

# RHEOLOGY BULLETIN

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## RHEOLOGY SHORT COURSE

A two-day short course on Extensional Rheology of Polymer Melts and Solutions will be offered in Monterey, October 3-4, 1998. Course content includes a discussion, with appropriate applications, of the available experimental techniques for measuring the extensional properties of polymer solutions and melts. Also to be discussed are constitutive equations relevant for describing these properties and their importance in the computational modeling of polymer processing operations. Professors D.G. Baird, G.H. McKinley and D.F. James are the course instructors. A complete description and registration information will be included in the July 1998 issue of the Rheology Bulletin.

## 70th ANNUAL MEETING MONTEREY, CA OCTOBER 4 - 8, 1998

The Autumn 1998 meeting of the Society of Rheology will be held at the Monterey Marriott Hotel in Monterey, California. The meeting organizers are:

### Technical Program Chairs:

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**INSTRUMENT EXHIBIT** Companies involved with rheological instrumentation will exhibit their products at the annual meeting.

**POSTER SESSION** A poster session will be held in Monterey. Abstracts should be submitted using the web-based procedure by August 21, 1998. The session chair is:

Susan J. Muller  
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Visit the Society of Rheology on the web at  
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The city of Monterey sits in the heart of the celebrated Monterey Bay that is home to John Steinbeck's historic Cannery Row, dozens of fine restaurants and shops, and the wondrous sea life of the world-renowned Monterey Bay aquarium. Visitors to this region can take advantage of the spectacular coastline of northern California, championship golf at 17 courses (including famous Pebble Beach), and the charm of Carmel-by-the-Sea. The Monterey Marriott is located adjacent to the Fisherman's Wharf area of the city and has recently been extensively renovated and updated. Hotel facilities include fine restaurants, pools, and exercise facilities.

Monterey can be reached within 1.5 hours by car from San Francisco or directly using its excellent regional airport. The Monterey Peninsula Airport is serviced by American, Delta, Northwest, United, and US Airways. Many flights utilize standard, jet aircraft, and the incremental cost of adding Monterey to a flight itinerary is normally quite modest.

October is a peak tourist month for the Monterey area, and the climate is generally very pleasant. For this reason, meeting attendees are advised to book their travel as early as possible.

**Registration and housing forms, and other information on the Monterey meeting will be included in the July Bulletin.**

## TECHNICAL PROGRAM FOR MONTEREY

G. Marrucci will give a plenary lecture entitled, "Recent progress in the theory of entangled polymers in fast flows," while Steve Granick will speak on "Interfacial Rheology."

Authors wishing to present a paper in Monterey should submit an abstract by **May 15, 1998**. The preferred medium for submitting the abstract is through the World Wide Web using the SOR abstract submission page at:

<http://www.umecheme.maine.edu/sor/>

Otherwise abstracts submitted via e-mail or on the enclosed form should be sent to the Technical Program chair, P.T. Mather, with a copy to the appropriate symposium chair. The planned symposia and their organizers follow:

### 1. EXTENSIONAL AND ELONGATIONAL FLOWS:

David James  
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### 2. RHEOLOGY AND MICROSTRUCTURE OF ELECTRO & MAGNETO- RHEOLOGICAL FLUIDS:

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### 3. VISCOELASTIC PROCESSING FLOWS: THEORY AND EXPERIMENT

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### 4. ANALYTICAL & NUMERICAL SOLUTIONS TO FLOW PROBLEMS:

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### 5. INTERFACIAL RHEOLOGY AND RHEOLOGICAL MODIFIERS:

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**6. POLYMER FRICTION, SLIPPAGE, AND DYNAMICS NEAR SURFACES:**

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**7. COUPLING FLOW AND ORDER IN FLUIDS:**

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**8. RHEOLOGY OF SOLIDS:**

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**11. NEW EXPERIMENTAL METHODS:**

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**13. JET BREAKUP, ATOMIZATION & SPRAYING OF NON-NEWTONIAN LIQUIDS:**

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**14. SUSPENSIONS AND EMULSIONS:**

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**15. GENERAL SESSION:**

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**A TRIBUTE WRITTEN IN HONOR OF THE  
MANY YEARS OF DEVOTION TO THIS SOCIETY  
BY THE RETIRING TREASURER, E.A. COLLINS**

Our July Bulletin includes, under the entries for the Executive Committee of the Society of Rheology, the following one:

Treasurer: Edward A. Collins

That's NOT CORRECT!

The entry given is not one of editorial or other error; indeed such an entry has appeared on every Bulletin for an entire quarter century, and Society members have voted for Edward Collins as their treasurer a total of 13 times. But, even in the recollections of several elderly writers whose remembrances of events long past is better than those of recent encounters have we ever known him to act merely as treasurer. He was, on behalf of the Society:

The experienced individual who could negotiate fiercely with hotels for better rates for accommodations as well as for meeting rooms.

The consistent guardian of the Society's resources who insisted that Executive Committee members should be sufficiently devoted to the office to which each was elected to use their own (professional or personal) resources to cover the costs of attending committee meetings.

The rheologist who ensured that our short courses were populated sufficiently to cover all expenses, and sometimes more -- by calling industrial friends and urging them to enroll themselves and their associates on those numerous occasions when preliminary registration levels were a cause for concern.

The investor of our Society's modest reserves in financial instruments which were not only safe but which paid far higher interest rates than AIP was able to obtain for us.

