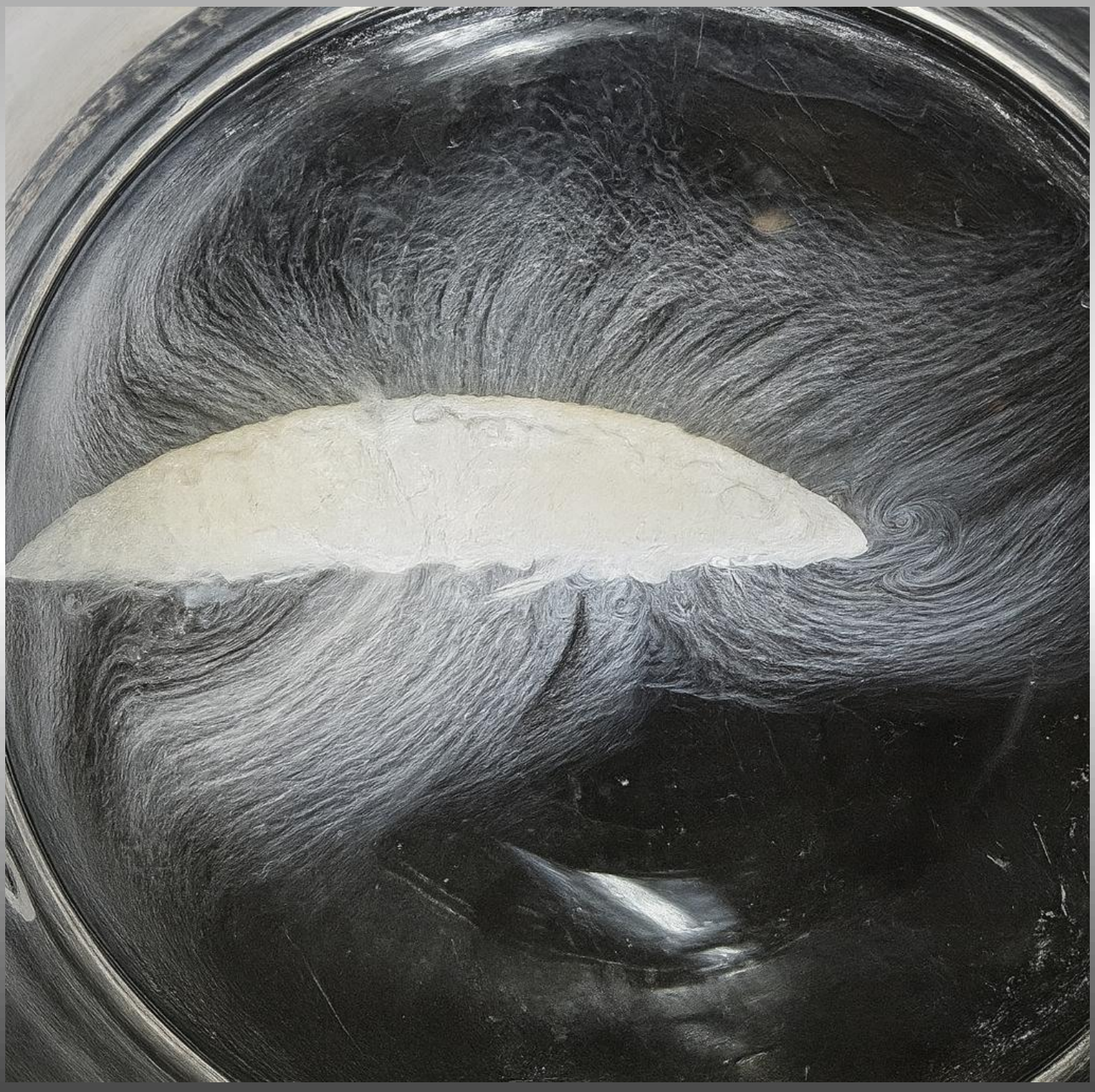
The News and Information Publication of The Society of Rheology
Volume 95 Number 1, August 2026

Rheology Bulletin

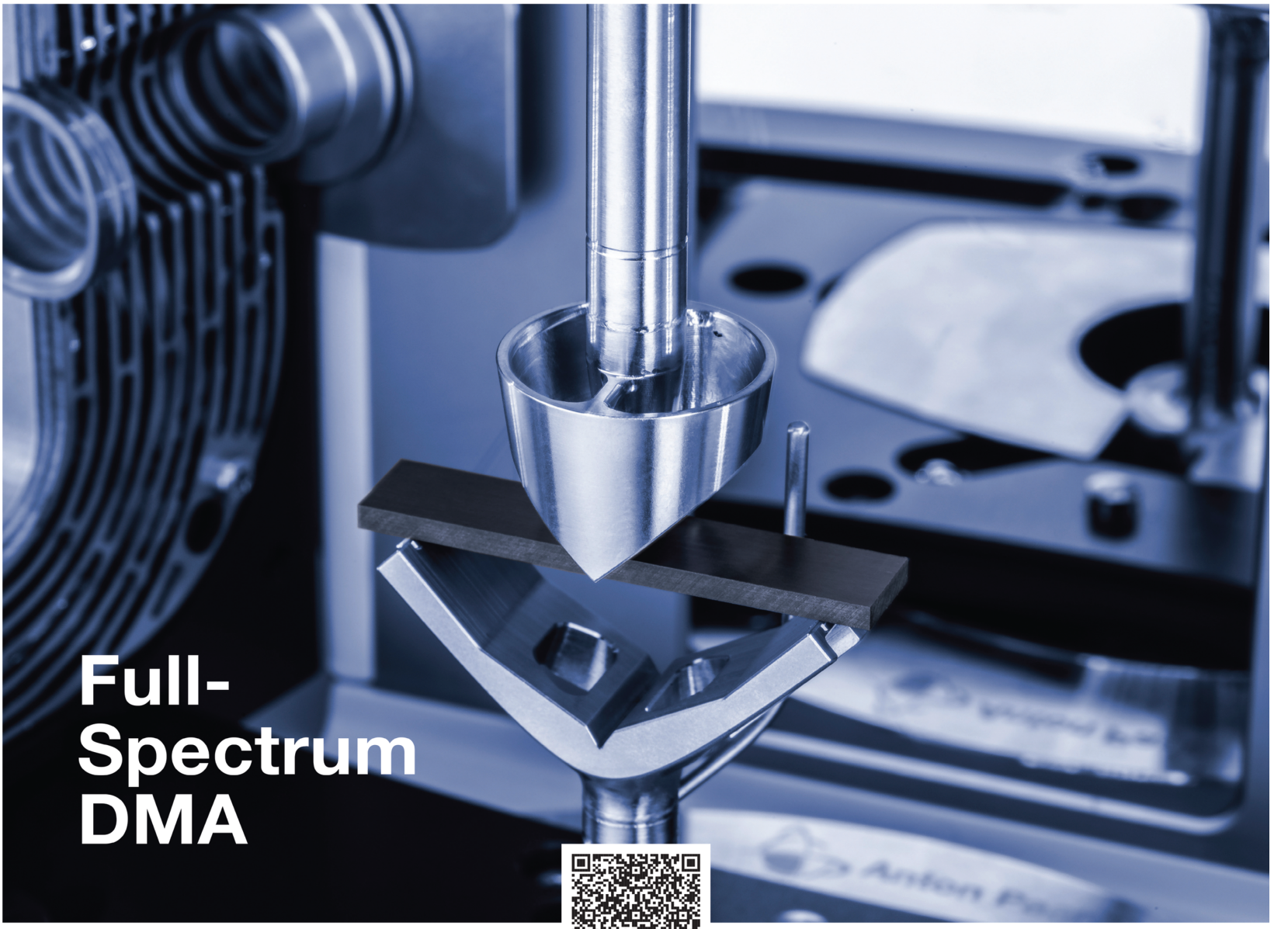


Inside:

- *Viscosity of Hydrocarbon-based Liquids*
- *Dense Suspension Rheology*
- *In Memoriam: Jan Mewis*
- *Come to Boston in October*
- *SOR Awards*

The Society of Rheology

Anton Paar



Full-Spectrum DMA

Dynamic Insight Across Every Stage of Material Transformation

Low-Temp DMA
Is your DMA cool enough to go subambient without additional cooling devices?

High-Temp DMA
Can your DMA handle the heat your materials experience?

Flexible DMA
Does your DMA need tools to mount your materials?

Immersion DMA
Is your material performing in fluid, but your DMA testing it dry?

Executive Committee

(Jan 1 2025–Dec 31 2026)

President
Jeffrey Morris

Vice President
Roger Bonnecaze

Secretary
Kalman Migler

Treasurer
S. Lisa Biswal

JoR Editor
Dimitris Vlassopoulos

Past-President
Jonathan Rothstein

Members-at-Large
Arezoo Ardekani
Rossana Pasquino
Charles Schroeder

Student Representative
Jiye Lee

Table of Contents

06 Letter from the President
08 SOR Meeting Report (Santa Fe)
11 Welcome to the New SOR Website!
14 Student Affairs Report
16 Meet the New SoR Communications Liaison and Student Representative
17 Come to Boston! SoR 97th Annual Meeting
19 Bingham Medal
22 Metzner Award
24 2026 Elected Fellows
28 News from JOR
30 Technical Article: Understanding the Viscosity of Hydrocarbon-based Liquids
38 Technical Article: Network Science Insights in Dense Suspension Rheology
45 In Memoriam: Jan Mewis and Miroslav Grmela
48 Secretary's Report
50 Treasurer's Report
54 Poem: Pebble

On the Cover: Porous hydrogel can be synthesized from oil-in-water emulsion templates. In this work, as-synthesized hydrogels based on poly(ethylene glycol) diacrylate and chitosan reveal a hidden elegance when immersed in water. The water uptake by the pore network expels the residual oil and surfactants from the porous network of the hydrogel, in drifting plumes that curl and flow like the dancing tendrils of a jellyfish. These patterns evoke the shadowed grace of Gustave Doré's paintings. These dynamics play a crucial role in solvent exchange, which is particularly important for drug delivery in the pharmaceutical industry.



The *Rheology Bulletin* is the news and information publication of The Society of Rheology (SoR) and is published yearly in August (in non-pandemic years). Subscription is free with membership in The Society of Rheology. Letters to the editor may be sent to Carlos R. López-Barrón at *carlos.r.lopez-barron@exxonmobil.com*

Serial Key Title: Rheology Bulletin
LC Control No.: 48011534
Published for The Society of Rheology by AIP Publishing LLC (AIPP) a subsidiary of the American Institute of Physics
ISSN: 0035-4538 CODEN: RHBUAV
CALL NUMBER: QC1.R45

The *Rheology Bulletin* is archived at *www.rheology.org/SoR/publications/rheobulletin/.*

SoR Committees

Membership Committee (2026)
- Travis Walker, Chair
- Carina Martinez
- Sara Reynaud
- Antonio Perazzo
- Mazi Jalaal
- Giovanniantonio Natale
- Jiye Lee (student member)

Education & Outreach Committee (2026)
- Abhinendra Singh, co-Chair
- Thomas O'Connor, co-Chair
- Sumana Chakrabarti
- Parth Kelkar
- Sara Hashmi
- Matt Helgeson
- Maggie Qi
- Javen Weston

Bingham Award Committee (2026)
- Randy Ewoldt, Chair
- Jacinta Conrad
- Sara Hashmi
- Saad Khan
- Michael Rubinstein
- Jan Vermant

Metzner Award Committee (2026)
- Sujit Datta, Chair
- Xiang Cheng
- Julia Kornfield
- Safa Jamali
- Gordon Christopher

SoR Fellowship Committee (2026)
- Maryam Sepehr, Chair
- Will Hartt
- Steve Hudson
- Srinivas Raghavan
- Paulo de Souza Mendes

Journal Publication Award Committee
- Dimitris Vlassopoulos (Editor)
- Emanuela Del Gado (Associate Editor)
- Evelyne van Ruymbeke (MAL)
- Simon Rogers (MAL)
- Norbert Willenbacher (previous winner)

Meeting Policy Committee (2026)
- Roger Bonnecaze, co-chair (VP)
- Andy Kraynik, co-chair
- Kalman Migler, Secretary
- Rae Robertson-Anderson, Webmaster
- Albert Co, Webmaster

Audit Committee (2026)
- Jeffrey Martin, Chair
- Brian Edwards
- Paul Salipante
- Lisa Biswal (ex officio)

Financial Advisement Committee (2026)
- Anne Grillet, Chair
- Ryan Murphy
- Jonathan Seppala
- Jeff Morris (president, ex officio)

Nominating Committee (2026)
- Rajesh Khare (Chair)
- Evelyne van Ruymbeke
- Steve Hudson

Ad Hoc Committees:

Centennial Celebration Committee (2026)
- Safa Jamali, Chair
- Jonathan Rothstein, Co-Chair
- Gareth McKinley
- Jeff Morris
- Peter Olmsted
- Vivek Sharma

2026 Annual Meeting Committee

Technical Program
- Travis Walker
- Arezoo Ardekani

Local Arrangements
- Gareth McKinley
- Safa Jamali

Community Development Committee (2026)
- Katie Weigandt, Chair
- Ria Corder
- Jesse Gadley
- Peter Gilbert
- Ali Mohraz
- Jae Park
- Kelly Schultz
- Maryam Sepehr
- Arshiya Bhadu (student)

Rheology Venture Fund Committee (2026)
- Roger Bonnecaze, Chair
- Arezoo Ardekani
- Rosana Pasquino
- Charles Schroeder

Journal of Rheology Editorial Office

Editor:	*Dimitris Vlassopoulos*
Associate Editor	*Emanuela Del Gado*
Editorial Assistant	*Ania Bukowski*

Society Service Appointments

Webmaster	*Albert Co and Rae Robertson-Anderson*
Editor of Rheology Bulletin and Communication Coordinator	*Carlos R. López-Barrón*
Social Media Director	*Christine Roberts*
Communications Liaison	*Elise Chuqiao Chen*
Director, International Outreach Program	*Gerald G. Fuller*
SoR Historian	*Gareth McKinley*

External Committees/Organizations for 2026

American Institute of Physics (AIP)	
SoR Designee to AIP Governing Board	*Eric Furst*
SoR Member Representative to AIP	*Jonathan Rothstein*
SoR Liaison on AIP History Committee	*Gareth McKinley*
Soft Matter Association of the Americas (IUPAP)	
SoR Representative	*Jaciinta Conrad*

AIP Publishing (AIPP)

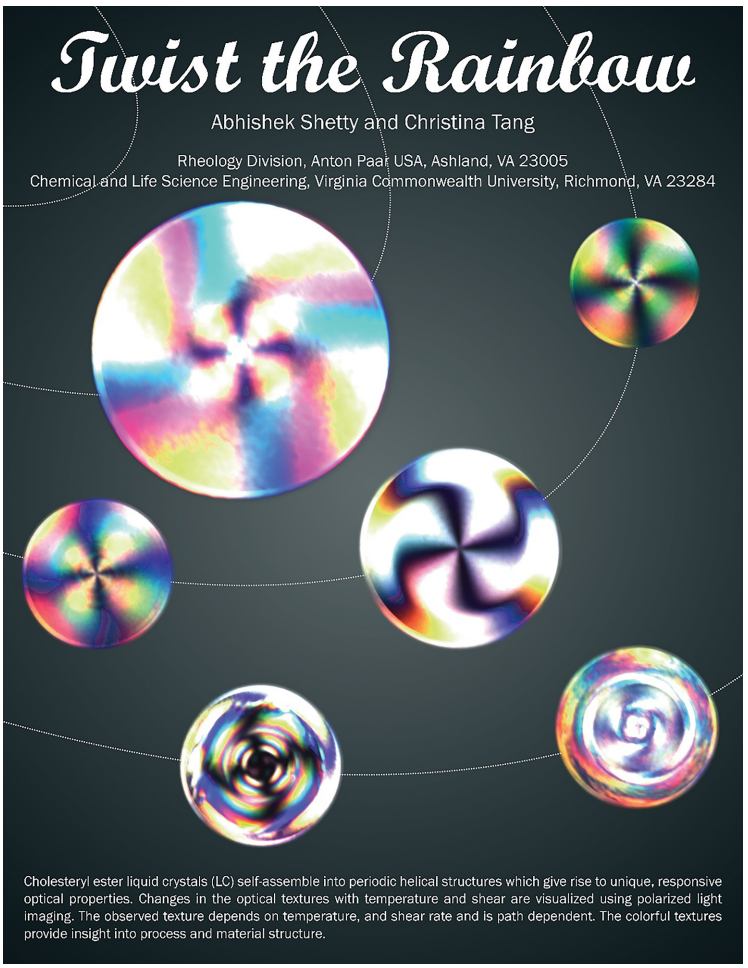
SoR Designee to AIPP Board of Managers	*TBA*
SoR Representatives on AIPP Publishing Partners Committee	*Peter Olmsted*
	Simon Rogers

International Committee on Rheology

SoR Delegate to ICR — *Michael Graham*
Secretary to the ICR — *Gerrald Fuller*

US National Committee on Theoretical and Applied Mechanics

SoR Representative to NCTAM — *Anne M. Grillet (2023-2027)*



Letter from the President



Dear Society of Rheology Members:

The past year has been eventful and exciting for your Society, and I am pleased to say that it has been very successful. Before looking back on the year's accomplishments and calling attention to a number of upcoming activities, I first give a heartfelt thanks to you as members of the Society. It is an honor and a privilege to serve you as President of SOR. I am deeply proud to do my part for this Society; my pride stems not only from SOR's unyielding commitment to its technical mission but equally from the warm, welcoming, and supportive nature of its members. I am especially grateful for the continuous flow of generosity from Society members as you volunteer time and bring ideas and energy to initiatives that advance rheological science.

Speaking of rheological science, I want to point out that a significant portion of this is archived in the Journal of Rheology, with leadership from Editor-in-Chief Dimitris Vlassopoulos and Associate Editor Emanuela Del Gado. For JOR and the Rheology Bulletin you are now reading, edited by Carlos López-Barrón, the SOR partners with American Institute of Physics Publishing (AIPP). This is a very valuable relationship to our all-volunteer Society. Such partnerships are crucial to extend our reach and increase our effectiveness, and I highlight some other partnerships and related interactions below.

In taking the helm at SOR, I have had occasion to reflect on where we came from and consider where the Society can go. Recall that the Society began in 1929, as a group of American and European scientists who saw the need for a branch of mechanics focused on the flow, i.e. on the dynamics, of materials. From this beginning, a global reach developed. Cooperation between rheologists around the world is a hallmark of the Society and the scientific culture of rheology. The Society works closely with and promotes the efforts of affiliated societies in many countries around the globe, including two large consortia of national societies – the European Society of Rheology (ESR) and the Asia-Pacific Society of Rheology (APSR). SOR members gain from these interactions through the expanded reach of our work in promoting human welfare in the various applications of our field of study – in engineering, geophysical, materials and medical sciences to name a few. This spirit of global cooperation gives me great confidence in the future of rheological sciences.

Looking back just on the past year, I can say it has been a very productive one for SOR. Through the efforts of many, led by then-President Jonathan Rothstein, two accomplishments are especially noteworthy. First, SOR messaging to the world has been modernized, with a new logo and branding program guided by Past President Anne Grillet. Second, our webmaster Rae Robertson-Anderson unveiled the new SOR website at the 96th Annual Meeting in Santa Fe. The website construction was led by Rae and our past webmaster extraordinaire Albert Co, in partnership with AIP, of which SOR is a member society. I am personally incredibly impressed by www.societyofrheology.org. While it is still a work in progress, Rae has created a dynamic website that has proven very effective in spreading the Society message, providing access to rheology for nonmembers as well as ways for members to engage with SOR.

Looking ahead, the 97th Annual Meeting of The Society of Rheology will be held this Fall at the Boston Park Plaza, October 25-29, 2026. The meeting is coordinated by the local chairs Safa Jamali and Gareth McKinley with help from a new partnership SOR established with the American Physical Society's meeting planning service. The scientific content of the meeting has been developed by technical program chairs Arezoo Ardekani and Travis Walker, who have assembled a fantastic slate of invited talks and contributed sessions led by an outstanding group of symposia chairs. In Boston, we will welcome the 2026 class of SOR Fellows, and have the chance to honor Bingham Medalist Roger Bonnecaze and Metzner Award winner Jeffrey Richards with plenary lectures. New this year will be a special session, coupled to a short course and supported by a Rheology Venture Fund award. The session will focus on the interplay of tribology with rheology (tribo-rheo for short), and is chaired by Lilian Hsiao and Antonio Perrazzo. This session will feature an international group of speakers from universities as well as industrial and national laboratories. For students and post-docs, awards for posters sharing work on the tribo-rheo theme are planned. The special session is entitled "Tribo-rheology: Flow and friction in predicting texture and performance" and complements the fundamental and hands-on SOR short course of the same title offered October 24-25. The course is instructed by Lilian with support from co-instructors James Eickoff of Anton Paar and Keith Coasey of TA Instruments.

Looking a bit farther ahead, the 20th International Congress of Rheology will be hosted by the Chinese Society of Rheology (CSR) in Guangzhou, China, June 20-25, 2027. CSR President Xue-Feng Yuan has brought together a strong international team and the program is an exciting one, with special sessions honoring 50 years of study for each of the Doi-Edwards theory and the Boger fluid, two touchstones for rheologists. SOR, ESR, and APSR awardees will be honored by plenary session lectures.

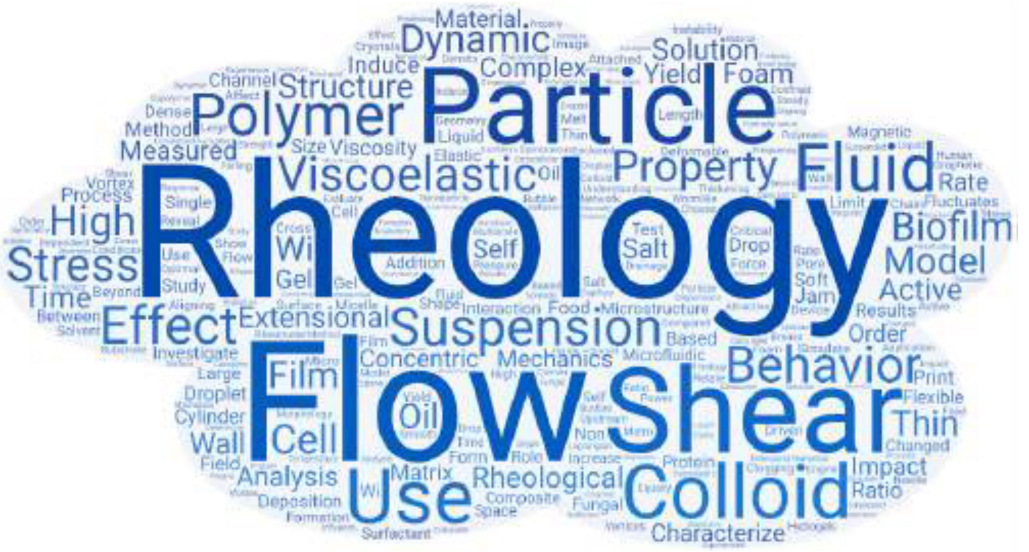
As I noted, the Society began in 1929, so we are getting close to a *very* big SOR birthday. A range of technical retrospectives and fun events are planned for the SOR Centennial Year of 2029. The biggest event will be the Society's Centennial meeting, to be held at the Hilton Baltimore Inner Harbor, September 20–27, 2029. Get that in your calendars – you don't want to miss it!

There's clearly not space to point to all the wonderful things, big and small, that the Society has achieved over the past year. In hitting some of the highlights, I want to emphasize that we can do none of it without the volunteer efforts of you as SOR members,

and I am working hard to make sure that your efforts are amplified and multiplied for the greater good through our partnership with AIP and its member societies such as APS, as well as with the global network of rheologists.

As we approach its Centennial, we have a great deal to look back on with pride as we celebrate the legacy of the Society. And I can't stress enough that with a wonderfully supportive and vibrant membership, the future is bright for SOR.

With warm wishes,
Jeff Morris
Chemical Engineering and Levich Institute for Physicochemical Hydrodynamics
CUNY City College of New York



Report from Santa Fe: 96th SOR Annual Meeting

Christine Roberts

The 96th Annual Meeting of the Society of Rheology was held from October 19th to 23rd in Santa Fe, NM, in the Santa Fe Community Convention Center. The technical program was curated by program chairs Reza Foudazi and Lilian Hsaio, and the local arrangements chair was Christine Roberts. Valuable support was provided by the local arrangements committee, including Anne Grillet, Andy Kraynik, Josh McConnell, Andrew Schmalzer, and Rekha Rao, with special help from Norah Collins.

Over 400 registrants spanning 30 countries explored the City Different while exchanging ideas and new discoveries in the field of rheology. The diverse crowd included students, academics, industrial rheologists, exhibitors, and members of government laboratories who inspired each other throughout a robust technical program. The return to Santa Fe reprises successful meetings that were held in the same location in 2010 and 1990. Highlights of the meeting include:

- ***Short Courses.*** Well-attended virtual and in-person short courses**,** including *Fundamentals of Powder Rheology and Granular Flow,* instructed by **James Gilchrist** and **Abhi Singh** with help from **Thomas O'Connor** and **Alban Sauret,** and *Applied Powder Rheology* instructed by **Abhi Shetty** and **James Eickhoff.**
- ***Rheology Research Symposium.*** The RRS took place at the Santa Fe Plaza Hilton from Saturday, Oct 18th to Sunday, Oct 19th. Organized by the Rheology Community Development Committee, this event provided 25 graduate students and postdoctoral researchers with the opportunity to connect with mentors from industry, academia, and government laboratories. Discussions included career paths in rheology, resume writing, and how to make an effective pitch. Students also received a travel grant covering meeting registration and travel expenses.
- ***Community Engagement.*** Student members volunteered at the **Santa Fe Children's Museum**, bringing squishy curiosities and hands-on demonstrations to introduce museum attendees to rheology fundamentals under the guidance of **James Gilchrist**.
- ***Welcome Reception.*** A wonderful welcome reception was held in the open air of the Santa Fe Convention Center plaza. A string quartet provided entertainment, and refreshments were served, all thanks to a generous gift from **Anton Paar**.



