

Professor Mostafa Barigou BEng, PhD, DSc

Chair of Chemical Engineering

[School of Chemical Engineering \(/schools/chemical-engineering/index.aspx\)](/schools/chemical-engineering/index.aspx)

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About

Mostafa Barigou is Professor of Chemical Engineering and Head of Postgraduate Studies (Research) in The School of Chemical Engineering.

He has over 150 publications in scientific journals, books and conference proceedings on experimental and modelling problems in the general field of Fluid Dynamics, Rheology and Transport Processes with a special interest in Complex Fluids.

Complex fluids are extremely diverse in origin and composition. Examples include: colloidal suspensions, emulsions, foams, organized molecular systems, polymer solutions, gels, paints, food products, pharmaceutical formulations, mineral slurries, inks, fermentation broths, blood, biofilms, mucus, cytoplasm.

The aim of the research is to contribute to the enhancement of fundamental scientific knowledge as well as to provide engineering solutions to all industries concerned. The research has been mainly funded by UK Research Councils and industry.

Qualifications

- DSc, Experimental and theoretical studies of complex flows and complex fluids, 2011
- PhD, Chemical Engineering, 1987
- BEng (1st Class Honours), Mechanical Engineering, 1982
- Accreditation as a Teacher in Higher Education: Staff And Educational Development Association (SEDA) scheme for the accreditation of teachers in higher education, 1995
- Certificate in Teaching and Learning in Higher Education (University of Plymouth), 1994
- Fellow of the Institution of Mechanical Engineers (FIMechE), 2002
- Chartered Engineer (CEng), 1999

Biography

Professor Barigou graduated in 1982 with a First Class Honours BEng in Mechanical Engineering, having been awarded the Elijah-Hepworth Memorial Prize for best graduate. He subsequently earned a PhD in Chemical Engineering in 1987. After a postdoctoral period as a Research fellow in Cambridge and a brief spell at Plymouth University as a lecturer in Food Engineering, he joined the School of Chemical Engineering at Birmingham as a lecturer in 1995, where he was subsequently promoted to Senior Lecturer (1999), Reader (2002), and Full Professor (2005).

Professor Barigou's research interests span wide areas of chemical engineering, biochemical engineering, food engineering and life sciences.

Early mixing work developed novel instrumentation for the measurement of local bubble properties and hydrodynamics in gas-liquid dispersions in stirred vessels. More recent work has used advanced diagnostic techniques such as Particle Image Velocimetry (PIV), micro-PIV and Planar Laser Induced Fluorescence (PLIF). It has also exploited, for the first time, the novel Positron Emission Particle Tracking technique (PEPT) to study the agitation and mixing of rheologically complex fluids including single-phase and multiphase fluids, and in particular solid-liquid suspensions, pastes and slurries. Prof. Barigou is a member of the Positron Imaging Centre at the University of Birmingham, and is a co-Investigator on the EPSRC Platform Grant which supports the Centre.

The detailed 3-D pointwise data offered by PEPT are unique as there are no other techniques which can be used to probe opaque systems with such a great detail and accuracy. New Lagrangian trajectography techniques have been developed for the analysis of mixing in these complex systems. The unique data provided by PEPT are also being used to validate Computational Fluid Dynamics (CFD) models and software. CFD has also been exploited in modelling the flow of single-phase and multiphase complex fluids with and without heat transfer, at scales ranging from microfluidics to industrial.

Post-doctoral research with Prof. J. F. Davidson, FRS, FREng, at Cambridge, continued later at Birmingham, has been concerned with the study of foam film hydrodynamics as well as the formation, stability and flow of foams and their control by physical/chemical means. Recent work has looked at Pickering emulsions and 'Pickering foams' stabilized with colloidal particles, which can lead to new materials with unique structures and properties. Studies of the microstructure and rheology of colloidal systems, and more generally complex fluids, have underpinned all these research activities.

Prof. Barigou has supervised many PhD students (>20) and postdoctoral fellows (>10) from 17 different countries.

A list of publications below illustrates Professor Barigou's interests over the years.

Teaching

- Fluid mechanics
- Rheology
- Multiphase systems

- Multiphase flows and interfacial phenomena
- Advanced transport processes

Postgraduate supervision

Prospective research students interested in doing a research degree (PhD, MPhil) with Professor Barigou should contact him by email (m.barigou@bham.ac.uk (<mailto:m.barigou@bham.ac.uk>)) attaching a full CV.

