Formulation Science & Technology

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FORMULA X

Understand Formulate Innovate

Manchester, UK

24 – 27th June 2019

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Formulation Science & Technology FSG Group

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Welcome

The Formulation Science and Technology Group of the Royal Society of Chemistry is excited to be organising Formula X - Understand, Formulate, Innovate at The University of Manchester, following on from the first Formula in Asia, Formula IX - Multiscale Structures and Functionalities for Future Formulation which happened Beijing in October 2017. The first Formula conference was held in 1987, 31 years later Formula X will continue the tradition of bringing together the best industrial and academic science and engineering which are accelerating the application of formulation across Europe.

The conference theme of "Understand, Formulate, Innovate" highlights the direction of travel for the formulating industries where more research and development is now aimed at developing the understanding before formulation occurs, which is driving new types of innovation. While traditional formulation science research is still important, it is now being applied to more and more complex formulations, and even for the most complex formulation digital techniques are being used to limit the formulation space that needs to be explored.

We are excited to host this meeting at the University of Manchester, and have prepared a program with opportunities to discuss the latest developments with the best scientists in the area and to be inspired by extraordinary keynote lecturers.

We are providing a platform for the 2030 Roadmap for the European Formulation Industries to be presented to the community, as well as two workshops: The AceForm4.0 workshop will revolve around up to three selected topics for cross-sectorial, cross-value chain collaboration as identified in the 2030 Formulation roadmap to stimulate new partnerships and define consortia for research projects in the context of identified funding possibilities within Horizon 2020 and Horizon Europe. In addition, iFormulate will run a "Design for Formulation" workshop that will highlight the applicability of quality by design across the formulated product industries and provide attendees with a number of take away methods which they can implement immediately.

You will also have the oppotunity to visit the Materials Innovation Factory at the University of Liverpool, or to a number of laboratories at the University of Manchester including the Unilever formulation laboratory, the Graphene Engineering Innovation Centre and the Henry Royce Institute.

We hope you will engage with all the opportunities at this conference and that you will have fruitful and rewarding exchanges of ideas.

Prof. Simon Gibbon	Dr. Helen Ryder	Dr. Flor Siperstein
FSTG Chair	*FSTG Secretary*	*FORMULA X Chair*

MONDAY 24th June

C2 – PLENARY SESSION

14:00 Welcome: Professor Simon Gibbon – RSC-FSTG / AkzoNobel R&D

14:15 K-1

Plenary – Formulation of low dimension carbon particles for composites and supercapacitor applications
Professor Ian Kinloch, University of Manchester

Chair: Simon Gibbon

PARALLEL SESSIONS

C2 – Session A
Advances in Dispersed Systems
Chair: Flor Siperstein

15:00 C-18

AGEING OF SUSPENSIONS – CAN WE BETTER UNDERSTAND THEIR STABILITY AND DESIGN FORMULATIONS WITH IMPROVED STABILITY?

Malcolm Faers
Bayer AG, Formulation Technology, Monheim, Germany

15:20 C-30

PARTICLE MIGRATION IN INKJET-PRINTED DROPLETS

Jack G. J. Goodall, L. Yang, C. D. Bain
Department of Chemistry, Durham University, UK

C9 – Session B
Novel Formulation Development
Chair: Simon Gibbon

C-16

PREDICTIVE SCIENCES AND HIGH THROUGHPUT SCREENING COMBINED FOR EFFICIENT FORMULATION DEVELOPMENTS

Sander van Loon, Alejandro Gutierrez, Jose Ignacio Martinez Sanchez, Gwenola Le Mouee, Beverley Fricker
VLCI, Amsterdam, Netherlands

C-45

ADVANCED CONTROL IN POWDER PROCESSING (THROUGH MODELLING AND CONTINUOUS PROCESSING) TO DELIVER NOVEL FORMULATIONS

David Berry, Tim Addison, David Parmley, Chester Aguirre, Emily Atkinson, Sofia Matrali, Jacquin Wilford-Brown, Caroline Kelly, Mark Taylor
CPI Ltd, Wilton, UK

MONDAY 24th June

PARALLEL SESSIONS

	C2 – Session A (cont'd) Advances in Dispersed Systems Chair: Flor Siperstein	C9 – Session B (cont'd) Novel Formulation Development Chair: Simon Gibbon
15:40	C-03 APPLICATION OF A FULL-FACTORIAL DESIGN TO THE CONTROL OF COLLOIDAL CHARACTERISTICS OF NON-ISOCYANATE POLYURETHANE NANOPARTICLES PREPARED BY NANOPRECIPITATION **Nathalie Sintes-Zydowicz**[1], Thomas Querette[1,2], Claire Bordes[3], Etienne Fleury[2] *[1] University of Lyon, IMP, CNRS 5223, Université Lyon, Villeurbanne, F-69622, France* *[2] University of Lyon, IMP, CNRS 5223, INSA de Lyon, Villeurbanne, F-69621, France* *[3] University of Lyon, LAGEPP UMR 5007, 69622 Villeurbanne Cedex, France*	C-51 UTILISING MODELLING APPROACHES FOR THE SCALE UP OF SPRAY DRYERS **Hassan Abdullahi**[1], Christopher L. Burcham[2], Thomas Vetter[1] *[1] School of Chemical Engineering and Analytical Science, University of Manchester, Manchester, UK* *[2] Eli Lilly & Company, Indianapolis, USA*
16:00	C2 – FLASH POSTERS	
16:30	C15 – POSTER SESSION AND WELCOME RECEPTION	

TUESDAY 25th June

C2 – PLENARY SESSION

09:00 K-2

Plenary – Nanotechnology and the differentiated medicine
Professor Ijeoma F. Uchegbu, University College London School of Pharmacy

Chair: Ulla Elofsson

PARALLEL SESSIONS

C2 – Session A
Novel Characterisation of Formulations I
Chair: Gordon Tiddy / Helen Ryder

09:45

STRUCTURE AND DYNAMICS OF GLYCEROL IN GAMMA ALUMINA NANOPORES

Gerardo Campos-Villalobos
School of Chemical Engineering and Analytical Sciences, The University of Manchester, UK

10:05

A NOVEL COARSE-GRAINED MODEL TO SIMULATE HIGH MOLECULAR WEIGHT POLYMERS IN CONTACT WITH SOLID SURFACES

Giuliana Giunta, Ali Karimi-Varzaneh and Paola Carbone
School of Chemical Engineering and Analytical Sciences, The University of Manchester, UK

C9 – Session B
Formulation of Pharmaceuticals and Biologicals I
Chair: Ijeoma Uchegbu / Ulla Elofsson

C-43

FORMULATION OF ENZYMES FOR INDUSTRIAL APPLICATIONS

Sonja Kübelbeck, **Grit Baier**, R. André, K. Tücking
BASF SE, Formulation Platform, Team: Formulation of biological actives, Ludwigshafen, Germany

C-13

FORMULATION OF ENVIRONMENTALLY FRIENDLY COSMETIC CREAMS

Chi Zhang, James Winterburn, Thomas L Rodgers
School of Chemical Engineering and Analytical Sciences, The University of Manchester

TUESDAY 25th June

C2 – Session A (cont'd)
Novel Characterisation of Formulations I
Chair: Gordon Tiddy / Helen Ryder

C9 – Session B (cont'd)
Formulation of Pharmaceuticals and Biologicals I
Chair: Ijeoma Uchegbu / Ulla Elofsson

10:25 C-12

FORMULATION OF MIXED MOLECULAR/MACROMOLECULAR HYDROGELS BASED ON MODIFIED AMINOACIDS AND POLYSACCHARIDE

Géraldine Rangel Euzcateguy[1], Caroline Parajua-Sejil[1], David Chapron[2], Philippe Marchal[3], Guillaume Pickaert[1], Alain Durand[1]

[1] *Université de Lorraine, CNRS, LCPM, F-54000 Nancy, France*
[2] *Université de Lorraine, CentraleSupélec, LMOPS, F-57000 Metz*
[3] *Université de Lorraine, CNRS, LRGP, F-54000 Nancy, France*

C-27

A SYSTEMS-BASED APPROACH TO DIGITAL DESIGN AND OPERATION IN THE FORMULATION OF PHARMACEUTICALS

Martin R. Edwards[1], Charles M. Gordon[1], Robert H. Peeling[1], John A. Henderson[1], Sean K. Bermingham[2]

[1] *Britest Limited;*
[2] *Process Systems Enterprise Limited*

10:45 COFFEE BREAK

PARALLEL SESSIONS

C2 – Session A
Novel Characterisation of Formulations II
Chair: Gordon Tiddy / Helen Ryder

C9 – Session B
Formulation of Pharmaceuticals and Biologicals II
Chair: Ijeoma Uchegbu / Ulla Elofsson

11:15 C-06

CONCENTRATED SILICONE EMULSIONS: HOW TO PREDICT THEIR SHELF LIFE?

