molecule (Tait and Franks, 1971).

(2) *Bulk to Subsurface Diffusion* — it is governed by the bulk diffusion coefficient and is also thought to occur within seconds to minutes. This diffusion process is brought about by the solute concentration gradient set up by the subsurface to surface diffusion (Ward and Tordai, 1946).

(3) *Molecular reorientation of segments and/or denaturation of molecules in the surface* — governed by the in-plane surface diffusion coefficients and takes from minutes to hours. At the equilibrium concentration the surface solute molecules tend to increase the surface viscosity above that expected for an equivalent concentration of solute in the bulk. This is due to the unfolding of solute molecules leading to an increase in the volume occupied and hence an increase in the resistance to the flow of molecules past each other in the surface. The process of molecular reorientation and/or denaturation and their influence on the surface rheological properties can depend on several factors e.g solute type, solute concentration, solvent, ionic concentration and pH. Molecules with a high charge density would be expected to repel each other, occupy less volume and would have lower viscous

properties at the equilibrium separation than those with a low charge density occupying a greater volume. The formation of networks at the surface depends greatly on the solute's ability to interact with other molecules through entanglements or intermolecular bonds.

In 1977 Warburton derived an inverse relationship between surface rigidity modulus and time for segments of macromolecules being immobilized through their adsorption at the surface. The derivation was based on a statistical model proposed by Smoluchowski (1918) for the rate of coagulation of an aerosol or fog:

$$n_t = \frac{n_0}{1 + 4\pi DRn_0 t}$$

where n_t = number of free uncoagulated particles in unit volume at time, t after the start of the process, n_0 = initial number of particles, D = diffusion coefficient for the particles, and R = capture radius for the particles.

Warburton made a comparison between the concept of coagulation in an aerosol or fog and the immobilization of segments of macromolecules adsorbed at a surface but having sufficient freedom of movement within the plane of the surface for two adjacent segments to come together within the critical radius and capture a cross-link. Warburton derived the following equation:

$$G_t = G_\infty - \frac{G_\infty}{1 + at}$$

which can be rearranged as

$$\frac{1}{G_t} = \frac{1}{G_\infty} + \frac{1}{G_\infty a t}$$

where G = dynamic surface rigidity modulus at time (t) or at infinite time (∞) and $a = 4\pi DRn_0$. The theory suggests that a graph of $1/G_t$ against $1/t$ (double-reciprocal plot) should give a straight line of gradient $1/G_\infty a t$, and intercept $1/G_\infty$.

The derivation assumes that (1) the concentration of macromolecules in the bulk is insufficient to cause gelation and that gelation only occurs at the surface, and (2) the thickness of the surface film remains substantially constant during the film gelation time, which is untrue at short times when the bulk to subsurface and subsurface to surface diffusions are predominant.

APPARATUS

The measuring head of the ORSSR consists of a platinum du Nouy ring suspended from the moving coil of a galvanometer. Measurements are made by placing the plane of the ring in the interface and oscillating it at a resonance through a small angle, θ (Figure 1). The oscillation is set up by passing an input sine-wave voltage through the galvanometer head and the resultant movement recorded as an output voltage using a proximity probe and displacement transducer unit. The real part of the dynamic surface elastic modulus (G_s) of the sample is calculated from the change in the resonant frequency of the system monitored by the electronic feedback circuit used to achieve normalised resonance. In this paper G_s is the only parameter of the films being analyzed.

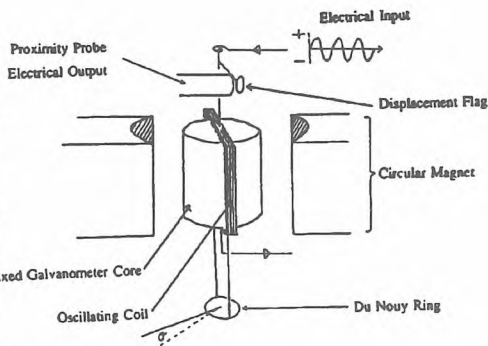


Figure 1: The operating head (galvanometer movement) of the Oscillating Ring Surface Shear Rheometer.

METHOD

Aqueous solutions of 0.5%, 1%, 2%, 3% and 5% W/V acacia were prepared from commercially available powder (B.D.H. Chemicals, Poole, Dorset) by mixing with a magnetic stirrer. Collagen solutions ($3 \times 10^{-4}\%$, 0.0015%, 0.003%, 0.006% and 0.012%) were prepared from a stock 0.3% W/V solution in dilute acetic acid, Pancogene S (Gattefosse, Saint-Priest Cedex, France) by diluting with distilled water or distilled water adjusted to an appropriate pH with potassium hydroxide or hydrochloric acid. The use of LAL (Atlas Bioscan, Bognor Regis, West Sussex) and endotoxins (National Institute of Biological Standards and Control, South Mimms, Herts) needed specialized aseptic procedures and required all surfaces contacting the solutions to be rendered free from endotoxins. Measurements of the surface films formed by acacia and collagen were conducted at room temperature whereas LAL and endotoxin reaction was measured at about 37.5°C.

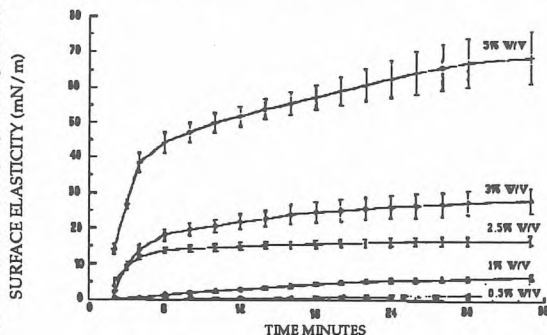


Figure 2: The effect of concentration on the surface films formed by acacia.

RESULTS AND DISCUSSION

The acacia studies (Figure 2) confirm the concentration dependent surface film forming properties reported by Kerr (1985) and Barnes (1988). The high standard error questions the use of acacia as a standard film former. The source of this error was attributed to the considerable variability in the nature, location, and biodegradability of the proteinaceous components which coexist with the polysaccharides. Acacia is very fragile when subjected to heat and undergoes autohydrolysis when exposed to ultra violet light (Anderson and McDougall, 1987). All these factors serve to highlight the possible variations in polysaccharide branching and the consequent effects they could have on forming surface films with a reproducible elastic modulus. Warburton's theory, confirmed using collagen (Warburton, 1978), can be applied successfully to these results (double-reciprocal plot - Figure 3). The non-linearity observed in the double reciprocal plot at short time periods (less than 5 minutes) substantiates Warburton's assumption that at short times the theory cannot be expected to hold due to the first and second surface adsorption processes dominating the physical changes being measured. At lower concentrations of acacia linearity is exhibited after longer periods of time and could be explained by the less concentrated macromolecules requiring longer to concentrate at the surface and achieve the surface excess of higher concentrations.

Collagen also forms concentration dependent visco-elastic films (Nithiananthan, 1991). The lower concentrations clearly show a time lag at the beginning of the experiment which could be associated with the gradual build-up of the surface excess (Figure 4). At higher concentrations the time lag is reduced but the standard error increases

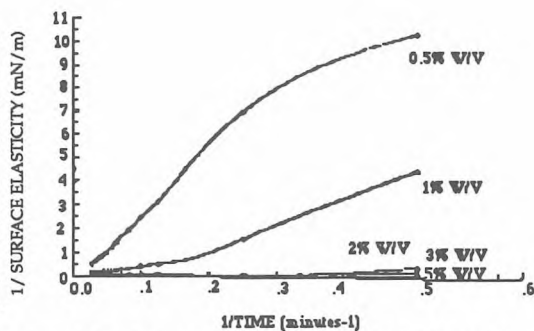


Figure 3: Double-reciprocal plot of surface elasticity against time for films formed by acacia at different concentrations.

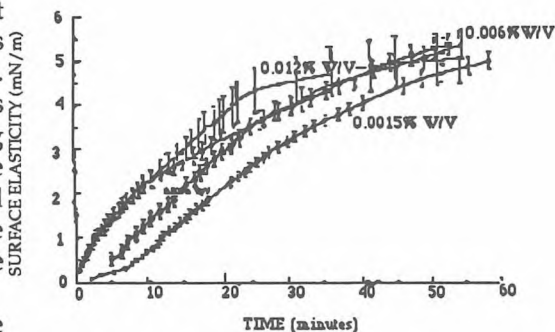


Figure 4: The effect of concentration on surface films formed by collagen.

significantly with increasing concentration. A concentration of $3 \times 10^{-4}\%$ was also studied but not illustrated since a maximum G_{∞} of 1.1 mN.m^{-1} was achieved. This could be attributed to a surface excess insufficient to produce any significant cross-linking and entanglement. All other concentrations seem to tend towards a common G_{∞} . This is substantiated by

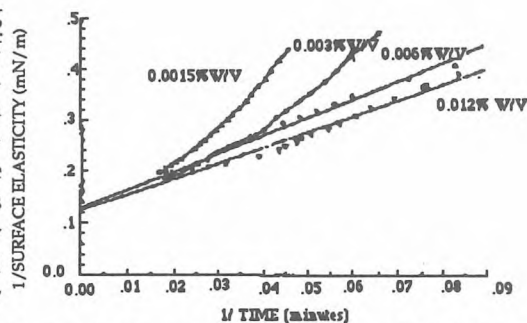


Figure 5: Double-reciprocal plot of Figure 4 to illustrate linear region.

the double reciprocal plot (Figure 5) which shows G_{∞} to be about 8 mN.m^{-1} . Concentrations 0.006% and 0.12% seem to obey Warburton's theory, the non-conformity of the lower concentrations is probably due to the surface adsorption processes limiting the kinetics of cross-linking and entanglement. Generally, the results indicate that the difference between the concentration of collagen that produces an insufficient surface excess and those concentrations that produce maximum rate of surface elasticity build-up is quite narrow.

The adsorption of collagen at the surface is the compounded result of various kinds of interaction between the collagen, the surface, the solvent and any other solutes present. The major driving force behind this adsorption is considered to be the resultant increase of entropy. This increase is partly due to collapse or alteration of the water structure around hydrophobic parts of the polypeptide chain, and partly due to structural alterations inside the molecules as they are adsorbed. The most important factors affecting structural changes in the protein are: (1) variation in the number and kind of amino acid residues (Dolz and Heidemann, 1986) exposed to the aqueous solvent, (2) changes in intra- and intermolecular van der Waals interactions, (3) disruption or formation of ion pairs, (4) disruption or formation of hydrogen bonds involving peptide units, side chains and water molecules and (5) the tendency of hydrophobic parts to orientate themselves so that they project out of or away from the aqueous medium at the surface.