Doctoral research students

Professor Barigou has supervised many doctoral research students:

- Shuai Tian; PhD; Computational modelling of complex flows of complex fluids; ongoing.
- Zainab Talib; PhD; Flow and mixing of complex fluids; ongoing.
- Li Liu; PhD; CFD of the flow and mixing of complex fluids in stirred vessels; ongoing.
- Shih-Chi Chu; PhD (part time); The effects of nano-particles on foams; ongoing.
- Sara Ghorbanian Farah Abadi; PhD; The role of rheology in the flow and mixing of complex fluids; ongoing.
- Saki Onakoya; PhD; Rheology and microstructure of mycoprotein pastes; ongoing.
- Ukachukwu Oguh; EngD; Process intensification and continuous processing for PGM refining hydrometallurgy; 2012.
- Noraziah Muda Omar; PhD; Rheology and microstructure of restructured food products; 2011.
- Antonio Guida; PhD; Using positron emission tomography and particle tracking to study solid liquid mixing in stirred vessels; 2010.
- Tim Watts; PhD; in collaboration with Medical School; Comparative effect of haemodynamic variables and rheological properties of blood on the margination and adhesion of leukocytes and platelets; 2010.
- Stephen Ademola Adegbite; PhD; Coating of catalyst supports: links between slurry characteristics, coating process and final coating quality; 2010.
- Luke Adams; PhD; CFD modelling of non-Newtonian flows in mechanically agitated bioreactors; 2008.
- Ken Chung; PhD; Mixing in high throughput experimentation reactors; 2008.
- Muhammad Eesa; PhD; CFD studies of complex fluid flows in pipes; 2008.
- Iwan Edwards; EngD; The role of global and local mixing parameters in the precipitation of catalyst precursors; 2008.
- Alex Heuer; EngD; Formulation and stability of model food foam microstructures, 2007.
- Ivy Aboagye; PhD; Rheological and microstructural studies of oil-in-water emulsions; 2007.
- Belinda Nantumbwe; PhD; Removal of toxic metals from wastewaters by biosorptive methods; 2007.
- Khai Sin Lim; PhD; Studies of foam microstructure and rheology; 2005.
- Sakirat Onakoya; MPhil; The effects of solid particles and ultrasound on the rheological properties of biopolymers; 2006.
- Jonathan Hall; PhD; Fluid dynamics, mixing and mass transfer in high throughput screening reactors; 2004.
- Nicola Yates; PhD; The squeeze-flow rheometry of foods; 2002.
- Frank Wiggers; PhD; The flow behaviour of foams and films; 2000.
- Yasser Fangary; PhD; Characterisation of mixing processes using positron emission particle tracking; 2000.
- Michaela Morey; PhD; Nestlé - UK; Rheological studies of molten chocolate; 1999.

Research

RESEARCH THEMES

Our research makes use of a range of experimental and modelling tools and techniques to investigate the dynamics, structure and rheology of complex fluids. Our interests include:

- Application of advanced flow diagnostic techniques such as Positron Emission Particle Tracking (PEPT), Positron Emission Tomography (PET), Particle Image Velocimetry (PIV), Planar Laser Induced Fluorescence (PLIF), and micro-PIV to complex flows
- Computational Fluid Dynamics (CFD)
- Multiphase flows (solid-liquid, gas-liquid, liquid-liquid)
- Mixing in mechanically agitated vessels (gas/liquid/solid)
- Microfluidics (e.g. blood flow)
- Formation, flow and stability of foams, emulsions, and thin liquid films
- Rheology and microstructure of colloidal systems: foams, suspensions, emulsions
- Development of foam control techniques (ultrasound, mechanical, chemical)
- Application of ultrasound techniques to enhance product structure and processing
- Rheological and microstructure tailoring (e.g. using biopolymers and gels)
- Food engineering/processing

RESEARCH ACTIVITY

Selected Research Projects

- EPSRC Platform Grant for the University of Birmingham Positron Imaging Centre; with Prof. DJ Parker (Physics), Prof. JPK Seville, Prof. PJ Fryer, Dr S. Bakalis (Chem. Eng.); 2009- 2013.
- The flow and mixing of complex fluids; 2010-2013.
- Flow, margination and adhesive interaction of blood cells with the vessel wall – An interdisciplinary approach; with Prof. G. Nash (Medical School) and Dr C. Thornton (Civil Eng.); EPSRC; 2005-2008.