Roland Ramsch[1], Gérard Meunier[1], Giovanni Brambilla[1], **Stéphane Ugazio**[2]

[1] *Formulaction, 3-5 rue Paule Raymondis, 31200 Toulouse, France*
[2] *Dow Silicones Belgium, Parc Industriel zone C; 7180 Seneffe, Belgium*

C-47

LABEL-FREE CHARACTERISATION OF BIOLOGICAL DRUGS IN PLASMA

Sebastian Hansson[1], Mats Leeman[1], Lars Nilsson[2]

[1] *SOLVE R&C, Lund, Sweden*
[2] *Department for Food Technology, LTH, Lund University, Sweden*

TUESDAY 25th June

C2 – Session A (cont'd)
Novel Characterisation of Formulations II
Chair: Gordon Tiddy / Helen Ryder

11:35 C-34

AUTOMATED SYSTEM TO ASSESS STABILITY OF COMPLEX FORMULATIONS AT MACRO SCALE

Léopold Mottet[1], Fabio Zonfrilli[2], Dirk Bontinck[3], Peter Van Den Berg[3], Kris Ver Donck[4], Reindert De Beule5, Michael Van de Steene[5], Johan Paul[5]

[1] *Flamac, Division of SIM, TechnologiePark 48 9052 Zwijnaarde Gent,Belgium*

[2] *Procter & Gamble, Temselaan 100, 1853 Grimbergen,Belgium*

[3] *Allnex, Rue d'Anderlecht 33, 1620 Drogenbos, Belgium*

[4] *Confluence Consulting, Acacialaan 53, 3020 Herent, Belgium*

[5] *Nucomat, Spieveldstraat 45, industrial park E17/3265, 9160 Lokeren, Belgium*

11:55 C-36

LAB SCALE METHODOLOGY TO MEASURE FORMULATION LOSSES DUE TO RAIN

Niall Rae Thomson[1], Chris I. Lindsay[1], Brett L. Symmonds[2] and Vitaliy Khutoryanskiy[2]

[1] *Syngenta, Jealott's Hill International Research Centre, Bracknell RG42 6EY, UK*

[2] *Reading School of Pharmacy, University of Reading, Whiteknights, PO Box 224, Reading RG6 6AD, UK*

C9 – Session B (cont'd)
Formulation of Pharmaceuticals and Biologicals II
Chair: Ijeoma Uchegbu / Ulla Elofsson

C-33

FORMULATION OF DUAL COMPONENT SOLID DRUG NANOPARTICLES FOR IMPROVED ORAL BIOAVAILABILITY OF DARUNAVIR AND RITONAVIR

Alison C. Savage[1], Samantha J. Ashcroft[1], Helen Box[2]2, Joanne Sharp[2], Darren Moss[2], Megan Neary[2], Andrew Owen2 and Steve P. Rannard[1]

[1] *Department of Chemistry, University of Liverpool, Crown Street, Liverpool, L69 7ZD, UK*

[2] *Department of Molecular and Clinical Pharmacology, Materials Innovation Factory, University of Liverpool, Liverpool, L7 3NY, UK*

C-46

CHARACTERIZATION OF COMMERCIAL PHARMACEUTICAL TABLETS AND MODEL BINARY MIXTURES TOWARD AN IMPROVED UNDERSTANDING OF TREATMENT EFFICIENCY

N. Grati[1], H. Guesmi[1], C. Parajua-Sejil[2], **Alain Durand**[2], H. Galai[1], A. Alatrache[1]

[1] *Laboratory of Materials, Treatment and Analysis (LMTA), National Institute of Research and Physical-chemical Analysis, Technopark of Sidi-Thabet, 2020, Ariana, Tunisia*

[2] *Université de Lorraine, CNRS, LCPM, F-54000 Nancy, France*

TUESDAY 25th June

12:15 C2 - EXHIBITOR AND SPONSOR PRESENTATIONS

13:00 LUNCH

14:00 C15 - NETWORKING, EXHIBITION AND POSTER SESSION

C2 – PLENARY SESSION

15:45 K-3 **Plenary** – Elaboration and time stability study of capsules made of double emulsions
Dr Véronique Schmitt – CNRS Centre de Recherche Paul Pascal, Bordeaux

Chair: Alain Durand

16:30 2030 Roadmap for the European Formulation Industries - Dr Isabel Mira – RISE (Room C2)

PARALLEL WORKSHOPS

17:00 Room D2 - iFormulate Workshop - Design for Formulation Workshop

Sign up essential!

Room C2 - AceForm Workshop - European Formulation Interest Group Meeting

Wednesday 26th June

C2 – PLENARY SESSION

09:00 K-7

Plenary – FORMULATION OF CATALYSTS - MESOPOROUS ZEOLITES
Dr Xiaolei Fan, The University of Manchester
Chair: Flor Siperstein

PARALLEL SESSIONS

C2 – Session A
Formulation of Nanomaterials I
Chair: Karin Persson / Flor Siperstein

09:45 C-14

FORMULATION OF NANOTECHNOLOGIES FOR THE DELIVERY OF NUCLEIC ACIDS

Annalisa Tirella[1,2], Enrique Lallana[2], Julio M Rios De La Rosa[2,†], Ponpawee Pingrajai[1], Arianna Gennari[3], Maria Pelliccia[1,‡], Ian Stratford[1,4], Marianne Ashford[5], Sanyogitta Puri[5], Nicola Tirelli[2,3]

[1] *Division of Pharmacy and Optometry, Faculty of Biology, Medicine and Health, Stopford Building, University of Manchester and Manchester Academic Health Science Centre, Manchester, M13 9PT, UK.*

[2] *North West Centre for Advanced Drug Delivery (NoWCADD), Division of Pharmacy & Optometry, School of Health Sciences, Faculty of Biology, Medicine and Health, Stopford Building, Manchester, M13 9PT, UK.*

[3] *Laboratory for Polymers and Biomaterials, Fondazione Istituto Italiano di Tecnologia, 16163, Genova, Italy*

[4] *Manchester Cancer Research Centre, The University of Manchester, 555 Wilmslow Road, Manchester, M20 4GJ UK.*

[5] *Pharmaceutical Sciences, Innovative Medicines Biotech Unit, AstraZeneca, Macclesfield, SK10 2NA, UK.*

† Present address: BiOncoTech Therapeutics S.L, Calle Catedratico Agustín Escardino 9, 46980, Paterna, Valencia, Spain.

‡ Present address: GSK R&D, Gunnels Wood Road, Stevenage, Herts, SG1 2NY, United Kingdom

C9 – Session B
Emulsions and Suspensions I
Chair: Cecil Pagnoux / Jordi Esquena

C-39

ENCAPSULATION IN DOUBLE EMULSIONS - FUNDAMENTAL ANALYSIS OF STABILITY

Stephanie Nachtigall[1], C. Holtze[1], A. Laurenzis[1], S. Bachmann[1], M. Vranceanu[1], G. Oetter[1], F. Runge[1], V. Götz[2], S. Hosseinpour[2], W. Peukert[2], N. Leister[3], H. P. Karbstein[3]

[1] *BASF SE, Ludwigshafen, Germany*

[2] *Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany*

[3] *Karlsruhe Institute of Technology, Germany*

Wednesday 26th June
PARALLEL SESSIONS

C2 – Session A (cont'd)
Formulation of Nanomaterials I
Chair: Karin Persson / Flor Siperstein

10:05 C-17

FORMULATION OF DELIVERY SYSTEMS FOR CAROTENOID-RICH EXTRACTS FROM MICROALGAE

Isabel Mira[1], Malin Svensson[2], Karin Persson[1], Anna Fureby[1]
[1] RISE, Research Institutes of Technology, Stockholm, Sweden
[2] LECO Corporation in Sweden, Stockholm, Sweden

10:25 C-32

CHITOSAN/CARBOXYMETHYL CELLULOSE-STABILIZED POLY(LACTIDE-CO-GLYCOLIDE) PARTICLES AS BIO-BASED DRUG DELIVERY CARRIERS

Supharat Inphonlek[1], Panya Sunintaboon[1], Michèle Léonard[2], **Alain Durand**[2]

[1] Department of Chemistry, Faculty of Science, Mahidol University, Rama 6 Road, Bangkok 10400, Thailand
[2] Université de Lorraine, CNRS, LCPM, F-54000 Nancy, France

C9 – Session B (cont'd)
Emulsions and Suspensions I
Chair: Cecil Pagnoux / Jordi Esquena

C-23

ENCAPSULATION OF WATER-IN-WATER (W/W) EMULSIONS INSIDE POLYELECTROLYTE CAPSULES

N. Salinas[1], P. Mendoza[1], L. Corvo1, C. Miquel[1], Y. Beldengrün[1], J. Miras1, C. González[2], **Jordi Esquena**[1]
[1] Institute of Advanced Chemistry of Catalonia (IQAC-CSIC), and Networking Research Center on Bioengineering, Biomaterials and Nanomedicine (CIBER-BBN), Barcelona, Spain.
[2] Department of Chemical Engineering and Analytical Chemistry, University of Barcelona, Spain.