Since G_{∞} appears to be independent of the concentration of collagen it can be inferred that the concentration which quickly produces a saturated surface lies between 0.003% and 0.006% W/V. Higher concentrations probably result in the formation of surface multilayers which seem to reduce the reproducibility of the strength of the surface film, as shown by

the increased standard error. This implies that sub-surface layers of collagen molecules interfere with the cross-linking and entanglements between molecules in the surface.

The surface elastic moduli of films formed by collagen (0.003% W/V) in different pH environments were, first reported by Warburton (1978) and re-investigated here with respect to the reproducibility of these measurements (Figures 6 and 7). The G_s dependence on hydrogen ion concentration observed support Warburton's findings. Proteins in aqueous solution will contain both anionic and cationic groups. The charge due to those covalently bound, i.e. fixed ionic groups is referred to as the proton charge. The net number of proton charges on a protein molecule is a function of the pH of its environment. Since the net charge contributes to a large extent to the conformational properties of proteins it is to be expected that changes in pH will affect the surface film forming properties of collagen. The pH determined for each test solution is that of the water used in diluting the collagen and may not necessarily be the true bulk pH. Since a very high dilution was prepared it is assumed that the small volumes of collagen (pH 4.0 to 4.5) used would not have had a significant effect on the pH of the water. Furthermore the assumed pH is that of the bulk and may not be representative of that at the surface.

The elastic modulus (G), which is dependent on the intra- and inter-molecular interactions as well as the surface adsorption process, is optimal (G_∞) when the bulk pH is in the region 7.0 to 7.2. The point of

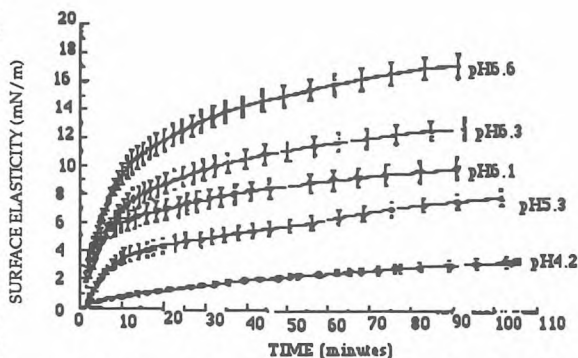


Figure 6: The effect of acidic bulk pH on the surface films formed by collagen.

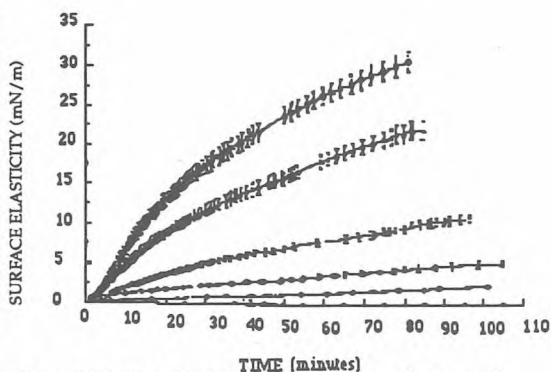


Figure 7: The effect of basic bulk pH on the surface films formed by collagen.

zero charge (isoelectric point) for collagen is in the pH region 7 to 8 (Veis, 1978). If, in the isoelectric state, the equal numbers of positive and negative charges are more or less evenly distributed over the molecule, the net intramolecular Coulombic interaction would be attractive and hence favour a compact structure (Norde and Lyklema, 1978). At pH values deviating from the isoelectric point the free energy of the conformation is raised and the collagen molecule would be expected to assume a less compact structure. If the pH at which maximum G_{∞} occurs is assumed to correspond to the isoelectric point of collagen then it can be concluded that collagen as a compact molecular structure gives rise to surface films with a larger surface elastic modulus.

The reproducibility of the surface elastic films formed during the reaction of LAL (diluted to 10% V/V) with endotoxin concentrations 0.01, 0.1, 1 and 10 EU/ml were the best achieved using the ORSSR (Figure 8). The kinetics of surface elastic film formation is unprecedented and cannot be analysed using Warburton's Theory. The mechanism of LAL-endotoxin reaction however can be used to explain the curve profiles and their rank orders observed. The LAL contains two essential components: (1) an enzyme cascade series, which is activated by the presence of endotoxins and (2) a coagulogen protein which has three subunits (A-C-B) which is cleaved by the activated enzymes in the cascade series to release the C peptide. The combination of peptides A and B through disulphide bonding then occurs. The magnitude of A-B disulphide bonding throughout the reaction sample using undiluted LAL gives rise to a firm gel. By diluting the LAL to 10% V/V the existence of bulk gelation is not measurable using the ORSSR, it was therefore assumed that when using LAL 10% A-B bonding was only taking place at the surface. Larger concentrations of endotoxin give rise to greater LAL enzyme cascade activation and hence greater proportion of coagulogen proteins being cleaved. Consequently stronger surface elastic films would be expected from greater endotoxin concentrations and are clearly shown in Figure 8. The time delay in surface elasticity build-up during the initial stages of the reaction

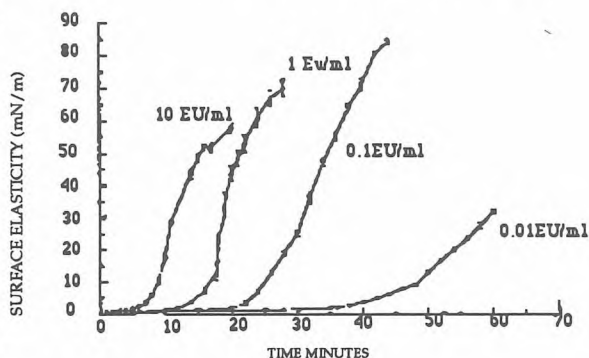


Figure 8: The surface elastic films formed during the reaction of 10% LAL with different concentrations of endotoxin.

series occurs with consequent cleavage of coagulogen. Although the concentration of endotoxin affects the rate at which surface elasticity build-up occurs it is unclear whether the limiting step is due to the reaction pathway (enzyme cascade activation or coagulogen cleavage) or surface film formation.

CONCLUSIONS

The reaction of LAL with endotoxin appears to produce surface films with better reproducibility than those produced by acacia and collagen. The poor reproducibility achieved using acacia and collagen could be attributed to the variable proteinaceous components present. The LAL protein content however is well characterized and the manufactured product is quality controlled using a rheological technique which although crude has proved successful for LAL's application. The LAL reaction with endotoxin is to date the most accurate surface rheological standard for the ORSSR studied but is not easy to use. The handling of LAL and endotoxin requires considerable degree of technical skill, these reagents are also expensive and are stable for a maximum of four weeks.

ACKNOWLEDGEMENTS

The author would like to thank the Humane Research Trust for his grant, Atlas Bioscan (Bognor Regis, West Sussex) for supplies of LAL, Dr. S. Poole (National Institute of Biological Standards and Control, South Mimms, Herts.) for supplies of endotoxin, and Gattefosse (St. Priest Cedex, France) for supplies of collagen (Pancogene S).

REFERENCES

- Anderson, D. M. W. and McDougall, F. J. (1987) *Food Addit. and Contam.*, 4(3): 257.
- Barnes, D. M. H. (1988) Ph. D. Thesis. University of London.
- Dolz, R. and Heidemann, E. (1986) *Biopolymers*, 25: 1069.
- Kerr, H. (1985) Ph. D. Thesis. University of London.
- Levin, J. and Bang, F. (1968) *Thromb. Diath. Haem.*, 19: 186.
- Liu, T-Y., Seid, R. C., Tai, J. Y., Liang, S. M., Sakmar, T.P., and Robbins, J. B. (1979) *Prog. Clin. Biol. Res.*, 29: 147.
- Nithiananthan, A. (1991) Ph. D Thesis. University of London.
- Norde, and Lyklema, J. (1978) *Colston Papers*, 29: 11-40.
- Scheraga, H. A. (1964) *Ber. Bunseng.*, 68: 838.
- Sherriff, and Warburton, B. (1974) *Polymer*, 15: 253.
- Shotton, E. and Wibberley, K. (1959) *J. Pharm. Pharmacol.*, 11: 120T.
- Silberberg, A. (1968) *J. Chem. Phys.*, 48: 2835.
- Smoluchowski, Z. (1918) *Phys. Chem.*, 92: 129.
- Tait, M. J. and Franks, F. (1971) *Nature*, 230: 91.
- Traub, W. and Piez, K. A. (1971) *Advan. Protein Chem.*, 25: 243.
- Weis, (1978) *Colston Papers*, 29: 259-272.
- Warburton, B. (1978) *Colston Papers*, 29: 273-283.
- Ward, A. F. H. and Tordai, L. (1946) *J. Sci. Instruments.*, 21: 143.

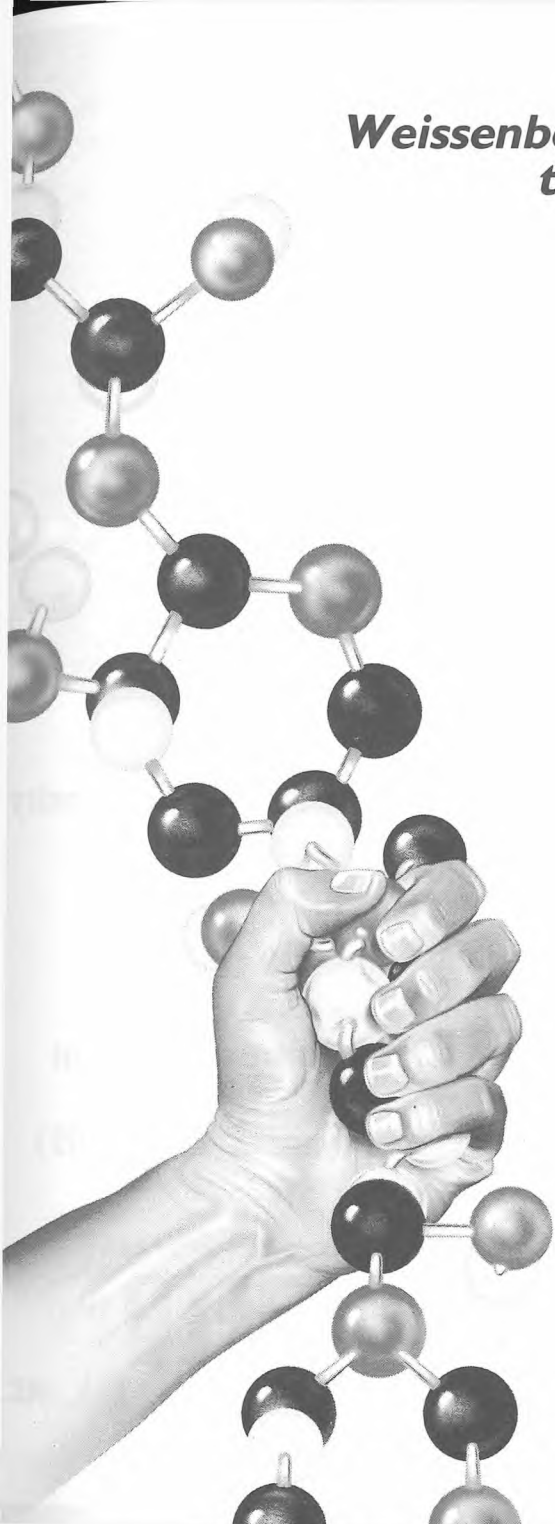
THE FLUID DYNAMICS OF DRILLING AND COMPLETION

This seminar was held at the Institution of Mechanical Engineers on February 24th, 1992. Marking the Institution's first venture into this subject area, it aimed to bring together industrialists and research workers with a common interest in the oil production industry.