The charterer of aircraft (when this was in vogue and possible) to enable Society members to attend overseas congresses at low cost.

The persistent "concerned citizen" who believed a better balance between industrial and academic presentations and publications was important for the welfare of the organization.

AND ALSO

The Treasurer.

Not all these activities -- e.g. the first two -- earned him encomia from those with whom he worked. But they all contributed to the functioning and continuity of this Society when our reserves were so modest that a single major slip could entirely terminate our existence, and a sequence of only two or three minor ones would do likewise.

Many members of this Society, the writers included, have profited from association with committed unpaid professionals. Indeed, the functioning and the strengths of most professional organizations depend upon just such commitments. But do any of us know even a single individual whose devotion to, and love for, his profession exceeds that enumerated above? In recognition of the love for our Society shown by Ed Collins several of us, during an especially dreary Executive Committee meeting a few years ago, sought refuge in the spirits of Gilbert and Sullivan and penned the following quasi-quatrains:

He is the very model of a treasurer tried and true  
The guardian of our cash whether it be old or new:  
Investing it with wisdom at the highest interest rate.  
We'll not be paupers ever with Ed's hand on the gate.

No president could challenge Ed's empyrean reach  
Of the economic facts of life which he alone could teach.  
Executive decisions might drift us to and fro  
But Ed's hand on the tiller kept us in the dough.

Of course, no human activity is awash in unbounded joys and free of all difficulties. Chartering of aircraft to reduce travel costs is a case in point -- wherein we experienced problems as well as savings. Let us consider an event which Debbie Cook, the Journal's editorial assistant for many years, and the editor experienced about eight years ago. We were visiting the AIP publishing center in Woodbury, Long Island, to help in assessing the wisdom of moving responsibility for printing the Journal from John Wiley to AIP. An informative meeting with the principals there was followed by a tour of the actual publishing plant. As we proceeded, we were astonished to have a publishing employee rush up to us with the words, "I so wanted to meet the Society of Rheology representatives, to thank them for what they did for me at the time of the 1972 International Congress in France." His story was compelling.

The commercial airlines were very wary of revenue losses to charter operations, and accordingly the law restricted charters to "pre-existing members and employees of an organization or club." Since all of us are members of AIP, it was possible for AIP employees to avail themselves of the charter, and this man did -- he had never been to Europe before and this charter offered a unique opportunity to do so. After the plane took off, an individual whom he did not know introduced himself on the PA system as the Society's organizer of the charter and stated he had a financial problem to bring to the attention of all on board. The captive audience, perhaps expecting an unanticipated fare increase, evidently greeted the speaker with considerably less than excessive exuberance. "It is this," he went on to say "In setting the fare, we assumed the plane would be far less than filled. Since we did nearly fill the entire plane, we received more money than needed and so I'll return the difference to you now." He then proceeded to walk down the aisle of the plane, handing everyone a bill of large denomination! And so most of the passengers were very happy indeed. Not all charters turned out that way. As one example of this, the same printer was informed, when he wished to sign up for a subsequent one, that the legal restrictions now extant required formal membership in the Society. So he joined us! However, the charter was subsequently canceled, and so he did not receive this second expected benefit from his membership. He did, however, receive the Journal and Bulletin issues for the year and felt these to be so valuable that he now wished to return them to us.

None of the writers of this tribute was actually present on this charter flight and cannot verify the implicit suggestion that the generous cash-disbursing individual was indeed Ed Collins. However, as he did arrange several later charters, and was the treasurer in 1972, it seems quite likely that he was involved in this episode. In any event, "the story is such vintage Ed Collins material," several 1972 members advised, that it should be included in this narrative. If the attribution is incorrect, perhaps the actual organizer can be identified as the story may be worth saving in the lore of this Society.

Ed Collins was born and grew up in Winnipeg, a city located just barely below Canada's "green line" marking the northern boundary beyond which the growing season is too short for cultivation of cereal grains. Perhaps it was his residency in this region which enabled him to greet imperfect suggestions for the future of the Society with a stare as icy as the nearby tundra. And, adopting some of the life-styles of the Crees and Assiniboines who were the original inhabitants of the region, as well as among his neighbors, he became an ardent hunter and fisherman. Perhaps a part of this heritage, and the constant coping with a hostile climate, is what has helped him to develop the ability to love and to commit which he has shown this society -- clearly the "tough love" (to use a current phrase) which we needed to survive and prosper.

Derived from this culture too is his gastronomical love for game and fish dishes. And, like Ed, many of us who share that interest are willing to pay the price necessary, at least occasionally, to enjoy such foods in truly great restaurants. But can anyone match Ed's payment of \$800 for a single duck -- and this a bird with the feathers still on it! What an esoteric epicurean you must be, Ed!! To say nothing about your generosity in then donating this uniquely expensive culinary delight to the Manitoba game warden who brought its true value to your attention. So one sees that Ed Collins, ever the careful conservator of Society of Rheology resources, may also be an inherently generous individual in his personal encounters.

What of the future? Will the inspirational commitment and tough love you gave this society, Ed, be remembered and adopted by your successors on the Society's Executive Committee? We believe you can be assured of this. Indeed, if your commitment was honed in part by the harsh subarctic environment in which you lived during your youth, just imagine the tough love we might be receiving two years from now with a president who lived 900 km further north than you did! Do be assured, too, that as we await future developments we'd like to do so in your company; we look forward to your continued participation in our meetings, and our friendships, for many years to come.