- The application of Positron Emission Tomography to unsolved mixing problems; EPSRC; 2004-2008.
- CFD modelling of non-Newtonian flows in mechanically agitated vessels; EPSRC; 2004-2008.
- The effects of nano-particles on consumer goods; Procter and Gamble & EPSRC; 2005-2009.
- CFD modelling of multiphase flow in non-Newtonian fluids; 2004-2008.
- Design and optimisation of induction air nozzles by CFD modelling; DTI & Jet Environmental Techniques; 2003-2006.
- Effect of freezing on dough behaviour; in collaboration with Prof. P.J. Fryer; CSM Bakery Europe; 2003-2005.
- A rule-based multidisciplinary engineering approach to the optimal design of flexible food processing systems: demonstration via yoghurt manufacture; in collaboration with Prof. P.J. Fryer; DEFRA-Faraday; 2002-2005.
- Formulation engineering for improved catalysts manufacture; EPSRC & Johnson Matthey Catalysts; 2004-2008.
- Stability of foams – Effects of shear and pressure on the rheological properties and stability of aerated food systems; EPSRC & Unilever Colworth; 2003-2007.
- Rheology and microstructure of restructured food products; 2003-2007.
- The influence of biopolymers on the rheology, microstructure and functionality of multiphase systems; 2003-2006.
- Foam microstructure and rheology; ORS Award & School; 2001-2004.
- The effects of thickeners and gelling agents on the rheology of food suspensions; EPSRC; 2001-2004.
- Fluid dynamics, mixing and mass transfer in high throughput screening reactors; EPSRC & Johnson Matthey Catalysts; 2001-2004.
- The squeeze-flow rheometry of foods; BBSRC & Unilever Colworth; 1999-2002.
- The flow behaviour of foam films; EPSRC; 1997-2000.
- Characterisation of mixing processes using Positron Emission Particle Tracking; DTI-MAFF Link Scheme; 1996-2000.
- The flow of foams in pipes and fittings; EPSRC; 1997-00.
- Vibration effects on chocolate rheology; BBSRC & Nestlé; 1996-1999.

Other activities

Research Councils:

Member of EPSRC Peer Review College

Reviewer for:

- Biotechnology and Biological Sciences Research Council (BBSRC)
- The Royal Society
- European Commission
- Research Council of Norway
- ETH Zurich Research Commission, Switzerland
- The Danish Council for Strategic Research (DSF)
- Qatar National Research Fund (QNRF)
- Natural Sciences and Engineering Research Council of Canada (NSERC)

National / International Committees:

- Member of European Working Party on Mixing - European Federation of Chemical Engineering
- Member of Fluid Mixing Subject Group Committee: Institution of Chemical Engineers (IChemE)
- Member of Food Engineering Group Committee - Society of Chemical Industry (SCI)

Editorships

- International Journal of Food Properties
- International Journal of Chemical Engineering
- Bulletin Of Chemical Reaction Engineering & Catalysis

Publications

Over 150 publications in refereed journals, books, and conference proceedings.

Selected Publications

Barigou, M., Douaire, M., 2012, X-ray tomography and food microstructure, Chapter 11, in Food Microstructures: Microscopy, Measurement and Modelling; eds. V. Morris and K. Groves, Woodhead Publishing Ltd., Cambridge, UK, in preparation.

Barigou, M., Muller, F., 2011, Mixing of pharmaceutical solid-liquid suspensions, in Pharmaceutical Blending and Mixing, Chapter 11, eds. P.J. Cullen and C.D. Rielly, Wiley-Blackwell, Oxford, UK, in press.

Barigou, M., 2009, Solid liquid mixing, in Food mixing: principles and applications, Chapter 10, pp 199-229, ed. P.J. Cullen, Wiley-Blackwell, Oxford, UK, ISBN: 1405177543.

Guida, A., A.W. Nienow, Barigou, M., 2011, Lagrangian tools for the analysis of mixing in single- and multi-phase flow systems, AIChE J, in press, DOI: 10.1002/aic.12557.

Guida, A., Nienow, A.W., Barigou, M., 2011, Mixing of dense binary suspensions: multi-component hydrodynamics and spatial phase distribution by PEPT, AIChE J, 57(9), 2302-2315.

Eesa, M., Barigou, M., 2011, CFD simulation of transverse vibration effects on radial temperature profile and thermal entrance length in laminar flow, AIChE J, 57(1), 51-56.