About 10,000 oil and gas wells are drilled annually involving the pumping of more than a million cubic metres of drilling mud and cement. Because the fluids involved are non-Newtonian, in spite of the relative simplicity of the wellbore/drill pipe and wellbore/casing geometries, under laminar-flow conditions analysis of the downhole dynamics of mud and cement flow requires sophisticated numerical procedures and non-trivial computer power. Even under ideal conditions, laminar flow becomes unstable and leads ultimately to the transition to turbulent flow for which knowledge of the underlying flow physics is still lacking, particularly for non-Newtonian fluids. This meeting aimed to review recent advances in understanding this difficult area.

In his keynote address D. Llewelyn (B. P. Exploration) noted that costs are rising but oil prices are static so Research and Development is being squeezed. Meanwhile, some of the technical challenges in the oil industry are too big for a single company to handle and consequently he foresaw increased cooperation, along the lines of a recent research project on oil-based muds involving 14 oil companies. He also cited the problem of communication between various parties in the drilling team: a task force set up to investigate blockages in drill pipes, which cost 30 million dollars in 1988, found that most instances were caused by a lack of understanding of the warning signs and poor communications. Exercises designed to show that everyone has important information needing to be clearly communicated bore fruit and reduced the costs by 75%. He concluded that to be competitive research needs to be accurately targeted to meet specific problems.

In the first of the technical presentations Dr G. C. Maitland (Schlumberger Cambridge Research) summarised the rheology of drilling fluids. These materials are subjected to shear rates ranging from about 10^2 sec^{-1} in the drill pipe up to 10^4 - 10^5 sec^{-1} at the drilling bit, with possibly significant extensional components. Oil based muds are well described by the Herschel-Buckley model and the variation of rheological parameters with temperature and pressure are fairly easy to predict. Water-based muds are more complex and depend on the method of preparation and the extent to which the bentonite particles are dispersed. Mechanical (mixing) energy input, thixotropy and

A black and white photograph of a hand holding a complex polymer chain model. The model consists of numerous dark and light spheres connected by rods, representing atoms and bonds in a polymer structure. The hand is positioned in the lower left, with fingers gripping a part of the chain. The background is plain white.

Weissenberg Rheogoniometer takes the sheer stress out of rheology.

From the makers of the world's leading controlled stress rheometer, comes the new Weissenberg Rheogoniometer for the nineties.

Carri-Med have incorporated the latest in micro-processor and servo-drive technology to develop a state-of-the-art shear rate and control strain instrument offering:

- All essential measuring options: Steady shear, Oscillation, Step Speed Change, Step Strain Change, Superimposed Oscillation & Steady Shear.
- Testing over a wide range of fluids and solids including polymer melts at up to 500 °C. Various measuring fixtures can be accommodated.
- Software upgrades to match expansion of the instrument's capabilities eg Normal Force mode.
- Ease of use due to the high level of automation. The compact design requires minimal bench top space.
- Rapid production of final results. Raw data is accessible for research needs.

All this adds up to an instrument invaluable for scientists looking to characterize and predict properties such as pumping, coating, mixing, storage and sagging. Whatever the materials – paints/inks, polymers, pharmaceuticals, chemicals, food etc.

If you need to alleviate your rheology workload, the new Carri-Med Weissenberg Rheogoniometer is the answer. Contact us today for further information.



CARRI-MED

Carri-Med Limited

Carri-Med House, Vincent Lane, Dorking, Surrey RH4 3YX, England.
Telephone: (0306) 886180 Fax: (0306) 885863 Telex: 859115

Announcing DVIII...

a stand-alone programmable rheometer – Ideally suited for viscosity quality control and research applications.

- Stand-alone capability (the computer's built in)
- Stores up to 10 measurement programs.
- 2500 discrete speeds allow generation of flow curves.
- Walk-away capability – test, display, print and store data without operator involvement.
- Available with Brookfield spindles, Coaxial Cylinder (DIN 53-019) and Cone/Plate geometries.
- "Budget-friendly" price.

Send for brochure



BROOKFIELD

BROOKFIELD ENGINEERING LABS, INC.

Brookfield Viscometers Ltd.,

The Seedbed Centre, Langston Road, Loughton, Essex IG10 3TQ.

Tel: 081 502 4220, Fax: 081 502 3714, Tlx: 914653 EFIA G.

temperature are all important and there are experimental difficulties with slip at the walls of a viscometer and of sedimentation and centrifugation during testing.

Dr S. H. Bittlestone (Schlumberger Cambridge Research) described the theoretical modelling of cement and mud flow. Finite element methods can be used for laminar and turbulent flows of Newtonian liquids, but much work remains to be done on transitional flow and the effects of thixotropy, viscoelasticity and the superimposition of rotational and longitudinal flows.

Professor M. P. Escudier (University of Liverpool) described experimental work in progress at Liverpool and at Imperial College aimed at validating the mathematical models mentioned in the previous paper. They use flow loops up to 11 metres in length and 100mm in diameter with fixed or rotating cores to simulate the drill string which may also be offset to simulate an eccentric annulus. Flow is monitored by laser doppler anemometry, which sets a fundamental requirement for the model fluid to be transparent, in addition to having similar rheological characteristics to mud and cement. This is almost met by polymeric solutions of carboxy methyl cellulose and xanthan gum, by laponite, a synthetic clay, and by a slurry of silica in mineral oil, but none of these liquids is completely satisfactory.

Dr J. T. Ford (Heriot-Watt University) described the various ways in which rock cuttings are transported along the shallow angle pipes associated with deviated wellbores. Using video filming in a large scale experimental rig his work had shown that the minimum velocity for solids transport depends on the mechanism of that transport and is higher for suspension flow than for rolling/sliding flow.

T. J. Lockett (AEA Petroleum Services) described the successful application of computational fluid dynamics to mud flows and cuttings transport in simulating the turbulent flow through the drill bit and the laminar flow in the annulus. It is possible to predict the onset of Taylor vortices and the analysis suggests that their presence can significantly improve the ability of such flows to transport cuttings.

Dr P. F. G. Banfill (University of Liverpool) outlined the rheology of cement slurries and drew attention to the uncertainties which result from carrying out measurements on particulate suspensions possessing a yield value in smooth walled, controlled speed, rotational viscometers. Undetected slippage results in a large underestimate of yield value. In addition, the industry standard method of preparing a slurry for laboratory testing puts in much more mechanical energy to the slurry than mixing and handling done in the field so, effectively, the two materials are completely different.

Dr C. Lockyear (B. P. Research) described the way in which cement displaces mud and outlined a current research programme aimed at confirming the petroleum engineers' field rules for effective displacement. This work has produced some new rules but has left unresolved some problems in the areas of mixing of cement with spacing fluid, of the erosion of the filter cake built up on the walls of the hole by absorption of water from the mud. In addition it is still difficult to predict the rheology of a slurry when it is down the hole.

The last talk was by L. M. Wickens (AEA Petroleum Services) and dealt with attempts to improve the models for the flow of a gas kick up the wellbore. These occur when a bubble of gas enters the well and rises to a possibly explosive emergence at the surface.

In discussion, it seemed that most delegates were satisfied with the seminar but some disappointment at the lack of representation from oilwell service companies was voiced. One delegate remarked that he had heard of the seminar through B. S. R. Bulletin, rather than through oil industry journals. Several voices supported an appeal for sharing information on rheological properties and on the formulations used for model fluids. These latter need to be transparent and possess a yield value.

For me, the novelty of presenting a paper in august surroundings with the portraits of famous early engineers looking on, together with the interest (for a building materials engineer) of taking coffee in the marble hall, was marred by the relentless rise in temperature in the meeting room through the day and the low elastic modulus of the seats.

Phil Banfill

NEWS OF OTHER SOCIETIES

GROUPE FRANÇAIS DE RHEOLOGIE

The Annual General Meeting of the group was held on November 21st, 1991 in Paris in conjunction with a lecture by M. Blanc entitled "Some recent results in the study of the dynamic and thermo-mechanical behaviour of high polymers". The next Annual Colloquium will be held in Marseille on November 25-27th, 1992 on the theme of rheology of suspensions and will deal with both fundamental and applied aspects in the process industries. For further information contact: ENSSPICAM, Avenue Escadrille Normandie Niemen, 13397 Marseille Cedex 13, France.

The group publishes "Les Cahiers de Rheologie" and invites original articles not exceeding 15 A4 pages on any aspect of rheology, which will be scrutinised by an editorial panel. While the official language is French articles in English are also acceptable. For further information contact the editor: Prof. R. Gaudu, ENSCPB, 351 cours de la Libération, 33405 Talence Cedex France.