Antony Beris receiving the Bingham Medal



Safa Jamali receiving the Metzner Award

- ***Plenary Lectures.*** The meeting kicked off with a compelling plenary lecture entitled Coupling Rheology and Microfluidics: Viscoelastic instabilities and emergent flow phenomena by **Amy Shen**. On Wednesday, **L Mahadevan** delivered the plenary Shaping the future using folding (origami), cutting (kirigami), and printing (coiling).
- ***Networking.*** A networking and social session was held at the Santa Fe History Museum, sponsored by **TA Instruments/Waters**. A lively flute player serenaded the crowd as attendees were able to explore the longest continually inhabited governmental seat in the United States.
- ***Technical Program Highlights.*** Special technical sessions were held, including an invited session on Rheology in the Geosciences, organized by **Christine Roberts, Sujit Datta, and Sachin Velankar**, supported by a Rheology Venture Fund. The Future of Rheology mini-session, organized by student members **Elise Chen** and **Arshiya Bhadu**, showcased the work of several promising graduate students and postdocs. Congratulations to **Alp Sunol**, who was voted to be the first-place winner of this session.
- ***Student-Industry Event.*** A student-industrial forum was held to introduce students to career options and mentors in industry and government laboratories. This lunchtime event was sponsored by **Dow** and **AIP**.
- ***Business Meeting.*** The business meeting unveiled a new website and a new logo to bring the society into the future.
- ***Named Lectures.*** Antony Beris was honored as the Bingham Medal awardee with a celebratory lecture entitled Rheology Magic. **Safa Jamali** was the Metzner Award winner, with a plenary lecture entitled Rheoinformatics: Seamlessly integrating theory, computation, and experiment through data-driven rheology. Both lectures were recorded and can be revisited online today by SoR members.
- ***Banquet.*** A Bingham medal reception and banquet were held at the Santa Fe Farmer's Market Pavilion.
- Bingham Medalist **Antony Beris** and Metzner Awardee **Safa Jamali** received their awards and were honored by their coworkers.
- The 2025 JoR publication award was given to **Michael Burroughs, Yuanyi Zhang, Abhishek Shetty, Christopher Bates, Matthew Helgeson,** and **Gary Leal** for their manuscript entitled "Flow-Concentration Coupling Determines Features of Nonhomogeneous Flow and Shear Banding in Entangled Polymer Solutions".
- Several Society of Rheology fellows were inducted, including **Paulo Arratia, Randy Ewoldt, Anke Linder, Joao Maia, Fernando Pinho, Matteo Pasquali,** and **Patrick Spicer**.
- Outgoing president **Jonathan Rothstein** recognized incoming president **Jeff Morris** and president-elect **Roger Bonnecaze**, and acknowledged the help of past president **Anne Grillet. Albert Co** and **Andrew Kraynik** were heartily thanked for decades of service to the website and meeting arrangements, respectively.
- ***Gallery of Rheology.*** The Gallery of Rheology was joined for the first time by a Video of Rheology session. Submissions were displayed throughout the week, and judges and popular choice awards were given. Judges' choice awards were *Jellyfish: Oil drainage from porous hydrogels* (**Goodarzi**), *Brownian dynamics simulations of chains in shear and extensional flow* (**Pincus**), and *Windmills of your polymer* (**Bhadu**). Popular choice awards were *Twist the Rainbow* (**Tang**) and *Waves, Spirals, and Chaos in Soft Matter!* (**Sato**).
- ***Poster Session.*** A vibrant poster session, sponsored by **Anton Paar**, showcased 88 posters across the field of rheology. Graduate students Hannah Szafraniec, **Abby Temple,** and **Teresiana Guarino**, along with postdoc **Chenxian Xu**, were honored with best poster prizes.



SOR Fellows at the Bingham Banquet

Closing Reflections - *I have always found the Society of Rheology to be a welcoming and inclusive organization for everyone interested in flow, and this camaraderie shines brightest at the annual meetings. This meeting had something for all attendees, whether that was reconnecting with longtime colleagues, sparking new research ideas, or advancing careers through mentorship and recognition. The local events committee sincerely thanks all who travelled to Santa Fe, and we look forward to seeing you again in Boston in 2026!* - Christine Roberts



Bingham Medalists at the Bingham Banquet

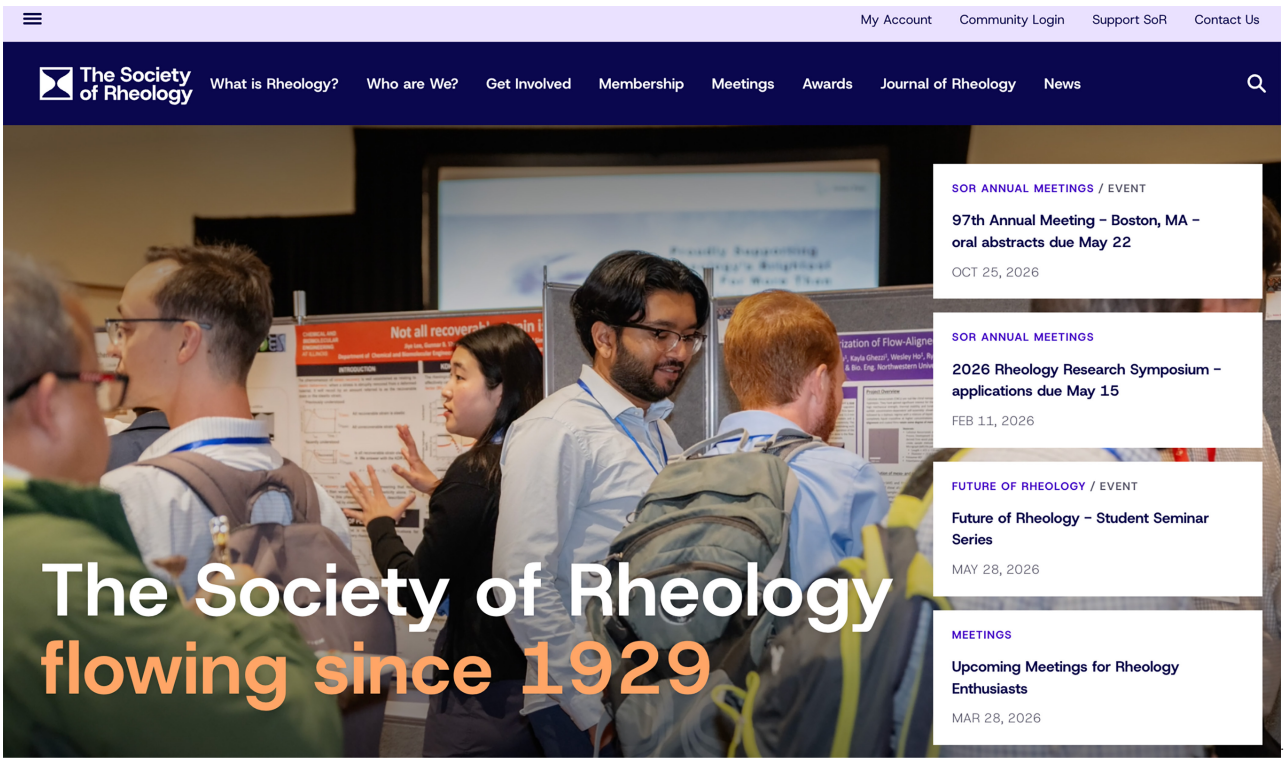
Welcome to the new SOR website!

Rae Robertson-Anderson

The Society of Rheology launched a new website in October 2025 at the 96th Annual Meeting in Santa Fe, NM. The work began in 2023, when Past SoR President, Jonathan Rothstein began discussions and negotiations with American Institute of Physics (AIP) to host the website on their new digital experience platform (DXP). In fall 2024, with the contract secured, I joined the SoR web team, along with long-time webmaster, Albert Co, to begin working with AIP to migrate the content from the old website to the DXP. In parallel, we began designing the new website from the bottom up, starting with a fresh palette, bespoke architecture and carefully curated content based on anticipated and desired user journeys. Albert and I met with the AIP team several hours a week for the following year to get everything in place and to ensure I was trained to be able to continue to build, update and maintain the new website. Several members of the SoR Executive Committee also reviewed website drafts and provided critical feedback to ensure the website would be accessible and engaging to newcomers while continuing to provide the valuable content from the old website that members had come to rely on.

Before we hear more about the new website…**let's learn a bit about the history of the website from Professor Albert Co at University of Maine**, who single-handedly designed the old website and maintained it for three decades.

"In *the January 1995 issue of Rheology Bulletin, then SoR President Robert C. Armstrong commented that he was looking for volunteers to create and maintain the website for The Society of Rheology. I responded and we met in Boston to go over the structures and plans for the website in the early summer of 1995. By the early fall of 1995, the SoR website was live at http://www.umecheme.maine.edu/sor. It was hosted at the server of the Chemical Engineering Department at the University of Maine. By late 1999, SoR acquired the domain names rheology.org and societyofrheology.org. Later SoR also obtained the domain name rheology.com from a supportive company. The website continued to be hosted on a series of Chemical*



Engineering servers at the University of Maine until late 2025.

The early web pages were coded in HTML with a simple text editor. As server and web technologies advanced over the years, the hardware and software for the SoR website were updated accordingly. In order to support the activities of SoR members, I developed several web apps in conjunction with the use of SQL databases. These included the abstract submission and management web apps, the web apps for public access of meeting programs and abstracts, the meeting registration and management web apps, the member web app with searchable membership directory, the biennial election web app, and the constitution and rules amendment voting web app."

Albert Co | University of Maine

We aim to bring new folks into the fold while also providing valuable and timely resources for our members.

The new website features a new modern logo, also unveiled in 2025, and new color palette and font that aim to invite, engage and keep visitors—members and non-members alike—coming back to explore.

The navigation pane takes users on a journey from simple curiosity about what rheology is (What is Rheology?), to learning more about the society (Who Are We?), to how to get involved (Get Involved), become a member (Membership) and join in our meetings (Meetings), to learning about our awards and awardees (Awards), and exploring society publications (Journal of Rheology) and news (News).

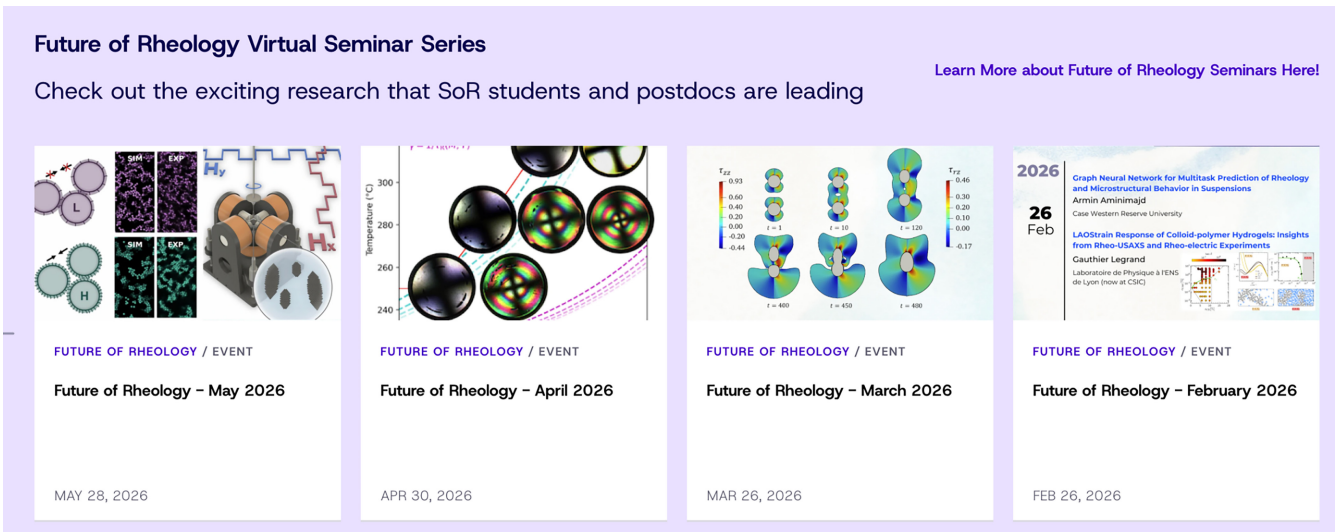
We also launched a monthly newsletter, News Flows, that features announcements, upcoming events, job opportunities, kudos, and other news from the SoR Executive Committee as well as SoR members. News Flows is sent via email to all members and then resides on the website for easy access and archiving. Members can contribute to the News Flows by posting their announcements on the new SoR Member Community- a virtual ecosystem where members can share useful information and resources, engage in discussions, post and search for job opportunities.

We designed and curated the architecture, content and 'look' and 'feel' of the website to highlight four themes that capture SoR's unique ethos.

The Society of Rheology is…

…a vibrant, dynamic and forward-looking society that supports the next generation of rheologists and embraces the future of rheology. The homepage prominently displays the student-led Future of Rheology Virtual Seminars which now each have their own dedicated event page. The Art of Rheology page features artwork submitted by students and postdocs to the Gallery of Rheology contest and the popular Rheology Comics, also designed by student members. We revived our Industry Spotlights that feature interviews with SoR members in industry, discussing everything from how to successfully navigate a career in industry, to what inspires them, to their day-to-day responsibilities. Finally, we feature awards for students and postdocs, including the Student Poster Award, Postdoc Poster Award and Gallery of Rheology Contest.

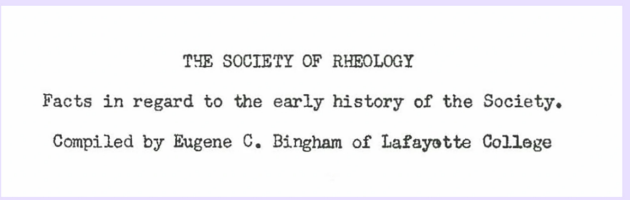
…a close-knit community that recognizes the unique identity and value of each of its members. We feature many photos, carousels and videos throughout the website that are refreshed often that feature members enjoying each other's company at meetings and other events. Our Who Are We? page showcases the bios of all of our Executive Committee members and lists our other committee members and volunteers. To engage more of our members in Society activities, we launched a new Volunteer Form that members can complete to express their interest in volunteering for different SoR activities. Our Awards page highlights all of our awardees, from student poster



December 17, 1928 – the term RHEOLOGY (re-ol-o-ji) was coined by EC Bingham

December 19, 1929 – the Society of Rheology was officially founded.

December 19-20, 1929 – the first Society of Rheology Meeting was held at the National Bureau of Standards

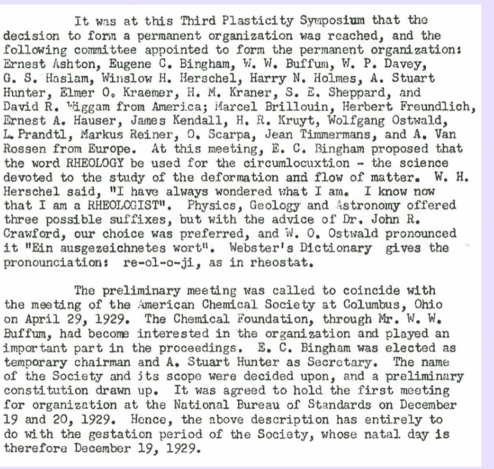


THE SOCIETY OF RHEOLOGY

Facts in regard to the early history of the Society.

Compiled by Eugene C. Bingham of Lafayette College

Bingham's History Snippet



It was at this Third Plasticity Symposium that the decision to form a permanent organization was reached, and the following committee appointed to form the permanent organization: Ernest Ashton, Eugene C. Bingham, W. W. Buffum, W. P. Davey, G. S. Haslam, Winslow H. Herschel, Harry N. Holmes, A. Stuart Hunter, Elmer O. Kraemer, H. M. Kraner, S. E. Sheppard, and David R. Wiggam from America; Marcel Brillouin, Herbert Freundlich, Ernest A. Hauser, James Kendall, H. R. Kruyt, Wolfgang Ostwald, L. Prandtl, Markus Reiner, O. Scarpa, Jean Timmermans, and A. Van Rossen from Europe. At this meeting, E. C. Bingham proposed that the word RHEOLOGY be used for the circumlocuxtion - the science devoted to the study of the deformation and flow of matter. W. H. Herschel said, "I have always wondered what I am. I know now that I am a RHEOLOGIST". Physics, Geology and Astronomy offered three possible suffixes, but with the advice of Dr. John R. Crawford, our choice was preferred, and W. O. Ostwald pronounced it "Ein ausgezeichnetes wort". Webster's Dictionary gives the pronounciation: re-ol-o-ji, as in rheostat.

The preliminary meeting was called to coincide with the meeting of the American Chemical Society at Columbus, Ohio on April 29, 1929. The Chemical Foundation, through Mr. W. W. Buffum, had become interested in the organization and played an important part in the proceedings. E. C. Bingham was elected as temporary chairman and A. Stuart Hunter as Secretary. The name of the Society and its scope were decided upon, and a preliminary constitution drawn up. It was agreed to hold the first meeting for organization at the National Bureau of Standards on December 19 and 20, 1929. Hence, the above description has entirely to do with the gestation period of the Society, whose natal day is therefore December 19, 1929.

The founding of The Society of Rheology

December, 1944 – EC Bingham published the History of the Society of Rheology 1924 – 1944

Bingham's History of Society of Rheology.pdf (.pdf, 2 mb)

> I have always wondered what I am. I know now that I am a RHEOLOGIST.
>
> — Winslow H Herschel

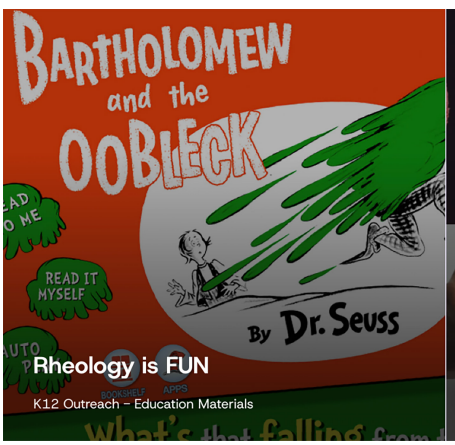
awardees to Bingham Medalists, searchable by year and name to easily discover the amazing members who we have recognized over the years.

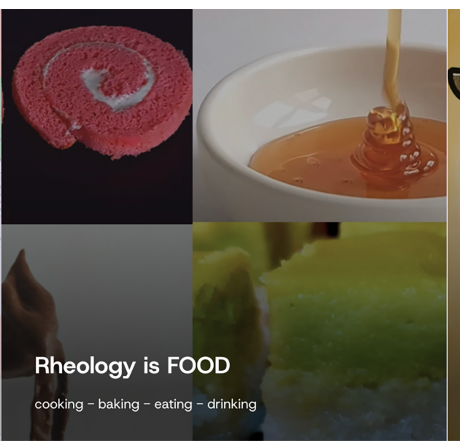
…proud of our rich history and values the traditions that have carried us through the years. We have a dedicated History page that highlights our rich history through newspaper clippings, Oral Histories and a Past Presidents Yearbook. We have all of the previous Meeting pages and Bulletins from over the years accessible for those wishing to dive into the past.

…passionate about sharing the wonders of rheology with the world. Our What is Rheology? page is designed to draw passers-by in to discover how fun and accessible rheology is. We have our motto 'Everything Flows' translated into 80 different languages and feature links to several pages that explore the world of rheology in whimsical and educational ways. Rheology is Fun showcases the K-12 outreach activities we do and provides resources for educators. Rheology in the Kitchen features videos from the popular Soft Matter Kitchen and more fun with food and recipes. We prominently feature our Rheology Venture Fund projects that aim to engage more audiences in the rheology through projects ranging from Rheology Comics to DIY Rheology to special sessions at our annual meetings on Geology Rheology and Space Rheology.

Do you have ideas on how to make the website even better? Do you want to get involved with website content generation and/or curation?

Reach out to Rae Robertson-Anderson at web_admin@rheology.orgto share your thoughts and ideas!







Student Affairs Report

The Society of Rheology (SOR) community thrives when its student members and early-career researchers are engaged and encouraged. Over the past year, a range of student-led activities has been organized under the support of SoR.

Future of Rheology, a well-attended virtual seminar series, showcases outstanding work by students, postdoctoral scholars, and early-career researchers, while sparking engaging discussions with a broad audience. Each month offers something new to think about: Why does vegan mayo taste different from traditional mayo? What can we learn from watching a drop land on glass? How does cornstarch connect to network science? How do molecules move inside a cell?

But the series is about more than just intriguing science. It also shines a spotlight on the people behind the work, giving student researchers greater visibility within the community. We are continuing to expand our reach through newsletters and social media. To recognize outstanding contributions, top speakers of the year are invited to present in a mini-session at the annual meeting. This year, six outstanding speakers from 2024 seminars presented at the 2025 SoR Annual Meeting in Santa Fe.

It is well-recognized fact that among all scientists, rheologists are experts at having fun. As a brief departure from our Trivia night tradition, we hosted a ***Student Pottery Night*** in the artistic setting of Santa Fe. While we did not finish all the drink tickets, our clay-working skills certainly impressed the owners, who were prompted to ask, "What exactly do you study in rheology?" "Well," we replied, "we study the deformation of squashy things."

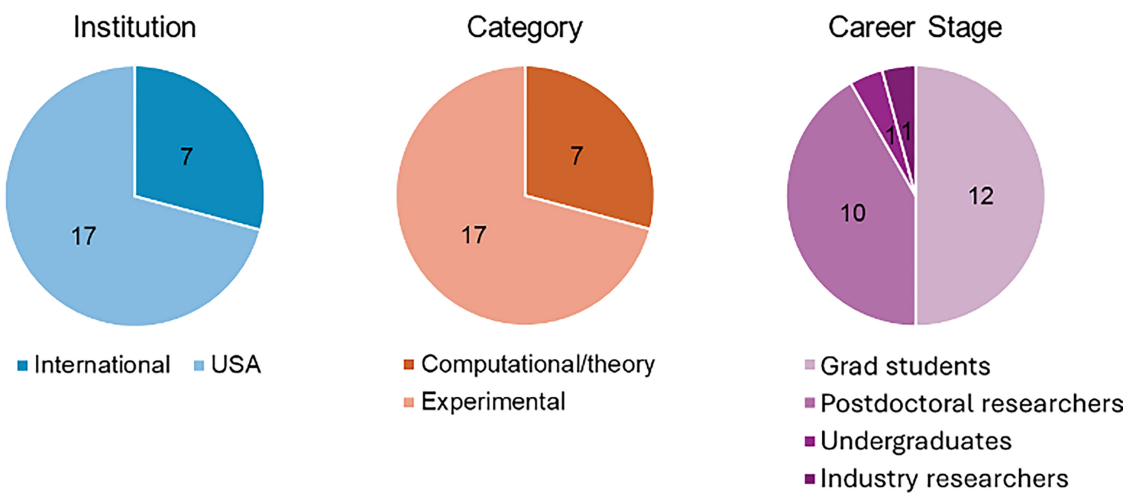


FIGURE 1. Demographics of speakers for the Future of Rheology seminar series (2025).



FIGURE 2. Left: Poster for the January 2026 Future of Rheology virtual seminar. Right: Speakers and organizers at the Future of Rheology mini-session, Society of Rheology Annual Meeting (2025), Santa Fe. From left to right: Arshiya Bhadu (co-chair), Manish Kumar, Anutka Datta, Michel Orsi (second place), James Grieber, Alp Sunol (first place), Nadia Nikolova (third place), and Chuqiao Chen (co-chair).



FIGURE 3. Student Pottery Night at the 2025 SoR Annual Meeting in Santa Fe. The challenge of the month featured Halloween pumpkins, though several rheometer-inspired creations were particularly impressive. See photos above for the "rheo" masters of clay.

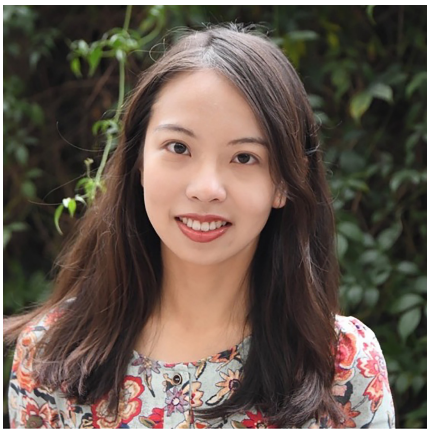
Meet the new SoR Communications Liaison and Student Representative

Jeff Morris

Meet Elise Chen, Inaugural SoR Communications Liaison

Elise (Chuqiao) Chen is a postdoctoral researcher at University of California, Santa Barbara, working at the interface of polymer chemistry and rheology. Her doctoral research at University of Chicago focused on designing stimuli-responsive particles to tune the rheology of dense suspensions. She now studies coacervation in ionic polymers and the dynamics of polyelectrolyte complexes.

After two rewarding years as the SoR Executive Committee Student Representative, she is pleased to continue these efforts as the inaugural **SoR Communications Liaison**. Through developing website and social media content, she hopes to let the excitement of rheology flow to a broader community. Suggestions and ideas are always welcome!



Elise (Chuqiao) Chen, SoR Communications Liaison

> *"I feel very fortunate that Elise Chen has taken on SoR's new Communications Liaison (CL) role. The goal in establishing the CL position is to help the Society more effectively hear from, and share information with, its members. Elise was selected to take on the role of the CL following her service as the Student Representative on the Executive Committee. Elise is ideal for the position - she's a great listener, she shares information very effectively, and she loves rheology!"*
>
> SoR President, Jeff Morris

Meet Jiye Lee, 2026-2027 SoR Executive Committee Student Representative

Hi, I am Jiye Lee, a PhD student in Chemical and Biomolecular Engineering at the University of Illinois Urbana-Champaign, working with Professor Simon A. Rogers. I am also the newly appointed **Student Representative for the Society of Rheology Executive Committee**. I will be serving in this role for two years.

In this position, I'm especially interested in expanding opportunities for, and strengthening communication between student members. I believe that a supportive student community, in which everyone is welcome, can enhance professional development for early-career researchers.