Guida, A., Barigou, M., 2010, Shannon entropy for local and global description of mixing by Lagrangian particle tracking, Chemical Engineering Science, 65(10), 2865–2883.

Guida, A., Barigou, M., 2010, The effects of the azimuthal position of the measurement plane on the flow parameters determined by PIV within a stirred vessel, *Chemical Engineering Science*, 65(8), 2454–2463.

Eesa, M., Barigou, M., 2010, Enhancing radial temperature uniformity and boundary layer development in viscous Newtonian and non-Newtonian flow by transverse oscillations: A CFD study, *Chemical Engineering Science*, 65(6), 2199-2212.

Guida, A., Nienow, A.W., Barigou, M., 2010, PEPT measurements of solid-liquid flow field and spatial phase distribution in concentrated monodisperse stirred suspensions, *Chemical Engineering Science*, 65(6), 1905-1914.

Barigou, M., Chiti, F., Pianko-Oprych, P., Guida, A., Adams, L., Fan, X., Parker, D.J. & Nienow, A.W., 2009, Using positron emission particle tracking (PEPT) to study mixing in stirred vessels: validation and tackling unsolved problems in opaque systems, *Journal of Chemical Engineering of Japan*, 42(11), 839-846.

Pianko-Oprych, P., Nienow, A.W., Barigou, M., 2009, Positron emission particle tracking (PEPT) compared to particle image velocimetry (PIV) for studying the flow generated by a pitched-blade turbine in single phase and multi-phase systems, *Chemical Engineering Science*, 64(23), 4955–4968.

Chu, D., Chu, S.C., Barigou, M., 2009, Qualitative models of particle de-agglomeration, *Powder Technology*, 195, 171–176.

Chung, K.H.K., Simmons, M.J.H., Barigou, M., 2009, Local gas and liquid phase velocity measurement in a miniature stirred vessel using PIV combined with a new image processing algorithm, *Experimental Thermal and Fluid Science*, 33, 743–753.

Guida, X., Fan, D.J., Parker, A., Nienow, A.W., Barigou, M., 2009, Positron emission particle tracking in a mechanically agitated solid-liquid suspension of coarse particles, *Trans IChemE, Part A, Chem. Eng. Res. Des.*, 87(4), 421-429.

Chung, K.H.K., Simmons, M.J.H., Barigou, M., 2009, Angle-resolved PIV measurements of flow and turbulence fields in small-scale stirred vessels of different mixer configurations, *Industrial & Engineering Chemistry Research*, 48(2), 1008–1018.

Edwards, I., Axon, S.A., Barigou, M., Stitt, E.H., 2009, Combined use of PEPT and ERT in the study of aluminium hydroxide precipitation, *Industrial & Engineering Chemistry Research*, 48(2), 1019–1028.

Eesa, M., Barigou, M., 2009, CFD investigation of the pipe transport of coarse solids in laminar power law fluids, *Chemical Engineering Science*, 64(2), 322-333.

Nash, G.B., Watts, T., Barigou, M., 2008, Comparative rheology of leukocyte and platelet adhesion, *Biorheology*, 45: 52-53.

Zhang, W., Thornton, C., Nash, G., Barigou, M., 2008, A DEM study of flow and adhesive interaction of blood cells with the vessel wall, *Biorheology*, 45: 84-.

Eesa, M., Barigou, M., 2008, Horizontal laminar flow of coarse nearly-neutrally buoyant particles in non-Newtonian conveying fluids: CFD and PEPT experiments compared; *Int. J. Multiphase Flow*, 34(11), 997–1007.

Nash, G.B., Watts, T., Thornton, C., Barigou, M., 2008, Red cell aggregation as a factor influencing margination and adhesion of leukocytes and platelets, *Clinical Hemorheology and Microcirculation*, 39, 303–310.

Eesa, M., Barigou, M., 2008, CFD analysis of viscous non-Newtonian flow under the influence of a superimposed rotational vibration, *Computers & Fluids*, 37(1), 24-34.

Watts, T., Barigou, M., Nash, G.B., 2008, Blood rheological factors influencing adhesion of flowing leukocytes or platelets to vessel walls: I. Effects of varying haematocrit, *Biorheology*, 45: 126-127.

Watts, T., Barigou, M., Nash, G.B., 2008, Blood rheological factors influencing adhesion of flowing leukocytes or platelets to vessel walls: II. Effects of red cell aggregation, *Biorheology*, 45: 127-.