**Comments prepared by: Arthur B. Metzner  
with the assistance of numerous colleagues.**

### 1997 JOURNAL OF RHEOLOGY PUBLICATION AWARD

The 1997 Journal of Rheology Publication Award has gone to I. Vinckier, P. Moldenaers, and J. Mewis for their paper entitled, "Relationship between rheology and morphology of model blends in steady shear," and published in the Journal of Rheology, **40**, 613 (1996). The award was presented at the banquet at the Columbus meeting of the Society.

### Student-Member Travel Grants for Monterey

The Society of Rheology is again offering grants to support the cost of public transportation to the annual meeting of the Society to graduate student members of the Society. Details concerning eligibility, application procedure and application deadline may be found on the web page of the Society:  
<http://www.umecheme.maine.edu/sor/>

## TIME-TEMPERATURE SUPERPOSITION FOR POLYMERIC BLENDS

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### INTRODUCTION

Time-temperature superposition (TTS, also frequency-temperature superposition or the method of reduced variables) is a well-known procedure frequently applied, either to determine the temperature dependence of the rheological behavior of a polymeric liquid or to expand the time or frequency regime at a given temperature at which the material behavior is studied. For elementary models of polymers under deformation, it is not too difficult to show that the principle is indeed valid [1]. This is due to the fact that the various relaxation times belonging to a given relaxation process have the same temperature dependence. For example, the modified Rouse model has a relaxation spectrum:

$$G_i = \frac{\rho RT}{M} \quad \tau_i = \frac{6M\eta_0}{\pi^2 i^2 \rho RT} = \frac{\tau_1}{i^2}$$

in which all  $G_i$  and all  $\tau_i$  have the same temperature dependence. If we now define shift factors

$$a_T = \frac{\tau_i(T)}{\tau_i(T_0)} \quad \text{and} \quad b_T = \frac{G_i(T)}{G_i(T_0)}, \quad \text{we will find}$$

$$G'(\omega) = b_T \sum G_i(T_0) \frac{(\omega a_T)^2 \tau_i^2(T_0)}{1 + (\omega a_T)^2 \tau_i^2(T_0)}$$

so that  $G'(\omega)/b_T$  and similarly  $G''(\omega)/b_T$ ,  $G_d(\omega)/b_T$  and  $\delta = \text{atan}(G''/G')$  as a function of  $(\omega a_T)$  yield temperature independent curves. Note that the product of the horizontal and vertical shift factors equals the shift factor determined from the zero shear viscosity:

$$a_T b_T = \frac{\eta_0(T)}{\eta_0(T_0)}$$

According to Ferry TTS holds when: (i) exact matching of shapes of adjacent (time or frequency dependent) curves is obtained; (ii)  $a_T$  has the same value for all viscoelastic functions; (iii) the temperature dependence of  $a_T$  has a reasonable form (WLF, Arrhenius).

In practice, however, many reasons why the principle should fail are conceivable, like the occurrence of more than one relaxation mechanisms with distinct temperature dependences [2]. For example, in the vicinity of the glass transition temperature both energetically and entropically induced relaxations play a role, and in general TTS will not hold. Obviously, materials which change (chemically or physically) during the rheological measurement will not obey TTS.

In the case of inhomogeneous polymeric materials, in particular polymeric blends, the different components of the material will in general display a different temperature-dependent rheology, so that TTS will not hold for blends. Surprisingly, for many blends the principle is still reported to hold [3], see also Table 1. The question arises why this is the case. Furthermore, if indeed TTS fails, further inspection of this failure might give information on specific interactions present in the inhomogeneous system.

**Table 1:**

	TTS holds	TTS fails
Miscible	PS/PVME [1,25,26] SAN/SMA [2, own] SAN/PCL [30] PMMA/PVDF [2,3] PPO/PS [2,4,5,31] sPS/mPA2,10 [29] PS/PCHMA [32]	PEO/PMMA [21,27,own] 1,2PB/PIP [18-20,28]
Immiscible	ABS [6,7, own] SB/PB [14] PS/PC [9,10] HDPE/LDPE [11] LLDPE/LDPE [own] PA6/EVA [2] PS-co-SSA/PEA-co-VP [12] PS/PB [8] PE/PP [13,own] PP/EVA [23]	PS/PMMA [22] PS/LDPE [own] PE/EVA [15] PS/PEA [12] SAN/PMMA [own]