Jiye Lee. SoR Student Representative

As part of this effort, I am organizing the Future of Rheology seminar series, in which two speakers per month present their work. The series highlights the amazing research from early-stage rheologists, and is open not only to SOR members but also to the broader rheology community. Through this initiative, I hope to lower the barrier to participation and create more opportunities for early-career researchers to share their work and connect with others in the field.

Moving forward, I will continue supporting initiatives that increase student participation and strengthen engagement within the rheology community. I look forward to connecting with you soon.

Come to Boston in October 2026!

Arezoo Ardekani and Travis Walker

October 25 – 29th, 2026 in Boston, MA

Technical Chairs:
Arezoo Ardekani | Purdue University
Travis Walker | South Dakota School of Mines & Technology

Local Organizing Chairs:
Gareth McKinley | MIT
Safa Jamali | Northeastern University

Rheology Research Symposium Chair:
Katie Weigandt | NIST

Plenary Lectures

We welcome the 2026 Bingham Medalist and Metzner Awardee and two leaders in the field.

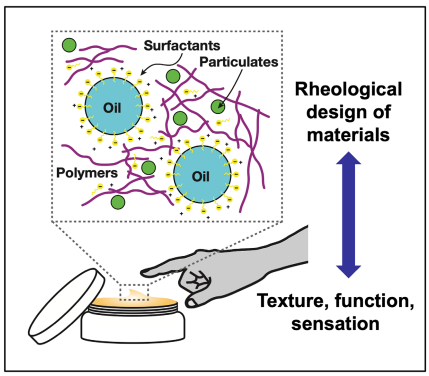
Technical Program

- Colloidal Suspensions and Granular Materials
- Self-Assemblies, Gels, and Networks
- Polymer Solutions, Melts, and Blends
- Interfacial Rheology, Surfactants, Foams, and Emulsions
- Biomaterials, Bio-fluid Dynamics, and Biorheology



97th SOR Annual Meeting Made with Google AI

- Flow-Induced Instabilities and Non-Newtonian Fluids
- Techniques and Methods: Rheometry, Tribometry, Spectroscopy, and Microscopy
- Additive and Advanced Manufacturing
- AI and ML in Rheology
- Applied Rheology for Industrial Applications
- Rheology and Sustainability for Energy and Production



Triborheology

- Rheology of Field-Responsive Materials and Soft Robotics.

Educational Short Course | October 24-25, 2026

Special Sessions

- Invited sessions on *Rheology in Biopharmaceuticals, Bioprinting, and Tissue Engineering* and *Tribo-rheology: Flow and Friction* will bring new topics to the meeting.
- The Future of Rheology. Early-career rheologists, will reprise their talks in a special



Roger T Bonnecaze
2026 Bingham Medalist | University of Texas at Austin



Jeffrey Richards
2026 Metzner Awardee | Northwestern University



Roseanna Zia
Dave Wollersheim Professor of Mechanical and Aerospace Engineering | University of Missouri



Howard Stone
Neil A. Omenn '68 University Professor of Mechanical and Aerospace Engineering | Princeton University

mini-session and will have an opportunity to win a prize for the best speaker.
- Postdocs and graduate students may participate in the Rheology Research Symposium, a student trivia night, and the Student-Industry Forum for connection and mentoring opportunities.

Social Events

As always, the social program

- Sunday | Welcome Reception | Boston Park Plaza Hotel
- Tuesday | Bingham Medal Banquet | Grand Ballroom of the Boston Park Plaza Hotel
- Wednesday | Poster session and Reception | Boston Park Plaza Hotel



Don't Forget!

- **Register** for the meeting by **September 4** to lock in Early Bird rates.
- Book your room at the Hilton Park Plaza by **September 7** to lock in conference booking rates.
- Submit your abstracts by **August 14** for:
  - Poster Presentations
  - Gallery of Rheology Images
  - Gallery of Rheology Videos

Roger T Bonnecaze - 2026 Bingham Medalist



Roger T. Bonnecaze is Dean of the Cockrell School of Engineering and Cockrell Regents Family Chair in Engineering, and a Professor in the McKetta Department of Chemical Engineering at The University of Texas at Austin. He earned his B.S. (Honors) in Chemical Engineering from Cornell University (1985), and his M.S. (1987) and Ph.D. (1991) in Chemical Engineering from the California Institute of Technology with John F. Brady, followed by a British Petroleum Postdoctoral Fellowship at the University of Cambridge (1991–1992), where he worked with Herbert Huppert on particulate suspensions in gravity currents and sediments. In 2017, Roger helped launch SandBox Semiconductor, a start-up based on the PhD work of Meghali Chopra who is now the CEO.

Major honors include the NSF Young Investigator Award (1993), David and Lucile Packard Foundation Fellowship (1994), AIChE Thomas Baron Award (2011), two Journal of Rheology Publication Awards (2005, 2014), and a Rheologica Acta Publication Award (2017). He is a Fellow of the Society of Rheology, the American Physical Society, the American Institute of Chemical Engineers, and the American Association for the Advancement of Science.

His research contributions span suspensions, emulsions, and complex fluids; rheological analysis and theory; and computational fluid mechanics, with a sustained focus on connecting macroscopic rheological response to the microphysics of dispersions.

Soft particle glasses (SPGs) are very concentrated suspensions of deformable particles such as emulsion droplets, vesicles, microgels, polymer-grafted nanoparticles, and micelles. They are widely used as rheology modifiers, matrices for bioprinting, or binders in ceramics extrusion. Over the past two decades Roger Bonnecaze has helped define the rheology of dense soft particulate matter in the regimes where constitutive ideas are most severely tested: the onset of flow from arrested states, strongly nonlinear viscometric response, and the influence of material history. Through theory, simulations and experiment, his pioneering work established that despite a considerable phenotypical diversity, SPGs can be described by universal rheology. In a second major contribution to the field, Bonnecaze expanded the understanding of wall slip in yield-stress dispersions as boundary rheology with mechanistic, parameter-dependent laws. His novel approach to separating bulk deformation from interfacial motion identified the underlying mechanisms that set slip–stick behavior. This overall arc emerged from major contributions in three key areas:

SPGs provide a controlled setting in which yielding and nonlinear viscometric functions can be traced to contact elasticity, near-contact structure, and shear-induced microstructural anisotropy via a contact network continually rebuilt under shear. The central rheological difficulty is that macroscopic signatures are often similar across materials even when the underlying contact mechanics, softness, and dissipation pathways differ. Bonnecaze addressed this issue via a theoretical framework modeling jammed assembly as a contact-elastic network coupled to viscous dissipation in the suspending fluid, making the physics explicit at the constitutive level (*J. Rheol.*, 2006; *Nature Materials*, 2011; *Soft Matter*, 2018; *J. Rheol.*, 2020).

His early work established how contact elasticity and near-contact structure enter the rheology of jammed soft particles (*J. Rheol.*, 2006), later expanded into a microstructure-based constitutive description in which the pair-distribution function under shear serves as the key structural input. Total and normal stress differences are not independent empirical signatures but instead emerge from the same shear-distorted microstructure. This opened the door to unified scaling theory that depends explicitly on contact elasticity and dissipation (*Nature Materials*, 2011). The resulting nondimensionalization, organized around the reduced shear rate and associated stress scales, collapses flow curves and viscometric functions across multiple soft glassy material classes, enabling meaningful comparison of data across systems that otherwise appear dissimilar in their chemistry and particle architecture (*Nature Materials*, 2011; *Soft Matter*, 2018, *J. Rheol.*, 2020a, *J. Rheol.*, 2020b, *Phys. Rev. Fluids*, 2017–2018). This work is central to how SPGs are modeled and designed: microstructure-based prediction of shear and normal stresses; dimensionless cross-material characterization; and a mechanistic link between macroscopic viscometric response and particle-scale relaxation and force statistics.

Soft glasses in time-dependent flows are the most challenging to model because material flow and relaxation depend on preparation history, ongoing deformation, and evaluation time. A challenge for the field has been to identify measurable microscopic quantities that encode this dependence in history-responsive constitutive descriptions in

a controlled, rather than post-hoc, way. Bonnecaze tackled this challenge by leveraging residual internal stresses and microstructural anisotropy as experimentally and computationally accessible memory kernels, developing a framework in which the evolving distribution of local stresses becomes a state variable. This work resulted in a scaling description of trapped internal stress in jammed SPGs after flow cessation (*PRL*, 2013). He established the functional dependence of trapped stress on solvent viscosity, particle elasticity, and packing through combined experiment and 3D simulation, providing predictive scaling laws (*PRL*, 2013, 2015).

Bonnecaze carried these ideas further into transient yielding and aging, showing that long-debated stress overshoots and relaxation in startup shear and flow reversal are shaped by the arrested contact network, and by the persistence of residual stress and strain. The work identified "directional memory": the material remembers prior shear direction – but reversal does not simply retrace the prior evolution (*J. Rheol.*, 2021–2022). Memory and aging are placed on an operational footing: they can be separated, quantified, and compared across systems by prescribed protocols rather than being treated as irreducible complications. Overall, this work transformed history dependence from a qualitative descriptor into a measurable, modellable property of SPGs.

In this body of work, Bonnecaze constructed mechanistic slip laws based on elastohydrodynamic lubrication coupled to particle elasticity and particle–wall interactions. Using rheometry along with local velocimetry, he showed that smooth-wall flows near yielding separate into regimes in which bulk shear and slip contribute in distinct proportions, and that at sufficiently low stresses the apparent motion can be dominated by slip even when bulk deformation is negligible. This established that "flow curves" can be used to map the boundary condition (*J. Rheol.*, 2004). The associated mechanism was developed as an elastohydrodynamic lubrication problem, where slip is a consequence of the same contact-elastic physics that govern bulk response, expressed in a boundary geometry. These results have been extended to different surface chemistries (*J. Rheol.*, 2008, *Soft Matter*, 2012) and to permeable particles (*Soft Matter*, 2022).

Bonnecaze's contributions have advanced rheology in two major ways: (i) by providing constitutive models that explicitly connect viscometric signatures (shear stress and normal stress differences) to identifiable microstructural properties in soft particle glasses, and (ii) by establishing boundary rheology relationships that render wall slip measurable, predictable, and comparable across materials and surface chemistries. In both of these areas, the unifying impact is interpretability and predictability: his models and scalings turn historically system-specific observations – yielding, nonlinear viscometric response, and history dependence – into quantities that can be compared across materials, geometries, and protocols with a clear physical basis.

by John Brady (CalTech)

The Society of Rheology Mission Statement

Our Vision

An international community of rheologists working towards common goals as articulated in our founding Constitution.

Values

We are the nexus of excellence in the theory and practice of rheology. We are committed to advancement and promotion of the rheological sciences and practice of rheology broadly across diverse groups of individuals, disciplines and industries.

Mission

We aim to expand the knowledge and practice of rheology through education, partnership and collaboration with associated fields, industries, and organizations, as well as to disseminate to diverse communities what rheology is, and how it impacts humanity and the world.

– Adopted by the SoR Executive Committee, 10 June 2017

Jeffrey Richards - 2026 Metzner Awardee



Dr. Richards received his PhD in August 2014 from the Department of Chemical Engineering at the University of Washington. After graduating from UW, he performed postdoctoral research at the University of Delaware and the NIST Center for Neutron Research in Gaithersburg, MD as a National Research Council Fellow. Dr. Richards joined the Chemical and Biological Engineering faculty at Northwestern in 2018 where his research focuses on engineering the electrical properties of soft materials for electrochemical energy storage applications. During his time at Northwestern, Dr. Richards received the National Science Foundation's CAREER award, the American Chemical Society's Distinguished New Investigator Award, and the 2023 Society of Rheology Publication Award.

In 2011, a new technology, the semi-solid flow battery, emerged from a group at MIT that utilized a flowing suspension of granular and Brownian particles. Key to the function of this battery was the addition of a conductive additive, typically carbon black nanoparticles, that created an electrically percolated network under flow to supply electrons to the electrochemically active granular particles. While this technology showed promise as a low-cost, grid-scale battery storage system, many challenges stem from the coupling between the flow behavior and the electrical transport in these suspensions. Rheo-electric measurements emerged as a powerful tool to interrogate this coupling and reveal the underlying physics determinative of the rheological behavior of these complex suspensions and their electrical properties.

Motivated by this technology and the desire to interrogate the microscopic origin of electron transport in suspensions of carbon black, Richards built a Couette rheo-electric geometry capable of interrogating electrical properties under steady shear and capable of performing simultaneous neutron scattering measurements [1,2] to examine the evolving microstructure of these complex suspensions under flow. This Couette was compatible with an ARES-G2 rheometer set up for primitive instrument control with a Python interface to coordinate with rheo-electric and scattering data acquisition.

Richards' collaborative work on understanding the rheology and electrical transport in carbon black suspensions with Norman Wagner and Julie Hipp at the University of Delaware during his postdoc ***redefined how we understood the rheology and electrical properties of these suspensions both in the quiescent state and under flow.*** Relevant publications are summarized below:

"Clustering and Percolation in Suspensions of Carbon Black," Langmuir 2017 [3]. By combining ultra-small angle neutron scattering with impedance spectroscopy, **this work proved that mechanical and electrical percolation are independent from one another and electrical percolation arises from the dynamics of carbon black agglomerates which form the building blocks of the stress bearing bonds that give carbon black suspensions their yield stress.** This disproved a prevailing view at the time which was that the stress bearing bonds (physical contacts) between carbon particles formed the conducting pathway for electrons.

"Structure-property relationships of sheared carbon black suspensions determined by simultaneous rheological and neutron scattering measurements," Journal of Rheology 2019 [4]. In this work, USANS measurements showed that the flow curve of a carbon black suspension could be divided into two regimes, a strong flow regime where the suspension is sheared at stresses well above the yield stress and a weak flow regime where the suspension exhibits stress equal to or less than the yield stress. **This work proved that in the strong flow regime carbon black agglomerates break up self-similarly or at constant fractal dimension whereas in the weak flow regime shear-driven heterogeneities dominate the rheological response.**

"Direct measurements of the microstructural origin of shear-thinning in carbon black suspensions," Journal of Rheology 2021 [5]. **Following the prior work from 2019, this work provided direct experimental evidence that the self-similar break up of carbon black agglomerates could be predicted by the Mason number, the dimensionless ratio of the shear forces acting to breakup agglomerates to the cohesive forces holding them together.**

While this collaborative work provided a strong microstructural basis for predicting suspension rheology, the electrical properties remained difficult to predict and understand. As Professor Richards began his faculty career at Northwestern, ***he developed new model systems to unveil for the first time the role that particle dynamics play in suspensions of conducting particles.*** Significant works and contributions are highlighted below.

"Quantifying the hydrodynamic contribution to electrical transport in non-Brownian suspensions," PNAS 2022 [6]. **This work was a first of its kind contribution showing the electrical diffusivity is quantitatively predicted by shear drive self-diffusion, predicted by a new scaling law identified by Richards and validated by simulations from Jim Swan.** At the time of this publication, there was no precedent for this new insight.

"Quantifying electron transport in aggregated colloidal suspensions in the strong flow regime," PNAS 2024 [7]. **This work showed that the electrical diffusivity of carbon black suspensions could be predicted using the scaling law**

developed in the 2022 PNAS paper. Again, this non-intuitive result had no precedent at the time.

Richards continues to innovate in the field of electrically responsive suspensions by developing new synthesis strategies [8,9] to engineer colloidal dynamics to elicit unique mechano-electric transduction pathways, apply the physics of the fluid Mason number to predict the suspension rheology of battery slurry [10-12] and develop new tools to study responsive soft matter at the microscale and macroscale [13-15]. His future plans include revisiting engineering the colloidal physics of suspension electrodes for semi-solid flow batteries by chemically modifying the surface of carbon black for colloidal stability in electrochemically relevant environments.

Richards has contributed significantly to society service by reviewing for the *Journal of Rheology*, *Rheological Acta*, and *Macromolecules*. He has served as a session chair at Society of Rheology Meetings and area 1J AIChE Annual Meeting. At the 2024 Society of Rheology meeting, Richards hosted a workshop on automated Rheo+ measurements whose attendees included both industry and academia. TA Instruments now sells a commercial rheo-electric accessory based on designs originating from his published work. In addition to the commercial accessory, Richards maintains a long standing collaboration with TA instruments to enable external control of their rheometers using script based programming. This allows rheological tests to be automated and synchronized with other measurements and is now available to broader rheology community.

by
Wesley Burghardt
(Northwestern)

Richards, J. J., Gagnon, C. V. L., Krzywon, J. R., Wagner, N. J., Butler, P. D. (2017). Dielectric RheoSANS — Simultaneous interrogation of impedance, rheology and small angle neutron scattering of complex fluids. *Journal of Visualized Experiments*, 2017(122), e55318–e55318. https://doi.org/10.3791/55318

Richards, J.J., Wagner, N. J., Butler, P. D. (2017). A strain-controlled RheoSANS instrument for the measurement of the microstructural, electrical, and mechanical properties of soft materials. *Review of Scientific Instruments*, 88(10). https://doi.org/10.1063/1.4986770

Richards, J. J., Hipp, J. B., Riley, J. K., Wagner, N. J., Butler, P. D. (2017). Clustering and Percolation in Suspensions of Carbon Black. *Langmuir*, 33(43), 12260–12266. https://doi.org/10.1021/acs.langmuir.7b02538

Hipp, J. B., **Richards, J. J.**, Wagner, N. J. (2019). Structure-property relationships of sheared carbon black suspensions determined by simultaneous rheological and neutron scattering measurements. *Journal of Rheology*, 63(3), 423–436. https://doi.org/10.1122/1.5071470

Hipp, J. B., **Richards, J. J.**, Wagner, N. J. (2021). Direct measurements of the microstructural origin of shear-thinning in carbon black suspensions. *Journal of Rheology*, 65(2), 145. https://doi.org/10.1122/8.0000089

Lin, H., Majji, M., Cho, N., *Zeeman, J. R.*, Swann, J., **Richards, J. J**. (2022). Quantifying the hydrodynamic contribution to electrical transport in non-Brownian suspensions. *Proceedings of the National Academy of Sciences*, 119(29)e2203470119. https://doi.org/10.1073/pnas.2203470119

Hipp, J. B., Ramos, P. Z., Liu, Q., Wagner, N.J., **Richards, J. J**. (2024). Quantifying electron transport in aggregated colloidal suspensions in the strong flow regime. *Proceedings of the National Academy of Sciences.* 121 (34) e2403000121 https://doi.org/10.1073/pnas.2403000121

Brucks, M. D., Arslanova, A., *Smith, C.B.*, **Richards, J. J.** (2023). Electroless Deposition of Silver onto Silica Nanoparticles to Produce Lipophilic Core-Shell Nanoparticles. *Journal of Colloid and Interface Science* 646, 663-670. https://doi.org/10.1016/j.jcis.2023.05.059

Brucks, M. D., Arslanova, A., *Byrne, N. F.*, Hui, J., Hersam, M.C., **Richards, J. J.** (2025) Anisotropic electrical transport in mechanically responsive gels containing silver-coated non-Brownian particles. *Advanced Materials*. *Accepted* https://doi/org/10.1002/adma.202415066

Liu, Q., **Richards, J. J.** (2023). Rheo-electric measurements of carbon black suspensions containing polyvinylidene difluoride in N-methyl-2-pyrrolidone. *Journal of Rheology*, 67(3), 647–659. https://doi.org/10.1122/8.0000615

Invited Article in September 2024 edition: **Richards, J. J.**, Hipp, J.B. (2024). The black powder behind battery power, *Physics Today*, 77 (9), 26–32 https://doi.org/10.1063/pt.ercw.haga

Gupta, Y., Liu, Q., **Richards, J. J.** (2025) Physical Scaling for Predicting Shear Viscosity and Memory Effects of Lithium-Ion Battery Cathode Slurries *Soft Matter, Accepted* https://doi.org/10.1039/D4SM01493F ***featured in the Soft Matter Emerging Investigators Series***

Lin, H., Blackwell, B. C., *Call, C. C.*, Liu, S., Liu, C., Driscoll, M. M., **Richards, J. J.** (2023). FSVPy: A python-based package for fluorescent streak velocimetry (FSV). *Journal of Rheology*, 67(1), 197–206. https://doi.org/10.1122/8.0000521

Cho, N., Shi, J., Murphy, R., Riley, J. K., Rogers, S., **Richards, J. J.** (2023). Extracting Microscopic Insight from Transient Dielectric Measurements made during Large Amplitude Oscillatory Shear on Inverse Worm-like Micelles. *Soft Matter*, 19 (48), 9379-9388. https://doi.org/10.1039/D3SM00786C

Patel, K. J., Bowles, S., Matolyak, L. E., Vogus, D., Wang, C., Nagy, G., **Richards, J. J.** (2024) Mapping structure and rheology of pH-responsive resins for low-VOC coatings. *ACS Applied Materials & Interfaces* 16 (51) 70874-70882 https://doi.org/10.1021/acsami.4c15652

https://www.mccormick.northwestern.edu/research-faculty/directory/profiles/richards-jeffrey.html

Northwestern University

https://www.societyofrheology.org/awards/wesley-r-burghardt-fellow-elected-2017

Wesley Burghardt

2026 Elected Fellows of The society of Rheology



Patrick Anderson

Eindhoven University of Technology

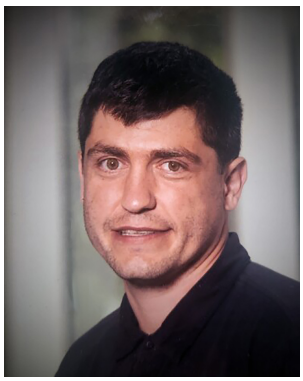
Professor Anderson studied Applied Mathematics at Eindhoven University of Technology (TU/e), where he also received his PhD from the Department of Mechanical Engineering, graduating in 1999 with prof. Han Meijer as his advisor. Following a one-year break working for Océ Technologies on hot-melt inkjet printing, he joined the Polymer Technology group, starting as an assistant professor and in 2011 promoted to full professor and chair of the group. He is the Dean of the Department of Mechanical Engineering at TU/e, a position he has held since 2022.

Patrick's research combines deep physical insight with methodological innovation and has significantly advanced the fundamental understanding of viscoelastic mixing and multiphase flow, while simultaneously providing practical frameworks that connect theory, computation, and experiments. A defining feature of Prof. Anderson's contributions is their consistent connection to technological accomplishment and processing practice. His research includes significant programs spanning polymer processing and manufacturing-relevant complex-fluid phenomena and rheology. In addition, his advisory engagements with industrial stakeholders demonstrate translation of rheology-based insight into industrially relevant contexts. This combination of rigorous scholarship and application has propelled Partick to the forefront of the rheology and complex fluids communities.

Partick's international standing in rheology and complex fluids is further evidenced by an extensive record of plenary, keynote, and invited lectures. Recent highlights include a plenary lecture (2025) on measuring and predicting structure development during processing flows and invited/keynote contributions addressing rheology-relevant manufacturing and modeling themes, including benchmark-type problems on interfacial rheology (2020) and processing concepts linked to additive manufacturing (2025). This sustained level of visibility has been recognized by a number of teaching and research awards from the computational mechanics, rheology, and polymer processing communities.

Marco Caggioni

Procter & Gamble, Corporate Engineering Technology Laboratory



Dr. Marco Caggioni has spent more than sixteen years at The Procter & Gamble Company (P&G) as a leading rheologist, driving the business and encouraging new rheologists in the company while remaining externally focused and engaging the academic community. Reflecting his capacity to simultaneously impact industry and the scientific community, Marco has authored over 55 publications and 24 patents focused on various rheological phenomena. His exceptional ability to bridge the gap between fundamental academic research and the solution of commercially significant problems sets him apart as a sustained contributor to the field. His work consistently demonstrates a unique talent for identifying industry-relevant issues and cleverly applying novel academic techniques, whether theoretical or experimental. Marco's mastery areas include:

Collaboration: Dr. Caggioni is integral to the Society of Rheology ecosystem. In addition to being a leading technical contributor within P&G, he invests time into retaining academic connections and making public-domain contributions to rheology. He has led tens of industry-sponsored research and consulting programs (~$1.5M toward universities including Harvard, Lehigh, IUPUI, UNSW, Delaware, UCSB, U-Milano, Cornell, Georgetown, Fribourg, U-Cincinnati, Northeastern, and Washington University). Additionally, he has supported externally funded projects, such as co-authoring NSF GOALI project with Lehigh. He is also a lead contributor for the open source Github toolbox used to facilitate rheology curve fitting and AI integration: rheopy (https://github.com/rheopy). Caggioni' s commitment to fostering academia-industry collaboration is evident in his active mentorship of students and early career researchers, many of whom have gone on to work in both industrial and academic settings.

Characterization of Microstructured Liquids: Marco's first two publications in the Journal of Rheology focused on microrheology of structured systems made from gellan

gum and insoluble cellulose fibers. He masterfully adapted microrheology techniques to drive scale up and achieve product consistency on the manufacturing scale. Marco's most cited articles regard arrested coalescence and engineering waxy/fatty dispersions (from food stuffs to shampoos). With an eye toward future applications, he also contributed to one of the first application of neural network to the rheology problem of inferring viscosity of a formulation from its chemical composition.

Microstructure Design: Marco's "Three component model" has a large fan base since it represents a physically intuitive, and easy to understand variation of the Herschel-Bulkley description of yield stress fluid; the model combines the viscous contributions of background fluids with the yielding mechanics of packed emulsions, all while enabling description of the transitional flows that occur. The work has broad applications and is already widely cited as a basis for modeling and experimental studies. Complementing this, he presented at various SoR meetings showing how to design liquids through an additive approach of different microstructures, selectively (and independently) altering the background viscosity the yield stress and relaxation time in yield stress fluids. His authorship of articles on consumer product design is influencing curriculum at universities.