C-40

DEVELOPMENT OF A SURFACE ENHANCED RAMAN SCATTERING METHOD FOR THE QUANTIFICATION OF BACTERIA: APPLICATION TO THE CHARACTERIZATION OF PROBIOTICS ENCAPSULATED IN MICROSPHERES

Elie Akanny[1], Anne Bonhommé[1], Carine Commun[4], Anne Doleans-Jordheims[4,5], François Bessueille[1], Sandrine Bourgeois[2,3], Claire Bordes[2]
[1] Université de Lyon, Institut des Sciences Analytiques, UMR 5280, CNRS, Université Lyon 1, ENS Lyon – 5, rue de la Doua, F-69100 Villeurbanne, France
[2] Univ Lyon, Université Claude Bernard Lyon 1, CNRS, LAGEPP UMR 5007, 43 boulevard du 11 novembre 1918, F-69100, VILLEURBANNE, France
[3] Université de Lyon, Université Lyon 1, ISPB-School of Pharmacy, F-69008 Lyon, France
[4] Equipe de Recherche Bactéries Pathogènes Opportunistes et Environnement, UMR CNRS 5557

Ecologie Microbienne, Université de Lyon 1 & VetAgro Sup, Villeurbanne, France
[5] Laboratoire de Bactériologie, Institut des Agents Infectieux, Centre de Biologie et Pathologie Nord, Hospices Civils de Lyon (HCL), Lyon, France

Wednesday 26th June

10:45 COFFEE BREAK

PARALLEL SESSIONS

C2 – Session A
Formulation of Nanomaterials II
Chair: Karin Persson / Flor Siperstein

11:15 C-02 VACCINE ADJUVANT ACTIVITY OF CONIFER-DERIVED OIL-IN-WATER NANOEMULSIONS

Christopher B. Fox[1], Neal Van Hoeven[1], Brian Granger[1], Susan Lin[1], Jeffrey A. Guderian[1], Airn Hartwig[2], Nicole Marlenee[2], Richard A. Bowen[2], Vagif Soultanov[3], Darrick Carter[1]
[1] IDRI, Seattle, WA, USA
[2] Colorado State University, Fort Collins, CO, USA
[3] Prenolica Limited, South Melbourne, Victoria, Australia

11:35 C-11 DISSOLUTION OF SURFACTANT LAMELLAR PHASES

Mitha Al-Jabri, Thomas L.Rodgers
School of Chemical Engineering and Analytical Science, The University of Manchester, UK

C9 – Session B
Emulsions and Suspensions II
Chair: Cecil Pagnoux / Jordi Esquena

C-09 STUDY OF ORGANIC/INORGANIC SUSPENSIONS: THE CASE OF CEMENT SUSPENSIONS CONTAINING LATEXES

Maeva Riegert[1], Rénal Backov[1,2], Véronique Schmitt[1]
[1] Centre de Recherche Paul Pascal. UMR CNRS 5031, Université de Bordeaux, 115 Avenue Albert Schweitzer, 33600 Pessac, France.
[2] Department of Civil and Environmental Engineering, Massachusetts Institute of Technology, 77 Mass Avenue, Cambridge, MA 02139, USA.

C-26 STUDY OF THE DISPERSION BEHAVIOR OF AQUEOUS SUSPENSIONS OF TITANIA NANOPOWDER

Fadoua Sallem[1], Ieuan Cornu[2], Lucas Villatte[2], Pierre-Marie Geffroy[1], Graziella Goglio[2] and Cécile PAGNOUX[1]
[1] IRCER, Centre européen de la céramique, Université de Limoges, 12 Rue Atlantis 87068 Limoges, France
[2] Institut de Chimie de la Matière Condensée de Bordeaux, UPR CNRS 9048, Université Bordeaux-1, 87 Avenue du Dr Albert Schweitzer, 33608 Pessac Cedex, France

Wednesday 26th June
PARALLEL SESSIONS

C2 – Session A (cont'd)
Formulation of Nanomaterials II
Chair: Karin Persson / Flor Siperstein

C9 – Session B (cont'd)
Emulsions and Suspensions II
Chair: Cecil Pagnoux / Jordi Esquena

11:55 C-37

COMPUTER SIMULATIONS OF SODIUM LAURETH SULPHATE WORMLIKE MICELLES

Charlie Wand, Paola Carbone, Andrew Masters
School of Chemical Engineering and Analytical Science, The University of Manchester, Oxford Road, Manchester, M13 9PL, UK

C-29

STABILIZATION OF PICKERING EMULSIONS BY BIODEGRADABLE PLGA NANOPARTICLES: INTERFACIAL STRUCTURE

C Albert[1], **Nicolas Huang**[1], N Tsapis[1], S Geiger[1,2], V Rosilio[1], G Mekhloufi[1], D Chapron[1], B Robin[1], M Beladjine[1], V Nicolas[3], E Fattal[1], F Agnely[1]
[1] *Institut Galien Paris-Sud, CNRS UMR 8612, Univ. Paris-Sud, Université Paris-Saclay, Faculté de Pharmacie, 5 rue J.B. Clément, F-92296 Châtenay-Malabry, France*
[2] *Laboratoire Structures, Propriétés et Modélisation des Solides (SPMS) UMR CNRS 8580, CentraleSupélec, Université Paris-Saclay, 3 Rue Joliot Curie, 91190 Gif-sur-Yvette, France*
[3] *Plateforme d'imagerie cellulaire MIPSIT, SFR-UMS-IPSIT, Univ. Paris-Sud, Université Paris-Saclay, Faculté de Pharmacie, 5 rue J.B. Clément, F-92296 Châtenay-Malabry, France*

12:15 C2 - Overview of Thursday's Visits – Materials Innovation Factory at Liverpool / Graphene Engineering Innovation Centre / Unilever Laboratory at University of Manchester / Henry Royce Institute - Imaging and Characterisation

13:00 LUNCH

C2 – PLENARY SESSION

14:00 K-5

Plenary – Particle formation in drying processes – from single particles to full scale
Dr Anna Fureby, RISE & **Dr Jacob Sloth Overgaard**, GEA Niro
Chair: Malcolm Faers

Wednesday 26th June
PARALLEL SESSIONS

	C2 – Session A Formulation Processing and Scaleup Chair: Tom Rodgers / Claudio Fonte	C9 – Session B Innovative Coatings and Films including Functional Surfaces, Wetting and Surface Texture Chair: David Calvert / Simon Gibbon
14:45	C-44 CROSSING THE VALLEY OF DEATH: THE FUNDAMENTAL SCALE-UP PROBLEM **John Williams**, Joanna Newton, Ivan Lowdon, Nigel Okey, Mona Gayle-Jinadu, Kin On Ho, Mary Moore *CPI Ltd, Wilton, UK*	C-28 RISE RAPID SUBSTITUTION TOOL: A QUICK SCREENING TOOL FOR FINDING ENVIRONMENTALLY FRIENDLY, CHEAP AND READILY AVAILABLE SOLVENTS **Petru Niga**, Marie Syren and Martin Andersson *RISE – Research institutes of Sweden, Sweden*
15:05	C-24 LIQUID-LIQUID MIXING FACILITIES FOR DEVELOPMENT OF MODEL PREDICTIVE CONTROL FOR INDUSTRIAL SCALE-UP **Min Zhang**[1], Katharina Roettger[2], Georgina Wadsley2, Peter Fryer[1], Federico Alberini[1], Alex Smith[2], Keith Nyatsungo[2], Sofia Matrali[2], Hanta Rabarjoelina[2], Glenn Ward[2], Mark Taylor[2], John Carroll[2], Maryam Asachi[3], Elaine Martin[3], Andrew Schofield[4], John Royer[4], Wilson Poon[4] *[1] University of Birmingham, Birmingham, UK* *[2] CPI Ltd, Wilton, UK* *[3] University of Leeds, Leeds, UK* *[4] University of Edinburgh, Edinburgh, UK*	C-15 NEW ADDITIVES TO FULFILL THE REQUIREMENTS OF RELEASE COATING APPLICATIONS **Aymeric Genest**, Frédéric Marchal, Frédéric Magd, Perrine Theil *Elkem Silicones, 55 & 85 avenue des frères Perret 69191 Saint-Fons, France*