BSR WORKING PARTY ON TRANSPARENCY IN RHEOMETER OPERATION AND COMPUTER SOFTWARE

As we all know, rheometry requires the application of force or movement to a surface in contact with the liquid to be measured. Then the reaction of the liquid to that force or movement is monitored via a corresponding movement or force on the same or another surface. A simple example is that of a cone and plate viscometer where the plate is rotated about an axis through its centre. The reaction is the movement of the top cone against a restraining spring. The movement of the plate can be a step, a steady speed, an oscillatory motion or whatever. The reaction is monitored as the movement of the restraining spring. From the application of the movement, the measuring of the spring deflection etc. through calculations involving distances, angles, compliance, and movement to the final display of the rheological properties of the liquid held between the cone and plate many assumptions and calculations are made. How reliable are they? In the distant past (not so distant for some of us!), experimentalists would make their own measurements of every pertinent quantity such as sizes, angles, spring compliance, speed etc. and thence make — by hand — their own step-by-step calculations until eventually the rheological parameter of interest was found. They then plotted it and if necessary fitted it to a flow-law, again by means of their own calculations.

Nowadays we are spared these chores by the rheometer manufacturer having reduced everything to computer control and software manipulation. However a number of influential voices have been raised to make the statement that such matters are too important to be left to the rheometer manufacturers. Others, being less critical would like there to be some standard or accepted way that things were done and perhaps these be given the imprimatur of the BSR. Certainly in these days of BS 5750 and laboratory accreditation etc., some action must be taken to check what is being done and surely the BSR has a vested interest in at least being involved in the debate. In other words what are the questions a discerning buyer should be asking the representatives of viscometer manufacturers?

Thus it seems reasonable to ask the questions set out below about various rheometers, first of all as a pilot study for those machines that produce a flow-curve of shear stress/viscosity versus shear rate. Afterwards, if the exercise is successful we could turn to those machines that make more sophisticated measurements.

If you, as a viscometer manufacturer, have not been contacted about the survey, please get in touch with me at the address below, preferably by filling in the answers!

Dr H. A. Barnes, Unilever Research, Port Sunlight Laboratory, Quarry Road East, Bebington, Wirral, L63 3JW.

B. S. R. RHEOMETER SURVEY

1. PRELIMINARY SURVEY FOR STRAIN-CONTROLLED INSTRUMENTS

- (1) How is the speed created, monitored and controlled? What calibration equipment are you using and can it be traced back to a national standard?
- (2) How is the speed converted into an electrical signal and how linear is the response?
- (3) Is the speed applied to the rotating geometry through a spring and if so, is the movement being monitored after the spring? What is the compliance of the spring?
- (4) In the test geometry, how have the dimensions, flatness and angles been measured? Is the accuracy of the measuring equipment traceable to an acceptable standard? If geometries supplied by a third party do they do so to BS5781.
- (5) How is the force converted into an electrical signal? Is there any time lag between speed and torque measurements? What is the linearity of the system? Are the calibration forces and angle measurements traceable?
- (6) How are edge and end effects accounted for?
- (7) Is the overall machine calibration made using absolute measurement of parameters or are standard liquids used? If so what is the source of the liquids?
- (8) What computer system/microchip is used to collect the speed/torque data?
- (9) What zero errors might be expected in hardware and software and how are they dealt with?
- (10) How are data points fitted to flow laws? Which flow laws are provided and is the data fitted to them?
- (11) What account is taken of secondary flow, turbulence, viscous heating etc?
- (12) What means of output are available in terms of hard copy and computer storage? Is your software up to ISO 1001 standard?

SCHOLARSHIPS AND GRANTS1992

SCOTT BLAIR SCHOLARSHIP AND SCOTT BLAIR BIORHEOLOGY SCHOLARSHIP

In memory of the work and example of Dr G. W. Scott Blair, the Society and Pergamon Press make available a series of scholarships to encourage excellence in research. The Scott Blair Scholarship of the Society is for research in any field of rheology while the Scott Blair Biorheology Scholarship, funded by Pergamon Press, but administered by the Society, is for research in biorheology. The aim is to enable the scholars to undertake activities which would not normally be possible without such a grant, such as a period of work at an overseas University. Both scholarships are available for award in 1992.

PhD students, or equivalent, who are completing their first year of research, and are members of the British Society of Rheology, may apply to become a Scott Blair Scholar. PhD students, or equivalent, who are completing their first year of research in the field of biorheology, and are members of the British Society of Rheology, may apply to become a Scott Blair Biorheology Scholar.

The scholarships will have a value of £500 per annum (or such value as shall from time to time be decided by Council) to be used at the absolute discretion of the scholar. Subject to a satisfactory report from their supervisors, the scholarships will be renewable for a maximum of one more year. Thus they will usually be available during the second and third years of a normal PhD project.

In addition to the annual payment, Council will consider applications for additional funding to attend conferences. The scholars will be expected to present the results of their research at meetings of the Society, and to make occasional contributions to the Bulletin.

The Awardees of the Biorheology Scholarships will be expected to present the results of their research at meetings of the British Society of Rheology, and will be encouraged to publish them in the Journal "Biorheology" in accordance with its editorial policy.

The award of the Scholarships will be decided by Council who cannot enter into correspondence with unsuccessful applicants, and who reserve the right not to award a scholarship in any particular year.

Applications for the Scholarships should be sent to the Secretary of the British Society for Rheology as soon as possible. The application should be on no more than two sides of A4 paper and contain: personal details of the applicant, a description of the research, notes on any special uses envisaged for a proportion of the scholarship, and an endorsement from a person with supervisory responsibility for the research.

TRAVEL GRANTS FOR STUDENTS

The Society makes grants to students engaged in research in rheology to attend and present their work at meetings on rheology, both its own and those of other societies. Members of the Society, who are full-time students, may apply in writing to the Secretary to be considered for an award and that application should be supported by the student's supervisor. The application should give details of the proposed expenditure, the title and date of meeting and the title of the paper to be presented. They should be submitted in time for consideration at a Council meeting before the money is needed, i.e by the beginning of March, June, September or December.

The amount and number of such awards will be at the discretion of Council.

NORTH MIDLANDS GROUP

The third meeting was held on Thursday March 26th, in the Department of Civil and Structural Engineering, University of Sheffield, when Dr Peter Prentice of the Department of Manufacturing Engineering, Nottingham Polytechnic, gave a talk on Polymer Melt Rheology as a Design Aid. He discussed the properties of various polymer melts, but particularly of the various types of polyethylene, in relation to the design of extruder screws, and emphasised the inadequacy of the melt flow index as an indicator of performance. It was interesting to note that the difficulty of convincing industrial users of the inadequacy of single-point measurements is just the same in this field as in the concrete industry, and perhaps in others as well.

The next meeting will be on Tuesday September 8th and will take the form of a visit to the Research and Development Laboratories of British Gypsum at East Leake. Prior registration for this visit is essential. We should still like to welcome more members, particularly any from industry. Contact Dr G. H. Tattersall, 174 Millhouses Lane, Sheffield S7 2HE (Tel. 0742-365144).

COMMENTARY ON 268TH COUNCIL MEETING

"Out of the Car Park, and follow the railway viaduct until you come to the Staff House. That's the new conference centre at UMIST". With a backlog of business from previous meetings, the meeting started promptly at 11 am. In order to streamline the agenda, all officer's reports had been circulated beforehand. An unstreamlined train crosses the viaduct and temporarily deafens us to David's words. What! He's at Any Other Business already. Oh it's all right, just making a list of topics for said item of the agenda. Phil, Dick and Malcolm have sent their apologies, Roy is on his way. Hello to the Council's nomination for the next President, Ralph Oliver.

On with the minutes of the last meeting. The usual crop of spelling errors. Some discussion of the Abstracts; could we get more information on numbers sent out, and a breakdown of costs and income. It does appear that we are doing rather better financially since Pergamon passed out of Maxwell's hands! 11: 22 and the minutes signed. Now for the reports.

Main item from the President concerned the 1996 International Congress. Four bids had been received, and we had to list them in our order of preference. Mexico? Too soon after the 9th Congress. Besides, who will believe you when you say that you're off to Acapulco on business. Slovenia? Didn't realise that they had a society. Anyway, it will not be Europe's turn, and that part of Europe is rather unstable at the moment. So, would it be Quebec or San Diego? As the bidders from each city say that they would be working with the bidders from the other, then the only difference between them is the location. So San Diego gets the vote. Another item from the President concerns a local meeting with the Chemical and Physical Society at UCL on "Rheology History and State-of-the-Art", volunteer required to organise. Thank you Treasurer, now on to your report. The accounts are in a healthy state, particularly since most advertisers have parted with the requisite number of green ones. VAT raises its head again. Should we deregister? Is it worth it to keep going in and out? Is the Pope a Catholic? Let's wait to see what happens at the budget. On to the Secretary. Those readers who have been waiting with bated breath to know who represents the Society on outside committees will have to keep waiting until the AGM when all will be revealed.

The Membership Secretary is still playing the numbers game but appears to have a winning hand. We may have a final total by the next meeting. Well done in advance. As the Bulletin Editor could not be with us, his report was read *in absentia*. Observant readers will have noticed that in this and the previous Bulletin the adverts have been

scattered about, rather than grouped at the end. However, Tony notices that with Volume 34/4, moving one of these adverts could mean that one could rip the lot out without losing the page sequence, not that anyone would wish to do so. Not much to report from the Abstracts Editor, all seems to be well.

On to the next item, Conferences, and it's only just noon! Malcolm could not be with us, but he has sent a fax. In fact it is the Programme for the September meeting. Is there a slot for the Council Meeting. No, so we will have to arrive a day early. What about the AGM, scheduled for 17:30 on the second day? Well there is a lecture tabled for 17:00, but as it is Malcolm himself giving it, we are sure the AGM will start on time. Next came discussion of the meeting next spring here in the Conference Centre. Some members of the council glance uneasily at the high rise student hall of residence on the other side of the viaduct. Fortunately it has been fitted with double glazing since they last stayed there. It was then noted that if we are to make a bid to host the 13th International Congress in 2000 (our Diamond Jubilee year) then planning should start soon.

How are the various working parties getting on? Howard Barnes has sent a draft of a questionnaire he plans to send to all instrument manufacturers concerning software and machine precision. It seems to be what is required. His group is allocated a small travel budget. David Cheng reports that the Handbook WP have drawn up a list of topics and items, which will appear in this or the next bulletin. Momentarily we forget that we also have a Scott Blair and Archivist WP. A report on their first meeting has already been distributed, and is to be discussed later in the agenda.

Last item before lunch. Nick Hudson reports that arrangements for the European School of Rheology are going well. The second circular and provisional programme have been sent out. Nearly forty enquiries and five firm bookings already. The instrument manufacturers are also clamouring for a chance to show their wares.