Matthew Liberatore

Trine University

Professor Matthew Liberatore has been a contributor to the scholarship of rheology as well as service to the Society of Rheology (SOR) for many years. His rheology research broadly covers polymer, colloid, surfactant, and energy-related materials. He has contributed to topics including biomass materials, entangled polyelectrolytes, flow assurance and transport of oils and emulsions, shear thickening in colloidal slurries, and mechanical characterization of polymer membranes. Empowering this spectrum of projects are a series of unique experimental capabilities. His laboratory has significantly contributed to the areas of high-pressure rheology, controlling humidity and water content during mechanical characterization and dynamic mechanical analysis, rheo-small angle light scattering, and high-shear rheology reaching over 100,000 s-1 relevant in many industrial applications. His publications are well cited, and his work has been translated to industry.

He received a B.S. in Chemical Engineering from the University of Illinois Chicago (UIC) and M.S. and Ph.D. degrees from the University of Illinois Urbana-Champaign. He began is work in rheology as a graduate student under the direction of Anthony McHugh followed by postdoctoral studies under the advisement of Norman Wagner at the University of Delaware. His independent positions have included 10 years as a faculty member at the Colorado School of Mines followed by being a Professor at the University of Toledo.

During all of these positions, mentoring students and leadership in the Society of Rheology has been central to Professor Liberatore's career. He has mentored dozens of graduate and undergraduate students in the field of rheology, and these students have earned many awards, including two poster awards at SOR meetings. He has served as a session chair many times at SOR meetings, organized and judged the poster session, and was an inaugural member of the Diversity and Inclusion Committee of SOR. In this last role, he helped organize the first Rheology Research Symposium exclusively for students, gave a talk as part of the symposium about giving great scientific presentations, and mentored several students in the cohort.

Finally, Professor Liberatore served as the Local Arrangements Chair for the Society of Rheology Annual Meeting in Denver, Colorado in October 2017. These five years of effort culminated in the 89th Society of Rheology Annual Meeting with over 400 participants, more than 100 individual events and sessions, and a budget with a small surplus. Professor Liberatore managed over 1,100 emails related to the meeting is one of his lasting memories of this experience.



Eugene Pashkovski

The Lubrizol Corporation

Eugene Pashkovski is one of those very rare individuals who is able to successfully straddle the academic/industrial divide — and manages to make important contributions on both sides of the fence. He is an ambassador for the Lubrizol Corporation (well-known to a whole generation of rheologists as a supplier of Carbopol "model" yield stress fluids), as well as an experienced industrial rheologist. Over the past decade he has employed various shear and extensional rheometers to correlate rheological properties of engine oils with fuel economy increase (FEI). He developed tribological models using the Oldroyd-B and Giesekus constitutive models to explain the role of engine oil viscoelasticity in FEI that increased with the Trouton ratio of oils due to reduction of viscous energy losses in the hydrodynamic lubrication regime. Eugene's work fundamentally shifted the perspective of polymers from merely being viscosity modifiers to performance polymers being a critical element of modern engine lubricant formulations.

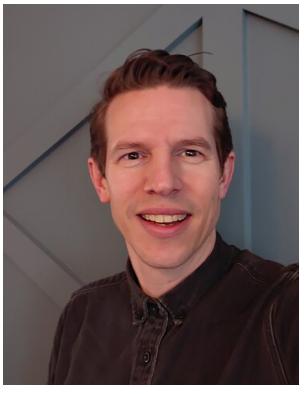
As the hydraulic fluid efficiency was associated with linear poly(ethylene)-co-(propylene) (OCP), it was essential to explain the mechanism by which this product provided energy savings of 3-8%. Viscosity measurements and accompanying theoretical analyses using the FENE and PTT models verified that the viscoelastic effects tend to reduce the magnitude of the secondary flow pattern, commonly known as the

Dean-vortex regime, which arises in curved geometries, by an average of 15% compared to the base liquid.

By performing time-resolved mechanical spectroscopy on oil-based colloidal gels, Eugene and his team have also quantified the gelation behavior and provided a physical explanation for the temporal evolution of the viscoelastic properties of an important class of Marine Diesel Cylinder Lubricants (MDCLs). The collapse of viscoelastic spectra, onto a master curve that spans over ten orders of magnitude in frequency helped to compactly capture the rheological behavior of these materials using a Fractional Zener model, accurately measuring the temporal evolution of viscoelastic properties through the gelation with high temporal resolution. The application of optimized windowed chirps was used to predict the lifetime of these marine lubricants and improve the stability of these products.

Eugene and his team have also investigated the effect of breaking and reptation times of micelles on the linear and non-linear rheology of viscoelastic mixed anionic-zwitterionic surfactant solutions. It was demonstrated that the value of the breaking time (rather than the Maxwellian relaxation time) controls a metastable branch on the stress-rate diagram. Transient flow responses corroborated the quasi-static flow findings and further revealed the significance of microscopic dynamic parameters on flow behavior. In work with Dave Weitz and Luca Cipelletti, he has contributed to the understanding of slow dynamics in soft glassy materials (SGM), including compressed emulsions and biopolymer microgels, using camera-based diffusion wave spectroscopy and multi-speckle dynamic light scattering, combined with a series of creep experiments to understand the effect of aging on slow dynamics.

He is a regular attendee at SOR meetings, serving as a Keynote Speaker, lead author of a technical article in the Rheology Bulletin, speaker and mentor at the Industrial Rheology Lunch and a Judge at the Future of Rheology session also.



Robert Poole

University of Liverpool

Prof. Rob Poole has made significant scientific contributions to the field of rheology and has been a leader in our community. Rob has been a council member of the British Society of Rheology (2009-2018) and serves as President of that organization (2025-2027). He was one of three lead organizers for the AERC meeting held in Leeds (UK) in 2024. Since 2019, Rob has been co-Editor in Chief of the Journal of Non-Newtonian Fluid Mechanics. One of the hallmarks of Rob's scientific work is the combination of experimental, numerical, and theoretical approaches to rheology. Rob is well-known in the field of non-Newtonian fluid mechanics and for his work on purely elastic instabilities and turbulence.

Purely elastic instabilities, drag reduction, and elastic turbulence: At low Reynolds (Re) numbers, instabilities can arise in complex fluids that are totally absent in the corresponding low Re flow of Newtonian fluids. Early work was motivated by experiments from the Arratia group that showed a steady symmetry-breaking instability in a "cross-slot" geometry for a flexible polymer solution even in the limit of vanishing inertia. Rob (in collaboration with Manuel Alves and Paulo Oliveria) showed how such a symmetry-breaking bifurcation could be captured numerically with the very "simple" Oldroyd B model even in two-dimensional simulations. Subsequent numerical work showed such steady symmetry-breaking instabilities were endemic to a range of related geometries, including flow-focusing devices and the so-called "mixing separating" geometry. A taxonomy for understanding the various instabilities that can be observed in shear-dominated, extension-dominated, and "mixed" kinematics flows was published by Rob as a "Purely-Elastic Instability Flow Map" (PEFIM). More recent work on the cross-slot geometry, which combined simulations and experiments, showed how instability onset could be controlled by the addition of a cylinder at the stagnation point. This addition was especially important in understanding the root cause of the instability, as its introduction completely changes the dynamics of the stagnation point yet, for small enough diameters, did not affect critical conditions.

Other important work in this area, once again in collaboration with Alves but also with the Lindner group, has been undertaken on the "serpentine" channel and in particular in illustrating how instability onset, this time to a time-dependent flow, scales with the aspect ratio of the geometry, how shear thinning stabilizes the onset, and how this geometry can be used as a microfluidic rheometer for measuring relaxation times. Rob and his group also used this geometry to illustrate the significant enhancement in heat transfer that can be observed by inducing an elastic instability and then elastic turbulence. Rob's group was also the first to use elastic turbulence to generate emulsions. Finally, by deliberately exploiting the polymer degradation observed during classical turbulent drag reduction by polymers and studying pipe, channel and square duct flows, Rob and his team were the first to tie a measurable fluid property (the "CaBER" relaxation time) to the degree of drag reduction thus allowing for an a priori quantitative prediction of drag reduction from a knowledge of polymer relaxation time, flow rate and geometric length scale.



Rekha R. Rao

Sandia National Laboratory

Dr. Rekha Rao is a Distinguished Member of Technical Staff at Sandia National Laboratories (Albuquerque, New Mexico). She came to Sandia in 1990 after earning her BS from UC Berkeley and PhD from the University of Washington, both in Chemical Engineering. Rekha is an expert in the computational mechanics of complex fluids, including theoretical development, numerical algorithms, and finite element implementation. She is a founder of Goma 7.0, an R&D 100 winning open-source software package for process flow modeling. She has authored 120 peer-reviewed journal articles, reports, and proceedings. Her projects have ranged from manufacturing, and energy-production, to environmental issues, and polymer processing but all have focused on complex fluids, including suspensions, emulsions, foam, polymers, slurries and other yield stress fluids.

Dr. Rao has received several awards. In 2012, Rekha won the Asian American Engineer of the Year Award, given for a combination of technical excellence and community service. In 2018, she won a "Career Achievement Award in Government," from the Women of Color in STEM Conference. In 2023, she was made a Fellow of the US Association of Computational Mechanics (USACM). Rekha has received many Sandia internal awards including two Employee Recognition Awards, three Director's Awards, six Certificate of Excellence Awards, and seven years of Royalty Awards. Rekha is Vice-President of the US Association of Computational Mechanics; In July 2024, she will become the USACM President. As the first female USACM President, she will be a powerful role model for women and minorities in computational mechanics. Rekha was the Technical Program Chair for the US National Congress on Computational Mechanics last July 2023.

Rekha chairs the Female Research Committee of the IACM, mentoring and encouraging women in computational mechanics. At Sandia, she actively supports women researchers and encourages junior staff. She is on the Professional Development Committee for the Sandia Women's Action Network events and founded the "Women in Research" Seminar Series. Away from work, Rekha enjoys spending time with her family, friends, and two dogs. She loves cooking, gardening, reading, walking/hiking, and traveling.



Shi-Qing Wang

University of Akron

Shi-Qing Wang is internationally recognized for paradigm-shaping contributions to nonlinear polymer rheology and polymer fracture, distinguished by a sustained emphasis on conceptual pictures, physical mechanisms, mechanical stability, and failure of constrained macromolecular systems.

His research reframed nonlinear rheology by demonstrating that many hallmark responses of entangled polymer melts and solutions – stress overshoot, flow heterogeneity, yielding, and rupture – originate from intrinsic mechanical instabilities of the load-bearing network of topological constraints (uncrossability-induced entanglement), rather than from purely homogeneous constitutive behavior. Through carefully controlled rheological and velocimetric experiments, he and his students provided some of the clearest and most influential experimental evidence for shear banding in well-entangled polymer melts, thereby challenging long-standing assumptions that such materials necessarily flow homogeneously.

A lasting contribution of his work is the establishment of yielding and failure as genuine physical processes in polymeric liquids. By directly linking stress localization, sharp stress drops, and irreversible structural changes to the breakdown of the entangled network under large fast deformation, he introduced a stability-based and structure-based framework that unifies shear banding, stress overshoot, and rupture. This perspective has reshaped interpretation of both shear and extensional rheology and clarified the physical origin of nonlinear responses that had previously been treated largely through phenomenological constitutive modeling.

Wang has also made major contributions to nonlinear extensional rheology, demonstrating that rupture and strain-hardening behavior in entangled polymers reflect the intrinsic integrity and failure of the molecular constraint network, rather than being governed solely by capillary or geometric instabilities. His work further extended these ideas to polymer glasses and solid polymers, establishing deep conceptual connections between the nonlinear mechanics of entangled melts and the plasticity and failure of amorphous solids.

These contributions are synthesized and articulated in his authoritative monograph *Nonlinear Polymer Rheology* (Wiley, 2018), which has become a principal reference for the physics of nonlinear deformation, flow instability, yielding, and rupture in polymeric liquids.

More recently, Wang has taken a paradigm-changing approach to elastomeric fracture. In a Perspective published in *Macromolecules*, he proposed a new framework for elastomeric fracture to replace the prevailing paradigm of the past seven decades. This work clarifies long-standing misunderstandings and establishes a unifying connection between fracture, nonlinear rheology, and chain scission via covalent-bond dissociation in highly stretched polymer network – placing his contributions in direct continuity with the classic advances of Gent, Rivlin, and Smith in elastomer mechanics, and climaxing in an upcoming book *Physics of Deformation, Fracture Mechanics and Adhesion in Polymers* (Wiley, 2026).

Collectively, Shi-Qing Wang's work has redefined the scientific foundations of nonlinear polymer rheology and fracture by unifying instability, yielding, and failure within a coherent, physically transparent framework grounded in molecular constraints and mechanical stability.

News from the Journal of Rheology

The 2026 Best Paper Award goes to....

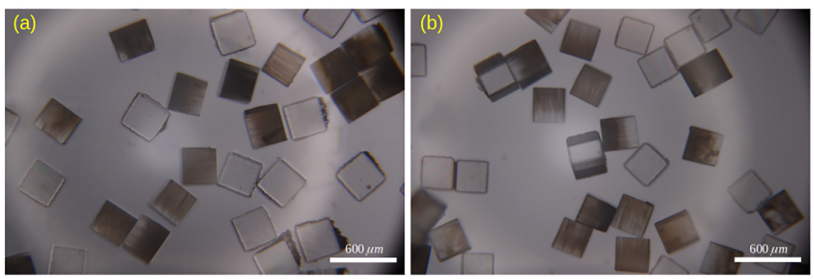
Rheology of suspensions of cubic particles

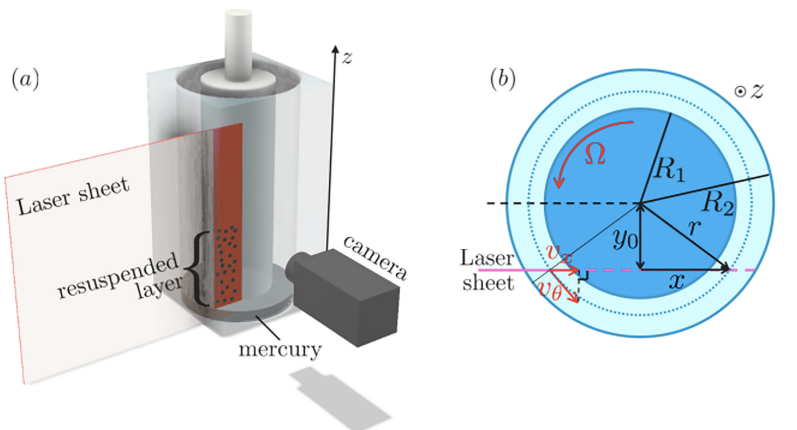
E d'Ambrosio, D Gilbert, F Blanc, C Cohen, E LemaireInstitut de Physique de Nice, UMR 7010, CNRS, Université Côte d'Azur.

J. Rheol. 69, 807-828 (2025).

In this work, cubic particles were fabricated using a soft lithography technique and suspended in a Newtonian fluid. Rheometric experiments were conducted to determine the Einstein and Batchelor coefficients in the dilute and semidilute regimes, revealing stronger hydrodynamic interactions compared to spheres.

Publication Award





Cover Image for JOR Award

Arthur B. Metzner Centennial Commemorative Issue

Topics include:

- Polymer melts and solutions
- Liquid crystals
- Particulate and fiber suspensions
- Polymer processing
- Extensional flow
- Composite materials
- Flow through porous media

Metzner Issue

Deadline for article submissions: October 31, 2026



Arthur B Metzner

Special issue: Networks with Dynamic and Covalent Bonds and Applications

Topics: Covalent adaptable networks, vitrimers, recyclable elastomers, and related networks

Guest editors: Evelyne van Ruymbeke & Salvatore (Christian) Coppola

Strict deadline for submission: 31 January 2027

Contents of this Special Issue will be discussed at the final conference of the European MSCA project 'ReBond' (5-9 September 2027, Crete)





Space Issue

Special issue: Space applications and low gravity

Guest editors: Olfa D'Angelo, Thomas Voigtmann and Norman J. Wagner

Volume 70, Issue 3 (May/June 2026)

The 15 articles in the collection include:

Rheology in space—A review of past and present ESA experiments

A. Martinelli; L. Cristofolini; D. Orsi; F. Ravera; L. Liggieri; A. Salonen; T. Podgorski; C. Minetti; M. Sperl; L. Cipelletti; N. Murdoch; M. Braibanti; S. Vincent-Bonnieu; B. Saint-Michel

https://doi.org/10.1122/8.0001074

Rheology beyond Earth

Olfa D'Angelo; Thomas Voigtmann; Norman Wagner

https://doi.org/10.1122/8.0001216

Join us on LinkedIn

LinkedIn

Understanding the Viscosity of Hydrocarbon-based Liquids

Eric B. Sirota

Abstract

A framework is described for quantitatively understanding and predicting the compositional and temperature dependence of the viscosity of hydrocarbon-based liquids, based on the Modified-Arrhenius equation which captures behavior associated with the approach to the glass transition, even at temperatures well above it. The framework is shown to apply across a broad range of materials, including bitumen, asphalt, lubricants, vegetable oils, and polymer solutions used as viscosity modifiers. When the viscosity–temperature relationship is parametrized as $\eta(T) = \eta_\infty \, exp\{D/[(T/T_0)–1]\}$ with a fixed fragility (D), the two parameters, T_0 and η_∞ vary systematically with composition and chemical changes such as oxidation. Importantly, this parameterization leads to simple linear blending rules for T_0 and η_∞ which predict the highly nonlinear, and even non-monotonic viscosity behavior observed in blends.

Introduction

General prediction of viscosity, especially on blending, has always been difficult. This author's research on viscosity began in the early 1990s with the challenge of developing a fundamental mechanistic understanding, in order to predict and control the viscosity of extremely heavy asphaltene-rich bitumens. Over four decades, that research expanded to include oils of all kinds, from crude oil to vegetable oils. A key enabler was working at the interface of physics, chemistry, and engineering, interacting with technical experts from all parts of our energy and chemicals businesses. But most important has been working in an organization which recognizes the importance of (1) fundamental scientific understanding of our technologies; (2) engagement with the outside scientific community; and (3) the long-term commitment to such research.

As far as the scope of the problem, both from data in the literature and from within our company (ExxonMobil), it was obvious that the problem at hand was not about non-Newtonian shear-dependent rheological behavior, but simply viscosity. Other effects come in when, for example, polymers are added, or when a second phase is present, particularly wax particles which crystallize at lower temperatures forming gel-like structure and a yield-stress. However, that is a different phenomena which can be explained separately (but still requiring knowing the Newtonian viscosity of the continuous liquid phase). Too often when multiple phenomena and mechanisms are present and not separately recognized and modeled, understanding the system can be intractable.

Experimentally we found evidence of viscosity drop associated with increased shear rates, which is often confused with non-Newtonian behavior. Too often, viscosity studies are done isothermally, i.e. characterizing the viscosity of different feeds or blends at a single temperature. However, it is essential to measure and be aware of the temperature dependence, since shear generates heat within the sample, especially in highly viscous liquids. Since rheometers control the temperature at the Couette or plate surfaces where the temperature is usually measured, shear will give rise to a temperature gradient *within* the liquid, where the sample temperature can be significantly above the wall/measured temperature. So, in asphalts, which in the absence of polymer addition are Newtonian, but where the viscosity can drop an order of magnitude over a 10°C rise in temperature, this can be a very large effect.

For oils, in practice, viscosity is all about temperature. This is unlike colloidal systems, where viscosity is essentially athermal, with the temperature-dependence only arising from the continuous liquid phase. Temperature dependence must be front and center in measurement and modeling of oil viscosity. In fact, a 6 order-of-magnitude variation of heavy bitumen viscosity with temperature (over the relevant temperature ranges) is comparable to its variation iso-thermally by dilution with low-viscosity solvent.[1]

More fundamentally, viscosity is about volume or free-volume.[2, 3, 4] The ease of moving around depends on how much empty space there is. In a very crowded cocktail party, you can't move around and mingle. In a lattice model analogy with a "sliding tile puzzle", if there were no empty space nothing could move. With two empty spaces it would be much easier than with one empty space. When free volume disappears, diffusion stops, resulting in a glass transition.

Pressure couples directly to volume, and very-high (GPa) pressures are needed to study this.[5] But practically, these pressures are not readily accessible and "free volume" cannot be directly measured. Temperature is easy to measure and control, and is, in practice, the most important lever on viscosity and it links to volume via the thermal expansion coefficient. Therefore, we use the formulation of the free-volume based concepts without parametrizing free-volume explicitly, in the form of the modified-VTF Vogel-Tammann-Fulcher or modified-Arrhenius equation,[6] (which is mathematically equivalent to the Williams-Landel-Ferry WLF equation).

$$\eta(T) = \eta_\infty \exp\left(\frac{D}{\frac{T}{T_0} - 1}\right) \quad (1)$$

Single-phase viscosity of oils follows the modified-Arrhenius form (eq 1).[2] There are three parameters: T_0, η_∞ and D. Figure 1 illustrates the equation's behavior and what the parameters represent. T_0, the Kauzman temperature, is the asymptotic temperature where the viscosity diverges. The glass transition or T_g, is viscometrically defined as where the viscosity reaches 10^{13} Poise, so T_g is connected to T_0, but a little higher. η_∞ is the high-temperature limiting viscosity, and D controls how the viscosity varies between those limits.

Measured viscosities as a function of temperature are just part of this curve, and are informed by the glass transition even at temperatures far above it. Viscosity data, even with multiple orders-of-magnitude variation, only cover a relatively small fragment of the curve, and it is extremely difficult to uniquely independently determine all three parameters accurately. Therefore, free fits do not give systematic results, as they should for systematic variations in composition. Using a large data set allowing D to float, D = 7.5 was chosen from its average value, "arbitrarily" as the song says.[7] And fixing that value did not noticeably degrade the fit quality. Figures 2(a) and 4 show typical data sets fit to the two free parameters, obtaining essentially perfect fits over a wide viscosity range; and most importantly as discussed below, the variation of T_0 and η_∞ are systematic and sensible. When data does not fit this form, it is usually experimental error, shear induced heating, or the appearance of a 2nd phase due to wax crystal formation. The use of this functional form itself is not new. Fixing D was the critical step.

One doesn't need many data points to get T_0 and η_∞. As long as one has two trusted viscosities (η_a at T_a, and η_b at T_b) at two temperatures that are not too close together, the parameters can be easily calculated analytically:

$$y = -\frac{D(T_a - T_b)}{\ln(\frac{\eta_a}{\eta_b})} + (T_a + T_b),$$
$$T_0 = \frac{y - \sqrt{y^2 - 4T_aT_b}}{2}, \quad (2)$$
$$\eta_\infty = \eta_a \exp\left(\frac{-D}{\frac{T_a}{T_0} - 1}\right)$$

With this parametrization, T_0 and $\ln(\eta_\infty)$ essentially blend linearly with volume fraction, examples of which are shown in Figures 2(b), 3(a) and 4. Generalized, for multiple components:

$$T_0 = \Sigma_i \phi_i T_{0,i} \qquad ln\,\eta_\infty = \Sigma_i \phi_i ln\,\eta_{\infty,i} \quad (3)$$

These are not blending rules for viscosity at such-and-such a temperature. These two parameters give the blending behavior at *all* temperatures. And the highly non-linear, and sometimes non-monotonic blending behavior of viscosity at a given temperature is simply explained without resorting to complicated empirical blending indexes or ad-hoc corrections.

It's very insightful to look at a T_0-η_∞ map with a logarithmic η_∞ axis, as shown in Figure 3(a). To understand it, we superimpose iso-viscosity curves for a given temperature (100°C here), with the 100 cP curve bolded. To get a given viscosity at a given temperature, there is a locus of (T_0, η_∞) pairs which will fulfill that, which comprise the iso-viscosity curves. Every oil or mixture has a coordinate on such a plot. $\eta(T)$ for such pairs that give 100cP @100°C are shown in the Figure 3(b). One can not only calculate, but visualize the blending behavior, since with this parametrization a mixture will lie on a straight line between the components. Regardless of type of product, be it asphalt or lubricants, one can populate the map with different possible components and can therefore get to any target viscosity-temperature behavior by choosing what, and how much, to blend. Following an iso-viscosity curve towards the lower right is lower-T_0 and higher-η_∞. The purple arrows point to the directions of higher viscosity grades, and towards better quality.

When you look at viscosity this way, many apparently "anomalous" behaviors are simply explained. For example: Some blends exhibit non-monotonic viscosity behavior: At a constant temperature, the viscosity goes down and then up on varying concentration (ϕ). If one component has a higher T_0 (meaning higher viscosity at lower T) and the second has a higher η_∞ (giving higher viscosity at higher T), then $\eta(T)$ curves will cross at some temperature, as in Figures 4(a,c). Since there are different functional dependences of viscosity on T_0 and η_∞ near that temperature, the viscosity cannot be constant with ϕ, and thus must exhibit extrema. Therefore, the non-monotonic behavior is not an anomaly, but rather an intrinsic consequence of the simple theory.