1. Stadler et al. *Polymer* **29**, 1643 (1988), 2. Han & Chuang, *JAPS* **30**, 4431 (1985), 3. Wu, *JPS:B:PP* **25**, 557 (1987), 4. Prest & Porter, *JPS A2* **10**, 1639 (1972), 5. Schmidt, *JAPS* **23**, 2469 (1979), 6. Aoki, *J. Soc. Rheol. Jpn.* **7**, 20 (1979), 7. Masuda et al. *Pure & Appl. Chem.* **56**, 1457 (1984), 8. Wang & Lee, *JAPS* **33**, 431 (1987), 9. Wisniewski et al. *Eur. Polym. J.* **21**, 479 (1985), 10. Lipatov et al. *JAPS* **26**, 499 (1981), 11. Curto et al. *Rheol. Acta* **22**, 197 (1983), 12. Bazuin & Eisenberg, *JPS:B:PP* **24**, 1021 (1986), 13. Alle & Lyngaae-Jorgensen, *Rheol. Acta* **19**, 94 (1980), 14. Watanabe & Kotake, *Macromol.* **16**, 769 (1983), 15. Fujimura & Iwakura, *Kobunshi Ronb., Eng. Ed.* **3** 1864 (1974), 16. Yanovski, *Chem. Eng. Comm.* **32**, 219 (1984), 17. Cavaille et al. *JPS:B:PP* **25**, 1847 (1987), 18. Kannan & Kornfield, *J. Rheol.* **38**, 1127 (1994), 19. Zawada et al. *Macromol.* **27**, 6861 (1994), 20. Roovers & Toporowski, *Macromol.* **25**, 3454 (1992), 21. Colby, *Xth Int. Congr. Rheol.* p 278 (1988), 22. Han & Kim, *Polymer* **34**, 2533 (1993), 23. Cassagneau et al. *JAPS* **58**, 1393 (1995), 24. Zorn et al. *Macromol.* **28**, 8552 (1995), 25. Ajji et al. *JPS:B:PP* **29**, 1573 (1991), 26. Mani et al. *J. Rheol.* **36**, 1625 (1992), 27. Colby, *Polymer* **30**, 1275 (1989), 28. Arendt et al. *Rheol. Acta* **33**, 322 (1994), 30. Han & Yuang, *JAPS* **33**, 1199 (1987), 31. Stadler & De Araujo, *Macromol. Chem. Macromol. Symp.* **38**, 243 (1990), 32. Friedrich et al. *Polymer* **37**, 2499 (1996).

### HOMOGENEOUS BLENDS

Homogeneous polymeric materials with a distribution of chain lengths are the simplest class of blends to consider. In general, the chain length will not influence the relaxation mechanism, and in practice no influence of chain length on the activation energy is found. Branched polymers are a separate class, since they may be considered as blends of polymers with various amounts of branching. In most cases more branching is found for longer chains, while in addition the longest chains are responsible for the longest relaxation times. Since branching does affect the temperature sensitivity of the rheology [4], an inhomogeneous branching distribution may cause failure of the TTS principle. LDPE for example needs a considerable vertical shift in the superposition procedure (in steady shear this can equally well be explained by a stress-dependent activation energy) and TTS is sometimes slightly

violated. A more pronounced example of this effect is branched EPDM. Figure 1 shows the master curves of the storage and loss moduli  $G'$  and  $G''$  of a long chain branched EPDM as a function of the reduced angular frequency  $\omega$  at 125 °C. In addition we have plotted the phase angle  $\delta = \text{atan}(G''/G')$  versus the absolute value of the complex modulus. This way of plotting eliminates the effect of shifting along the frequency axis, and yields temperature independent curves when TTS holds. Furthermore, direct insight into the amount of a resulting vertical shift (here along the  $G_d$ -axis) is readily observed, which cannot be seen from a  $G' - G''$  plot. Therefore, failure of TTS can conveniently be read from the plot. Indeed, failure of TTS is clear for this example of a long-chained branched EPDM.

Interestingly, in some cases, e.g. for materials in which branching is introduced by peroxide or electron beam irradiation, it is possible to shift the long times side of the relaxation time spectrum using one activation energy (related to the branched polymer) and the other side with a lower activation energy (the linear components).

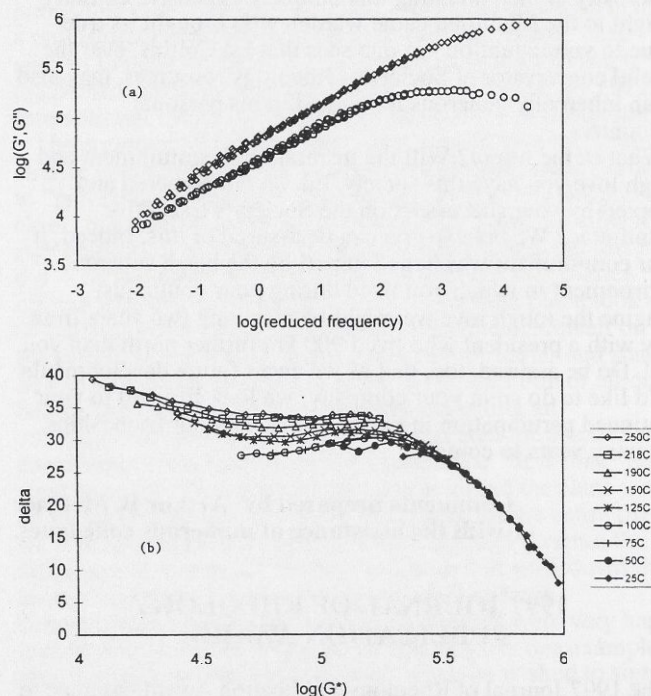


Figure 1 Dynamic mechanical results of a long chain branched EPDM. a) Storage and loss moduli as a function of reduced angular frequency at a reference temperature of 125 °C. b) Phase angle as a function of dynamic modulus at various temperatures.