We return after lunch to find a pop group practising somewhere in the building — they stop after about thirty minutes. The trains now don't seem so bad. It is time to bring all the Memoranda up to date. Carole has done some sterling work in gathering together and cross referencing those which may be still applicable. We have to go through them all to see which are in force, which should be kept for factual or historic reasons, and which can be removed. This is real committee work, delving through the minutiae. The following are the more memorable items.

When the Australian Branch departed to form their own Society, it seems that it was agreed that we would send them 54 free copies of each edition of the Abstracts. Should this continue in the light of Mr Keating saying that Australia doesn't want anything from Britain. Next it is seen that although using one's car to come to a Council Meeting is an allowable expense, a mileage charge had not been set, so we do so. A frantic check by Peter Anderson on the present crop of claim forms to see if anyone has asked for more. There are no Oliver Twists, but someone has requested less! Over the years, for various reasons, there had been agreements to send gratis copies of the Bulletin to sundry non-members. It was decided that we need to find out who, why, and what we are getting in return. The composition of Awards Committees seemed to have changed over the years, so Carole was tasked to produce a suitable protocol for next meeting.

That item completed, and its time for tea. What, 16: 35 already, we are slipping behind. The Council are keen to appoint an Archivist. Are there any volunteers out there? Geoff Brownsey has already produced a general job description, so we need to make it specific for the Society's needs. More of this next meeting and at the AGM. Doug and Phil are working on a new Brochure for the Society, and we see a draft copy. Tony remarks that the £1 joining fee has remained the same for as long as he can remember, and perhaps it should be increased. This renders most of us speechless, until he suggests an alternative of scrapping it entirely. However, it is enshrined in the Constitution so is a matter for the A. G. M..

The next item concerned the Scott Blair Collection. The working party are doing a splendid job, and have identified some deficiencies. Notably early bulletins (1940 to 1958), Scott Blair's book "Introduction to Biorheology", and the proceedings of the 1984 and 1988 International Congresses. If any reader wishes to donate any of these items, they are requested to contact Mervyn Jones at Aberystwyth, or any member of Council.

Remaining on the theme of rheologists of note, Nick informed Council of the James Clark Maxwell Trust which is buying his former residence in Edinburgh and setting up a museum. At the next meeting we shall discuss possible donations from the Society to assist with this.

Finally, the last item, the next meeting. Ross Priory on Loch Lomond has been booked for June. Will we have difficulty going there and back during one day? Yes, so the local organiser is tasked to book overnight accommodation. The meeting closes at 17: 15 with the backlog removed, and it's back out to the viaduct, some going one way to the station, whilst others going the other to the car park.

Nick Hudson

THE SCOTT BLAIR COLLECTION

The Society has set up a Working Party to oversee the day-to-day affairs and promote the use of the Scott Blair Collection at U. C. W. Aberystwyth. One of its main functions will be to acquire new and interesting old books, periodicals and conference proceedings. It will also manage the deposit of archival material pertaining to the British Society of Rheology.

The Working Party aims to acquire all new books on rheology for the Collection, especially those reviewed in *Journal of non-Newtonian Fluid Mechanics* and in *Rheology Abstracts*, and all proceedings of International Conferences.

The Collection itself is in the basement of the Hugh Owen Library, and public access is unlimited, with study tables and chairs for users. Items are labelled 'for reference only' but are available for loan through the inter-library loan system.

Some highly desirable material is not present in the Collection and we appeal to members who may have any of the following items which they would be prepared to donate to the Collection to contact Dr W. M. Jones, Department of Mathematics, University College of Wales, Penglais, Aberystwyth, Dyfed SY23 3DZ.

G. Scott Blair, *Introduction to Biorheology*.

International Conference on Rheology, Sydney 1988.

Rheology Leaflet, before 1941.

Rheology Bulletin, 1968 to the present.

In addition we appeal to those members who have books published to consider donating a copy to the Collection. Please contact Dr Jones in the first instance.

During 1991 donations were received from the following:

British Society of Rheology (4 items), Dr K. Spencer Jones (2 items), Dr W. M. Jones (2 items), Professor Z Rigbi (1 item), Professor K. Walters (3 items).

In addition to these donations Elsevier Science Publishers have kindly offered to donate copies of 38 different titles from 1940 to the present day. We are very grateful for this donation and the titles will appear in the next catalogue listing.

Finally, Mrs. Ghosal, the Assistant Librarian, has prepared, for internal use, a list, in alphabetical order by title, of Scott Blair's collection of journal reprints and other items. The list, of nearly 300 titles, is too long to be reproduced here, but if any members wish to have a copy (for the price of photocopying) should contact Mrs. C. Ghosal, Hugh Owen Library, UCW Aberystwyth, Dyfed, SY23 3DZ.

THE SCOTT BLAIR COLLECTION
DONATIONS 1991

The original Catalogue was published in the Bulletin 1989, Vol. 32, No. 2 pp. 56-83. Supplement No. 1 was published in the Bulletin 1991 Vol. 34, No. 1 pp. 20-27. This Supplement lists donations up to January 1992.

Banfill, P. F. G. *Rheology of fresh cement and concrete*. See:- International Conference on Rheology of Fresh Cement and Concrete.

Barber, D. J. *An introduction to properties of condensed matter* [by] D.J. Barber and R. Loudon. Cambridge, 1989.
SCOTT QC173.4.C65.B2

Barnes, Howard Anthony. *Introduction to rheology*, [by] H.A. Barnes, J.F. Hutton and K. Walters. Amsterdam, Oxford, 1989 (1991 printing) (Rheology series; 3).
SCOTT QC189.5.B2

Brinker, C. Jeffrey. *Sol-gel science: the physics and chemistry of sol-gel processing*, [by] C. Jeffrey Brinker, George W. Scherer. Boston, 1990.
SCOTT TP810.5.B8

British Society of Rheology. Golden Jubilee Meeting, Edinburgh, 1990. See:- European Rheology Conference, 3rd, Edinburgh, 1990.

Conference of European Rheologists, 2nd, Prague, 1986. Progress and trends in rheology II: proceedings of the Second Conference of European Rheologists, Prague ... 1986; editors: H. Giesekeus.
SCOTT QC189.5.A1.E9

Conference of European Rheologists, 3rd, Edinburgh, 1990. See:- European Rheology Conference, 3rd, Edinburgh, 1990.

Conference on Rheology in Medicine and Pharmacy, British Society of Rheology, London, 1970. Papers and discussions ...
In:- *Rheologica acta*, Vol. 10, no. 1, 1971.
Shelved with the journal.

Comportements mécaniques des matériaux composites: journées des 20 et 21 novembre 1969 organisées par le Groupement pour l'avancement de la mécanique industrielle . . . [et al.] [Paris?], 1970 (Cahiers du Groupe français de rhéologie. T.11 no. 3 septembre 1970 Supplément).
SCOTT QC189.5.A1.C1 Pam Qto

Dealy, John M. *Melt rheology and its role in plastics processing: theory and applications*, [by] John M. Dealy and Kurt F. Wissbrun. New York, 1990.

SCOTT TA455.P5.D2

[European Rheology Conference], 2nd, Prague, 1986. See:- Conference of European Rheologists, 2nd, Prague, 1986.

European Rheology Conference, 3rd, Edinburgh, 1990. Third European Rheology Conference and Golden Jubilee Meeting of the British Society of Rheology: edited D.R. Oliver, London, 1990.

SCOTT QC189.5.A1.E9

Groupe français de rhéologie. Colloque annuel, 1977, Paris. Thermodynamique des comportements rhéologiques. [Paris], [1980] (Cahiers du Groupe français de rhéologie. Numéro special, janvier 1980. Abstracts in English and German.

SCOTT QC189.5.A1.C1 Pam

Hull, Harry H. *An approach to rheology through multivariable thermodynamics, or Inside the thermodynamic black box*. Pittsburgh, Pa., 1981.

SCOTT QC311.H9

Instrumentation reference book; edited by B.E. Noltingk. London, 1988.

SCOTT QC53.I5

International Conference on Rheology of Fresh Cement and Concrete, 1990, University of Liverpool. Rheology of fresh cement and concrete: proceedings of the International Conference organized by the British Society of Rheology, University of Liverpool, U.K. March 16-29; edited by P. F. G. Banfill. London, 1991.

SCOTT TA680.I6

International Congress of Biorheology, 1st, Lyon, 1972. See:- International Congress on Rheology, 6th, Lyon, 1972.

International Congress on Rheology, 6th, Lyon, 1972. Proceedings convened jointly with the First International Congress of Biorheology. Shelved with the journal

McComb, W.D. *The physics of fluid turbulence*. Oxford, 1990.
SCOTT QA913.M1

Morgans, W. M. *Outlines of paint technology*. 3rd ed. London, 1990.
SCOTT TP936.M8

Nuttingk, B. E. Instrumentation reference book. See:- Instrumentation reference book.

Progress and trends in rheology II. See:- Conference of European Rheologists, 2nd, Prague, 1986.

Prony, R. Essai 'expérimental et analytique'. . . Offprint from:- *Journal polytechnique* Vol. 1 no. 2 pp. 24-76, 1795. With a review by Zvi Rigbi.
SCOTT QC175.3.P9 Pam Qto

Renardy, Michael. *Viscoelasticity and rheology*. See:- Viscoelasticity and rheology.

Rhéologie et hydrotechnique: session des 19 et 20 mars 1970 organisée conjointement par la Société hydrotechnique de France et le Groupe français de rhéologie. [Paris?], 1970 (Cahiers du groupe français de rhéologie. Numéro spécial. Hors série. Some English abstracts.
SCOTT QC189.5.A1.C1 Pam Qto

Rheology of fresh cement and concrete. See:- International Conference on Rheology of Fresh Cement and Concrete.

Shulman, Z. P. Nestatsionarnye protsessy konvektivnogo perenosa v nasledstvennykh sredakh / Z.P. Shulman, B.M. Khusid; pod redaktsiei R.I. Nigmatulina. Minsk, 1983.
SCOTT TA455.P58.S5

Sobotka, Zdenek. *Rheology of materials and engineering structures*. Amsterdam, Oxford, 1984. (Rheology series; v. 2). Translation of: Reologie hmot a konstrukci.
SCOTT TA404.8.S6

Societa Italiana di Reologia. Scuolo-convegno, 1st, 1971, Siena. Atti . . . : Proceedings of the First Meeting of the Italian Society of Rheology, Siena, May 13-15, 1971. Vol. 1 Lezioni: Main lectures; a cura di S. Ajroldi, G. Pezzin, editors. Milano, [1971?]. Papers in Italian or English with English and Italian summaries.
SCOTT QC189.5.A1.I8 Qto

Society of Rheology. Annual Meeting, 1954, National Bureau of Standards, Washington D.C. [Papers. Pt. 1] In:- *Journal of applied physics* Vol. 26 no. 7 July 1955 pp. 785-917. Rheology issue.