The behavior of blends of an 8 cSt poly-alpha-olefin (PAO) with both Naphthenic acids and Canola Oil (triglycerides with three ~18-carbon chains, MW~880) are shown in Figure 4. Blends of 8 cSt PAO with Naphthenic Acids (Baker CAS No:1338-24-5) and Canola oil. $\eta(T)$ for the pure components are shown in Figure 4(a,c) with the higher T_0 component shown in pink and the lower T_0 one in

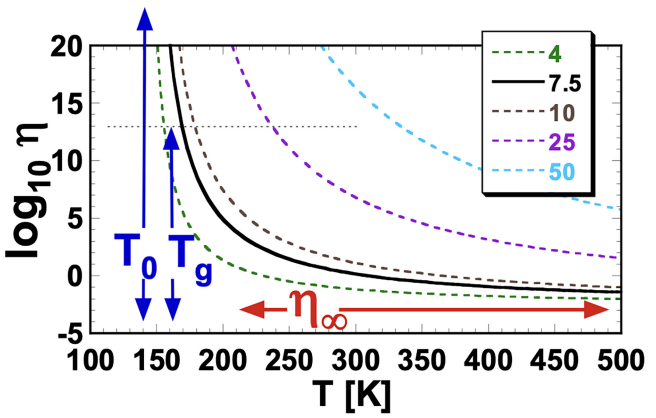


FIGURE 1. $\eta(T)$, illustrating the asymptotic behavior and meaning of the parameters of the modified-VTF equation, here plotted for T_0=140, η_∞=0.002, D=7.5, and showing T_g. Other values of D are listed in the legend and are shown with thin dashed curves. *(Adapted with permission from Ref [1]. Copyright 2025. ACS.)*

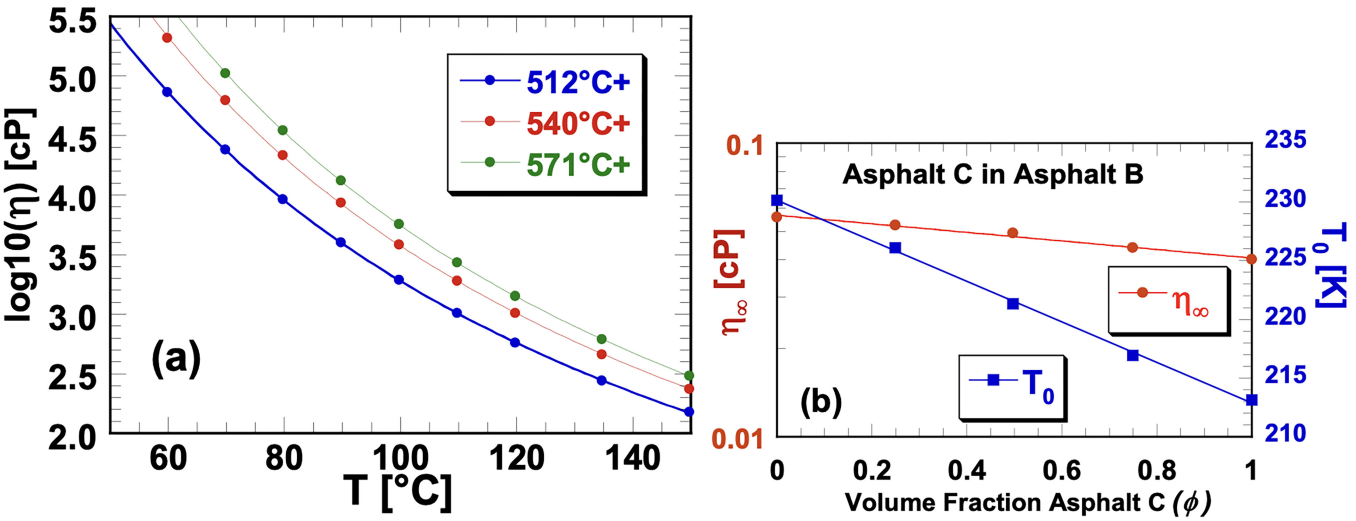


FIGURE 2. (a) $\eta(T)$ of Asphalt A, a vacuum resid from a typical crude oil, for different distillation cuts. The fit with D=7.5 passes through all the points and is shown with solid lines. **(b)** Typical blending behavior of T_0 and η_∞ derived from $\eta(T)$ of binary blends plotted vs. ϕ shown here for a pair of asphalts.

green. The insets show the viscosity as a function of concentration, at the temperature where the $\eta(T)$ curves cross. Figure 4(b,d) shows T_0 and η_∞ derived from $\eta(T)$ of binary blends, plotted versus volume fraction ϕ. Different functional dependences on T_0 and η_∞ result in extrema and thus non-monotonic behavior on blending, at temperatures near the $\eta(T)$ crossing.

Parametrized this way, dependences on chemical composition appear systematic.[1] For example, T_0 for the paraffins and other aliphatics is low and initially increases with MW but levels off in the high-MW polymer limit, as we know T_g does for polymers. T_0 is higher with ring-containing species, polar functionalities, and other characteristics associated with higher T_g. η_∞ increases with, and depends mostly just on the MW, continuing to increase strongly with MW. This dominates the high viscosity of polymers, especially polyolefins. This is different than the comparably lower-MW petroleum components where high viscosity is dominated by high T_0.

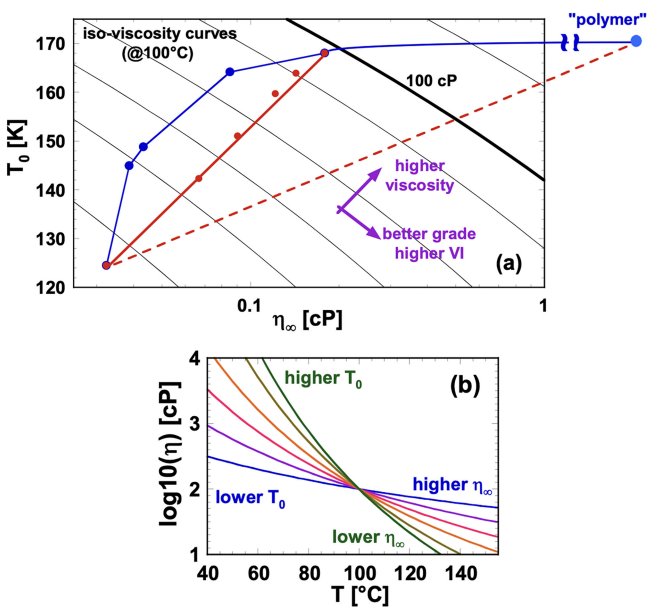


FIGURE 3. (a) T_0-η_∞ map where mixtures will lie on lines between their components. The direction of higher viscosity grades and better quality are shown with the purple arrows. Measured values for a series of pure PAOs of increasing MW and viscosity grade are shown with the blue points. Measured blends of the lightest and heaviest are the red points. The blends fall to the lower right of the pure components, meaning smaller sensitivity of viscosity to temperature. The thin diagonal black curves are iso-viscosity curves at 100°C, and run diagonally, with the 100cP curve bolded. The extension to the right representing the much higher MW regime, is schematic and shows the efficient thickening effect of a polymer viscosity modifier. **(b)** $\eta(T)$ for (η_∞, T_0) along the 100cP@100°C iso-viscosity curve.

Lubricants

A better lubricant's viscosity is less sensitive to temperature. It needs to be pumpable in cold weather so you can start your car on a cold day; but it should not lose its lubrication performance at high temperature. The Viscosity Index or VI, is an industry property specification designed to quantify this. [8] High VI means "better", i.e. less sensitive to temperature. VI was historically defined as a piecewise continuous function of the viscosities at 40 and 100°C. It exhibits anomalous blending behavior, which was also simply explained[1] by considering the parameterization of T_0 and η_∞, rather than kV100 and VI as is common in the industry. So, in the opinion of the author, one should not use VI within R&D or in doing science. Try to understand T_0 and η_∞; not VI, because you can't. You can always map back to VI.

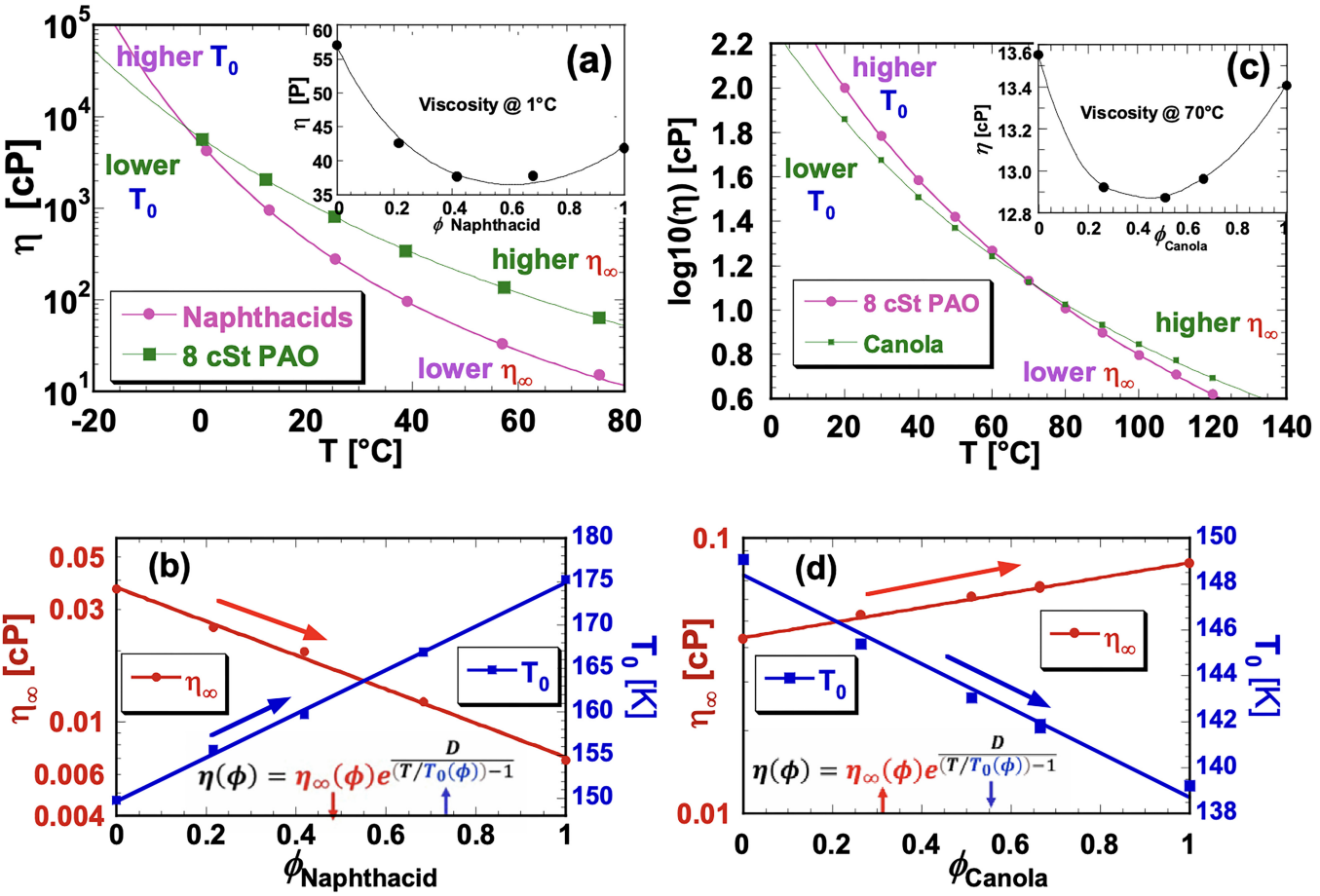


FIGURE 4. Blends of 8cSt PAO with **(a,b)** Naphthenic Acids (Baker CAS No:1338-24-5) and **(c,d)** Canola oil. **(a,c)** $\eta(T)$ for the pure components with the higher T_0 component shown in pink and the lower T_0 one in green. The insets show the viscosity as a function of concentration, at the temperature where the $\eta(T)$ curves cross. **(b,d)** T_0 and η_∞ derived from $\eta(T)$ of binary blends plotted vs. volume fraction ϕ. Different functional dependences on T_0 and η_∞ result in extrema on blending when T is near the $\eta(T)$ crossing. *((a,b) adapted with permission from Ref [1]. Copyright 2025. ACS.)*

It's known that extreme-bimodal blends of synthetics make higher quality lubricants. [9] Why? For the increasing MW grades, T_0 levels off and η_∞ continues to rise, thus forming a curved path on a T_0-η_∞ map as in Figure 3. Comparing the pure components to the blends of the extremes for a given viscosity grade, the blends are lower and to the right. That is a weaker dependence on temperature and thus better quality. The extreme bimodal blends will be to the lower right by simple geometry and have a higher VI than a single component (with equivalent 100°C viscosity). No special explanation needed; it comes right out of the theory.

Polymers

This simple framework is not applicable to entangled high-MW polymer melts where other physical mechanisms leading to complicated rheology occur. However, we can consider dilute or semi-dilute polymer solutions in the Newtonian limit.

As we also needed to do with asphaltenes, we must dispense with thinking in terms of Intrinsic Viscosity [η], and picture of polymers in solution following the Einstein relation (shown schematically in Fig. 5(a)) behaving colloidally as hard spheres, which they are not; and as it cannot account for the temperature-dependence associated with the polymer. One should consider [η] as the $\phi \to 0$ limit of the blending of T_0 and η_∞. Often reported slope changes or breakpoints of the viscosity as a function of concentration at c* are an artifact of plotting constant-temperature viscosity on a linear scale, assuming the Einstein relation for colloids. Shown in Figure 5 is the rising viscosity as a function of concentration, calculated for solutions of a T_0=202K material and T_0=70K liquid. In Figure 5(a) the viscosity is plotted on a linear axis where an apparent break from the linear behavior is often described in the colloidal framework. However, increasing the scale of the viscosity shows the apparent breakpoint shift to lower concentrations, while on the logarithmic scale (Figure 5(b)) these continue to increase linearly and smoothly; no breakpoint.

Figure 6 shows η_∞ and T_0 derived from $\eta(T)$ measured on solutions of an ethylene-propylene copolymer (M_w = 99 Kg/mol, 72% C_2) in Pristane (2,6,10,14-Tetramethylpentadecane, MW=268.5). They exhibit the linear blending behavior that we regularly observe, as described above. Extrapolating T_0 and η_∞ to 100% polymer will give an "effective" T_0 and η_∞ for blending them in

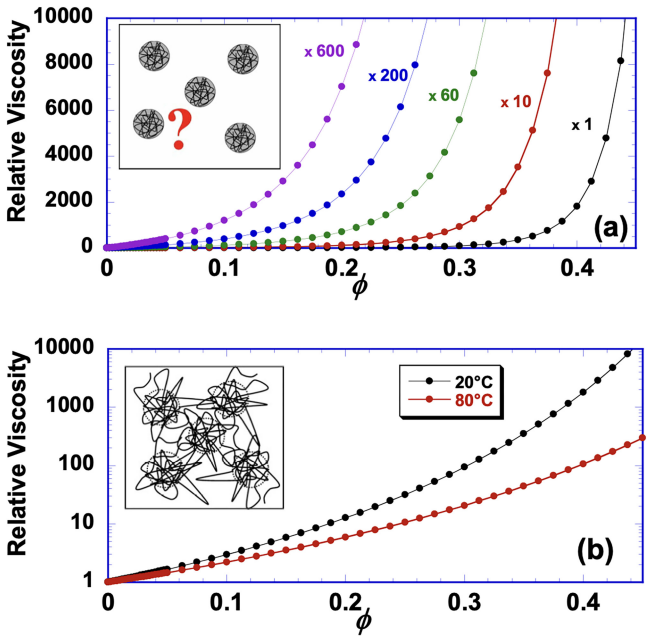


FIGURE 5. Calculated viscosity upon blending a T_0=202K material into a T_0=70K liquid. **(a)** At 20°C, with the curve shown scaled by a series of larger factors, giving an apparent earlier breakpoint to a non-linear rise. Schematic representing soluble polymers as solid colloids. **(b)** Shown on a logarithmic viscosity scale, which shows continuous behavior, for 20°C as well as 80°C. Schematic representing soluble polymers as soluble polymers.

solution; but does not simply extrapolate to neat polymers or concentrated solutions where the polymers are entangled.

This approach easily explains the sometimes-observed negative Intrinsic Viscosities,[10] which are essentially a low-T_g (low-T_0) polymer "plasticizing" the higher T_0 solvent.[11]

Besides providing a new approach to describing and quantifying polymer solution viscous behavior, soluble polymers are practically important as viscosity modifiers or VI improvers for lubes, asphalt and other oils.[12, 13] As the MW becomes very large, η_∞ continues to increase, as shown in Figure 7. Here, the polymer η_∞ values are recalculated from the polybutadiene data of Colby et al.[14] and the low-MW points are data on n-alkanes from the DIPPR database.[15] For low-MW polymers, the viscosity is known to increase nearly linearly with M_w, while at high-MW when they are entangled, it increases as $\eta \propto M_w^{3.4}$.[16,17] The crossover occurs at M_c where entanglements set in.[18,19] However, entanglements are suppressed in dilute solutions of polymers, where $M_c(\phi) \sim M_c/\phi$, extending the linear regime.[20] So the rise in effective-η_∞ as a viscosity modifier in dilute solution would more likely be that associated with the extrapolation of the lower MW slope, since the high exponent is due to entanglements which would not be present in dilute solution.

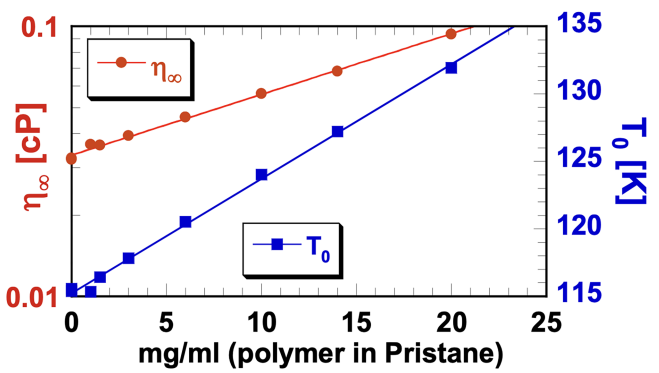


FIGURE 6. η_∞ and T_0 of ethylene-propylene copolymer (M_w = 99000, 72% C_2) solutions in Pristane as a function of polymer concentration.

Looking at the schematic "polymer" point in Figure 3(a), which is very high η_∞, we see the viscosity grade can be strongly increased while improving quality. Thus, the mechanism responsible for the behavior of viscosity modifiers is the same phenomenon that improved properties through extreme bi-modal blends.

While polymer data is not always acquired and/or presented with multiple temperature data points, in some cases it is parameterized using the Modifier Arrhenius (VTF) equation (or its equivalent). Even if the raw data is not available, knowing the temperature range over which it was measured (i.e. where that equation represents the data), one can re-parametrize the results with a constant D. When the WLF equation is used, it can be easily mapped to the modified-VTF parametrization. Polymer viscosities are sometimes reported using the Melt Index (MI), which can be related to a nominal low-shear Newtonian melt viscosity $\eta = 80000$ *Poise/MI*.[21] Additionally, for high-MW polymers where T_0 has already leveled off, a viscosity measured at a fixed temperature will yield the MW dependence of η_∞. Systematically looking at the viscosity of polymers this way would be very insightful.

Asphalt

Asphalt binder contains asphaltenes and is a non-fuel disposition of petroleum vacuum resid. Asphaltenes are molecules in an aromatic-rich, relatively high-MW fraction of petroleum, and are defined by solubility, e.g. toluene-soluble/heptane-insoluble. Their prevalence imparts especially high viscosity to heavy crude oils, bitumen and asphalt. They are usually problematic, but are a beneficial component of asphalt. Asphaltene molecules are usually soluble in crude oil and they are not colloidal dispersions. Understanding asphaltenes as molecules in a highly non-ideal solution, and overcoming the prevalent notion in the literature of "asphaltenes as colloids" or particles (or "nano-aggregates"), enabled us to make significant strides in understanding, and

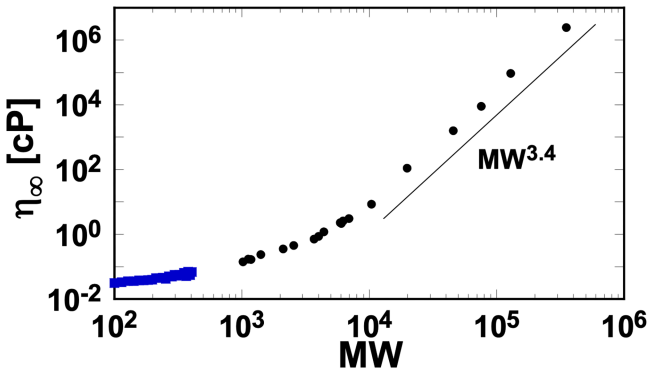


FIGURE 7. η_∞ vs. MW (black) recalculated from the polybutadiene data of Colby et al.[14] and (blue) n-alkane data from DIPPR[15].

predictions of both viscosity and phase behavior.[22,23,24]

Asphalt specifications[25,26] are essentially designed to ensure that the road should not rut under the weight of heavy trucks on a hot day, and should not be brittle (or glass-like) and crack in cold weather. So "better" asphalt (for a given viscosity or hardness grade) means weaker viscosity sensitivity to temperature, just like for lubricants. Asphalt properties measured through specification test methods are manifestations of actual fundamental physical properties. Most asphalt properties are simply manifestations of viscosity on the $\eta(T)$ curve. For example, the softening point is the temperature at which the sample yields under specific test conditions, which can be associated with reaching a given viscosity (~14000 cP).[1] The Penetration is measured as the distance travelled by a needle under a given force, in a given time which is also a measure of viscosity. [27] So, if you know T_0 and η_∞, then you could predict most asphalt properties.

One can put asphalt components on a T_0 -η_∞ map like Figure 3(a), where to the upper right is a "harder" or more viscous asphalt, and towards the lower right is a "better" asphalt in terms of sensitivity to temperature. Linear blending on such a map can enable selecting a blend with a chosen property target.[28]

Physical and chemical changes causing highly non-linear changes to viscosity behave systematically within this framework and can be represented as paths on the map, shown in Figure 8(a). The compositional path taken on distillation of asphalt to higher cutpoints moves primarily linearly and most importantly to higher T_0, but also slightly increased η_∞. We point out that this turns out to be linear over a finite boiling point range but actually depends on the actual (η_∞,T_0) of the components as a function of boiling point.

Asphalt oxidation occurs in the hot mix plant; at lower temperatures due to aging on the road; as well as during air-blowing, a high-temperature process, sometimes used in asphalt manufacturing to increase its viscosity. While industrially considered totally different things, scientifically we studied them together with a continuum of oxidation temperatures. Viscosity at a reference temperature is a highly non-linear function of oxidation severity. But T_0 exhibits a simple linear increase with oxidation time at temperature, where the rate of increase increases with temperature and can be understood in terms of chemical reaction activation energies.[1] (Figure 8(a)) Along with systematic changes to η_∞, this can enable prediction of the oxidized or aged property changes from the initial asphalt's properties.

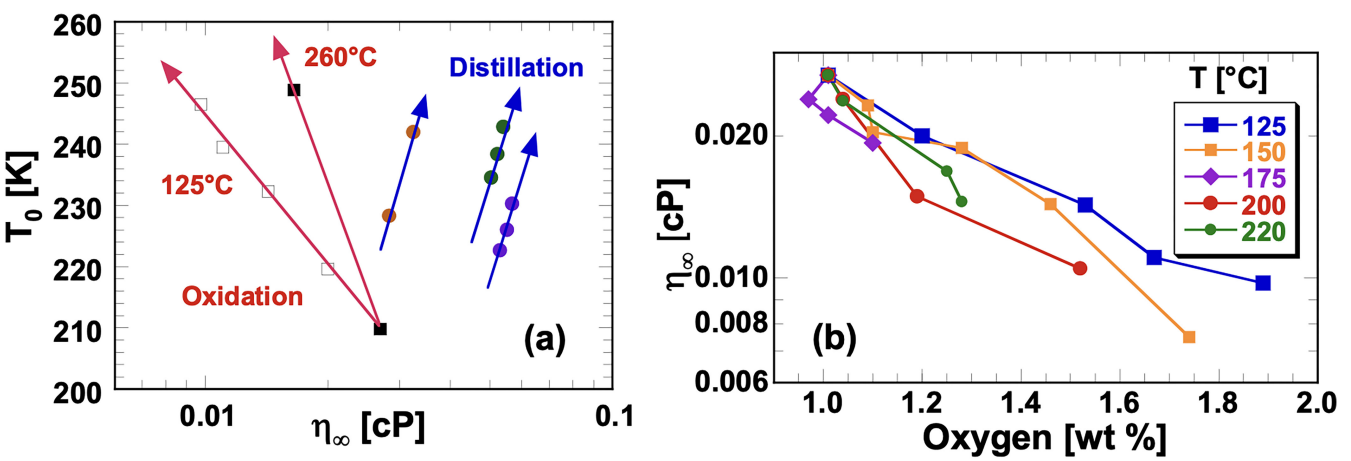


Figure 8. (a) T_0-η_∞ map showing the paths taken upon distillation to make higher cutpoint vacuum residues from 3 different crude oils (circle, with blue arrows); and the oxidation paths (red arrows) for both higher-temperature (air blowing) and lower-temperature (aging) conditions. While T_0 increases for both, the low-temperature process decreases η_∞ more significantly; thus requiring a higher T_0 to reach the same viscosity of a soft asphalt oxidizing at high- (solid square) and low- (open squares) temperatures, where different chemistries dominate. **(b)** η_∞ for an asphalt oxidized at various temperatures ranging from 125 to 220°C, each for multiple durations. Further details on this experiment can be found in [1].

High pressures are relevant to boundary lubrication. While viscosity is a highly non-linear function of pressure, T_0 increases linearly and systematically allowing simple functional forms for the temperature and pressure dependence of viscosity at any temperature. Pressures directly couple to free volume, and T_0, the largest lever on viscosity, increases roughly linearly with pressure.

Conclusions

This framework is immensely useful; but everything is not so simple: There can be non-linearities in the blending of T_0. Non-linearities are usually negligible, but there are cases where they can be observed with careful measurement. We understand this in terms of Excess Volume of mixing. This means effectively adding "free volume" when two liquids are mixed.

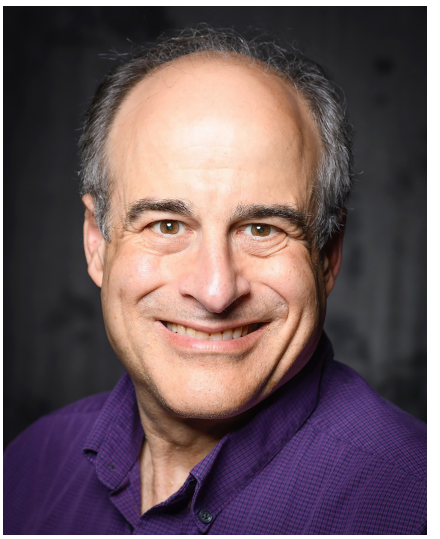
Oxygen content seems to reduce η_∞. Shown in Figure 8(b) is the measured η_∞ for oxidation of a 390°C+ cutpoint asphalt, by bubbling air, with oxidation temperatures ranging from 125 to 220°C for multiple durations ranging from 60 to 3000 minutes. While the reaction rate increases by an order-of-magnitude over this range,[1] the dependence of η_∞ on oxygen content is independent of oxidation temperature, with η_∞ decreasing systematically. We also note that alcohols have lower η_∞ than comparable alkanes. The trend is systematic. But a correlation is not the answer, it poses a question: Why?