### MISCIBLE BLENDS

Until the end of the 1980's it was thought that for miscible blends of chemically differing polymers the dynamics of the two components would have the same temperature dependence [5], due to their intimate mixing. However, measurements on PEO/PMMA blends, assumed to be miscible, showed a clear failure of the TTS principle [6]. It was suggested that the components retain their own temperature sensitivity in the blend due to heterogeneities on a very small scale, while the local dynamics may be influenced by each component's surroundings [7]. When strong interactions between



# THE SOCIETY OF RHEOLOGY

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Preferred Session
Title of Paper

Last Name of First Author		Last Name of Second Author	
First Name	Middle Initial	First Name	Middle Initial
Institution		Institution	
Mailing Address		Mailing Address	
City/State	Zip/Postal Code/Country	City/State	Zip/Postal Code/Country
Phone	Fax	Phone	Fax
E-mail Address		E-mail Address	
SOR Member <input type="radio"/> Yes <input type="radio"/> No		SOR Member <input type="radio"/> Yes <input type="radio"/> No	

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Number of Authors	Type of Institutions of Authors (Check all that apply) <input type="checkbox"/> Academic <input type="checkbox"/> Industry <input type="checkbox"/> Government
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Author Names to be listed in the Abstract Book
Author Affiliations to be listed in the Abstract Book (256 characters <i>maximum</i> )

➤ **Attach an abstract (2000 characters *maximum*) with this form.** ◀

Please use Times New Roman or equivalent of at least 12 points.

components play a role, it is thought that the strong coupling may result in one single temperature dependence [8]. Obviously, when the temperature sensitivities of both components are comparable (close  $T_g$ 's), TTS will also hold. The occurrence of local heterogeneities, and therefore failure of TTS, is reported to be very sensitive to the difference in glass temperature of the blend components [9]. Interestingly, a miscible SAN-SMA blend with  $\Delta T_g = 47^\circ\text{C}$ , seems to obey TTS quite well, see Figure 2.

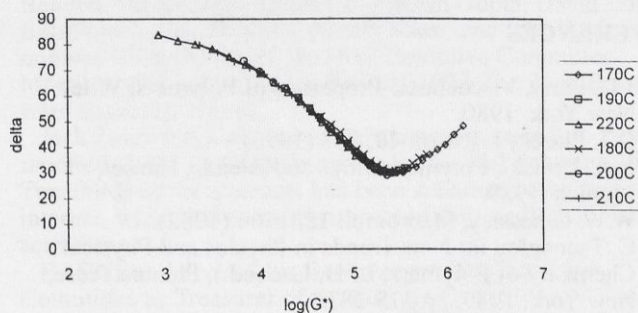


Figure 2 Phase angle as a function of dynamic modulus for a 40:60 SAN/SMA blend at various temperatures.

### IMMISCIBLE BLENDS

In principle, immiscible blends will not obey TTS due to the different temperature dependencies of both components. Surprisingly, however, for many blends successful application of TTS is reported, see Table 1. The simplest reason may be that the activation energies or WLF parameters of the components are not too far apart. On the other hand, the experimental accuracy with which a measurement is performed may well be a factor affecting the decision whether or not TTS is thought to hold. It should be realized that in many cases the only criterion is the visual inspection of the experimental results on a certain (most often logarithmic) scale. Consequently, the same blend may be found to obey TTS on the basis of capillary measurements while it fails if dynamic mechanical results are used. Furthermore, measurements at large deformations like capillary experiments are suspect due to the fact that the blend morphology may change during flow.

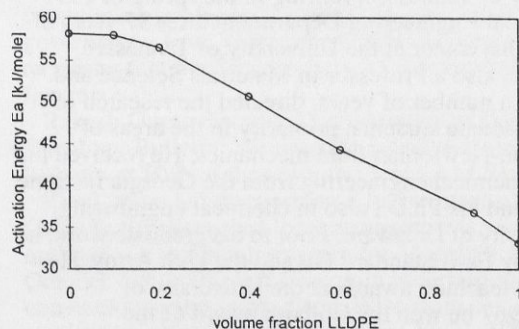


Figure 3 Activation energy as a function of volume fraction LLDPE in a LDPE/LLDPE blend.

Even if activation energies of the two components in the blend are different, failure of TTS may be subtle and therefore experimentally unseen, e.g. when the contribution of one of the two components to the measured stress signal is small. This may be due either to small volume fractions or low viscosity of one of the components, or to the fact that the relaxation of one

of the components falls outside the experimental time regime. Furthermore, broad molar mass distributions yield structureless dynamic spectra, which may in practice result in successful application of TTS. In the latter case, it is possible to find the activation energy of the blend using a simple mixing rule, see Figure 3. The subtleness of failure of TTS is illustrated in Figure 4, where the phase angle  $\delta$  is plotted versus  $G_d$  for a 40:60 LDPE/LLDPE blend at three different temperatures. The experimental symbols indicate that within small scatter TTS seems to hold, while calculated curves at the three different temperatures using a simple log additive blending rule indicates failure (i.e. the three drawn curves do not superpose). Interestingly, although the activation energies of LDPE and LLDPE are differing by about a factor of two, the calculated curves almost perfectly superpose between moduli of  $10^4$  and  $10^5$  Pa. Obviously, the arguments to explain the successful application of TTS in practice to immiscible blends are equally well applicable to miscible blends. In fact, a nice example is the 1,2-PB/PI system, for which TTS is reported to hold [10] and -- after close inspection -- to fail [7,11].

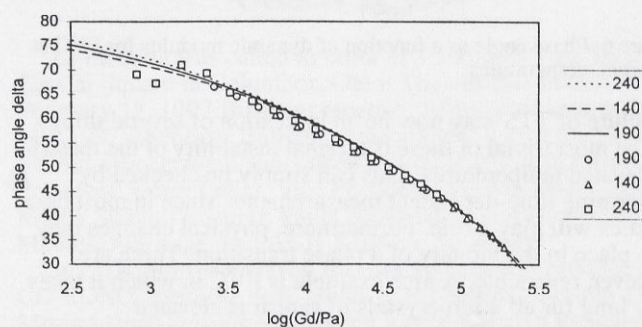


Figure 4 Phase angle as a function of dynamic modulus for a 40:60 LDPE/LLDPE blend at three different temperatures. Symbols indicate experimental results, drawn lines are calculations based on a log-additive mixing rule applied to the two components.