Wednesday 26th June
PARALLEL SESSIONS

C2 – Session A
Formulation Processing and Scaleup
Chairs: Tom Rodgers / Claudio Fonte

C9 – Session B
Innovative Coatings and Films including Functional Surfaces, Wetting and Surface Texture
Chair: David Calvert / Simon Gibbon

15:25 C-42

PREDICTING THE DROPLET SIZE DISTRIBUTION OF EMULSIONS PRODUCED IN A SONOLATOR

Thomas P. John[1], S. Carrillo De Hert[1], Z. Ren[1], A. Kowalski[2], T.L. Rodgers[1]

[1] *School of Chemical Engineering and Analytical Sciences, The University of Manchester, UK*

[2] *Unilever R&D, Port Sunlight, UK*

15:45 C-31

SCALE-UP OF NARROW DISPERSITY EMULSIONS FOR HIGH VOLUME MANUFACTURING AGAINST DEMANDING REQUIREMENTS

Dai Hayward[1], Marijana Dragosovac[2]

[1] *Micropore Technologies Ltd, Loughborough, UK*

[2] *Loughborough University, UK*

C-48

PARTICLE LEACHING FROM POLYMERIC COATINGS

Eugenio Bonetti[1,2], Ander Cervellera Dominguez[3,4], Peter Visser[4], Simon Gibbon[5], **Flor R. Siperstein**[1]

[1] *School of Chemical Engineering and Analytical Sciences, The University of Manchester, UK*

[2] *AkzoNobel, Malmö, Sweden*

[3] *School of Materials, The University of Manchester, Mannchester, UK*

[4] *AkzoNobel, Rijksstraatweg 31, 2171 AJ Sassenheim, The Netherlands*

[5] *AkzoNobel, Stoneygate Lane, Felling, Gateshead, Tyne & Wear, UK*

C-52

STUDYING MICROSTRUCTURE OF COATINGS TO UNDERSTAND FORMULATION EFFECTS ON FUNCTION

Simon Gibbon[1], Chi Lo[2,3], Apoorva Ambarkar[2,3], Lee Fielding[2], Stephen Edmondson[2], Keimpe van den Berg[3], Bob Luigjes[3]

[1] *AkzoNobel, Stoneygate Lane, Felling, Gateshead, Tyne & Wear, UK*

[2] *School of Materials, The University of Manchester, Mannchester, UK*

[3] *AkzoNobel, Rijksstraatweg 31, 2171 AJ Sassenheim, The Netherlands*

16:05 Networking & Coffee

19:00 Conference Dinner

Thursday 27th June
PARALLEL SESSIONS

	C2 – Session A Novel Characterisation of Formulations III Chair: Gordon Tiddy / Helen Ryder	C9 – Session B Emulsions and Suspensions III Chair: Cecil Pagnoux / Jordi Esquena
09:00	C-38 NOVEL XANTHAN AMPHIPHILIC DERIVATIVES FOR STABILIZING SURFACTANT-FREE O/W EMULSIONS Céline Fantou[1], Sébastien Comesse[1], Frédéric Renou[2] and **Michel Grisel**[1] *[1] NormandieUniv, UNILEHAVRE, FR 3038 CNRS, URCOM, 76600 Le Havre, France* *[2] Le Mans Université, IMMM UMR-CNRS 6283, Polymères, Colloïdes, Interfaces 72085 Le Mans Cedex 9, France*	C-07 EMULSIFICATION OF VISCOUS BIO-BASED ALKYD RESIN BY CATASTROPHIC PHASE INVERSION Christel Pierlot[1], **Jesús F. Ontiveros**[1], Marianne Catté[1], Jean Louis Salager[2] *[1] Univ. Lille, CNRS, Centrale Lille, ENSCL, Univ. Artois, UMR 8181 - UCCS - Unité de Catalyse et Chimie du Solide, F-59000 Lille, France* *[2] Laboratorio FIRP, Ingeniería Química, Universidad de Los Andes, Mérida 5101, Venezuela*
09:20	C-22 UNDERSTANDING CHEMOMECHANICAL INTERACTIONS DURING HARD SURFACE CLEANING PROCESSES **Perrakis Bistis**[1,2], Patricia Andreu Cabedo[1,2], Peter Fryer[1], Serafim Bakalis[3], Michael Groombridge[2] *[1] School of Chemical Engineering, University of Birmingham, Edgbaston, UK, B15 2TT* *[2] Procter & Gamble, Newcastle Innovation Centre, Newcastle-upon-Tyne, UK, NE12 9TS* *[3] School of Chemical Engineering, University of Nottingham, Nottingham, UK, NG7 2RD*	C-10 ON THE EFFECTS OF DROP SIZE DISTRIBUTION, DISPERSED PHASE VOLUME FRACTION, AND DISPERSED PHASE VISCOSITY IN EMULSION RHEOLOGY **Koay Ze Nian**[1], Claudio Pereira da Fonte[1], Adam J. Kowalski[2] and Thomas L. Rodgers[1] *[1] School of Chemical Engineering and Analytical Sciences, The University of Manchester, UK* *[2] Unilever R&D, Port Sunlight, UK*

Thursday 27th June
PARALLEL SESSIONS

	C2 – Session A (cont'd) Novel Characterisation of Formulations III Chair: Gordon Tiddy / Helen Ryder	C9 – Session B (cont'd) Emulsions and Suspensions III Chair: Cecil Pagnoux / Jordi Esquena
09:40	C-08 CRUDE OIL BASED WIII MICROEMULSIONS OF ANIONIC/NON-IONIC SURFACTANTS DETERMINED BY DYNAMIC PHASE INVERSION SCANNING **Guillaume Lemahieu**[1], Jesús F. Ontriveros[1], Valérie Molinier[2], Jean-Marie Aubry[1] *[1] Univ. Lille, CNRS, Centrale Lille, ENSCL, Univ. Artois, UMR 8181– UCCS– Unité de Catalyse et Chimie du Solide, F-59000 Lille, France* *[2] Total Exploration Production, Pôle d'Etudes et de Recherche de Lacq, B.P. 47, 64170, Lacq, France*	C-35 DEPOSITION OF FUNCTIONAL ACTIVES ON TEXTILE SURFACES **Evangelia Argentou**[1,2], Anju Brooker[2], Carlos Amador[2], Peter Fryer[1], Jason Zhang[1] *[1] School of Chemical Engineering, University of Birmingham, Edgbaston, B15 2TT, UK* *[2] Procter & Gamble, Newcastle Innovation Centre, Newcastle-upon-Tyne, NE12 9TS, UK*
10:00	COFFEE	

C2 – PLENARY SESSION

10:30	K-6 Plenary – Formulation for 3D Printing **Professor Ricky Wildman** – University of Nottingham Chair: Isabel Mira
11:15	Future Formulation Activities - Alain Durand, SCF - Formula XI, Pierre Fillet award, EU-FIG, EuChems
11:45	Conference Ending - FSTG hands "Formula Baton" to Formula XI Organisers
12:00	LUNCH
12:30	Post-conference visits - Manchester and Liverpool - sign up essential.

Poster Programme

Posters will be displayed during all breaks throughout the conference.

Poster presenters are expected to make themselves available for the two official poster sessions:

Monday 24th June

16:00-16:30 Flash Poster - rapid poster flashes
16:30-18:00 Poster Session and Welcome Reception

Tuesday 25th June

14:00-15:45 Poster Session

There are three poster prizes themed around characterisation, formulation and materials.