As the song[7] says, "The third parameter is called *D*. We set (at 7.5) arbitrarily." There must be compositional dependence to *D*. What is it? How would one incorporate a variable *D* in a way that maintains the meaningfulness of T_0 and η_∞? And how would that parameter blend?

In summary: Practically, parametrizing viscosity this way simplifies the complex. It's applicable for oils, well-beyond the energy industry. It is useful. It should be systematically and routinely applied to data, which will be able to teach us a lot and relate chemical composition to viscosity. There is still more to be scientifically understood.

Acknowledgements

I would like to acknowledge the late Roger M. Cohen, my lab director who put me on this path, and countless others who helped me along this way.



Eric B. Sirota

ExxonMobil Technology and Engineering Company, Energy Sciences Division Route 22 East, Annandale, NJ 08801, USA Email: Eric.B.Sirota@ExxonMobil.com and Eric@EricSirota.com

Eric received his PhD in Physics from Harvard in 1986, studying with Peter Pershan. He then came to Exxon's Corporate Research lab in Clinton, New Jersey, as a post-doc working with Sunny Sinha and Cyrus Safinya. He never left. Eric became a fellow of the APS (Division of Condensed Matter Physics) in 2021 for pioneering x-ray scattering techniques in soft condensed matter, particularly studying alkyl-chain crystallization. He continues to do fundamental soft condensed-matter physics, studying crystallization, phase-separation, and viscosity, in simple and complex hydrocarbon systems; Working at the interface of chemistry and engineering, he has been able to apply that science across a broad industry. He often says: *"Alkanes don't care what business sector they're in; they crystallize when the physics says they should."*

Eric is also a composer/playwright, writing musical theatre. One of his 5 musicals, *Frankenstein*, was adapted as a movie after playing Off-Broadway for 3 years. He is currently developing another work about music and Alzheimer's. (https://EricSirota.com)

References

1 Sirota, E. B. The Viscosity of Oils. *Energy & Fuels* **2025**, *39* (30), 14511–14533. DOI: 10.1021/acs.energyfuels.5c02322.

2 King, H. E., Jr.; Segre, P. N.; Appel, M. Viscosity and Diffusion. In *Encyclopedia of Applied Physics V23*, Trigg, G. C. Ed.; Vol. 23; Wiley, 1998.

3 Grest, G. S.; Cohen, M. H. Liquids, Glasses and the Glass Transition: A Free-Volume Approach. In *Advances in Chemical Physics*, Prigogine, I., Rice, S. A. Eds.; Vol. 48; Wiley, 1981; pp 455–525.

4 White, R. P.; Lipson, J. E. G. Polymer Free Volume and Its Connection to the Glass Transition. *Macromolecules* **2016**, *49* (11), 3987–4007. DOI: 10.1021/acs.macromol.6b00215.

5 Cook, R. L.; King, H. E.; Herbst, C. A.; Herschbach, D. R. Pressure and Temperature-Dependent Viscosity of 2 Glass-Forming Liquids - Glycerol and Dibutyl Phthalate. *J. Chem. Phys.* **1994**, *100* (7), 5178–5189. DOI: 10.1063/1.467276.

6 Williams, M. L.; Landel, R. F.; Ferry, J. D. Mechanical Properties of Substances of High Molecular Weight .19. The Temperature Dependence of Relaxation Mechanisms in Amorphous Polymers and Other Glass-Forming Liquids. *Journal of the American Chemical Society* **1955**, *77* (14), 3701–3707. DOI: 10.1021/ja01619a008.

7 Sirota, E. B. *The Viscosity Song (Supporting Information from "The Viscosty of Oils)*. 2025. https://pubs.acs.org/doi/10.1021/acs.energyfuels.5c02322#_i48.

8 ASTM. *Standard Test Method for Pour Point of Petroleum Products, ASTM Standard D97-17b*; West Conshohocken, PA, 2003, 2022.

9 Haigh, H. M.; Carey, J. T.; Galiano-Roth, A. S.; Wu, M. High viscosity novel base stock lubricant extreme viscosity blends. 2007.

10 Abe, F.; Einaga, Y.; Yamakawa, H. Intrinsic-Viscosity of Oligobutylenes and Polyisobutylenes - Treatments of Negative Intrinsic Viscosities. *Macromolecules* **1991**, *24* (15), 4423–4428. DOI: 10.1021/ma00015a026.

11 Yang, X.; Wang, S. Q. Exporing the Origin of Negative Viscosity Change in Polymer Solutions. *Macromolecules* **2000**, *33*, 3128–3133.

12 Martini, A.; Ramasamy, U. S.; Len, M. Review of Viscosity Modifier Lubricant Additives. *Tribol Lett* **2018**, *66* (2). DOI: ARTN 58 10.1007/s11249-018-1007-0.

13 Polacco, G.; Filippi, S.; Merusi, F.; Stastna, G. A review of the fundamentals of polymer-modified asphalts: Asphalt/polymer interactions and principles of compatibility. *Adv Colloid Interfac* **2015**, *224*, 72–112. DOI: 10.1016/j.cis.2015.07.010.

14 Colby, R. H.; Fetters, L. J.; Graessley, W. W. The melt viscosity-molecular weight relationship for linear polymers. *Macromolecules* **1987**, *20* (9), 2226–2237. DOI: 10.1021/ma00175a030.

15 DIPPR. *DIPPR Project 801: Evaluated Process Design Data*; American Institute of Chemical Engineers (AIChE).

16 Lohse, D. J.; Milner, S. T.; Fetters, L. J.; Xenidou, M.; Hadjichristidis, N.; Mendelson, R. A.; García-Franco, C. A.; Lyon, M. K. Well-defined, model long chain branched polyethylene.: 2.: Melt rheological behavior. *Macromolecules* **2002**, *35* (8), 3066–3075. DOI: 10.1021/ma0117559.

17 Mendelson, R. A.; Bowles, W. A.; Finger, F. L. Effect of Molecular Structure on Polyethylene Melt Rheology.1. Low-Shear Behavior. *J Polym Sci A2* **1970**, *8* (1pa2), 105–+. DOI: 10.1002/pol.1970.160080109.
18 Pearson, D. S.; Strate, G. V.; Vonmeerwall, E.; Schilling, F. C. Viscosity and Self-Diffusion Coefficient of Linear Polyethylene. *Macromolecules* **1987**, *20* (5), 1133–1141. DOI: 10.1021/ma00171a044.
19 Colby, R. H.; Fetters, L. J.; Graessley, W. W. Melt Viscosity Molecular-Weight Relationship for Linear-Polymers. *Macromolecules* **1987**, *20* (9), 2226–2237. DOI: 10.1021/ma00175a030.
20 Graessley, W. W. *Polymeric Liquids & Networks Dynamics and Rheology*; Garland Science, 2008. DOI: https://doi.org/10.1201/9781003573487.
21 Longworth, R.; Pieski, E. T. Melt Index as a Measure of Newtonian Melt Viscosity. *J Polym Sci Pol Lett* **1965**, *3* (3pb), 221. DOI: 10.1002/pol.1965.110030313.
22 Sirota, E. B. Physical structure of asphaltenes. *Energy & Fuels* **2005**, *19* (4), 1290–1296, ; Proceedings Paper. DOI: 10.1021/ef049795b.
23 Sirota, E. B. The Effect of Compositional Distribution on Asphaltene Precipitation. *Energy & Fuels* **2026**, *40* (15), 7950–7963. DOI: 10.1021/acs.energyfuels.6c00608.
24 Sirota, E. B.; Lin, M. Y. Physical behavior of asphaltenes. *Energy & Fuels* **2007**, *21* (5), 2809–2815. DOI: 10.1021/ef060634c.
25 *Asphalt Institute - Specifications*. Asphalt Institute, 2022. https://www.asphaltinstitute.org/engineering/specification-databases/.
26 Zeiada, W.; Liu, H. Q.; Ezzat, H.; Al-Khateeb, G. G.; Underwood, S.; Shanableh, A.; Samarai, M. Review of the Superpave performance grading system and recent developments in the performance-based test methods for asphalt binder characterization. *Constr Build Mater* **2022**, *319*. DOI: ARTN 126063 10.1016/j.conbuildmat.2021.126063.
27 Davis, R. L. The ASTM Penetration Method Measured Viscosity. *Journal of the Assoc. of Asphalt Paving Technologists* **1981**, *50*, 116.
28 Sirota, E. B. Selection and blending of feeds for asphalt manufacture. U.S. Patent 20150191598A1, 2014.

Network Science Insights in Dense Suspension Rheology

Abhinendra Singh

Abstract

Suspension rheology is a cornerstone of the Society of Rheology, as evidenced by its meetings and publications. Decades of work have focused on the non-Newtonian behavior of these materials, including yielding, shear thinning, and shear thickening. Yet dense suspensions continue to surprise us. A seemingly simple mixture of particles and liquid can abruptly become harder to flow, yield from a solid-like state, or jam outright when sheared. Increasingly, these behaviors are understood not only by where the particles are but also by how they are mechanically connected. Under deformation, particles form, break, and reorganize the contact and force networks that carry stress across the material. Network science offers a useful language for describing these mesoscale structures. In this article, I introduce this emerging perspective and discuss how concepts such as force chains, loops, rigid clusters, and percolating contact networks are providing new ways to think about yielding, discontinuous shear thickening, and shear jamming. I close with what remains open, especially the challenge of extending these ideas to the three-dimensional, polydisperse, and chemically complex suspensions that arise in practice.

Introduction

Particulate suspensions are everywhere—in industry and in nature. They appear as paints, cement, and ceramic slurries; as foods such as mayonnaise and molten chocolate; in pharmaceutical formulations and 3D-printing inks; and as mud, blood, and many other materials familiar to rheologists. Despite their apparent simplicity, particle–liquid mixtures exhibit remarkably rich flow behavior. Squeeze a bottle of ketchup, and it suddenly flows; strike a cornstarch suspension, and it solidifies[1]. The same action can produce opposite responses. More generally, a suspension that flows easily under one condition may resist deformation, or even behave as a solid under another, spanning a wide range of macroscopic responses that include yielding, shear thinning, shear thickening, and shear jamming[2–4].

These diverse phenomena share a common thread: each can be framed as a transition in which rigidity is gained or lost within the material's underlying structure during deformation (Fig. 1). Yielding is the transition from a soft viscoelastic solid to a flowing liquid when the applied stress exceeds the material's yield stress σ_y. It reflects the breakdown of an internal structure supported by a microscopic particle network and has been the subject of several topical reviews[5–7].

The reverse can also occur. Increasing the applied stress or deformation rate can increase viscosity and trigger shear thickening, either continuously (CST) or abruptly (DST). At sufficiently high solid concentrations, this can culminate in a shear-jammed solid (SJ) above a characteristic stress σ_{sj}. As Fig. 1 illustrates, yielding and shear jamming are similar rigidity transitions viewed from opposite directions: yielding breaks down an elastic backbone of interparticle interactions, whereas shear jamming builds a stress-bearing network.

This article presents a perspective on both transitions through a shared lens: the loss of rigidity during yielding and the emergence of rigidity during shear jamming. It asks not only how the macroscopic response evolves under deformation but also which microscopic interactions and mesoscale structures drive it. How do interparticle interactions organize into networks that resist or fail under stress? Many rheologists already reach for this picture in their own systems: a polymer rheologist thinks in

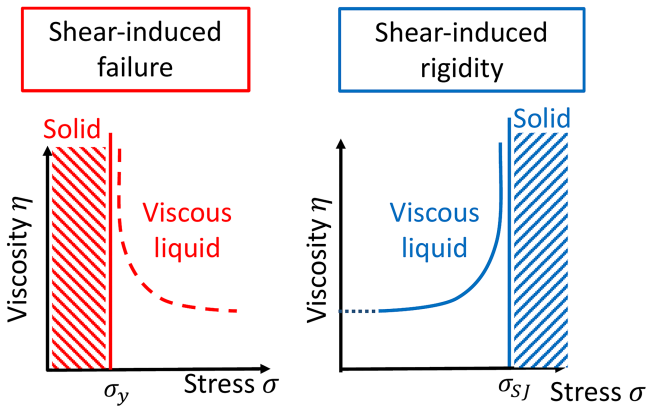


FIGURE 1. Typical rheological transitions related to loss or emergence of rigidity of the underlying force network. Loss (left) or emergence (right) of rigidity under deformation: yielding (left) and shear jamming (right). Both transitions are associated with the breakage (left) or formation (right) of an elastic backbone in the network formed by interparticle interactions. Shaded regions denote the solid-like behavior.

terms of transient entanglement networks, a gel rheologist in percolating clusters, and a granular physicist in force chains. Network science offers a way to make that shared instinct more quantitative across systems. I draw on how these ideas have been developed for polymer networks[8,9], colloidal gels[10–15], granular systems[16], and, more recently, dense suspensions.

Contacts and constraints: beyond a purely fluid-mechanical picture

Suspension rheology has traditionally been viewed through a fluid-mechanics lens[2,17], in which pairwise lubrication and long-ranged hydrodynamic interactions are the dominant contributions. In this picture, particle motion perturbs the surrounding fluid streamlines as the suspension deforms. For perfectly smooth, rigid particles, continuum hydrodynamics predicts that the lubrication force diverges as $1/h$, where h is the gap between two particle surfaces: as the gap closes, it becomes ever harder to squeeze the intervening fluid out, and the particles should never quite touch[17].

A more recent perspective suggests that, in real suspensions, the lubrication film between two particles must eventually break down. This reminds us that perfectly smooth, rigid particles are an idealization[18,19]. Once that idealization fails, direct particle contacts can form. From this vantage point, the surprising non-Newtonian response of dense suspensions arises not from hydrodynamics alone but from the interplay between interparticle interactions and the applied stress[1,4,18]. These interactions are governed by the solid–fluid interfacial chemistry of both phases, as well as by frictional interactions between particles, which depend on particle roughness and surface chemistry[4,20,21].

This framework can be recast in terms of a more general and abstract concept: *constraints*. The non-Newtonian response then arises from a competition between constraints and applied stress. *Stress-released* constraints reduce viscosity, leading to shear thinning; *stress-activated* constraints increase viscosity, leading to shear thickening. Framing the problem this way has, over the past decade, helped unify dry granular physics and suspension rheology[4,22–24].

The intuition behind constraints is simple: how many contacts does a particle need for the system to be mechanically stable? Each constraint on relative motion removes degrees of freedom (DOF). As additional modes of relative motion are constrained, fewer contacts per particle are needed to achieve mechanical stability. This threshold is captured by the isostatic coordination number Z_{iso} and the corresponding volume fraction at which the system jams, ϕ_J drops accordingly. This establishes a hierarchy. A purely lubricated particle experiences no constraints in sliding or rolling modes; if only excluded volume counts, isostaticity requires $Z_{iso} = 2D$ (= 6 in 3D) with $\phi_J^0 \approx 0.64$. If sliding is also forbidden, the requirement drops to $Z_{iso} = D + 1$ (= 4 in 3D) with $\phi_J^\mu \approx 0.57$. If rolling is also constrained, it drops further to $Z_{iso} = D(D+1)/(2D-1)$ (= 2.4 in 3D) with $\phi_J^\mu \approx 0.35$. In this language, yielding and shear jamming can be viewed as departures from and approaches to isostaticity.[4,18,21,23,24].

The strength of the constraint picture is that what matters is the number of constraints, or equivalently the available (or lost) degrees of freedom, rather than only the precise physical or chemical origin of these constraints. Mean-field models built on this idea successfully predict steady-state, strain-averaged flow. By construction, though, they are largely agnostic to mesoscale rearrangements: *how the contacts are spatially organized and how that organization carries stress.* This is the aspect I focus on in the rest of this article.

From contacts to force-chain networks

Constraints that are activated, as in friction, or released, as in adhesive or attractive systems, provide a unifying framework for understanding shear jamming and yielding. But invoking the isostatic condition immediately raises a fundamental question: *which contacts are present, and how are they arranged?* Counting constraints tells us when a system can become rigid; it does not tell us what the rigid structure looks like or how stress is transmitted through it. Framed in terms of rigidity, the question becomes: *what geometrical and topological features of the contact or force network produce the observed flow behavior?*

This question has brought network- and graph-theoretic methods into the study of suspension rheology. These tools offer statistical descriptions of microstructure—and, ultimately, a possible route to controlling flow—that constraint-counting mean-field models cannot provide by construction. The approach is increasingly used across rheology and the broader soft-matter communities.

Why the frictional network?

Rheologists routinely ask why a given behavior appears: what microstructure underlies it? The usual structural descriptors, the pair correlation function $g(r)$ and the structure factor $S(q)$, are invaluable for quantifying the spatial organization of particles[2,25,26]. But the spatial arrangement of particles is not the same as knowing which particles bear the load. This is where the network view adds to an old intuition. The aphorism widely attributed to polymer rheologist Prof. Richard S. Stein—"*Rheology without morphology is theology, while morphology without rheology is just zoology*"—reminds us of the coupling between flow and structure. For dense suspensions, the morphology that matters is not only where the particles are but also how they are mechanically connected: the morphology of the contact and force network, not of particle positions alone.

Simulations that resolve both lubrication and frictional contact forces have made this concrete[27,28]. Comparing shear rates just below and just above the onset of DST—that is, unconstrained versus constrained states- the traditional measures ($g(r)$ and $S(q)$) and showed only minimal differences, even though the viscosity changed by nearly an order of magnitude. In contrast, analysis of the frictional contact network showed that the two states were remarkably different[18,28]. These observations helped motivate the use of graph- and network-theory approaches in dense suspensions.

Motivation also runs deep in granular physics, where jamming has long been linked to enduring contacts that form force networks. These networks transmit stress and correlate motion over distances far larger than a single particle but smaller than the sample—a natural mesoscale structure. Force chains are a canonical example: filament-like strings of particles that carry most of the load.

Cates *et al.* pioneered the concept of force chains and defined them as linear strings of rigid particles in point contact[29]. This definition is useful because it highlights both the stability and fragility of these structures. Under imposed deformation, such as simple shear, the stress field can be decomposed into principal compressive and tensile directions. As a particulate system is deformed, force chains naturally emerge in the direction of compression. However, such structures require orthogonal support because contacts can break under continued deformation. If the external deformation is perturbed sufficiently, the structure can fall apart; in this sense, it is *fragile*.

Stabilizing these force chains requires orthogonal support from other force-bearing particles along the tensile direction. This *hypothetical configuration* can then become mechanically stable, or jammed, under external deformation and behave as a fragile solid with a finite modulus. Experiments on photoelastic disks and simulations of granular materials have corroborated these ideas, establishing both the heterogeneity of particle forces and stresses and the experimental validation of shear jamming[30,31].

For dense suspensions, this lens is particularly useful. The particle arrangement may shift only subtly during a rheological transition, while the frictional contact network reorganizes dramatically. This suggests that the key question is not only where the particles are, but also which particles are mechanically connected, how those connections carry stress, and whether (and how) the resulting network can resist external deformation.

From particle space to network space

Once frictional contact or the force network is recognized as an important mesoscale descriptor, the next task is to quantify it. A useful starting point is that the particle configuration and the network provide *dual* descriptions of the same system: particle positions indicate where particles are, whereas the network indicates which particles are mechanically connected. In this sense, the particle configuration and the contact network offer complementary views of the same problem (see Fig. 2).

Network science studies systems of interacting entities, and its natural representation is a graph G, with entities as nodes V and interactions as edges E; thus, a graph is represented mathematically as $G \equiv \{V, E\}$[32,33]. An edge can be unweighted, recording only whether an interaction is present, or weighted, also carrying its strength.

Using the graph G, an adjacency matrix A can be constructed to represent the network. For an undirected and unweighted graph, A is defined as:

$$A_{ij} = \begin{cases} 1, & \text{if there is an edge between nodes } i \text{ and } j, \\ 0, & \text{otherwise.} \end{cases}$$

For a more general weighted network, the adjacency matrix is

$$W_{ij} = \begin{cases} w_{ij}, & \text{if there is an edge between nodes } i \text{ and } j, \\ 0, & \text{otherwise,} \end{cases}$$

where w_{ij} is the strength of the interaction between nodes i and j.

These definitions map naturally onto familiar objects: a frictional contact network is unweighted—it records only whether a frictional contact exists—whereas a frictional force network is weighted by the magnitude of the contact force. Force chains can then be viewed as filament-like structures composed of strongly weighted edges embedded in the force network. Formally, the network is encoded in an adjacency matrix

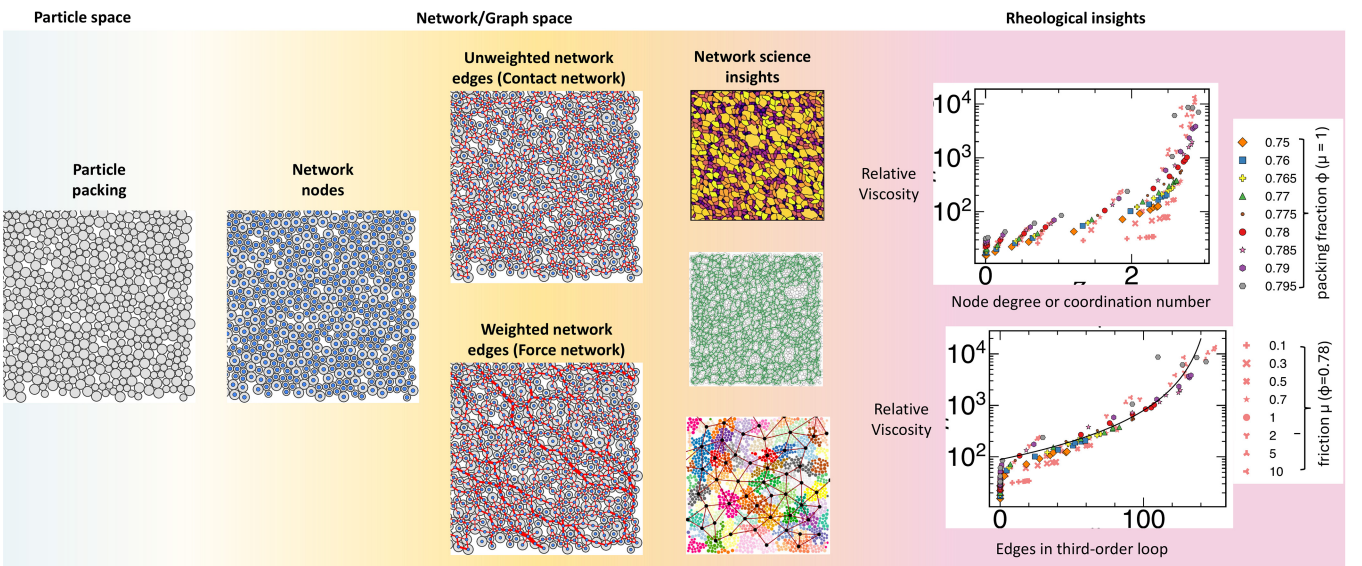


FIGURE 2: Insights into suspension rheology: from particle to network space. (Left) A packing of particles; (Middle) representation of particles as a graph, with particles as nodes and contacts or forces as unweighted or weighted edges, followed by network-theory-based decomposition; (Right) Relative viscosity plotted against (top) number of edges and (bottom) number of edges in third-order loops.

(binary for the contact network and force-weighted for the force network; see Eqs. 1 and 2). Information about nodes, edges, and weights is central to the network description used here.

Network-theory tools

Once the network is defined, a standard toolkit allows us to quantify its structure. Some diagnostics recur across particulate systems.

Degree: The simplest measure is the degree, i.e., the number of edges incident to a node. In the granular and suspension literature, this is the contact number, or coordination number Z, which largely controls mechanical stability and, through it, rheology[22,34]. Tracing connected sequences of edges yields loops, or cycles: closed paths that return to their starting node. The order of a loop (l) is its number of edges, so the smallest possible loop is a triangle—three particles in mutual contact, or a third-order loop.

Community structure and detection: Communities are groups of nodes that are more densely connected to one another than to the rest of the network. In other words, nodes within a community have many edges among themselves and relatively few edges connecting them to nodes in other communities[35]. Community-detection algorithms typically identify such groups by optimizing a quantity called modularity, which assigns nodes to the same cluster when they are densely connected within the community and weakly connected to nodes outside it[36].

Persistent homology: Persistent homology tracks how features, such as connected components and loops, are born and die as a force threshold (or edge weight) is swept from high to low. Picture lowering a water level over a landscape: islands appear, bridges form, and components merge[37]. Persistent homology tracks the birth and death of these structures, enabling one to distinguish short-lived features from robust structures that persist across a wide range of force scales[38].

Rigidity theory: Rigidity theory raises another fundamental question: can a network of contacts resist deformation? Connectivity alone is not enough—a connected chain can still bend or slide unless stabilized by sufficient contacts. This is Maxwell's constraint count: rigidity requires enough independent constraints relative to the available degrees of freedom[39,40]. The pebble-game algorithm operationalizes this idea by partitioning a contact network into rigid and floppy regions[41]. Originally devised for frictionless packings, it has recently been extended to frictional ones[42]. For suspension rheology, the key message is that connectivity alone is insufficient: the contact network must be organized to be mechanically rigid and capable of supporting stress.What insights does network science provide into suspension rheology?

A central question is whether network-based descriptions provide insight into suspension rheology beyond traditional particle-based measures. In particular, *can the organization of contacts and forces explain why suspensions yield, shear-thicken, or jam?* Network science has been applied to a wide range of disordered soft matter systems, including polymer networks[8,9], colloidal gels[10–15], granular systems[16]. When a material is represented as a network, the loss or emergence of rigidity can be framed as a phase transition: the appearance of a rigid spanning cluster can signal the transition, and the cluster's size or fractal dimension can serve as an order parameter.

These ideas were initially explored in frictionless two-dimensional granular packings within the framework of isotropic jamming. Below the jamming point, there is no persistent contact network; at the transition, a contact graph emerges, and every edge belongs to a single rigid cluster that spans the system with a diverging correlation length[43]. Friction changes this picture qualitatively. A frictional system can support one large rigid cluster (non-spanning) alongside a few fleeting, smaller ones, set in a sea of non-rigid bonds and particles without contacts[42].