Verein österreichische Chemiker. Sektion Rheologie. Arbeitstagung, Graz, 1965. Enthält die Vorträge anlässlich der Arbeitstagung der Sektion Rheologie des Vereins österreichischer Chemiker am 28. September 1965 in Graz. Articles in English or German. In:- *Rheologica acta* Vol. 5 no. 2 1966.

Viscoelasticity and rheology: proceedings of a symposium conducted by the Mathematics Research Center, the University of Wisconsin-Madison, October 16-18, 1984; edited by Arthur S. Lodge, Michael Renardy, John A. Nohel. Orlando, 1985 (Publication no. 53 of the Mathematics Research Center, the University of Wisconsin-Madison).
SCOTT QA931.V8

JOURNALS

AMENDMENTS

Documentation rheology. See:- Dokumentation Rheologie.

Dokumentation Rheologie / Documentation rheology. Nos. 39-51 (1973-85).

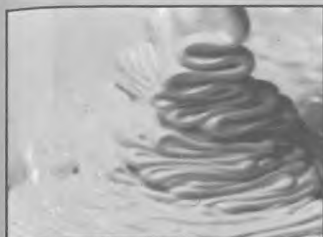
ADDITIONS

Rheology [Hannover] Vol. 1 April 1991.

Thermoplastics



Thermosets



Suspensions and Emulsions



Elastomers

action rheaction

**Rheometrics
Instruments for material
evaluation**

Viscosity
Elasticity
Yield stress
Thixotropy
Cure behavior
Thermomechanical properties
Impact

Rheometrics develops and manufactures a complete line of rheological and impact testing instruments for research, product development, quality control and process control.

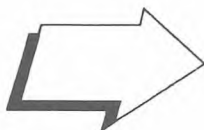
Rheometrics instruments are used widely in evaluating materials such as thermoplastics, thermosets elastomers, fluids and suspensions.

Rheometrics Europe GmbH
Hahnstrasse 70
D-6000 Frankfurt 71
(West Germany)
Phone (069) 6 66 68 36

Rheometrics UK
Market House, 62 St Judes Road
Englefield Green, Surrey TW20 0BT
Phone (0784) 439694/5

Rheometrics®

Polymer Laboratories



Rheological Test Equipment

PL CURE RHEOMETER

A versatile and robust instrument for measuring the cure and dynamic flow properties of a wide range of materials such as bitumen, concrete and cements, resins, powder paints, foodstuffs, explosives and pharmaceuticals.



ACER SERIES

Advanced Capillary Extrusion Rheometer Series

A range of robust instruments for measuring the flow properties of many materials such as polymer melts, foodstuffs, energetic materials, filled systems, rubbers and the new high-temperature polymers.



SLIT FLOW MONITOR (SFM)

A device for measuring the viscoelastic flow properties of various materials during extrusion. May be fitted to many capillary extrusion rheometers for research and quality control, and to extruders as on-line rheological monitors.

EXTRUDATE TEMPERATURE MONITOR (ETM)

A non-contacting on-line instrument for measuring the temperature of extrudates etc. Used for estimating shear heating effects during processing.

PL MICRO-CAPILLARY EXTRUSION RHEOMETER

A novel and unique instrument for determining the flow and elastic behaviour of spinning melts and dopes.

May be used also for printing inks, oils and other low viscosity materials.

NEW

Other instruments within the ACER range include 'Thrust' for measuring the pressure coefficient of viscosity; and the ESM extrudate swell monitor for on-line non-contacting measurement of diameter.

FOR FURTHER INFORMATION, CONTACT:

**Polymer Laboratories Ltd., Thermal Sciences Division,
The Technology Centre, Epinal Way, Loughborough, LE11 0QE. U.K.
Tel: (0509) 233300 Fax: (0509) 234905**



THE SCOTT BLAIR COLLECTION.
AMENDMENTS TO THE CATALOGUE

Insert:—

International Congress on Rheology. 9th Acapulco, Mexico, 1984. *Advances in Rheology*; edited by Baltasar Mena, Andres Garcia-Rejon, Carlos Rangel-Nafaile. Mexico 1984 4v.
SCOTT QC189. 5. A1. I6.

Advances in Rheology; edited by Baltasar Mena. See:- International Congress on Rheology, 9th, Acapulco, Mexico, 1984.

[This see reference is present in the 2nd ed. of the catalogue. Both the main entry and the two see references should be in the same catalogue.]

insert:—

Symposium on Biorheology, 1963, Brown University, Providence, R. I. [Proceedings] . . .; edited by A. L. Copley. See:- International Congress on Rheology, 4th, Brown University, Providence R. I., 1963 Vol. 4.

Copley, A. L. Symposium on Biorheology, 1963, Brown University, Providence, R. I. [Proceedings] . . .; edited by A. L. Copley. See:- International Congress on Rheology, 4th, Brown University, Providence R. I., 1963 Vol. 4.

International Congress on Rheology, 4th, Brown University, Providence R. I., 1963. Proceedings . . .; edited by E. H. Lee . . . New York, London, 1965 4v. Pt. 1 edited by E. H. Lee and Alfred L. Copley — pt. 4 is the Symposium on Biorheology, editor Alfred L. Copley. Pt. 1 has a review by G. W. Scott Blair.

SCOTT QC189. 5 A1. I6

[This entry is already in the catalogue. The main entry and the two references should be in the same catalogue].

Insert:—

Laboratory Practice Vol. 15 no. 1 January 1966; Vol. 15 no. 2 February 1966. Special Issue: Biorheology. London, 1966 2v.
SCOTT QP517. R48. L1 Pam Qto.

Amend:—

British Society of Rheology Bulletin no. 28 1950 —

Delete:—

Scott Blair, G. W., *Measurements of mind and matter*. London, 1950 Bibl. pp. 113-4. Author's copy, extensively annotated.
[This copy is included in the second entry for the book].

Delete:— from the list of Journals

Laboratory Practice Vol. 15 no. 1-2.

Rheology Abstracts 1-17 (1958/74).

RECENTLY PUBLISHED BOOKS

Information on recent books is given here for the benefit of members, but the Society cannot answer enquiries about the availability of particular titles. Place orders for books with publishers through booksellers and agents.

Dickinson, Eric, *An Introduction to Food Colloids* Oxford 1992, Oxford University Press, ISBN 0-19-855224-6 (hard back) 216pp. illus. £27. 50, ISBN 0-19-855223-8 (Paperback) £13. 95.

A central theme throughout this text is the way in which stability, texture and microstructure of food colloids depend on the state of aggregation of the dispersed particles. It also explains the crucial role of rheology in defining and interpreting the behaviour of colloidal systems.

Tattersall, G. H., *Workability and Quality Control of Concrete*, E & F Spon 1991 272pp. ISBN 0-419-14860-4 £27.50.

This book is written specifically for practising engineers and concrete technologists and incorporates the results of 20 years of research. It develops the treatment of workability as a property to be measured in terms of two constants. *Contents:* The importance of workability. Standard tests for workability. Flow properties of fresh concrete. Principles of measurement. The two-point workability test. Workability expressed in terms of two constants. Extremely low workability concretes. Factors affecting workability. Effect of mix proportions. Effect of chemical admixtures. Effect of cement replacements and fibres. Workability and practical processes. Specification of workability. Workability measurement as a means of quality control.

MEMBERSHIP NEWS

The following applications for membership were approved at the Council Meeting, March 3rd, 1992.

Mr T. Ahmed,
Polytechnic of Wales,
Pontypridd,
Mid Glamorgan.
(fetsa CDL)

Mr I. N. Forsdyke,
B. P. Research Centre,
Chertsey Rd.,
Surrey-on-Thames,
Middlesex, TW16 7LN.

Mr N. G. Henderson,
The University of Sheffield,
School of Materials,
Sir Robert Hadfield Bldg,
Mappin St, Sheffield, S1 3JD
(fetsa AG)

Miss M. P. Lambert,
Advanced Composites Group,
Slack Lane, Heanor Gate
Industrial Estate,
Heanor,
Derbyshire.
(fetsa BDFGH)

Mr A. R. McLelland,
The University of Sheffield,
School of Materials,
Sir Robert Hadfield Bldg,
Mappin St, Sheffield, S1 3JD.
(fetsa ABFGHM)

Dr A. D. Miles,
B.P. Chemicals Ltd.,
P. O. Box 21,
Bo'ness Road,
Grangemouth,
Stirlingshire.
(feta D)

Dr J. Szwabowski,
Institute of Building Technology,
Silesian Technical University,
ul Pstrowskiego 5,
44-100 Gliwice,
Poland.
(feta GK)

Dr M. A. Tehrani,
Schlumberger Cambridge Research,
P. O. Box 153,
Cambridge,
CB3 0HG.
(fetsa DFGN)

Dr David Cheng retired from Warren Spring Laboratory on 30 March 1992 but he will continue to offer consultancy and advice on Rheology of non-Newtonian Fluids. Basic Science and Applications: Measurement techniques, Product Development, Quality Control, Process Control, Process Plant Design and Operation.

His new address is:— 191 Icknield Way, Letchworth, Herts, SG6 4TT, U. K. Tel: (0462) 672146.

P. C. Anderson and Dr A. S. Taylor have retired from B. P. Research Centre Ltd..

Professors Emeriti John D. Ferry and Arthur S. Lodge have been elected to membership of the National Academy of Engineering. Both were formerly members of the Rheology Research Centre at the University of Wisconsin, Madison, U. S. A.. Professor Lodge received the Gold Medal of the British Society of Rheology in 1983.

FROM THE HON. MEMBERSHIP SECRETARY

Have you changed your address? By the middle of the year, I hope to be able to produce a new membership list from my records. It is clearly highly desirable that this is as accurate as I can make it.

If you believe that my record of your membership is deficient in any way, I would be greatly obliged if you could let me know as soon as possible at the address inside the front cover. I am particularly concerned with getting your contact address correct. Even the post code is useful, as it allows me to search the database by area. I recently had a request from the Sheffield area for just such a search.