Poster prizes kindly sponsored by FSTG, Formulaction and Henry Royce Institute

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New Developments in Emulsions and Suspensions	P-01	CONTROLLED SUPERSATURATION: ASSESSING THE USE OF EXCIPIENTS IN FORMULATION TO ENHANCE IN VIVO EXPOSURE FOR PRECLINICAL STUDIES **Katerina Vernerova**, Richard Taylor *UCB 208 Bath Road – Slough, Berkshire SL1 3WE - United Kingdom*
Formulation of Nanomaterials	P-02	DEPOSITION OF SOLID FABRIC ENHANCERS DURING CLOTHES DRYING: DYNAMICS OF ARTICLE MOTION **Chris Jones**[1], Peter J. Fryer [1], Patricia Andreu Cabedo[1], Carlos Amador[2], Al Corona[3] *[1] School of Chemical Engineering, University of Birmingham, Edgbaston, B15 2TT, UK* *[2] P&G Technical Centres Limited, Whitley Road, Longbenton, NE12 9TS, UK* *[3] P&G F&HC Innovation Centre, 5299 Spring Grove Ave., Cincinnati, OH 45217, USA*
Formulation of Nanomaterials	P-03	SYNTHESIS OF FLUORESCENT TAGGED POLYMERS **Mubark Alshareef**[1] Peter Quayle[1], Aula A. Alwattar[1,2], Athir Haddad, [1,2] Steve Edmondson[3] and Stephen Yeates[1] *[1] School of Chemistry The University of Manchester, Manchester M13 9PL* *[2] Chemistry Department, The University of Basrah, Iraq* *[3] School of Materials, The University of Manchester, Manchester M13 9PL*
Novel Characterisation of Formulations	P-04	SALT-TOLERANCE OF ETHOXY OR PROPOXYLATED ANIONIC SURFACTANTS: RATIONALIZATION OF THE ENHANCING EFFECT OF NON-IONIC GROUPS Jesús F. Ontiveros, Estelle Illous, **Guillaume Lemahieu**, Raphael Lebeuf, Jean M. Aubry *Univ. Lille, CNRS, Centrale Lille, ENSCL, Univ. Artois, UMR 8181 - UCCS - Unité de Catalyse et Chimie du Solide, F-59000 Lille, France*
Formulation of Biologics	P-05	CGRP ANTAGONIST PEPTIDE'S FORMULATION IN CHITOSAN MICROPARTICLES **Vera D'Aloisio**, Christopher Coxon, Gillian Hutcheon *School of Pharmacy & Biomolecular Sciences, Liverpool John Moores University, Liverpool, L3 3AF, UK*
Processing and Scale-up	P-06	NUMERICAL STUDY OF INKJET PRINTING OF WEAKLY VISCOELASTIC INKS **Pedro Torres**[1], P. Quayle[2], C. P. Fonte[1] *[1] School of Chemical Engineering & Analytical Science, The University of Manchester, Manchester M13 9PL, U.K.* *[2] School of Chemistry, The University of Manchester, Oxford Road, Manchester M13 9PL, U.K.*
Formulation of Nanomaterials	P-07	TUNING THE RHEOLOGY OF HYDROPHOBIC MATERIALS IN AQUEOUS SYSTEMS USING RESPONSIVE SURFACTANTS **Emma Jones**[1,2,3], Esther García-Tuñón [2,3] *[1]Leverhulme Research Centre for Functional Materials Design, University of Liverpool, L7 3NY* *[2]Materials Innovation Factory, University of Liverpool, L7 3NY* *[3]School of Engineering, University of Liverpool, L69 3GH*

Novel Characterisation of Formulations	P-08	COSMO-BACKFITTING AS A PROMISING IN SILICO TOOL TO CHARACTERIZE UNDEFINED POLYMERS: ILLUSTRATION OF THE CONCEPT ON THE SOLUBILISATION OF CELLULOSE ACETATE Floorian Laubé[1], Evamaria Hofmann[1,2], **Véronique Nardello-Rataj**[1], Jean-Marie Aubry[1] *[1] University of Lille, ENSCL, UCCS (UMR CNRS 8181), 59655 Villeneuve d'Ascq (France)* *[2] University of Regensburg, 93040 Regensburg (Germany)*
Formulation of Biologics	P-09	DEVELOPMENT OF ENTERIC POLYMER BASED MICROSPHERES BY SPRAY-DRYING FOR COLONIC DELIVERY OF *LACTOBACILLUS RHAMNOSUS GG* **Elie Akanny**[1], Sandrine Bourgeois[2,3], Anne Bonhommé[1], Cynthia Barratier[2,3], Carine Commun[4], Anne Doleans-Jordheims[4,5], François Bessueille[1], Claire Bordes[2] *[1]Université de Lyon, Institut des Sciences Analytiques, UMR 5280, CNRS, Université Lyon 1, ENS Lyon – 5, rue de la Doua, F-69100 Villeurbanne, France* *[2]Univ Lyon, Université Claude Bernard Lyon 1, CNRS, LAGEPP UMR 5007, 43 boulevard du 11 novembre 1918, F-69100, VILLEURBANNE, France* *[3]Université de Lyon, Université Lyon 1, ISPB-School of Pharmacy, F-69008 Lyon, France* *[4]Equipe de Recherche Bactéries Pathogènes Opportunistes et Environnement, UMR CNRS 5557 Ecologie Microbienne, Université de Lyon 1 & VetAgro Sup, Villeurbanne, France* *[5]Laboratoire de Bactériologie, Institut des Agents Infectieux, Centre de Biologie et Pathologie Nord, Hospices Civils de Lyon (HCL), Lyon, France*
Novel Characterisation of Formulations	P-10	METHODS FOR INVESTIGATING DISSOLUTION IN SURFACTANT SOLUTIONS **Rachel Hendrikse**, Professor Andrew Bayly , Professor Peter Jimack, Dr Xiaojun Lai *Faculty of Engineering, University of Leeds, Leeds, UK*
	P-11	POSTER WITHDRAWN
Formulation of Nanomaterials	P-12	LIPID-BASED NANOFORMULATIONS AS DELIVERY SYSTEMS FOR NEW AND IMPROVED DRUG MOLECULES Ronja Widenbring, Lukas Boge, **Anna Millqvist Fureby** *RISE, Research Institutes of Technology, Stockholm, Sweden*
Progress in Formulation of Pharmaceuticals	P-13	CEFOTAXIME-LOADED CHITOSAN NANOPARTICLES TO OVERCOME ANTIBIOTIC-RESISTANCE **Valeria Carini**, Katie Evans[1], Jo Foulkes[1], Giulia Scagnetti[1], Imran Y. Saleem[1], Sarah Gordon[1] *School of Pharmacy and Biomolecular Sciences, Liverpool John Moores University, Liverpool, L33AF*

Formulation of Nanomaterials	P-14	THE EC4SafeNano PROJECT AND THE CASE STUDY OF SURFACE CHEMICAL TRANSFORMATIONS OF NANO-TiO_2 SAMPLES UPON AGEING **Karin Persson**[1], Eric Johansson Salazar-Sandoval[1] Marie Ernstsson[1], Mikael Sundin[1] Volker Wachtendorf[2] Valentin Kunz[2] Wolfgang Unger[2], Marie-France Belinga-Desaunay-Nault[3], Iseult Lynch[3] [1] *RISE Research Institutes of Sweden, Sweden* [2] *Bundesanstalt für Materialforschung und –prüfung (BAM), Germany* [3] *University of Birmingham, UK*
Innovative Coatings and Films including Functional Surfaces, Wetting and Surface Texture	P-15	ANTI-FOULING MEMBRANES USING GRAPHENE OXIDE **Karin Persson**[1], Annika Dahlman[1], Kajsa Malmberg[1], Annika Krona[1], Staffan Filipsson[2], Kåre Tjus[2], Fredrik Hedman[2], Haofei Guo[3] [1] *RISE Research Institutes of Sweden, Sweden,* [2] *IVL, Swedish Environmental Institute, Sweden* [3] *Alfa Laval, Nakskov, Denmark*
	P-16	POSTER WITHDRAWN
	P-17	POSTER WiTHDRAWN
Novel Characterisation of Formulations	P-18	ACCELERATING CHEMICAL FORMULATION AND PROVIDING INSIGHTS USING COMPUTATIONAL METHODS **James L. McDonagh**[1], David Bray[2], Breanndan Conchuir[1], Alexander Harrison[1], Edward Pyzer-Knapp[1], Ardita Shkurti[2], Richard Anderson[2], William Swope[3], Michael Johnston[4] [1] *IBM Research UK* [2] *STFC Daresbury, UK* [3] *IBM Research Almaden, California, USA* [4] *IBM Research Dublin, Ireland*
Formulation of Nanomaterials	P-19	IN SILICO DESIGN OF NANOPARTICLES FOR TRANDERMAL DRUG DELIVERY APPLICATIONS **Rakesh Gupta**, Beena Rai *TCS Research, Tata Consultancy Services, Pune, India, 411013*