Interfacial effects can be seen as a relaxation mechanism with its own temperature dependence and therefore accountable for the failure of TTS. Figure 5 shows results of dynamic mechanical measurements on a PE/PS blend at various temperatures. Failure is apparent, in particular at reduced temperatures where the effect of interfacial tension is more pronounced. Blends undergoing a phase transition upon a change of temperature will, in principle, not obey the TTS principle [12]. Here the physical microstructure of the material changes with temperature.

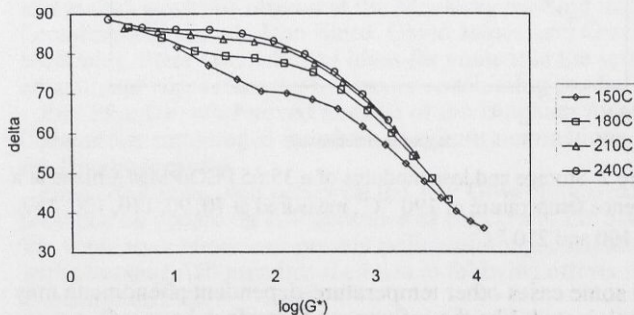


Figure 5 Phase angle versus complex modulus for a 20:80 LDPE/PS blend at various temperatures.



## TTS AS AN INDICATOR

In many cases, rheology (in particular dynamic spectra at various temperatures) can be used as an indicator of molecular structure. The most obvious example is the relation set up between molar mass distribution and the relaxation time spectrum. Furthermore, the activation energy may be used as an indicator of the type of material [13] or the amount of branching [14]. Also, the vertical shift factors may yield information on chain stiffness, or branching, although not much work has been devoted to these relations.

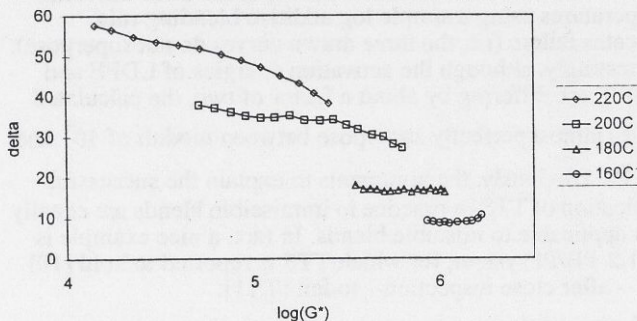


Figure 6 Phase angle as a function of dynamic modulus for PVC at different temperatures.

Failure of TTS may now be an indication of several things:

1. The most trivial of these is thermal instability of the material at elevated temperatures. This can simply be checked by performing time-dependent measurements, since in most cases kinetics will play a role. Furthermore, physical changes may take place in the vicinity of a phase transition. These are, however, reversible. A nice example is PVC in which it takes very long for all microcrystals to vanish at elevated temperatures, see Figure 6.
2. A priori it is expected that application of TTS fails in the case of blends. It is not too difficult to apply a blend rule to the dynamic spectra of both components of the blend and check the resulting curves at various temperatures. This is indeed illustrative, since this reveals if the extent of failure agrees with the experimental results, or, alternatively, that TTS is strictly speaking not applicable, but only to such a minor extent that the experimental results are superposable.

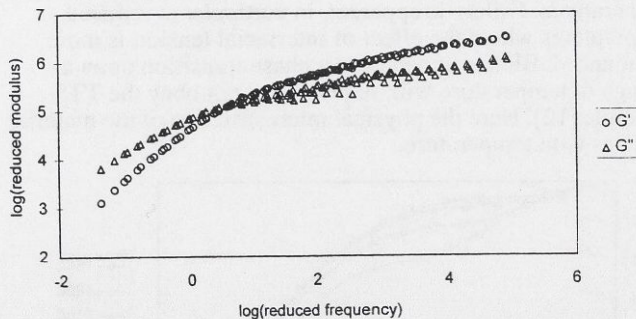


Figure 7 Storage and loss modulus of a 35:65 PEO/PMMA blend at a reference temperature of 190 °C, measured at 70, 90, 110, 130, 150, 170, 190 and 210 °C.

3. In some cases other temperature-dependent phenomena may be anticipated, like the influence of interfacial stresses, e.g. to be calculated using Palierné's model, or the effect of an equilibrium modulus, which can simply be subtracted before

the shifting procedure [15]. Interestingly, both effects are purely elastic, and therefore appear to show up predominantly in the storage modulus. Shifting of both  $G'$  and  $G''$  may now be used to have an indication of the existence of either additional elastic or frictional forces. Figure 7 shows a 35:65 PEO/PMMA blend, where the shifting of  $G'$  seems to be reasonable, while  $G''$  is not shiftable. Although, in principle,  $G'$  and  $G''$  are related according to the Kramers-Kronig relations, one might argue that in this case mostly local frictional interactions influence the temperature-dependent dynamics.