Colloidal gels offer a complementary view: rigidity emerges at strikingly low solid concentrations.[10–15,44,45] This behavior is linked to the growth of fractal clusters and their percolation into a single connected network[45], with the modulus arising from hierarchical structure and cluster-level elasticity[12,13]. Rigidity-based analyses show that attraction enhances correlations and lowers the rigidity-percolation threshold[46], and network tools can resolve sub-clusters within a single giant network, thereby tracing the gel's elasticity to the resilience of that network[44].

Dense suspensions differ from these systems in one important respect: under steady shear, they reach a dynamic steady state in which frictional contacts continuously form, break, and reform. The relevant question is therefore not the structure of a fixed network, but how the topology and geometry of these networks govern rheology[47–54], as summarized in Fig. 2.

Over the past decade, the following picture has emerged. At low stress, below the thickening onset, the physics is governed by conservative, non-contact forces—repulsion or attraction, along with hydrodynamics. Frictional contacts are largely absent. As stress increases beyond the characteristic onset stress, frictional contacts are activated, and the FCN becomes tenuous and aligned with the compressive axis. Such a structure, supported only by sliding constraints, is difficult to sustain under steady shear.

One way to stabilize it is through the same orthogonal support observed in granular matter (as proposed by Cates *et al*.[29]). As DST or shear jamming is approached by increasing either stress or particle concentration, frictional contacts also form along the tensile direction. These contacts stabilize the compressive force chains and, in doing so, they form closed loops. The appearance of loops in the FCN is therefore useful: it provides a structural signature of a network that has become capable of supporting stress, and it connects DST and SJ in suspensions to force-chain ideas from the dry granular literature[30,31,55].

Persistent homology quantifies these loops by asking not only whether they exist, but also how robust they are as the force threshold varies. In this measure, the persistence of loops in the force network is strongly correlated with viscosity and appears largely independent of solid concentration, applied stress, and even dimensionality[49]. That last point is particularly striking and has motivated much of the recent two-dimensional work on the topology–geometry–rheology link; one likely reason is that, under simple shear, the dominant structure lies in the flow and gradient directions, with comparatively little variation along the vorticity axis. In the same spirit, DST has been shown to coincide with the emergence of third-order loops, *i.e.*, triangles[50]. The relative viscosity can then be expressed as a function of the number of such loops, and the correlation is independent of concentration,

stress, and sliding-friction coefficient. This suggests that triangular motifs act as local building blocks of mechanically stable frictional networks[48,54] and brings graph theory and rigidity theory together: by Laman's theorem, the triangle is the smallest rigid unit in a two-dimensional bar-and-joint framework—it does not deform under load[56].

Rigidity-based methods point to a similar conclusion from a different angle. The pebble game and related tools track mechanically stable regions in the FCN, provide information on their size distribution under shear,[48,57] and show that DST and SJ are accompanied by large, nearly system-spanning rigid structures. Independent network analysis shows a similar picture: the force-bearing structures in the DST regime are more strongly interconnected and mechanically supported than those in the CST regime[53]. The emerging picture is that strong shear thickening is not simply about more contacts, but about contacts organized into structures that collectively resist deformation.

Three dimensions remain underexplored, but early results are consistent with this picture: shear thickening tracks the growth and eventual system-spanning connectivity of the FCN[47,51,54,58]. The onset of DST appears to coincide with the emergence of contact structures capable of transmitting stresses over distances larger than a typical particle size within the suspension. These findings are broadly consistent with the picture developed throughout this article: rheology depends not only on the number of frictional contacts but also on how those contacts organize into larger stress-bearing structures. A recent caution is that much of this work relies only on sliding constraints. When rolling resistance is added, force chains can percolate along the compressive axis and stabilize without the need for tensile support, so suspensions with nearly identical viscosities can support markedly different network architecture[52]. The question of which features of the network are essential to mechanical stability and which are interchangeable remains open.

Conclusions and a word of caution

Interaction-network descriptions have provided a useful new window into rheological transitions across disordered soft matter, from polymer networks and colloidal gels to granular materials and, more recently, dense suspensions. In dense suspensions, these ideas have been particularly useful because they provide a *mesoscale* level of description: larger than individual particles yet smaller than the sample size. This mesoscale organization, encoded in frictional contacts and force networks, has been instrumental in understanding discontinuous shear thickening and shear jamming.

The past decade has shown that frictional contact networks are critical for strong shear thickening. A recurring lesson is that higher viscosity does not arise simply from more contacts. Rather, what matters is *how those contacts are arranged into stress-bearing structures*. Network-science tools have made this picture more quantitative: loops, rigidity, persistence, and community structure each, in its own way, show that the organization of contacts is closely tied to the suspension's ability to resist deformation. Loop motifs, *nearly* system-spanning rigid clusters, and percolating subnetworks therefore provide complementary descriptions of the mechanical stability of contact networks. Together, these observations suggest that the *macroscopic* rheology of dense suspensions is shaped not only by *microscopic* particle interactions but also by the topology and rigidity of the *mesoscale* networks of these interactions.

Although most of the discussion here has focused on viscosity, the same mesoscale view may also help connect network structure to other rheological observables, especially normal stresses. Normal stresses reflect the anisotropy of the stress-bearing microstructure and are central to dense-suspension rheology. From a network perspective, this raises a useful question: *which features of the contact or force network control shear resistance, and which control stress anisotropy, dilation, and normal-stress differences*? Establishing such connections remains relatively open, but it could provide a more complete test of whether a proposed network measure captures the mechanics of the suspension rather than only correlating with viscosity.

At the same time, this emerging picture warrants caution. The link between frictional contact networks and suspension rheology is still developing, and it is too early to draw firm universal conclusions. Many current studies focus on idealized systems, often in two dimensions and with a single dominant interaction, such as frictional contact. Real-world suspensions are usually three-dimensional, polydisperse, and chemically complex. Their particles may interact through friction, adhesion, repulsion, attraction, hydrodynamics, or combinations of these mechanisms. In such systems, the relevant object may not be a single subnetwork but an embedded or multilayered one, in which different interaction types coexist and compete.

This matters because *similar bulk rheology need not imply similar mesoscale organization*. When additional constraints, such as rolling resistance, are included, suspensions with comparable viscosities can exhibit markedly different network architecture[52]. Thus, a network measure that tracks rheology in one system may not apply to another. To my mind, an important open question is which network features are universal, and which are system-specific.

Looking ahead, I see an important opportunity. Network science offers a framework for linking microscale, particle-level interactions to macroscopic flow via an intermediate mesoscale description. To make this perspective more broadly useful, new approaches will be needed to extend network-based analysis to three-dimensional, polydisperse, chemically complex, and industrially relevant suspensions. If successful, this could lead not only to a better description of suspension rheology but also to the ability to predict---and eventually design---the network structures that influence how these materials flow.

Acknowledgements

I am especially grateful to Bulbul Chakraborty, Karen Daniels, and Emanuela del Gado, who introduced me to network-science methods and generously shared their expertise. I thank Jeff Morris, Emanuela del Gado, Safa Jamali, Vivek Sharma, Sam Root, Benjamin Yavitt, Meera Ramaswamy, Shweta Sharma, and Ria Duggal for insightful comments and valuable discussions during the preparation of this article. I gratefully acknowledge financial support from Case Western Reserve University startup funds.



Abhinendra (Abhi) Singh is an Assistant Professor of Macromolecular Science and Engineering at Case Western Reserve University, where he has been since 2022. He earned his PhD in Mechanical Engineering from the University of Twente (The Netherlands) and completed postdoctoral training at the Levich Institute at the City College of New York and the University of Chicago. His research group focuses on the physics and rheology of dense suspensions, granular materials, and complex fluids, using computational, theoretical, and data-driven tools. A major focus of his recent work is linking microscopic particle-scale interactions to macroscopic flow behavior through mesoscale frictional contact networks, using network science, topology, and machine-learning-based models. His group's research is supported by early-career awards from the ACS Petroleum Research Fund Doctoral New Investigator program and the NSF CAREER program.

References

1. Ness, C., Seto, R. & Mari, R. The physics of dense suspensions. *Annu. Rev. Condens. Matter Phys.* **13**, 97–117 (2022).
2. Mewis, J. & Wagner, N. J. *Colloidal Suspension Rheology*. (Cambridge University Press, Cambridge, 2011). doi:10.1017/CBO9780511977978.
3. Denn, M. M. & Morris, J. F. Rheology of Non-Brownian Suspensions. *Annual Review of Chemical and Biomolecular Engineering* **5**, 203–228 (2014).
4. Singh, A., Kim, H., Morris, J. F. & Jaeger, H. M. Jamming and Yielding in Dense Suspensions. *Annual Review of Chemical and Biomolecular Engineering* **17**, 157–178 (2026).
5. Bonn, D., Denn, M. M., Berthier, L., Divoux, T. & Manneville, S. Yield stress materials in soft condensed matter. *Rev. Mod. Phys.* **89**, 035005 (2017).
6. Joshi, Y. M. & Petekidis, G. Yield stress fluids and ageing. *Rheol Acta* **57**, 521–549 (2018).
7. Ductile-to-brittle transition and yielding in soft amorphous materials: perspectives and open questions - Soft Matter (RSC Publishing) DOI:10.1039/D3SM01740K. https://pubs.rsc.org/en/content/articlehtml/2024/sm/d3sm01740k.
8. Kim, J. *et al.* Stress-induced plasticity of dynamic collagen networks. *Nat Commun* **8**, 842 (2017).
9. Broedersz, C. P., Mao, X., Lubensky, T. C. & MacKintosh, F. C. Criticality and isostaticity in fibre networks. *Nature Phys* **7**, 983–988 (2011).
10. Smith, A. D., Donley, G. J., Del Gado, E. & Zavala, V. M. Topological Data Analysis for Particulate Gels. *ACS Nano* **18**, 28622–28635 (2024).
11. Bantawa, M. *et al.* The hidden hierarchical nature of soft particulate gels. *Nat. Phys.* **19**, 1178–1184 (2023).
12. Whitaker, K. A. *et al.* Colloidal gel elasticity arises from the packing of locally glassy clusters. *Nat Commun* **10**, 2237 (2019).
13. Zaccone, A. Elasticity of Arrested Short-Ranged Attractive Colloids: Homogeneous and Heterogeneous Glasses. *Phys. Rev. Lett.* **103**, (2009).
14. Gado, E. D. *et al.* Colloidal Gelation. in *Fluids, Colloids and Soft Materials* 279–291 (John Wiley & Sons, Ltd, 2016). doi:10.1002/9781119220510.ch14.
15. Zaccone, A., Gentili, D., Wu, H., Morbidelli, M. & Del Gado, E. Shear-Driven Solidification of Dilute Colloidal Suspensions. *Phys. Rev. Lett.* **106**, 138301 (2011).
16. Papadopoulos, L., Porter, M. A., Daniels, K. E. & Bassett, D. S. Network analysis of particles and grains. *Journal of Complex Networks* **6**, 485–565 (2018).
17. Bossis, G. & Brady, J. F. The rheology of Brownian suspensions. *The Journal of Chemical Physics* **91**, 1866–1874 (1989).
18. Morris, J. F. Shear Thickening of Concentrated Suspensions: Recent Developments and Relation to Other Phenomena. *Annu. Rev. Fluid Mech.* **52**, 121–144 (2020).
19. Clavaud, C. & Singh, A. Quick starch guide: a perspective on shear thickening in dense non-Brownian suspensions. *Rheol Acta* **64**, 563–582 (2025).
20. James, N. M., Han, E., de la Cruz, R. A. L., Jureller, J. & Jaeger, H. M. Interparticle hydrogen bonding can elicit shear jamming in dense suspensions. *Nature Mater* **17**, 965–970 (2018).
21. Barrat, J.-L. *et al.* Soft matter roadmap*. *J. Phys. Mater.* **7**, 012501 (2023).
22. Singh, A., Ness, C., Seto, R., de Pablo, J. J. & Jaeger, H. M. Shear Thickening and Jamming of Dense Suspensions: The "Roll" of Friction. *Phys. Rev. Lett.* **124**, 248005 (2020).
23. Guy, B. M., Richards, J. A., Hodgson, D. J. M., Blanco, E. & Poon, W. C. K. Constraint-Based Approach to Granular Dispersion Rheology. *Phys. Rev. Lett.* **121**, 128001 (2018).
24. Richards, J. A. *et al.* The role of friction in the yielding of adhesive non-Brownian suspensions. *Journal of Rheology* **64**, 405–412 (2020).
25. Bender, J. & Wagner, N. J. Reversible shear thickening in monodisperse and bidisperse colloidal dispersions. *Journal of Rheology* **40**, 899–916 (1996).
26. D'Haene, P., Mewis, J. & Fuller, G. G. Scattering Dichroism Measurements of Flow-Induced Structure of a Shear Thickening Suspension. *Journal of Colloid and Interface Science* **156**, 350–358 (1993).
27. Mari, R., Seto, R., Morris, J. F. & Denn, M. M. Shear thickening, frictionless and frictional rheologies in non-Brownian suspensions. *Journal of Rheology* **58**, 1693–1724 (2014).
28. Seto, R., Mari, R., Morris, J. F. & Denn, M. M. Discontinuous Shear Thickening of Frictional Hard-Sphere Suspensions. *Phys. Rev. Lett.* **111**, 218301 (2013).
29. Cates, M. E., Wittmer, J. P., Bouchaud, J.-P. & Claudin, P. Jamming, Force Chains, and Fragile Matter. *Phys. Rev. Lett.* **81**, 1841–1844 (1998).
30. Majmudar, T. S., Sperl, M., Luding, S. & Behringer, R. P. Jamming Transition in Granular Systems. *Phys. Rev. Lett.* **98**, 058001 (2007).
31. Bi, D., Zhang, J., Chakraborty, B. & Behringer, R. P. Jamming by shear. *Nature* **480**, 355–358 (2011).
32. Albert, R. & Barabási, A.-L. Statistical mechanics of complex networks. *Rev. Mod. Phys.* **74**, 47–97 (2002).
33. Strogatz, S. H. Exploring complex networks. *Nature* **410**, 268–276 (2001).
34. Pradeep, S., Nabizadeh, M., Jacob, A. R., Jamali, S. & Hsiao, L. C. Jamming Distance Dictates Colloidal Shear Thickening. *Phys. Rev. Lett.* **127**, 158002 (2021).
35. Modularity and community structure in networks | PNAS. https://www.pnas.org/doi/full/10.1073/pnas.0601602103.
36. Newman, M. E. J. Modularity and community structure in networks. *Proceedings of the National Academy of Sciences* **103**, 8577–8582 (2006).
37. Aktas, M. E., Akbas, E. & Fatmaoui, A. E. Persistence homology of networks: methods and applications. *Appl Netw Sci* **4**, 61 (2019).
38. Kramar, M., Goullet, A., Kondic, L. & Mischaikow, K. Persistence of force networks in compressed granular media. *Phys. Rev. E* **87**, 042207 (2013).
39. Maxwell, J. C. L. On the calculation of the equilibrium and stiffness of frames. *The London, Edinburgh, and Dublin Philosophical Magazine and Journal of Science* **27**, 294–299 (1864).
40. Jaeger, H., Nagel, S. & Vitelli, V. Maxwell's Relevance to Modern Research in Materials. in *The Geometry of Equilibrium: James Clerk Maxwell and 21st-Century Structural Mechanics* (eds McRobie, A. & Baker, W. F.) 45–54 (Cambridge University Press, Cambridge, 2025). doi:10.1017/9781009397643.006.

41. Jacobs, D. J. & Hendrickson, B. An Algorithm for Two-Dimensional Rigidity Percolation: The Pebble Game. *Journal of Computational Physics* **137**, 346–365 (1997).
42. Henkes, S., Quint, D. A., Fily, Y. & Schwarz, J. M. Rigid Cluster Decomposition Reveals Criticality in Frictional Jamming. *Phys. Rev. Lett.* **116**, 028301 (2016).
43. Wyart, M., Nagel, S. R. & Witten, T. A. Geometric origin of excess low-frequency vibrational modes in weakly connected amorphous solids. *EPL* **72**, 486 (2005).
44. Nabizadeh, M. *et al.* Network physics of attractive colloidal gels: Resilience, rigidity, and phase diagram. *Proceedings of the National Academy of Sciences* **121**, e2316394121 (2024).
45. Kolb, M., Botet, R. & Jullien, R. Scaling of Kinetically Growing Clusters. *Phys. Rev. Lett.* **51**, 1123–1126 (1983).
46. Zhang, S. *et al.* Correlated Rigidity Percolation and Colloidal Gels. *Phys. Rev. Lett.* **123**, 058001 (2019).
47. Sedes, O., Makse, H. A., Chakraborty, B. & Morris, J. F. K-core analysis of shear-thickening suspensions. *Phys. Rev. Fluids* **7**, 024304 (2022).
48. van der Naald, M. *et al.* Minimally rigid clusters in dense suspension flow. *Nat. Phys.* 1–7 (2024) doi:10.1038/s41567-023-02354-3.
49. Gameiro, M., Singh, A., Kondic, L., Mischaikow, K. & Morris, J. F. Interaction network analysis in shear thickening suspensions. *Phys. Rev. Fluids* **5**, 034307 (2020).
50. D'Amico, A., Tu, S. & Singh, A. Topological insights into dense frictional suspension rheology: Third order loops drive discontinuous shear thickening. Preprint at https://doi.org/10.48550/arXiv.2501.02062 (2025).
51. Edens, L. E. *et al.* Shear stress dependence of force networks in 3D dense suspensions. *Soft Matter* **17**, 7476–7486 (2021).
52. Sharma, S., Sharma, A. & Singh, A. Frictional contact network in dense suspension flow. *Newton* **0**, (2026).
53. Nabizadeh, M., Singh, A. & Jamali, S. Structure and Dynamics of Force Clusters and Networks in Shear Thickening Suspensions. *Phys. Rev. Lett.* **129**, 068001 (2022).
54. Goyal, A., Martys, N. S. & Del Gado, E. Flow induced rigidity percolation in shear thickening suspensions. *J. Rheol.* **68**, 219–228 (2024).
55. Ball, R. C. & Blumenfeld, R. Stress Field in Granular Systems: Loop Forces and Potential Formulation. *Phys. Rev. Lett.* **88**, 115505 (2002).
56. Laman, G. On graphs and rigidity of plane skeletal structures. *Journal of Engineering Mathematics* **4**, 331–340 (1970).
57. Santra, A., Orsi, M., Chakraborty, B. & Morris, J. F. Rigid clusters in shear-thickening suspensions: A nonequilibrium critical transition. *Phys. Rev. Res.* **7**, 013275 (2025).
58. Boromand, A., Jamali, S., Grove, B. & Maia, J. M. A generalized frictional and hydrodynamic model of the dynamics and structure of dense colloidal suspensions. *J. Rheol.* **62**, 905–918 (2018).

In Memoriam: Jan Mewis (1938–2025)

Paula Moldenaers



Jan Mewis was born on April 22, 1938 in Borgerhout, near Antwerp. He studied Chemical Engineering at the Katholieke Universiteit Leuven in Belgium, where he received his master degree in 1961. While he worked at the IVP Laboratory, the research institute of the Belgian paint and printing ink industry, he obtained his PhD at the KU Leuven in 1967 with a thesis on "Tack of Printing Inks". In 1969 he returned to KU Leuven as a fulltime faculty member, where over the years he taught a wide range of courses, ranging from Rheology, Plastics Technology and Transport Phenomena to Safety of Chemical Plants and Hazardous Materials. He was chairman of the Chemical Engineering Department from 1989 to 1995 and again from 1999 until 2002 and coordinator of the Safety Engineering Programme from 1982 to 1987. In 1971-72 he spent a year at the University at Delaware with a NATO fellowship, working with professor A.B. Metzner. He was twice a visiting professor at the same university (1981 and 2004) and at Princeton University in 1982. He spent shorter visits at various universities in the US and Australia.

The research activities of Jan Mewis can be situated in the general area of rheology and processing of complex fluids. He authored or co-authored over 200 publications and gave hundreds of lectures and seminars all over the world on this topic. He is best known for his, often cited, work in three specific areas. In the area of suspension rheology he published with A.B Metzner the now classical paper on extensional flow of fibre suspensions as well as a series of papers establishing the rheology of sterically stabilized suspensions. Later he contributed substantially to the present understanding of the rheology of liquid crystalline polymers and that of immiscible polymer blends. In all these cases his approach was to link the rheology to the underlying flow-induced changes in microstructure. He successfully applied a wide range of rheological procedures for probing the microstructure during flow. This was supplemented very early by adding other techniques for in-situ, time-resolved structural analyses during flow. These included various scattering techniques, especially rheo-optics, as well as dielectric techniques. His trademark has been to develop and use an experimental methodology that produces theoretically meaningful results, thus bridging the gap between fundamental aspects of rheology and industrial applications. Jan Mewis is also known for his contributions to the controversial topic of thixotropy.

Over the years, Jan Mewis and his team were able to expand the Laboratory of Applied Rheology in Leuven, now known as the SMaRT laboratory (Soft Matter, Rheology and Technology) to one of the best equipped rheo-physical laboratories worldwide. Jan supervised numerous PhD theses and postdocs, and many of his former students have risen to prominent positions in academia and industry, making him the scientific father and grandfather of many rheologists worldwide.

For his various contributions to the field of rheology, both in breadth and in depth, Jan Mewis received the Gold Medal of the British Society of Rheology in March 2005 and the Society of Rheology's Bingham Medal in October 2005.

Jan Mewis was quite active in the rheological community. He was a co-founder and former president of the Belgian Group of Rheology, was chairman of the International Committee on Rheology (1992-96) after he co-chaired with Marcel Crochet (UCLouvain) the 11th International Congress on Rheology in Brussels in 1992 and until 2025 he was a member of the Executive Committee of the European Society of Rheology. Since October 2003 he was professor-emeritus but still active in research and consulting, always available to students to share his knowledge. His scientific activity can also be exemplified by the book on Colloidal Suspension Rheology (Cambridge University Press, 2011) he has published together with Prof. Wagner (University of Delaware).

Jan Mewis was very willing to collaborate with others but he only accepted to be a co-author of a paper if he felt he contributed significantly to the work. Several times he took off his name of joint papers because he felt that this condition was not fully satisfied. These norms and moral integrity (some would call it "old school") is something that deserves respect.

On a personal note, Jan and his wife Ria (who passed away in 2023) were well known and liked within the academic world at Leuven and also to the rheology community as a whole. They travelled a lot together and were universally known as kind, warm and charming people. Although it is fair to say that Jan has dedicated much of his life to rheology, he was also much interested in culture and history, always eager to discover new places. Jan Mewis will be sorely missed by all who knew him for his wisdom, knowledge, tranquillity and friendship.



Jan Mewis together with the professors of the SMaRT laboratory taken at the occasion of the 20th International School on Rheology in Leuven, September 2025.

In Memoriam: Miroslav Grmela (1939-2026)

Canadian Society of Rheology



Miroslav Grmela, a trailblazing Canadian physicist, passed away on June 16, 2026 in Montreal at the age of 87.

Grmela was a faculty member in the Department of Chemical Engineering at Polytechnique Montréal, where he made substantial contributions to the fields of thermodynamics, rheology and geometry. He amassed over 280 academic publications, including articles as recently as March 2026. In 2018, Grmela published a book about his theories and received the S.G. Mason Award from The Canadian Society of Rheology.

Grmela's greatest professional achievement was his discovery of how geometry simplifies Non-Equilibrium Thermodynamics. He was a founding researcher to discover the General Equation for Non-Equilibrium Reversible-Irreversible Coupling, a framework and formula for material evolution more commonly known as GENERIC. GENERIC is now a near-universal framework for understanding how physical systems evolve.

"Miroslav was one of the greatest figures in the field of non-equilibrium thermodynamics", said Michal Pavelka, a physicist at Charles University who was Grmela's former student and then his frequent co-author.

"Miroslav brought the concepts of geometry and a 'multiscale deductive paradigm' to [non-equilibrium thermodynamics]," Pavelka said. *Before him, the mainstream approach was inductive -- scientists took known equations for the conservation of mass, momentum, and energy, and tried to stretch them to include microscopic details. Miroslav shifted the field toward a deductive approach."*

Grmela's research was his passion and his raison d'etre, even in his old age. He was in the process of writing several articles when he abruptly died of a brain hemorrhage.

Grmela was born on May 30, 1939 and grew up in Prostějov, in the former Czechoslovakia during World War II. He earned his PhD in Prague at the Czech Academy of Sciences. Afterwards, he met his wife while completing mandatory military service. Miroslav's two children were born in Czechoslovakia before the family immigrated to Canada in 1969 and eventually settled in Montreal.

Grmela was a scientist, a mountaineer, a world-traveler, a chef, and a family man. He saw beauty and philosophy in abstract mathematics in a similar way to his appreciation for music, literature and art.

Grmela is survived by the love of his life — his wife — Viera Grmela, along with his two loving daughters and his four grandsons.

On behalf of the Canadian Society of Rheology, we extend our deepest condolences to his family, friends, colleagues, and former students.



Professor Grmela and his wife, Viera Grmela.

Secretary's Report - 2026

Kalman Migler



The Secretary's report consists of highlights from the Spring 2026 Executive Committee meeting. The minutes are available upon request from secretary@rheology.org

AIP: (Frank Graeff) Frank provided an overview of the AIP, which consists of 35 full and affiliate member organizations. Described their web platform and *AIP Exchange*, which now hosts the SOR website. Described AIP research on how early career scientists engage with scientific societies and their paths to becoming future leaders.

Publishing: (Alex Giglia, Peter Olmsted, Charles Schroeder) Publishing landscape is fast evolving due to new business models that need to be compliant with funding agencies. Described the new AIP Fusion model: all-inclusive services agreement with institutions, unlimited access, unlimited open access publishing.

JoR Editor's Report: (Dimitris Vlassopoulos) Described transition to *citation identifier* – it allows for papers to be available online sooner. Discussed special issues: gravity, Metzner special issue (2/27), Centennial volume ('29), two editors onboard. Providing sponsorships at other meetings. Discussed AI as a growing concern (data fabrication and review process). Announced Publication Award 2026: Rheology of Suspensions of cubic particles. Publication award announced (already disseminated to membership).