Innovative Coatings and Films including Functional Surfaces, Wetting and Surface Texture	P-20	TRIBOLOGICAL PROPERTIES OF POLY(IONIC LIQUID) BRUSHES IN ORGANIC AND AQUEOUS MEDIA **David Burgess**,[1] Ian McRobbie,[2] Peter Fryer,[1] & Jason Zhenyu Zhang[1] *[1] University of Birmingham, Edgbaston, Birmingham, B15 2TT, United Kingdom* *[2] Innospec, Innospec Manufacturing Park, Oil Sites Rd, Ellesmere Port, CH65 4HB, United Kingdom*
New Developments in Emulsions and Suspensions	P-21	BIAXIAL NEMATICS OF HARD CUBOIDS IN AN EXTERNAL FIELD **Effran Mirzad Rafael**[1], Daniel Corbett[1], Alejandro Cuetos[2], Alessandro Patti[1] *[1] School of Chemical Engineering and Analytical Science, The University of Manchester, M13 9PL, United Kingdom* *[2] Department of Physical, Chemical and Natural Systems, Pablo de Olavide University, 41013, Sevilla, Spain*
Formulation of Nanomaterials	P-22	COMPLEX MORPHOLOGIES FROM SELF-ASSEMBLY OF BLOCK-COPOLYMERS IN BINARY SOLVENTS **Gerardo Campos-Villalobos**, Flor R. Siperstein,Alessandro Patti *School of Chemical Engineering and Analytical Science, The University of Manchester, M13 9PL, Manchester UK*
Formulation of Nanomaterials	P-23	ENHANCED DYNAMICS OF GLYCEROL IN GAMMA-ALUMINA NANOPORES **Gerardo Campos-Villalobos**, Carmine D'Agostino, Flor R. Siperstein,Alessandro Patti *School of Chemical Engineering and Analytical Science, The University of Manchester, M13 9PL, Manchester UK*
Formulation of Nanomaterials	P-24	CROSS-OVER IN THE DYNAMICS OF POLYMER CONFINED BETWEEN TWO LIQUIDS OF DIFFERENT VISCOSITY **Giuliana Giunta** and Paola Carbone *School of Chemical Engineering and Analytical Science, University of Manchester, UK*
Formulation of Nanomaterials	P-25	COARSE-GRAINED MOLECULAR DYNAMICS SIMULATIONS OF POLYMER-SOLID INTERFACES IN NANOCOMPOSITES **Giuliana Giunta[1]**, Carsten Svaneborg[2], Ali-Karimi Varzaneh[3], Paola Carbone[1] ***[1]School of Chemical Engineering and Analytical Science, University of Manchester, UK*** *[2] Department of Physics, Chemistry and Pharmacy, University of Southern Denmark, Denmark* *[3]Continental, Hannover, Germany*
Formulation of Nanomaterials	P-26	PREDICTING ADSORPTION SELECTIVITY OF ETHANE AND ETHYLENE IN CARBON SLIT PORES **Huan Xiang**, Xiaolei Fan and Flor R. Siperstein *School of Chemical Engineering and Analytical Science, The University of Manchester, Manchester M13 9PL, United Kingdom*
Processing and Scale up	P-27	TURBULENT FLOW SIMULATION OF DISPERSION MICROSYSTEM WITH CUMULANT LATTICE BOLTZMAN METHOD **Ehsan Kian Far** *School of Chemical Engineering and Analytical Science, The University of Manchester*

Formulation of Nanomaterials	P-28	TOWARDS THE DEVELOPMENT OF A QSAR APPROACH TO HIGH CONCENTRATION GRAPHENE AND REDUCED GRAPHENE OXIDE DISPERSIONS EXFOLIATION **Aula Alwattar**[1, 2], Peter Quayle[1] and Stephen Yeates[1] *[1] School of Chemistry, The University of Manchester, Manchester, M13 9PL,UK* *[2] Chemistry Department, College of Science, The University of Basrah, Iraq*
Formulation of Nanomaterials	P-29	SYNTHESIS OF FLUORESCENT TAGGED POLYMERS Duplicate of P-03
Innovative Coatings and Films including Functional Surfaces, Wetting and Surface Texture	P-30	PREPARATION OF PHOSPHATE-FUNCTIONAL CORE-SHELL POLYMER LATEXES AND INVESTIGATION INTO THEIR USE IN PROTECTIVE COATINGS **Jack Saunders[1]**, Bob Luigjes,[2] Stuart B. Lyon,[1] Lee A. Fielding[1] *[1] School of Materials, University of Manchester, Manchester, M13 9PL, United Kingdom* *[2] Akzo Nobel Decorative Coatings B.V., Rijksstraatweg 31, 2171 AJ Sassenheim, The Netherlands*
New Developments in Emulsions and Suspensions	P-31	PICKERING EMULSIONS USING A FUMED SILICA AND A SILICA SOL – THE EFFECT OF MICROFLUIDIZATION **Isabel Mira[1]**, Karin Persson[1] Bernard P Binks[2] *[1] RISE Research Institutes of Sweden* *[2] Department of Chemistry and Biochemistry, University of Hull*
Novel Characterisation of Formulations	P-32	MOLECULAR MIGRATION IN POLY(VINYL ALCOHOL) MIXTURES **Katarzyna Majerczak**, Zhenyu Jason Zhang *School of Chemical Engineering, University of Birmingham, Edgbaston, B15 2TT, Birmingham, United Kingdom*

Formulation of low dimension carbon particles for composites and supercapacitor applications

I.A. Kinloch
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The superlative properties of isolated graphene sheets and nanotubes are often quoted, however the properties achieved when these nanomaterials is incorporated into bulk materials are typically a fraction of these values [1,2,3]. This issue, of course, is a symptom of most nanomaterials and arises from the challenges in formulating materials with high surface areas, making them highly prone to aggregation. This challenge is increased when one aims for multifunctionality, where different functionalities require conflicting microstructural requirements; e.g. electric percolation in polymer composites requires a percolated network of nanotubes, whereas mechanical reinforcement needs the nanotubes highly aligned in the direction of the load.

We have developed a range of functional approaches to control dispersion of carbon nanoparticles, including electrostatic [4] and steric approaches [5]. Alternatively hybrid materials are produced to reduce their impact of processing [6]. We then have measured their rheological properties [7,8] and looked at routes to control their microstructure during processing towards composite and supercapacitor applications.

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Nanotechnology and the differentiated medicine

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Pharmaceutical nanotechnology involves the formation of drug loaded nanoparticles from polymers, lipids and surface active agents [1]. Such nanoparticles have been used to formulate approved drugs, which target a particular clinical problem, such as: avoiding cardiotoxicity in the case of Doxil and avoiding hypersensitivity reactions in the case of the excipient used in Abraxane [2,3]. To gain approval, provide real patient benefit and encourage prescribing, it is essential that nanomedicines are sufficiently differentiated from a clinical perspective and preclinical data should support such potential differentiation, prior to proceeding to expensive clinical testing. An increase in bioavailability, for example, is often an insufficient driver for clinical development.

Over the last two decades, we have designed a large variety of self assembling polymers [4-6] and peptides [7,8] and used these to develop nanomedicines, which may be administered via the intravenous [7-9] oral [10-12] and intranasal [13] routes. Some of these preclinical stage nanomedicines have already demonstrated that they are well differentiated in a manner that is relevant to their clinical use. These nanomedicines show advantageous alterations in drug biodistribution and additional studies have illuminated some interesting mechanisms [7,12,14]. These nanomedicines will be discussed in the talk. Additionally diagnostic platforms are now being investigated within our laboratory [15].