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## Don Bogue Passes Away

Donald Chapman Bogue passed away at the age of 65 in Knoxville on November 11, 1997. He was Professor Emeritus at the University of Tennessee, retiring in the spring of 1997 from the Chemical Engineering Department after 37 years of service. During his career at the University of Tennessee, Professor Bogue, also a Professor in Materials Science and Engineering for a number of years, directed the research of more than 30 graduate students, primarily in the areas of rheology and non-Newtonian fluid mechanics. He received his B.S. degree in chemical engineering from the Georgia Institute of Technology and his Ph.D., also in chemical engineering, from the University of Delaware. Prior to his graduate work, he was employed by Esso Standard Oil and the U.S. Army. He received several teaching awards at the University of Tennessee. In 1967 he won the Colburn award of the American Institute of Chemical Engineers, and in 1987 he was elected a Fellow of the Institute. Professor Bogue maintained close ties with industry and was a consultant for several major industries and laboratories. In the 1970's he developed a strong interest in Japanese culture and language and spent three years as a visiting professor at Kyoto University. He also encouraged American students to study in Japan, and, due to his efforts, several American graduate students conducted research at Japanese Universities.

## MINUTES OF THE EXECUTIVE COMMITTEE MEETING October 19, 1997

The meeting was called to order at 9:00 a.m. in the Hyatt on Capitol Square in Columbus, Ohio. Executive Committee Members in attendance included: Kurt Wissbrun, Ron Larson, Ed Collins, Morton Denn, Bob Armstrong, Gerry Fuller, Jeff Giacomini, and Andy Kraynik. Invited guests included: Janis Bennett, Peter Clark, Albert Co, Rakesh Gupta, David James, Bob Powell, Eric Shaqfeh, Monty Shaw, and Jack Zakin. The minutes of the February 16, 1997 Executive Committee Meeting, which appeared in the July 1997 Rheology Bulletin, were approved as read.

Jack Zakin reported on local arrangements and Bob Powell reported on the technical program for the Columbus meeting. Two thirds of the abstracts had been submitted over the internet, which indicates the impact of this medium in Society activities.

Ed Collins delivered his final report to the Executive Committee as Treasurer of the Society. Details can be found in the Rheology Bulletin. Our healthy financial condition is a testament to diligent stewardship by Ed Collins over the past two decades. Ed's service to the Society, in matters both large and small, may never be surpassed.

Eric Shaqfeh, who served as chair of the Bingham Award Committee, presented ideas to increase nominations for the Bingham medal. Peter Clark, chair of the Education Committee, outlined the cost and content of a series of educational videos that the Society is considering producing. Ron Larson will form an ad hoc committee to study various options that were presented. As is customary, Jeff Giacomini reported that Society membership, now at 1728, continues to grow. He also discussed progress in revising the constitution. Webmaster Albert Co provided an overview of the ever-expanding Society of Rheology Home Page.

Janis Bennett provided an update on AIP activities of concern to the Society, such as production of a new membership directory. We voted to continue supporting the Physics Olympiad at an annual level of \$1500. We also decided to ask members at the upcoming business meeting whether or not the Society should participate with other AIP societies in formulating public policy statements aimed at the federal government. Kurt Wissbrun presented a letter from AIP requiring that the Society carry a Professional Liability Insurance Policy.

Rakesh Gupta discussed his activities as Editor of the Rheology Bulletin. We voted to set advertising rates in the Bulletin at 50% of those for the Journal of Rheology.

Ron Larson led discussion on future meetings of the Society. Gerry Fuller discussed local arrangements and Pat Mather outlined the technical program for Monterey, California, October 4-8, 1998. Jeff Giacomini indicated that the new convention center in Madison, Wisconsin, is now complete and awaits our annual meeting, October 17-21, 1999. We voted to accept a proposal submitted by Don Baird to organize the Winter 2001 meeting in Fort Myers, Florida.

David James, as secretary of the International Committee on Rheology, discussed a proposed site selection process for future International Congresses on Rheology. We voted to support formation of a balloting structure based on one vote for each of three regions: Europe, Asia-Pacific, and the Americas. The Society will cooperate with Canada and Mexico to decide the vote for our region.

Gerry Fuller led discussion on Student Travel Grants. We decided to revise guidelines to read that any student member, whose advisor is also an active member, is eligible to receive one travel grant during his/her career. We discussed a letter from Gary Leal concerning rules for accepting papers for presentation at Society meetings.

Morton Denn indicated that editorial activities for the Journal continue to run smoothly and presented data on manuscript flow and acceptance. Monty Shaw, Associate Editor for Finance, provided a financial report for the Journal. He will also analyze the rate assessed to document delivery services for Journal articles. Starting in 1998, the Journal will go on-line to institutional subscribers. We voted to produce archival CD-ROMs of back issues of the Journal through 1997. The set will be available to members (\$125 pre-publication and \$175 post-publication), current institutional subscribers (\$250), new institutional subscribers (\$475), and non-subscribers (\$2000).

After a brief executive session, the meeting was adjourned at 5:00 p.m.

## MINUTES OF THE BUSINESS MEETING October 21, 1997

The meeting was called to order at 5:30 p.m. in the Hyatt on Capital Square in Columbus, Ohio. The minutes of the February 18, 1997 Business meeting, which appeared in the July 1997 Rheology Bulletin, were approved as read. Newly elected officers were announced and included: Ron Larson, President; Gerry Fuller, Vice President; Morton Denn, Editor; Monty Shaw, Treasurer; Paula Moldenaers and Don Baird, Members-at-large; and Andy Kraynik, Secretary.