Heuer, A., Cox, A.R., Barigou, M., Singleton, S., Ginkel, M-V, 2007, Visualisation of foam microstructure when subject to pressure change, *Colloids and Surfaces A: Physicochemical and Engineering Aspects*, 311(1-3), 112-123.

Chung, K.H.K., Barigou, M., Simmons, M.J.H., 2007, Reconstruction of 3-D flow field inside miniature stirred vessels using a 2-D PIV technique, *Trans IChemE, Part A, Chemical Engineering Research and Design*, 85(A5), 560-567.

Adams, L., Barigou, M., 2007, CFD analysis of caverns and pseudo-caverns developed during mixing of non-Newtonian fluids, *Trans IChemE, Part A, Chemical Engineering Research and Design*, 85(A5), 598-604.

Hall, J.F., Barigou, M., Simmons, M.J.H., Stitt, E.H., 2005, Just because it's small doesn't mean it's mixed: ensuring good mixing in meso-scale reactors, *Industrial & Engineering Chemistry Research*, 44 (25), 9695-9704.

Miri, T., Barigou, M., Fryer, P.J., Cox, P.W., 2005, Flow induced fibre alignment in mycoprotein paste, *Food Research International*, 38, 1151-1160.

Lim, K.S., Barigou, M., 2005, Ultrasound assisted generation of foam, *Industrial & Engineering Chemistry Research*, 44 (9), 3312-3320.

Hall, J.F., Barigou, M., Simmons, M.J.H., Stitt, E.H., 2005, A PIV study of hydrodynamics in gas-liquid high throughput experimentation (HTE) with eccentric impeller configurations, *Chemical Engineering Science*, 60, 6403-6413.

Hall, J.F., Barigou, M., Simmons, M.J.S., Stitt, H.E., 2005, Comparative study of different mixing strategies in small high throughput experimentation reactors, *Chemical Engineering Science*, 60 (8-9), 2355-2368.

Lim, K.S., Barigou, M., 2005, Pneumatic foam generation in the presence of a high intensity ultrasound field, *Ultrasonics Sonochemistry*, 12 (5), 385-393.

Barigou, M., 2004, Particle tracking in opaque mixing systems: an overview of the capabilities of positron emission tomography, *Transactions IChemE, Chem. Eng. Res. Des.*, Personal Invitation from Editor, 82 (A9), 1258-1267.

Lim, K.S., Barigou, M., 2004, X-ray micro-computed tomography of cellular food products, *Food Research International*, 37 (10), 1001-1012.

Hall, J.F., Barigou, M., Simmons, M.J.H., Stitt, E.H., 2004, Mixing in unbaffled high throughput experimentation reactors, *Industrial & Engineering Chemistry Research*, 43 (15), 4149-4158.

Barigou, M., Deshpande, N.S., and Wiggers, F.N., 2003, Numerical simulation of the steady movement of a foam film in a tube, *Transactions IChemE, Part A, Chem. Eng. Res. Des.*, 81, 623-630.

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Fairhurst, P.G., Barigou, M., Fryer, P.J., Pain, J.P. and Parker, D.J., 2001, Using Positron Emission Particle Tracking (PEPT) to study nearly neutrally-buoyant particles in high solid fraction pipe flow, *Int. J. Multiphase Flow*, 27 (11), 1881-1901.

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Fairhurst, P.G., Barigou, M., Fryer, P.J., and Pain, J-P, 1999, Particle passage time distributions in vertical pipe flow of solid-liquid food mixtures, *Transactions IChemE, part C, Food and Bioproducts Processing*, 77 (C4), 293-301.

Ouazzane, K. and Barigou, M., 1999, A comparative study of two flow conditioners and their efficacy to reduce asymmetric swirling flow effects on orifice meter performance, *Transactions IChemE, part A, Chem. Eng. Res. Des.*, 77 (A8), 747-753.

Deshpande, N.S. and Barigou, M., 1999, Performance characteristics of novel mechanical foam breakers in stirred tank reactors, *Journal of Chemical Technology and Biotechnology*, 74, 979-987.

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Barigou, M., Mankad, S., Fryer, P.J., 1998, Heat transfer in two-phase solid-liquid food flows; *Transactions IChemE, Part C, Food and Bioproducts Processing*, 76, 3-29.

Lareo, C., Fryer, P.J. and Barigou, M., 1997, The fluid mechanics of two-phase solid-liquid food flows, *Transactions IChemE, Part C, Food and Bioproducts Processing*, 75, 73-105.

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