SOR Bulletin: (Carlos R. López-Barrón) Now putting Bulletin articles online as they become ready. They will live on website, included in Newsletter, and be available in the Bulletin itself.

Social Media: (Christine Roberts, Elise Chen) LinkedIn and X have 2000+ followers, with a recent increase in Instagram followers. Elise Chen suggests a *Viral Rheologists Contest.*

Website: (Rae Robertson-Anderson) New website is based around SoR ethos. More then 10k views per month. Working to integrate newsletter with website and encouraging more members to join the Community. Working to keep content fresh.

Treasurer's Report: (Lisa Biswal) Please see Treasurer's report in this Bulletin.

Financial Advisement Committee: (Anne Grillet) Reviewed accounts and investments and returns. We are moving to bring society finances in full compliance with the 2019 membership policy. Exploring an investment advisor.

Future Meetings:

- **2026 Boston:** (Safa Jamali, Gareth McKinley, Stephen Stull (APS), Arezoo Ardekani, Travis Walker) This meeting will be hosted with support from the APS meetings team. Proposing a 20% increase in registration fee, notwithstanding, the meeting projects a $58k loss, in line with SOR decisions. Technical Program on-track. Howard Stone and Roseanna Zia are plenary speakers, in addition to award speakers.
- **2027 International ICR:** (Gerry Fuller) Professor Huang Qian will play a leading role. Extremely well organized thus far. Special events: 50 years of Doi Edwards, 50 years of Boger fluids. Bingham and Metzner awards and Fellows announcements will be accommodated.
- **2028 Madison:** (Mike Graham w/ S. Stull presenting) Planning proceeding apace.
- **2029 Washington Centennial:** (Peter Olmsted, Kalman Migler) Contract signed for Hilton in Baltimore.
- **2031 ICR** will be in Americas. We will be soliciting bids.

Bingham Medal: (Randy Ewoldt) To be awarded to Roger Bonnecaze. Discussions centered on appropriateness of a VP to win an award (Constitution does not prohibit), discussions on how to improve submission of documents.

Metzner Award: (Sujit Datta w/ J. Morris presenting) To be awarded to Jeffrey Richards. Discussion centered on diversity of applicant pool, including putting in a mechanism for an applicant to maintain eligibility if they have had a career break.

Fellowship Committee: (Maryam Sepehr) Fellowships awarded to: Patrick Anderson, Marco Caggioni, Matthew Lieratore, Eugene Pashkovski, Robert Poole, Rekha Rao, S.Q. Wang. Discussion on evaluating industrial contributions. There was a large applicant pool.

Community Development Committee: (Katie Weigandt) Responsibilities include: Rheology Research Symposium (RRS), Student Industry Forum, New program: Early Career/New to Rheology Mentoring Program. RRS will include: career planning, mentoring, building your brand, k-12 outreach, CV workshop.

Membership Committee: (Travis Walker) Membership is: 74% academia, 17% industry, 4% Govt., 5% other. We are in 41 countries. Our ability to transition

from student to regular is limited. Can be difficult to transition students to regular members if their future careers do not require rheology.

Education & Outreach Committee: (Abhi Singh, Thomas O'Connor) Planning two-day short-course on tribo-rheology. Planning outreach event at Boston Museum of Science for 2026 annual meeting.

Centennial Committee: (Safa Jamali, Jonathan Rothstein) Planning events for Madison 2028 meeting in preparation for centennial. Putting histories on website, perspective articles in JoR, there is an umbrella committee.

Rheology Venture Fund: (Roger Bonnecaze) 2026 Awards to: Living Rheology Compendium, Tribo-rheology short course, RheoCosmetics: Flow and Performance.

Awards Banquet: Decision to offer discounted rate ($80) to students for Awards Banquet at students.

Treasurer's Report - 2026

S. Lisa Biswal



From a fiscal standpoint, 2025 was a strong year for The Society of Rheology (SOR). The Society closed the year with net income of $221,418, including unrealized investment gains. Excluding unrealized investment gains, SOR's net operating income was still a healthy $165,082. This positive result was achieved even with one-time expenses associated with the development and launch of the new SOR website and updated branding.

This report provides an overview of the Society's financial activities and how they are managed across various accounts, including those held at the American Institute of Physics (AIP), AIP Publishing (AIPP), Charles Schwab, and QuickBooks Online. Each section of this report is organized around the major activities that support the Society's mission.

Assets of The Society of Rheology

The AIP account holds funds derived primarily from membership dues and revenue from the *Journal of Rheology* (JOR). The Society's publishing partnership with AIP Publishing includes a guaranteed annual payment of $120,000, as well as a share of additional revenue from JOR publishing and advertising. These funds are sufficient to support the Society's annual operations.

The Schwab reserve account is intended for emergency expenditures and is invested primarily in low-risk, fixed-income assets such as certificates of deposit (CDs). In 2025, this account achieved a cumulative return of ~4%, which is reported as interest income on the balance sheet.

In 2018, SOR established a separate Schwab investment account for long-term equity investments to further support the Society's mission. An initial investment of $225,000 in a Schwab index fund has grown to $402,397 by the end of 2025. The remainder of the investment account is held in CDs with yields ranging from approximately 3% to 5%, contributing to a total 2025 return of 8%.

Prepaid expenses are categorized as assets and reflect funds already committed to future activities, including the annual meeting.

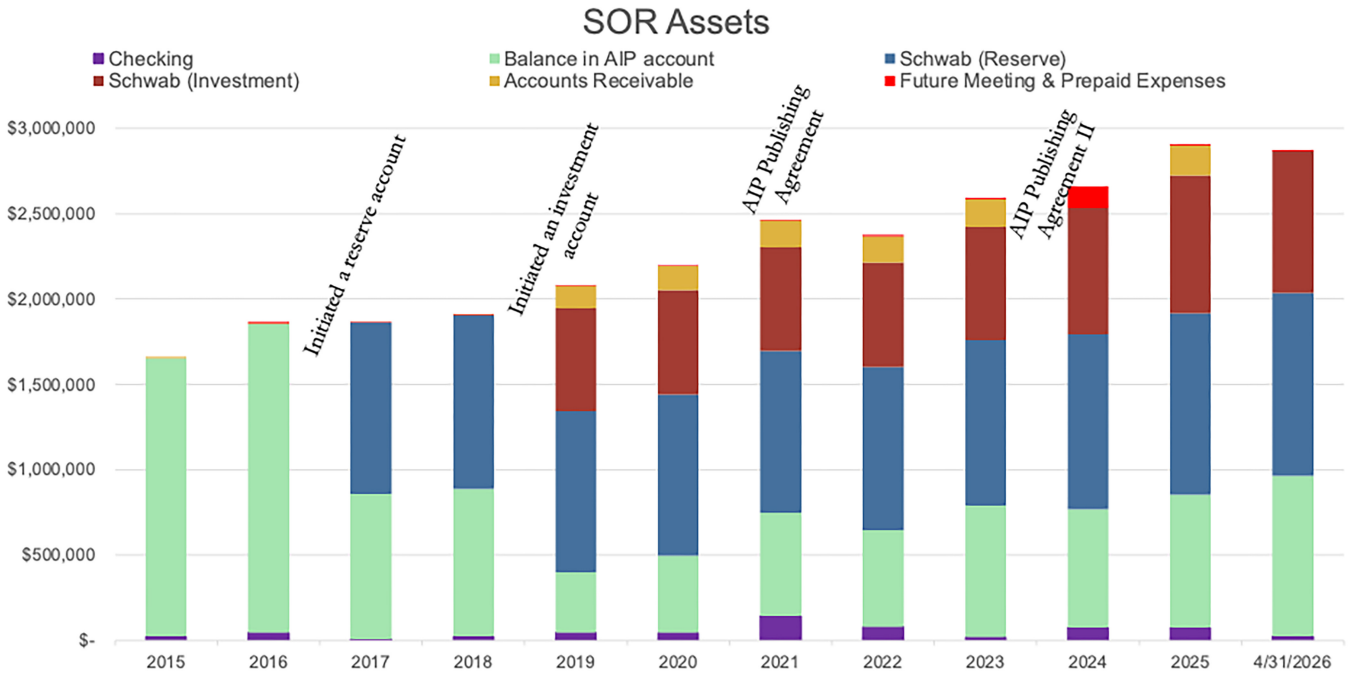


FIGURE 1. The Society of Rheology Assets from 2015-2026.

TABLE 1. Balance Sheet for SOR from 2021-2025.

The Society of Rheology, Inc. Balance Sheet	2025	2024	2023	2022	2021	2020
Assets						
Cash in checking account(s)	$ 75,789	$ 77,733	$ 21,963	$ 82,996	$ 142,871	$ 47,741
Balance in AIP account	$ 779,504	$ 692,926	$ 767,319	$ 562,945	$ 606,335	$ 449,440
Schwab (Reserve)	$ 1,059,693	$ 1,021,603	$ 971,353	$ 954,362	$ 945,408	$ 945,006
Schwab (Investment)	$ 808,462	$ 738,410	$ 661,111	$ 613,965	$ 608,881	$ 608,663
Accounts Receivable	$ 172,341		$ 160,341	$ 151,638	$ 155,730	$ 141,564
Future Meeting & Prepaid Expenses	$ 10,000	$ 128,560	$ 11,765	$ 11,000	$ 1,036	$ 36
Total Assets	**$ 2,905,788**	**$ 2,659,231**	**$ 2,593,852**	**$ 2,376,906**	**$ 2,460,262**	**$ 2,192,451**
Liabilities and Net Assets						
Liabilities						
Deferred revenue	$ 166,950	$ 141,811	$ 146,993	$ 29,374	$ 94,514	$ 40,745
Venture Capital Fund	$ 26,455	$ 26,455	$ 26,455	$ 26,455	$ 27,000	$ 27,000
Total Liabilities	**$ 193,406**	**$ 168,266**	**$ 173,448**	**$ 55,829**	**$ 121,514**	**$ 67,745**
Net Assets						
Publication reserve	$ 450,000	$ 450,000	$ 450,000	$ 450,000	$ 450,000	$ 450,000
Student travel grant reserve	$ 30,000	$ 30,000	$ 30,000	$ 30,000	$ 30,000	$ 30,000
Annual Meeting reserve	$ 300,000	$ 300,000	$ 300,000	$ 300,000	$ 300,000	$ 300,000
Operating reserve	$ 150,000	$ 150,000	$ 150,000	$ 150,000	$ 150,000	$ 150,000
Unrestricted	$ 1,560,965	$ 1,490,403	$ 1,287,547	$ 1,408,748	$ 1,194,706	$ 1,048,400
Net Revenue	$ 221,418	$ 70,561	$ 202,857	$ (17,671)	$ 214,042	$ 146,305
Total Net Assets	**$ 2,712,383**	**$ 2,490,965**	**$ 2,420,404**	**$ 2,321,077**	**$ 2,338,748**	**$ 2,124,706**
Total liabilities and net assets	**$ 2,905,788**	**$ 2,659,231**	**$ 2,593,852**	**$2,376,906**	**$ 2,460,262**	**$ 2,192,451**

A balance sheet summarizing the total liabilities and net assets is shown in Table 1.

Summary of Revenue versus Expenses

For fiscal year 2025, SOR closed with net revenue of $221,418. This total includes $56,336 in unrealized gains from changes in the value of the Schwab investment accounts. Excluding these unrealized gains, SOR's net income was $165,082, a strong result relative to the approved 2025 budget, which projected a net deficit of $68,000.

This positive outcome reflects strong revenue from the JOR, continued investment income from the Schwab accounts, and careful management of expenses, even with significant one-time costs associated with the new SOR website and branding.

Revenues of The Society of Rheology

Realized revenue sources for SOR are summarized in Figure 2. The majority of SOR's income continues to be derived from publication of JOR, which benefited from strong advertising revenue over the past year. Due to favorable interest rates, interest income also remained significantly higher than in previous years. Membership dues continue to provide a revenue stream, although dues revenue has declined significantly relative to prior years.

TABLE 2. Summary of SOR 2025 Net Revenue and Expenses.

The Society of Rheology			
Jan - Dec 2025			
Revenues		**Expenses**	
Dues	$ 33,036	AIP Fees	$ 27,119
Interest Income	$ 78,816	Awards	$ 9,851
Journal of Rheology	$ 292,341	Journal of Rheology	$ 54,405
Venture Fund (AIP)	$ 21,000	RRS	$ 47,291
		SOR Venture Fund	$ 19,573
		Annual Meeting	$ (2,248)
		Bulletin	$ 17,862
		ExCom Meetings	$ 5,993
		Website	$ 56,966
		Outreach Activities	$ 4,000
Unrealized Investment Value	$ 56,336	Operations	$ 19,300
Total Revenue	**$ 481,530**	**Total Expenses**	**$ 260,112**
Net 2025 Revenue	**$ 221,418**		

AIP provided a Venture Fund support for educational activities related to rheology. These are flow-through funds that are supplemented by SOR funds to support mission-driven programs and activities.

Annual meeting activity was historically reported within the revenue section. Beginning with this report, the annual meeting income and expenses are presented together in the expenses section to more clearly reflect the net financial impact of the meeting, which has resulted in a net cost to SOR in recent years.

Journal of Rheology

The Society's publishing partnership with AIP Publishing (AIPP) has contributed to increased revenues through broader consortium marketing and reduced production costs, thereby improving net income from JOR. Under the terms of the revised agreement signed in 2024, SOR receives a guaranteed minimum revenue of $120,000 annually, with any additional net income, after expenses, shared equally between SOR and AIPP.

As shown in Figure 3, JOR revenue remains steady and typically supports SOR's routine operations. The bar chart

illustrates SOR's net operating margin, defined as revenues minus expenses and excluding unrealized investment gains. This comparison highlights the critical financial role that JOR continues to play in supporting the Society's activities and mission. In 2025, SOR's share of JOR net revenue exceeded the guaranteed minimum, providing an important source of operating support for the Society.

Expenses of The Society of Rheology

Total 2025 disbursements were $178,558, excluding AIP membership fees and JOR publishing expenses, as summarized in Figure 4. Several major mission-driven activities came in below budget, including the Annual Meeting and the Rheology Venture Fund, which had a later-than-anticipated start. Even with the additional one-time costs associated with the new website migration and rebranding, 2025 expenses were below the approved budget of $313,500.

Major expenditures in 2025 included support for mission-driven initiatives such as the Rheology Research Symposium (RRS) and Outreach Activities. The Outreach Activities category includes JOR conference sponsorships and international activities. SOR's *Rheology Bulletin* expenses increased slightly due to higher postage costs. Operating expenses, including professional services such as accounting, legal support, and insurance, were comparable to the previous year.

The 2025 Annual Meeting in Santa Fe essentially broke even, with a modest net surplus of $2,248. The Society gratefully acknowledges generous sponsorship support from Anton Paar, TA Instruments, Dow Chemical, Sandia National Laboratory, and AIP. It is useful to compare the costs and revenues of the 2025 Annual Meeting with those of the previous year in Austin, as shown in Table 3. Registration revenue was comparable between the two meetings, although short-course revenue was lower in 2025. In addition, costs for the venue, catering, and audiovisual services were lower than in the prior year. The Annual Meeting continues to support the Society's mission through student and postdoctoral recognition and community-outreach activities.

As part of SOR's commitment to supporting the rheology community, meeting outreach activities included Student Pottery Night, Children's Museum

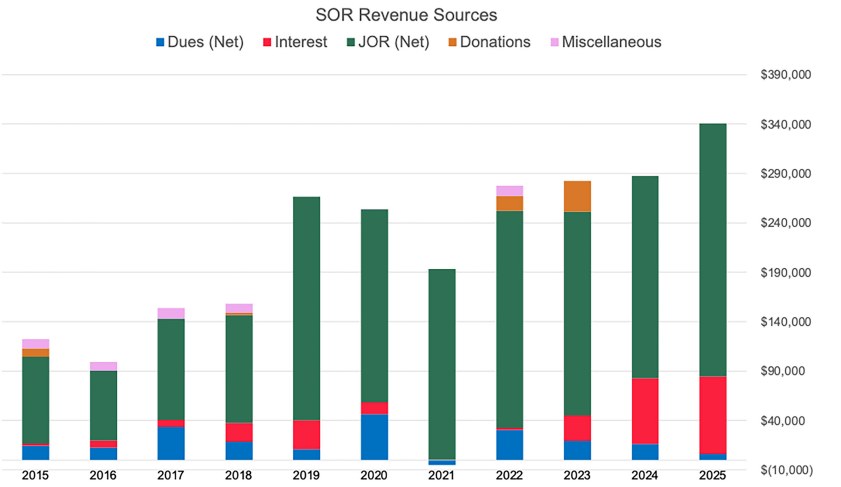


FIGURE 2. Revenue sources for SOR from 2015-2025.

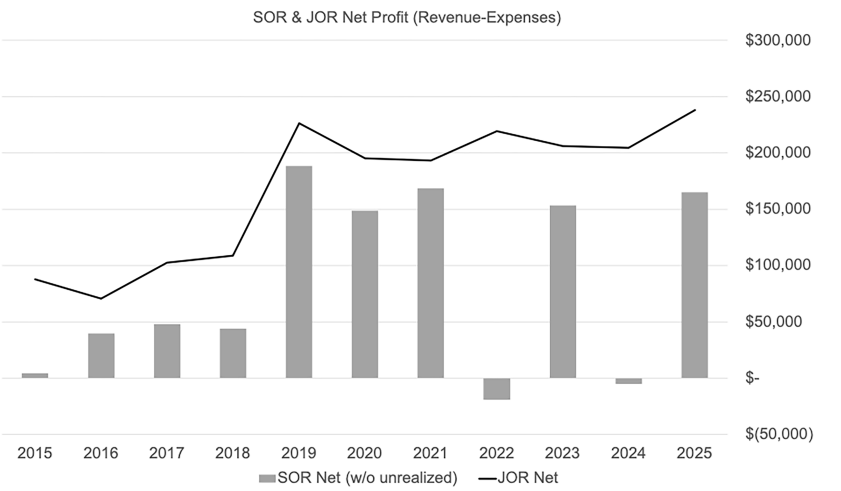


FIGURE 3. Bar chart shows SOR's net operating revenue (excluding unrealized investment gains); line plot shows annual JOR profit.

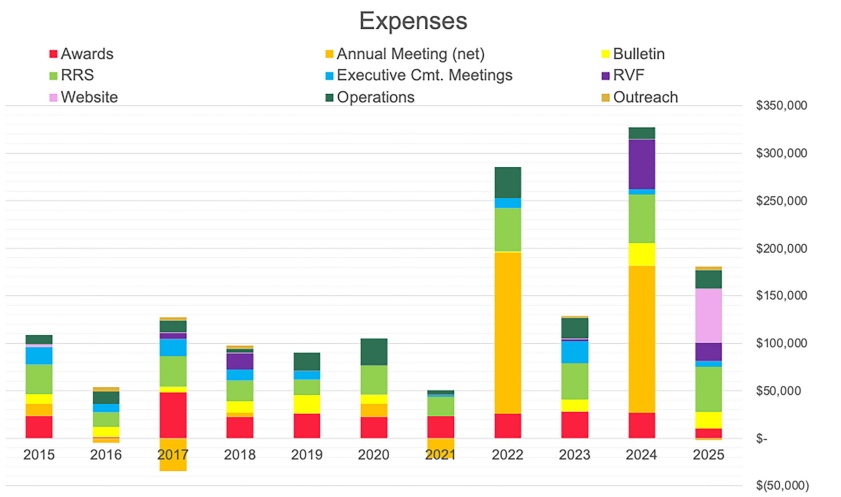


FIGURE 4. Expenses for The Society of Rheology from 2015-2025.

TABLE 3. Summary of 2025 Annual Meeting Operations.

	2025- Santa Fe	2024 - Austin
Annual Meeting (income)		
Registrations	$ 224,430	$ 212,745
Short Courses	$ 6,426	$ 43,410
Sponsorship	$ 64,500	$ 43,600
Net Income	$ 295,356	$ 299,755
Annual Meeting (Expenses)		
Rental Venue, Food, AV	$ 244,604	$ 414,063
Event Operations	$ 29,944	$ 16,576
Honorariums & Awards	$ 6,000	$ 10,103
Meeting Outreach Activities	$ 6,243	$ 6,280
Credit Card Processing Fees	$ 6,318	$ 7,524
Net Expenses	$ 293,108	$ 454,545
Net Total	**$ 2,248**	**$ (154,790)**

Outreach, and awards for outstanding student and postdoctoral oral and poster presentations. The Society also covered travel expenses for plenary speakers.

Budget for 2026

At the October 2025 business meeting, the membership voted to adopt the proposed 2026 budget, shown in Table 4. The 2026 budget includes continued support for the Boston Annual Meeting ($100,000), which is expected to have costs similar to those of the 2024 Annual Meeting in Austin. The Conference Discretionary Fund for the JOR Editor was also increased to $4,000 to support sponsorships of other rheology-related conferences.

As in the previous year, the 2026 budget projects a net deficit; however, expected gains from investment returns are anticipated to offset this shortfall, maintaining the Society's overall financial strength.

TABLE 4. Detailed list of receipts and expenses from 2021-2025 and approved 2026 Budget voted on at the Oct 2025 business meeting by the membership.

The Society of Rheology Receipts and Disbursements	Budget 2026	2025	2024	2023	2022	2021
RECEIPTS						
Dues	$ 50,000	$ 33,036	$ 47,143	$ 54,545	$ 66,590	$ 30,309
Interest	$ 50,000	$ 78,816	$ 66,379	$ 25,729	$ 2,250	$ 100
Venture fund (AIP)	$ 27,500	$ 21,000	$ 35,000	$ -	$ -	
Journal of Rheology	$ 260,000	$ 292,341	$ 252,435	$ 259,448	$ 261,986	$ 239,936
Donations				$ 31,000	$ 15,000	
Miscellaneous			$ 1	$ -	$ 10,423	
TOTAL RECEIPTS	**$ 387,500**	**$ 425,194**	**$ 400,958**	**$ 370,721**	**$ 356,250**	**$ 270,345**
DISBURSEMENTS						
Annual Meeting (net)	$ 100,000	$ (2,248)	$ 154,790	$ -	$ 169,078	$ (21,315)
Publications						
AIP Dues Bill & Collect.	$ 36,000	$ 27,119	$ 30,872	$ 34,997	$ 35,969	$ 35,417
Journal of Rheology	$ 55,000	$ 54,405	$ 47,783	$ 53,426	$ 42,492	$ 46,563
Bulletin	$ 14,000	$ 13,862	$ 11,610	$ 12,770	$ 1,371	$ -
Bulletin Editor Stipend	$ 4,000	$ 4,000	$ 12,000	$ -	$ -	$ -
Rheology Outreach						
Contributions and Prizes	$ 28,000	$ 9,851	$ 26,877	$ 28,065	$ 25,987	$ 23,062
Student travel/RRS	$ 60,000	$ 47,291	$ 51,225	$ 38,127	$ 45,567	$ 20,532
Rheology Venture Fund	$ 57,500	$ 19,573	$ 51,963	$ 2,021	$ -	$ 339
International Activities Fund	$ 3,000	$ 2,000	$ -	$ 1,939	$ -	$ -
History Project	$ 15,000	$ -	$ -	$ -	$ 1,092	$ -
JoR Editor Conference Fund	$ 4,000	$ 2,000	$ -	$ -	$ -	$ -
Operations						
Executive Cmt. Meetings	$ 10,000	$ 5,993	$ 5,622	$ 23,211	$ 10,971	$ 1,604
Pres. Discretionary Fund	$ 5,000	$ 4,478	$ 2,226	$ 3,339	$ 4,718	$ -
Treas. Discr. Fund	$ 3,000	$ 204	$ 204	$ -	$ 1,637	$ -
Progr. Chm. Discr. Fund	$ 5,000	$ -	$ -	$ -	$ -	$ -
Web-Promotion Discr. Fund	$ 15,000	$ 7,077	$ 4,859	$ 5,188	$ 313	$ 976
Website	$ 7,000	$ 56,966	$ 692	$ 906	$ -	$ 287
Liability Insurance	$ 8,000	$ 1,259	$ 6,336	$ 1,370	$ 11,862	$ 1,889
Accountant	$ 7,000	$ 6,730	$ 5,143	$ 6,428	$ 5,462	$ 1,850
Legal Fees	$ 5,000	$ (450)	$ 677	$ 5,407	$ 8,210	
Annual meetings, future	$ -	$ -	$ -	$ -	$ 10,607	$ (9,274)
Miscellaneous	$ 5,000	$ 1	$ (7,033)	$ -	$ -	$ -
TOTAL DISBURSEMENTS	**$ 446,500**	**$ 260,112**	**$ 405,845**	**$ 217,192**	**$ 375,334**	**$ 101,929**
OTHER RECEIPTS						
Unrealized Change in Value	$ -	$ 56,336	$ 75,449	$ 49,328	$ 1,414	$ 45,627
SOR Net	**$ (59,000)**	**$ 221,418**	**$ 70,561**	**$ 202,857**	**$ (17,671)**	**$ 214,043**

Pebble

I sit here, a pebble
sheer gravity keeps me down
come like a child
kick me around
pick me and see how far
I can bounce on water
for a moment or two
make me fly!





Vivek Sharma writes verses and essays in English and Hindi. He is the author of a book of poems titled Saga of a Crumpled Piece of Paper (Writers Workshop 2010), and has published work in Poetry, The Cortland Review, Muse India, Cha, and Lumina, among others. Rheologists know him as a professor of chemical engineering at the University of Illinois, Chicago, with an interest in everything that flows.

The ARES-G3™ Rheometer

For Those Who **PUSH BOUNDARIES** and **DEMAND QUALITY**

ENGINEERED for **RHEOLOGICAL EXCELLENCE**

POLYMERS



ELASTOMERS



COMPOSITES



INKS, PAINTS, AND COATINGS



See the ARES-G3 live at the Society of Rheology Meeting this October

Waters™

tainstruments.com

©2026 Waters Technologies Corporation. All rights reserved.