Kurt Wissbrun announced that the Society will produce a CD-ROM containing back issues of the Journal through 1997. Morton Denn delivered the Editor's report, which included statistics on manuscript flow. On average, papers contained in the latest issue of the Journal were accepted in final form in 143 days and published in 221 days. About 50% of manuscripts submitted for publication are accepted.

Ed Collins delivered his final report to a Business Meeting as Treasurer of the Society. Details can be found in the Rheology Bulletin. Our healthy financial condition is a testament to diligent stewardship by Ed Collins over the past two decades. Ed's service to the Society, in matters both large and small, may never be surpassed.

As is customary, Jeff Giacomini reported that Society membership continued to grow, up to 1728 from 1620 in the previous year.

Peter Clark, chair of the Education Committee, announced that a short course on "Extensional flows of polymer solutions and melts" would be offered at the Monterey meeting in 1998. Lecturers will include Don Baird, David James, and Gareth McKinley. Peter also solicited ideas for content in the series of educational videos that the Society is considering producing.

Eric Shaqfeh, who served as chair of the Bingham Award Committee, encouraged members to submit nominations for the Bingham medal.

Greg McKenna, who serves on the AIP Governing Board, provided an update on AIP activities of concern to the Society. We voted to continue our present policy of not participating with the other AIP member societies in lobbying efforts in Washington, D.C.

Webmaster Albert Co was recognized for maintaining the ever-expanding Society of Rheology Home Page.

Anthony Pearson welcomed members to participate in the

International Congress on Rheology in Cambridge, U.K., August 20-25, 2000. David Boger announced that Rheology Societies in the Pacific Rim were planning to organize regional meetings.

Upcoming annual meetings of the Society of Rheology were

announced. Gerry Fuller will chair local arrangements and Pat Mather will organize technical sessions in Monterey, CA, October 4-8, 1998. Jeff Giacomini is planning the meeting in Madison, WI, October 17-21, 1999. Don Baird will organize the Winter 2001 meeting in Fort Myers, FL.

The meeting was adjourned at 6:40 p.m.

## JOURNAL OF RHEOLOGY PROPOSED 1998 BUDGET

	<u>1998 Budget</u>
<b>REVENUES</b>	
1 Advertising Sales	\$ 21,000
2 Publication Award	1,000
3 Abstracts	200
4 Reprint Sales	2,200
5 Single Copy Sales	100
6 Non-Member Subscriptions	214,700
7 Subscriptions Prior	400
8 Royalties	<u>4,500</u>
<b>TOTAL REVENUE</b>	<b><u>\$244,100</u></b>
<b>EXPENSES</b>	
9 Advertising Production	9,000
10 Composition	40,000
11 Illustration	3,000
12 Editorial Mechanics	33,600
13 Editorial Office	44,000
14 Reprint Billing	1,100
15 Reprint Processing	500
16 Reprint & Mailing	6,000
17 Print & Binding	26,000
18 Paper	11,200
19 Mailing	18,300
20 Single Copy Expenses	800
21 Electronic Publishing	25,000
22 Member Fulfillment	12,070
23 Non-Member Fulfillment	3,050
24 Marketing & Other Business	5,400
25 Storage	250
27 Publication Award	1,000
28 CD Rom	58,700
<b>TOTAL EXPENSES</b>	<b><u>\$295,970</u></b>
<b>NET REVENUE</b>	<b><u>(51,870)</u></b>

**THE SOCIETY OF RHEOLOGY  
PROPOSED 1998 BUDGET**

**1998 Budget**

**REVENUES**

Due	58,000
Interest	35,000
Journal of Rheology	244,100
Mailing List Sales	1,300
Annual Meetings	5,000
Short Courses	<u>5,000</u>

**TOTAL REVENUE**

**348,400**

**EXPENSES**

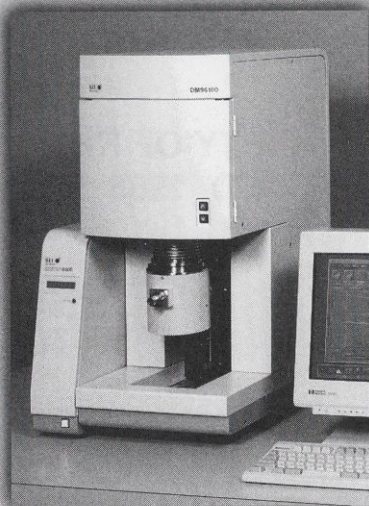
AIP Administrative Service	7,000
AIP Member Society Dues	5,800
AIP Financial Handling	4,500
AIP Physics Olympiad	1,500
Renewal Billing	2,000
Journal of Rheology	295,970
Bulletins & Abstracts	10,000
Short Courses	5,000
Bingham Award	2,500
Executive Cmt. Meeting	7,500
Pres. Discretionary Fund	1,500
Tres. Discretionary Fund	1,500
Program Chm. Discretionary Fund	2,000
Secretarial Services	1,000
Mailing	2,000
Office Expenses	4,000
Banking Services	250
Liability Insurance	170
Membership Directory	13,500
Membership Brochure	1,500
Accountant	1,500
Student Member Travel Grant	5,000
Advance Deposit For Future Mtg.	1,500
Miscellaneous	<u>3,000</u>

**TOTAL EXPENSE**

**380,190**

**NET INCOME**

**(31,790)**



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