BIOGRAPHY

Pier Luca Maffettone, PhD, is Full Professor in Chemical Engineering at University of Naples "Federico II" where he was [2013-18] Chairman of the Department of Chemical-Materials-and-Production Engineering and is [2020-] Member of the University Board. He graduated in 1988 in Chemical Engineering under the supervision of Prof. G. Marrucci, and received the Ph.D. in Chemical Engineering at the University of Naples "Federico II" in 1993 under the supervision of Prof. G. Astarita. Pier Luca Maffettone became Assistant Professor in Chemical Engineering at the University of Naples "Federico II" in 1994. In 1998 he became Associate Professor of Chemical Engineering at Politecnico di Torino, and then became Full Professor of Chemical Engineering at the University of Naples "Federico II" in 2005. He was visiting scientist at the University of Delaware, at Katholieke Universiteit Leuven, at the Stanford University, and at Okinawa Institute of Science and Technology. His main research activity is focused on modeling and simulation of the flow behavior of soft matter. In early stage of career, working in the group of Pino Marrucci he analyzed the rheology of liquid crystalline polymers within the framework of the rigid rod model of Doi and Hess both in bulk [Macromolecules, 1989, J. Rheol., 34, 1217-1230, 1990] and as monolayers in collaboration with the group of Gerry Fuller at Stanford [Macromolecules, 1996]. Later, he showed the occurrence of "Rheo-Chaos" in shear flows [PRL, 2001; PRL, 2003].

He proposed in collaboration with Mario Minale a simple but effective toy model for the deformation of a drop in linear flows with Newtonian [JNNFM, 2000] and/or viscoelastic liquids [JRheol, 2004]. The predictions of this model have been used as a rheological guide in several polymer blends and emulsion applications.

The work on cross-flow migration of particles suspended in viscoelastic liquids, started as a joint effort together with the group of Jan Vermant in Leuven and with Martien Hulsen in Eindhoven [J Rheol, 2008, [J Comp. Phys, 2007; JNNFM 2008]. The cross-streamline migration of a spherical particle in a viscoelastic fluid flowing in a wide slit microdevice was investigated through 3D finite element simulations. It was discovered a multiplicity of stable positions whereby the particle is driven towards the channel centerplane or the closest wall depending on its initial position through the gap, thus leading to the existence of an unstable separatrix. This phenomenon was considered a viscoelastic reversal of the well-known Segré-Silberberg effect, which is, instead, driven by inertia [JNNFM, 2009; 2010; 2011, LOC, 2012; ARFM 2017]. The results had then brought to the development of Rheo-Engineered microfluidics for Lab-on-a-chip applications. The cross-flow particle migration was also used to build a microrheometer to estimate the relaxation time of viscoelastic fluids, down to milliseconds [LOC, 2015; J Rheol, 2017]. He recently addressed in collaboration with Gerry Fuller the phenomena related to film rupture dynamics with viscoelastic interfaces showing the existence of a novel breakage scenario [PNAS 2021]

He is presently member of the Editorial Boards of Rheologica Acta and Journal Non-Newtonian Fluid Mechanics.

He is 2023 recipient of the Weissenberg award bestowed by the European Society of Rheology.

ABSTRACT

Microrheometers for High-Throughput-Experimentation

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Material design, development, and production traditionally rely on single trial-and-error experiments guided by human intuition and prior knowledge, resulting in prolonged timelines and significant waste generation. The adoption of systematic parallel screening through High Throughput Experimentation (HTE) expedites the development of materials with desired properties. In the realm of novel macromolecules, contemporary HTE workflows cover an extensive portion of the polymer knowledge and value chains, spanning from synthesis to final properties like processability and viscosity.

An integral challenge in this context involves the creation of specialized miniaturized rheometers capable of handling milligram-sized samples produced within microreactor grids. Recently, we have introduced purpose-built devices tailored for HTE methodologies. These setups furnish reliable and reproducible data using minute material quantities (a few milligrams or less) across a broad range of shear rates (currently, spanning from 0.1 to 1000 s^−1). The operation is straightforward, and the analysis time is notably short, typically on the order of minutes.

One solution[1] is based o a pressure driven, stress-imposed microdevice that can work to properly work at high temperatures and pressures to characterize highly viscous polymer melts. Such microrheometer can also serve to the characterization of other fluid properties, e.g., die swell, contact angle, and possible melt fracture.

On the other hand, utilizing stereolithographic 3D printing technology has facilitated the facile and precise manufacturing of a multipass microcapillary rheometer[2]. By moving the microrheometer rather than the pistons, we achieved flawless synchronization of fluid movement. The device also boasts the capability to conduct experiments in the oscillatory mode, enabling the measurement of elastic and loss moduli.

[1] D. Tammaro and P. L. Maffettone, A versatile and customizable low-cost printed multipass microrheometer for high-throughput polymers rheological experimentation, Physics of Fluids, 35, 063116 (2023)

[2] D. Tammaro, G. D’Avino, S. Costanzo, E. Di Maio, N. Grizzuti and P. L. Maffettone, A microcapillary rheometer for microliter sized polymer characterization, Polymer Testing, 102, 107332 (2021)