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Elaboration and time stability study of capsules made of double emulsions

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Double water-in-oil-in-water emulsions are interesting systems for encapsulation of hydrophilic drugs (see Figure 1) as vitamin B12 or a suspension of *Cydia pomonella Granulovirus*, used in organic agriculture to protect fruits against the Carpocapse insect. Using rotor-stator mixers, monodisperse double emulsions were prepared in a two-step process that may impact the encapsulation efficiency. Using both classical UV-Vis spectroscopy and, more originally, rheology we assessed the encapsulation efficiency and water exchanges during emulsification [1]. We showed that encapsulation reached high levels, close to 100% and that this encapsulation decreased only if two conditions are fulfilled simultaneously: (i) during the second emulsification step, the flow is turbulent and (ii) it leads to excessive fragmentation inducing formation of too small drops. We also discuss the effect of a deliberate osmotic pressure unbalance on the encapsulation and characterize the induced water fluxes.

Once prepared, these capsules could also release their content or exchange water between inner and external aqueous phases. Using the same techniques, rheology and UV-Vis spectroscopy, we built a lipophilic stabilizer concentration-inner droplet volume fraction diagram highlighting the domains where the double emulsion is stable towards encapsulation and/or water fluxes [2]. We showed the important role of non-adsorbed stabilizer concentration in the intermediate oil phase on the emulsion stability. In the non-stable domains, we describe the observed phenomena and we determine the mechanisms responsible for release.

We conclude that by a judicious choice of the composition, double emulsion may act as efficient capsules over a large period of storage.

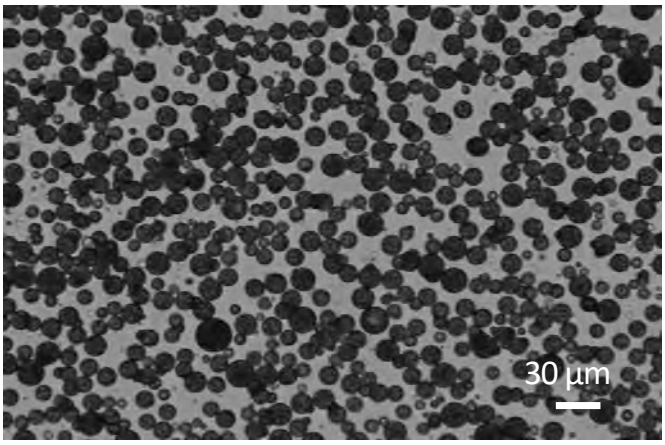

Figure 1: Microscopy image of the double emulsion: the high amount of inner aqueous droplets are responsible for the dark appearance of the oily globules.

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FORMULATIONS BY DESIGN: TOWARDS A MECHANISTIC UNDERSTANDING OF OLEOFOAM STABILITY

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Oil foams, or oleofoams, which are dispersions of gas bubbles in a continuous oil phase, are common in food products as well as the oil and gas industry. Recently, crystals of fatty acids or edible waxes have been found to provide stability and extend the applicability of oleofoams in aerated food formulations. There is evidence that the stabilisation is due to the adsorption of crystals onto the interface of the bubbles by the so-called Pickering mechanism. Because the excess crystals remaining in the continuous oil phase form an oleogel, the effect of the bulk rheological properties of the continuous phase is also important. In addition, these systems are extremely sensitive to temperature, because heating can melt the crystals, while cooling at different rates results in the formation of crystals with different size and shapes. We use a suite of analytical and experimental techniques to provide a mechanistic understanding of the stability of oleofoams upon changes in temperature. We evaluate the contributions of bulk and interfacial rheology below and above the melting point of a wax forming an oleogel in sunflower oil by studying the dissolution behaviour of single bubbles using video microscopy on a temperature-controlled stage. To assess the different rheological contributions, we compare the behaviour of a bubble embedded in an oleogel foam, and a bubble extracted from the oleogel foam and re-suspended in oil. In the first case, the bubble owes its stability to both bulk and interfacial rheology, while in the second case, the contribution of the interfacial dilatational rheology alone can be observed. We find that below the melting point of the wax, bubbles in the oleofoam are stable whereas bubbles that are only coated with wax crystals dissolve. Both systems are unstable against dissolution when heated above the melting point of the wax. These findings are rationalised through independent bulk rheological measurements of the oleofoam and oleogel at different temperatures, as well as interfacial rheological measurements of the wax-coated interface using a recently developed technique, drop shape fitting elastometry. In addition, we investigate in situ and in real time the formation of crystals at the interface of bubbles and in the bulk oleogel, and compare the crystal morphology and its effect on stability. The fundamental understanding of the microscale mechanisms governing oleofoam formation and stability underpin the design of future formulations that are ultrastable or responsive to stimuli.

Particle formation in drying processes – from single particles to full scale

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Powders are ubiquitous in the formulation industries, both as ingredients and final products. The characteristics and performance of a powder is designed by the formulation and the manufacturing process, and hence a detailed understanding about the interplay between components and processing is needed to design powders with desired properties. This presentation will provide an overview of particle formation in different powder production processes: spray-drying and spray-freeze-drying. Similar formulations are often used, although the particle structure and properties can be very different. The focus here is on formulations for proteins and food-type emulsions. Through working with formulation and process different particle structures can be obtained.

The mechanisms in particle formation occur on the nano- to microscale in spray-drying, while the production process may be operated on lab- to full scale. In order to design and simulate spray-drying processes, single particle drying is used as a tool to generate necessary data for modelling. A single droplet drying apparatus called the DRYING KINETICS ANALYZER™ (DKA) was developed by GEA. The apparatus is based on the principle of ultrasonic levitation where a single droplet is suspended in an acoustic field. While drying freely under well-defined conditions, the droplet is monitored with a video camera and a large number of measurements are made. Using the apparatus it is possible to quickly dry single particles of different formulations and evaluate the effects of a formulation change drying process and the final particle structure. Based on this the possibilities and limitations of using this apparatus for formulation development and spray drying process design is presented.

Formulation for 3D Printing

Professor Ricky Wildman
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The industrial uptake of Additive Manufacturing and 3D printing processes is growing rapidly but is being hampered by the lack of breadth of materials usable in such systems. Identifying, and then optimisating formulations for 3D printing is time consuming, and generally involves many tedious steps each of which require lengthy analysis.

We have developed a methodology that compresses and automates the formulation steps. In addition we incorporate assays that assess final material and product characteristics, such that screening can occur at all steps of the manufacturing workflow.

We demonstrate how this is possible for a biomedical application, showing how suitable choice of high throughput and fast assay methods can reduce the time for formulation of a 3D printed resin by a factor of 15, raising the possibility of ‘dialling up’ materials ready for bespoke product manufacture.

Formulation of Catalysts - Mesoporous Zeolites

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Synthetic zeolites, such as FAU Y and MFI ZSM-5 zeolites, are industrially important solid acid catalysts, especially in petrochemical fluid catalytic cracking (FCC) for producing gasoline range organics and gaseous products such as propylene. Reactivity, selectivity and accessibility are import features of zeolites, being critical to determine the performance of industrial catalysts formulated with zeolites.

Specifically, zeolites with the intrinsic microporous crystalline framework (0.3-0.8 nm) impose the accessibility and transport issues in some their applications involving bulky molecules, leading to the deactivation.

Accordingly, various strategies are being developed and explored to address the issues, such as the design and synthesis of nanozeolites and zeolite-type materials with intrinsic large pores, the templating method to prepare zeolites with secondary mesopores and the post-synthesis modification (such as dealumination and desilication) of zeolites to introduce the mesoporosity.

In this talk, the new post-synthesis modification strategies for formulating zeolites with mesoporous features, specifically the hierarchical mesoporous FAU Y and mesoporous low Si/Al ratio hollow ZSM-5 zeolites, will be presented. Additionally, their catalytic performance in model cracking reactions will also be discussed to demonstrate the effectiveness of these newly developed mesoporous zeolites.