Please help your Honorary Membership Secretary in this lonely task! Thank you.

Doug Hourston

OBITUARY

DR ROBERT ROSCOE

Dr Robert Roscoe, who was President of the British Society of Rheology from 1962 to 1964, died on March 20th, 1992. He had been a lecturer in Physics at King's College in the University of Durham from 1938 and Reader in Physical Rheology from 1973 to 1977, by which time the place where he worked had become the University of Newcastle upon Tyne.

Rob joined the Society in 1947 and had been an honorary member since 1978. Since his retirement, he and his wife Helen travelled widely, enjoying the rare birds of islands from Islay to Sri Lanka. He maintained an interest in rheology after his retirement and it was only increasing deafness that kept him away from the Society's Golden Jubilee meeting in Edinburgh.

His rheological interests were wide. He had a laboratory in which he investigated the materials that delight rheologists — notably solutions and suspensions. At the same time he published results in theoretical rheology ranging in topic from "An empirical constitutive equation for elasto-viscous liquids" (1964) to his invited lecture at the 1972 International Congress on Rheology in Lyon on bounds for the moduli of composite materials.

A handwritten note from him, sent with some reprints in 1977, states that "I am rather fond of the one on 'The steady elongation of elasto-viscous liquids' which was hardly noticed at the time and has now been long surpassed " This unwarranted modesty is typical of a rheologist whose papers are not full of references to his own previous work. In fact that paper, published in 1965, still has a message to those who would predict behaviour in elongation from properties measured in shearing flows — not the over-simplified "don't" — but "you can do this, provided that you remember the limitations of what you are doing'.

Personal memories include the 1964 Exeter conference of the Society where, as a young research student, I found him a welcoming and encouraging person. That proved to be the start of a friendship, of Ann and myself with Rob and Helen, which involved meeting in all sorts of unlikely places and only rarely in Newcastle. The last occasion on which the four of us met (by chance) was shortly before the opening of the Gateshead Garden Festival in 1990. That occasion was a tour, organized by the Natural History Society of Northumbria, of a "natural" wetland specially created for the Festival.

Rheology doesn't seem an old enough subject to have too many "Grand Old Men", but Rob was one of those — warm, unassuming, yet standing no nonsense. It was our pleasure to know him and count him as a friend for nearly thirty years.

I am sure I speak for the Society in saying that we shall miss him, and in offering our warmest sympathy to Helen and to their family.

Chris Petrie

CONFERENCE ANNOUNCEMENTS

RHEOLOGY OF GELS AND MICRO-STRUCTURED FLUIDS, AND GENERAL RHEOLOGY

THE ANNUAL CONFERENCE OF THE BRITISH SOCIETY OF RHEOLOGY
JOINT WITH GROUPE FRANÇAIS DE RHEOLOGIE
at Selwyn College, University of Cambridge,
September 15-16th 1992

This meeting will open at 9 a. m. on Tuesday September 15th and close at 4. p. m. on Wednesday September 16th.

PROVISIONAL SCIENTIFIC PROGRAMME

TUESDAY SEPTEMBER 15TH

The dynamics of solutions of highly stretched macromolecules in contraction flows. Implications for the elongational viscosity.

U. Cartalos & J. M. Piau, Institut de Mecanique de Grenoble

Rheology of an aqueous gel, A. Magnin & J. M. Piau, Grenoble.

Dynamic magnetic birefringence as a diagnostic tool in viscoelastic media.

J-C. Bacri & R. Perzynski, Universite Pierre et Marie Curie.

Effect of whey proteins and technological treatments of milk and curd on the viscosity of fresh cheeses.

M. Mahaut & J. Korolczuk, INRA.

Heat gelation of whey protein concentrates.

P. Gault & J. Korolczuk, INRA.

Effects of high pressure homogenization on the rheology of crushed tomatoes.

A. Trifiro & S. Gherardi.

Study of the gelation process in bovine and caprine milk systems fermented using "ropy" and "non-ropy" starter cultures.

I. Vlahopoulou & A. E. Bell, University of Reading.

Deformation, melting and relaxation of structured colloidal dispersions.

A. Bradbury, J. W. Goodwin & R. W. Hughes, University of Bristol

Rheology of granular suspensions.

S. N. Davies & G. H. Meeten, Schlumberger Cambridge Research.

Rheology of polymer gelation.

R. H. Colby, M. Rubenstein, J. R. Gilmor & C. P. Lusignan, Eastman Kodak Co..

Sheared suspensions and depletion flocculation.

D. M. Heyes & J. R. Melrose, University of Surrey.

Effect of shear on a lyotropic lamellar phase.

O. Diat & D. Roux, Centre de Recherche Paul-Pascal.

Modelling the thixotropy of CMC and aluminium silicate solutions under constant stress.

T. Benezech & J. F. Maingonnat, INRA-LGIA

Optical observations of flowing molten polymers.

P. Gao, M. R. Mackley & F. Zhao, University of Cambridge

WEDNESDAY SEPTEMBER 16TH

Dynamic characterisation of the yield behaviour of a silicone paste.

J. Varlet & A. Pouchelon, Rhone-Poulenc.

Rheology of an assembly of gel beads.

F. Lequeux & D. Grosshans, Institut le Bel.

Rheological behaviour of worm-like micelles.

S. J. Candau, A. Khatory & F. Kern, Universite Louis Pasteur.

Small deformation measurements of biopolymer gels.

S. B. Ross-Murphy, Kings College London.

Casein micelles in skim milk as adhesive hard spheres.

C. G. de Kruif, NIZO

Rheology of polysaccharide "weak gels": comparison of small and large deformation oscillatory measurements.

R. Lapasin, S. Pricl, R. K. Richardson & E. R. Morris, University of Trieste/Cranfield I. T..

Rheology and die swell of xanthan solutions.

C. Allain, M. Cloitre, P. Perrot & D. Quemada, University of Orsay.

Dynamic viscoelastic characterisation of sol-gel transition of a gelatin system. Effect of concentration and gel history on critical conditions.

C. Michon, G. Cuvelier & B. Launay, ENSIA.

A study of the setting properties of gelatin using the PL-Strathclyde rheometer.

R. E. Carter & F. S. Baker, Polymer Laboratories.

The viscosity of weakly structured dispersions: anomalous rheometric behavior due to wall slip.

R. Buscall & J. I. McGowan, ICI.

BRITISH SOCIETY OF RHEOLOGY/GROUPE FRANÇAIS DE RHÉOLOGIE
Rheology of Gels and Microstructured Fluids
Sidney Sussex College, Cambridge, September 15th-16th, 1992.

Please register me for the above meeting (BLOCK CAPITALS)

Name:

Affiliation:

Address to which correspondence should be sent

.....
.....
.....

Charges	Charge	VAT	Total	Please Tick your requirements
<i>All Delegates</i>				
Conference fee, including refreshments, lunches and Conference Dinner on 15th	£72.00	£12.60	£84.60	☐
Accommodation				
Dinner, Bed & Breakfast				
Night of Monday 14th	£28.00	£4.90	£32.90	☐
Bed & Breakfast				
Night of Tuesday 15th	£22.50	£3.94	£26.44	☐
Bed & Breakfast				
Night of Wednesday 16th	£22.50	£3.94	£26.44	☐

VAT Reg. No. 563-9230-32

Grand Total _____

Payment: Either by Cheque (made payable to British Society of Rheology)
or by Visa or Mastercard only

Card Type Number Expiry Date

..

Name on Card

Address

.....

Please charge £_____ to the above card

Signature Date

Please return as soon as possible to: Dr. M.R. Mackley, University of Cambridge,
Department of Chemical Engineering, Pembroke Street, Cambridge CB2 3RA, England.

EXPERIMENTAL RHEOMETRICAL MEASUREMENTS

A meeting to be held at the Manchester Conference Centre, UMIST,
Manchester, on March 31st-April 2nd 1993

CALL FOR PAPERS

Offers of papers are invited for this meeting which is intended to place an emphasis on practical testing of industrial and biological materials.

Speakers will be allocated a 30 minute slot, including discussion. The proceedings will not be published but the abstracts will be included with the programme.

Titles and abstracts (about 250 words) should be sent to Carole Moules, Kruss UK Ltd., 5/6 Carrington House, 37 Upper King Street, Royston, Herts., SG8 9AZ, as soon as possible. The closing date is June 1st 1992.

The meeting aims to bring together product formulation chemists, quality control personel, and production engineers, on the one hand, and research scientists, students and manufacturers of instruments, on the other.

There will be an open session during the meeting for people to identify their application problems with feedback from an invited group of experts as well as the audience.

A presentation of the preliminary findings of a study set up by the BSR to look at the transparency of rheometer operation and software analysis will be made.

Further details will appear in following issues of the Bulletin.

SECOND INTERNATIONAL SYMPOSIUM ON GAS CLEANING AT HIGH TEMPERATURES

This symposium will be held at the University of Surrey, September 27th-29th, 1993. The main subject area will be gas cleaning at temperatures above 250° C., but papers dealing with novel work at lower temperatures will be considered. 200 word abstracts should be submitted by May 26th, 1992.

For further information contact: Mrs Jean Libaert (ref. G93), Dept. of Chemical & Process Engineering, University of Surrey, Guildford, Surrey, GU2 5XH, U. K.. Tel: 0483 506330, Fax: 0483 303807.

THEORETICAL RHEOLOGY

A JOINT MEETING OF THE BRITISH AND DUTCH RHEOLOGY SOCIETIES
at Robinson College, University of Cambridge
September 22nd-24th 1993

A three day meeting on theoretical rheology will be held at Robinson College. It is proposed to cover topics on: Dilute and concentrated fluid behaviour, Pastes; Particles and Powders, Numerical Simulation

Robinson College is Cambridge's most recent College and participants will enjoy excellent conference and residential facilities. The College lecture theatre seats 240 people and it is hoped that the meeting will attract a wide and International participation.

Offers of theoretical papers and experimental work relating to theory should be sent to the address below, enclosing an abstract of the paper for consideration by the organising committee. If you would like to be put on the mailing list please indicate below. Dr. M.R. Mackley
Department of Chemical Engineering, University of Cambridge,
Pembroke Street, Cambridge, CB2 3RA.

I enclose an abstract for the Theoretical Rheology Meeting

☐

Please put me on the mailing list for the Theoretical Rheology Meeting

☐

(BLOCK CAPITALS)

NAME

ADDRESS

.....

.....

MATERIALS RESEARCH SOCIETY FALL MEETING
SYMPOSIUM M: FLOW AND MICROSTRUCTURE OF DENSE
SUSPENSIONS

November 30th- December 4th, 1992
Boston, MA, U. S. A.

The flow behaviour of suspensions is controlled by various aspects of the suspension microstructure, in particular the extent to which particles are flocculated or aggregated and the density of the suspension. In turn, the microstructure is strongly influenced by chemical interactions, both among particles and between particles and the liquid phase. Finally, processing is dominated by flow behaviour for a wide variety of suspensions.

This symposium will address recent advances in the flow behaviour of dense suspensions. Emphasis will be placed on both fundamental aspects and processing issues, particularly how interaction potentials and particle density relate to suspension dynamics, and how fundamental aspects of flow behaviour govern processing. The symposium will consist of both invited and contributed talks, and will probably include a poster session. A symposium of two to three days is anticipated and published proceedings are planned. Topics include: relationships between microstructure and flow behaviour, simulations of suspension structure and dynamics, behaviour of non-spherical particle suspensions, dynamics of flocculated suspensions, shear thickening in dense suspensions, processing of ceramic materials, processing of cementitious systems, flow behaviour of coatings.

Papers are invited on any of the above or related topics. Invited speakers will include the following: W. B. Russel, I. Aksay, J. Mewis and B. Ackerson (model suspensions and theory), F. Lange (processing ceramic materials), P. Banfill (processing concrete) and A. McHugh (processing polymer-modified cement).

SYMPOSIUM ORGANIZERS

Leslie J. Struble, Dept. of Civil Engineering, 2129 Newmark Civil Engineering Laboratory, University of Illinois, 205 N. Mathews, Urbana IL 61801-2397. Tel.: (217) 33-2544, Fax: (217) 333-9464

Geoffrey Maitland, Schlumberger Cambridge Research Ltd., P. O. Box 153, Cambridge CB3 0HG Tel.: 0223-325200, Fax: 0223-61473.

THE EUROPEAN SCHOOL OF RHEOLOGY

AUGUST 31ST — SEPTEMBER 11TH, 1992

UNIVERSITY OF STRATHCLYDE, GLASGOW, SCOTLAND

IN CONJUNCTION WITH: THE BRITISH SOCIETY OF RHEOLOGY, LE GROUPE
FRANÇAIS DE RHÉOLOGIE, LA SOCIÉTÉ BELGE DE RHÉOLOGIE, GRUPO DE
REOLOGIA ESPAÑA.

This is one of a number of courses in science and technology being organised under the European Communities Comett II scheme. The object is to teach the basics of the subject, leading on to state of the art rheology, to industrial scientists and higher education teachers and researchers.

The course has been structured over an eleven day period to provide a combination of lectures and seminars on the theory and practice of rheology. In parallel, there will be practical classes in which a number of instrument manufacturers will talk about and demonstrate their rheometers.

Participants will be asked before the start to specify their particular rheological interests and any rheological problems they may wish to have discussed. These will be dealt with in small group tutorials within the general programme.

We have assembled a distinguished group of experienced speakers for the course. Their talks will be augmented by printed lecture notes which will in themselves provide a valuable rheological reference guide for the future.

Lectures will be given by established European experts, both academic and industrial. The following have already agreed to take part: Prof. H. Barnes; Dr G. Brownsey; Prof. J. Ferguson; Dr N. Hudson; Prof. Z. Kemblowski; Prof. F. Leslie; Prof. J-M. Piau; Prof. P. Townsend; Prof. K. Walters.

The course content will be as follows: Introduction; basic concepts of rheology; theoretical basis for rheology; the molecular basis for flow; rheological behaviour of non-Newtonian fluids in shear; rheological behaviour of fluids with a yield stress; demonstration of rheological equipment; rheological behaviour of non-Newtonian fluids in extension; theory and practice of rheological measurement; relationship between rheology and polymer structure; rheometry; student seminars; suspensions and emulsions; viscosity and rheological concepts in industry; liquid crystals; process control using rheology;

industrial processes — pumping; fibre spinning; mixing, spraying, drag reduction, coating, flow in pipes, extrusion, flow in granular beds, two phase flow of liquids and gases; biological fluids and foods; numerical simulation and flow visualisation.

FEES SCHEDULE

REGISTRATION (includes lectures, notes, weekday lunches, course dinner and teas/coffees) Students £50, Academics £200, Industry £800.

ACCOMMODATION (includes bed, breakfasts, dinners and weekend lunches) Type a, Study bedroom £385, Type b, Hotel standard £800.

FOR FURTHER INFORMATION CONTACT: Dr N. E. Hudson, Dept. of Pure & Applied Chemistry, University of Strathclyde, 295 Cathedral Street, Glasgow G1 1XL, Scotland, U. K.

CONFERENCE DIARY

DATE	PLACE	DETAILS
26-29/5/92	Glasgow, U. K.	Residential Course: 'Theoretical, Experimental and Industrial Aspects of Rheology', contact: Dr N. E. Hudson, Dept. of Pure & Applied Chemistry, University of Strathclyde, Cathedral St., Glasgow G1 1XL.
31/5-5/6/92	Lake Garda, Italy.	'Rheology, Processing and Properties of Polymeric Materials', contact: Prof. G. Marrucci, Naples, Italy.
6-8/7/92	Wollongong, N. S. W. Australia	4th International Conference on Bulk Materials Storage, Handling and Transportation and 7th International Symposium on Freight Pipelines, contact: Prof. Peter Arnold, Dept. of Mechanical Engineering, The University of Wollongong, P. O. Box 1144, Wollongong, N. S. W. 2500, Australia.
17-22/8/92	Brussels Belgium	9th International Congress on Rheology, contact: Dr P. Moldenaers, Chemical Engineering Department, Katholieke University Leuven, W. de Croylaan 46, B-3001 Leuven, Belgium.
22-28/8/92	Haifa, Israel.	'18th International Congress of Theoretical and Applied Mechanics', I. U. T. A. M., contact: Prof. A. Solan, Secretary ICTAM 1992, Faculty of Mechanical Engineering, Technion — Israel Institute of Technology, Haifa 32000, Israel.
30/8-4/9/92	San Diego, California U. S. A..	'NETWORKS 92-11th meeting of the Polymer Networks Group', contact: NETWORKS 92, c/o BIOSYM Technologies Inc., 10065 Barnes Canyon Road, San Diego, California 92121-2777, U. S. A..
31/8-11/9/92	Glasgow, U. K.	European School of Rheology, contact: Prof. J. Ferguson, Dept. of Pure & Applied Chemistry, University of Strathclyde, Cathedral St., Glasgow G1 1XL.
1-5/9/92	Moscow, Russia.	"Current problem of rheology, biorheology and biomechanics", contact: V. Kulichikhin.
7-11/9/92	Brussels, Belgium.	'1st European Computational Fluid Dynamics Conference and 1st European Conference on Numerical Methods in Engineering', contact: Conference Secretariat, E. C. C. O., Rue Vilain XIII 17a, B-1050 Brussels, Belgium.

15-16/9/92	Selwyn College, Cambridge, U. K..	'Gels, microstructured fluids and general rheology', contact: Dr R. Buscall, ICI Corporate Colloid Science Group, P. O. Box 11, The Heath, Runcorn, Cheshire WA7 4QE.
17-18/9/92	Cambridge, U. K..	'Colloids in external fields', contact: The Royal Society of Chemistry, Burlington House, Piccadilly, London W1V 0BN.
28/9-3/10/92	Dnepropetrovsk, Ukraine	"Annual Meeting", Society of Rheology of the U. S. S. R., contact: V. Kulichikhin.
27/9-2/10/92	Baden-Baden, Germany.	EPF92: 4th International Symposium on Polymeric Materials, contact: Dr U. Biethan, FEA4, Hüls AG, P. O. Box 1320, D-4370 Marl 1.
10 or 11/92	Osaka, Japan	'40th Rheology Congress' Society of Rheology, Japan, contact: Prof. Kunihiro Osaki, Institute for Chemical Research, Kyoto University, Uji, Kyoto 611, Japan.
7-11/2/93	Santa Barbara, California, U. S. A..	'64th Annual Meeting', Society of Rheology, contact: Dr A. M. Kraynik, Division 1511, Sandia National Laboratories, Albuquerque, New Mexico 87185, U. S. A..
31/3-2/4/93	Manchester.	'Experimental rheometrical measurements', contact: Mrs C. A. Moules, Kruss UK Ltd., 5/6 Carrington House, 37 Upper King St., Royston, Herts. SG8 9AZ
22-24/9/93	Cambridge, U. K.	'Theoretical Rheology' contact: Dr M. R. Mackley, Dept. of Chemical Engineering, University of Cambridge, Pembroke St., Cambridge CB2 3RA.
17-21/10/93	Boston, Mass.,	'65th Annual Meeting', Society of Rheology, contact: Dr A. M. Kraynik, Division 1511, Sandia National Laboratories, Albuquerque, New Mexico 87185, U. S. A..
1994	Spain.	'4th European Conference on Rheology', contact: Prof. C. Gallegos, Departamento de Ingeniería Química, Universidad de Sevilla, Prof. García González, s/n (Edificio de Química), 41012 Sevilla, Spain.
1995	Caracas, Venezuela.	'3rd Caribbean Conference on Fluid Dynamics', contact: Dr H. Ramkissoo, University of the West Indies, Dept. of Mathematics, St. Augustine, Republic of Trinidad and Tobago.

A new age for rheology...

The Materials Testing Workstation from Cheema Technology Limited brings a new era of versatility to the measurement of complex rheological parameters:

- Direct emulation of theoretical model for viscoelastic response
- Rapid operation (350 ms. per reading)
- Comprehensive temperature control and ramping (-196 to 600 Celsius)
- Unequalled frequency range (0.001 to 400 Hertz)
- Small sample size (minimum 10 microlitres)
- Precisely controllable strain and frequency sweep
- Small sample gap (minimum less than 10 microns)
- Interchangeable sample plates for unrivalled versatility
- Inexpensive and disposable plates for hard setting materials
- Rheokinetics, chemorheology and electrorheology options
- Unique ability to irradiate sample during analysis
- Compact, with no compressed gas supply necessary

Ask for an information pack.

Cheema Technology Limited

Centre for Product Development,

Lenton Boulevard, Nottingham, United Kingdom NG7 2BY

Telephone 0602 424410 Facsimile 0602 790054 Email Compuserve 100014,1041