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Vaccine Adjuvant Activity of Conifer-derived Oil-in-Water Nanoemulsions

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Abstract: Next to aluminum salts, squalene nanoemulsions comprise the most widely employed class of adjuvants in approved vaccines. Despite their importance, the mechanisms of action of squalene nanoemulsions are not completely understood, nor are the structure/function requirements of the oil composition. In this study, we build on previous work that compared the adjuvant properties of nanoemulsions made with different classes of oil structures to squalene nanoemulsion. Here, we introduce conifer-derived polyprenol nanoemulsions as novel vaccine adjuvant compositions. In contrast with long-chain triglycerides that do not efficiently enhance an immune response, both polyprenols and squalene are comprised of multimeric isoprene units, which may represent an important structural property of oils in nanoemulsions with adjuvant properties. Oils were extracted from conifers and used to prepare oil-in-water nanoemulsions by microfluidization. Conifer-derived nanoemulsions were formulated with or without a synthetic TLR4 ligand and characterized regarding physicochemical and biological activity properties in comparison to squalene nanoemulsions. Emulsion droplet diameter stability was characterized by dynamic light scattering. Nanoemulsions were evaluated for in vitro biological activity using human whole blood, and in vivo biological activity in mouse, pig, and ferret models when combined with pandemic influenza vaccine antigens. Nanoemulsions comprised of conifer-derived polyprenol oils demonstrated long-term physical stability, stimulated cytokine production from human cells in vitro, and promoted antigen-specific immune responses in various animal models, particularly when formulated with the TLR4 ligand GLA. Conifer-derived nanoemulsions are compatible with inclusion of a synthetic TLR4 ligand and promote antigen-specific immune responses to pandemic influenza antigens in mouse, pig, and ferret models.

APPLICATION OF A FULL-FACTORIAL DESIGN TO THE CONTROL OF COLLOIDAL CHARACTERISTICS OF NON-ISOCYANATE POLYURETHANE NANOPARTICLES PREPARED BY NANOPRECIPITATION

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Nanoprecipitation is a straightforward method to obtain nano-sized polymeric particles. Nanoparticles from different polymers have already been prepared by this technique[1], but very few studies have focused on polyurethane polymers, despite their excellent mechanical properties and biocompatibility. Polyurethanes are usually synthesized by polyaddition of polyols and diisocyanates. However, for a few decades, the trend towards a greener and less toxic chemistry has encouraged research projects on non-isocyanate polyurethanes (NIPU). The greenest and most straightforward way to synthesize non-isocyanate polyurethanes is the polyaddition of bis-5(cyclic carbonate)s and diamines. The resulting polymer is called a poly(hydroxy)urethane (PHU) because of the presence of primary and secondary hydroxyl groups hanging off the main polymer chain that offers the possibility to post-functionalize the hydroxyl groups with chemical or biological functionalities[2]. We recently investigated the synthesis of PHU from hexamethylenediamine and sebacic bis-(cyclic carbonate), a bio-based cyclic carbonate and demonstrated that the nanoprecipitation technique was suitable for the preparation of PHU nanoparticles using DMSO or ethanol as the organic solvent[3]. The purpose of the present study was the improvement of the nanoprecipitation method applied to this novel polymer by the means of a full factorial design. Unlike the 'one-factor-at-a-time approach', this strategy allows determining not only the main effects of the experimental factors studied on the responses of interest but also their interaction effects. Here, we investigated the main effects and interaction effects of three independent variables − polymer concentration in the organic phase (X_1), water volume (X_2) and surfactant concentration in the aqueous phase (X_3) − on two responses – particle mean size (Y_1) and size distribution polydispersity (Y_2). In the meantime, a better understanding of the physical-chemical phenomena involved during the process is provided. Furthermore, we intended to determine the experimental conditions inducing the minimal size and PDI values. The surfactant concentration and its effect on micelles formation was particularly examined. Finally, we attempted to connect the nanosuspension stability over time with the initial characteristics of PHU nanoparticles.

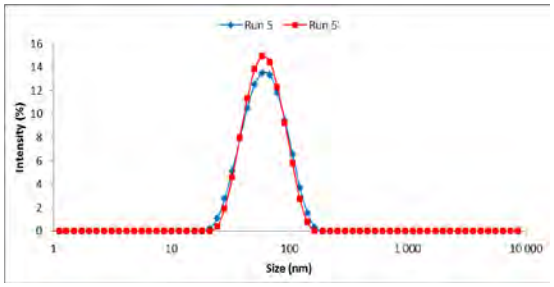

Figure 1 : Nanoparticle size distribution for sample 5 and 5'([PHU]=1g/l, V_{water} = 50 ml, [SDS]= 25.0 mmol/l)

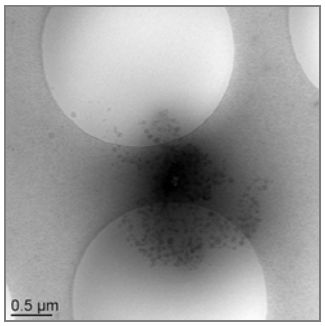

Figure 2: Cryo-TEM image of sample 8 after 57 days ([PHU]=5g/l, V_{water} = 150 ml, [SDS]= 25.0 mmol/l)

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CONCENTRATED SILICONE EMULSIONS: HOW TO PREDICT THEIR SHELF LIFE?

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Silicones represent a class of organic-inorganic polymers based on silicon that exist in a variety of forms[1]. For more than 70 years, they have been applied in many industries and have expanded in a diverse assortment of product types and applications. Due to their unusual surface properties, their resistance to the effects of weather and their ability to perform over a wide temperature range, silicones find many uses in the 21st century.
In addition to their unique features as pure materials, silicones often need to be formulated and delivered in an aqueous emulsion format[2]. It provides a convenient means for handling highly viscous substances, solvent free while being easy to clean. This product form is present in a range of key markets including: Personal care, Coatings, Textiles, Paper coating, Antifoam, Construction, etc

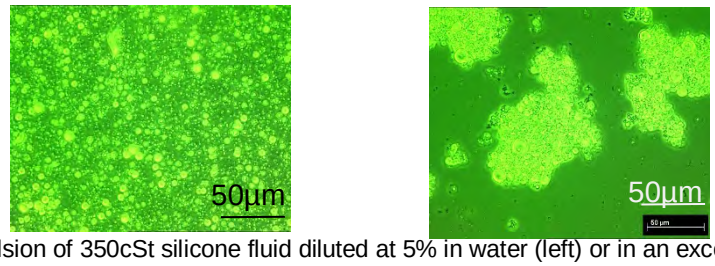

Figure: Coarse emulsion of 350cSt silicone fluid diluted at 5% in water (left) or in an excess of surfactant (right). An excess of surfactant induces the emulsion to flocculate through depletion.

While designing a silicone emulsion to perform in a final product application is challenging, its stability[3] over time is critical too. Creaming, freeze thaw, stability at high temperature, shear stability and electrolyte stability are some examples of hurdles that can be encountered by the product during its shelf life.
In this work, we will show that detection and prediction of the stability of concentrated emulsions are challenging and sometimes misleading. Indeed, these systems tend to gel in the presence of an excess of surfactant and depending on the sample volume, phase separation can occur. Multiple light scattering technique (Turbiscan) may not be able detect this gelation process besides, the phase separation being volume dependent, may not occur in 20mL measurement cells. However, Diffusion Wave Spectroscopy (DWS) based microrheology (Rheolaser Master), is a powerful tool to study weak gelation phenomena in concentrated emulsions, which is a precursor of phase separation. Thus, the combination of multiple light scattering and microrheology can overcome some of the issues faced to when working with concentrated systems.

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Emulsification of viscous bio-based alkyd resin by catastrophic phase inversion

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The extensive use of alkyd resins in coating industry stimulates the studies to obtain O/W emulsions and understand the influence of different variables in the water fraction required to the inversion and the final droplet size. Highly viscous bio-based isosorbide polyester resin is used to formulate a O/W emulsion by catastrophic phase inversion. Water was added to 20g of the viscous resin which contains a hydrophilic polyethoxylated surfactant (Brij O20) until the water/oil weight proportion is approximately equal. Temperature was fixed at 50°C and agitation speed at 400 rpm. The inversion is followed by conductivity, torque (figure 1) and light backscattering in order to compare the different signals and their performance to track the inversion[1,2].

Carboxylic functions in the resin can be neutralized with KOH. For non-neutralized resin, a polydispersed distribution with an average diameter of 1µm was attained at 3wt.% Brij O20 final concentration and a flowrate of 0.5mL/min of water. At the same conditions, for neutralized resins the droplet size is lower (200-300nm) and the emulsion has a narrow distribution. When the percent of neutralization increases, the water fraction at which the inversion occurs also increases. Neutralization of the resin must incorporate some small amphiphilic anionic molecules at the interface increasing the hydrophilicity of the system and widening the hysteresis zone [1].

The increase of the water flow rate (0.05-0.5 mL/min) increases the droplet size and diminishes the “inversion point”. The increase of surfactant concentration allows get smaller droplets, but emulsions with concentrations higher than 4%wt show asymptotic behaviour[1]. Different studied parameters allow optimize the final conditions and minimize the droplet size.

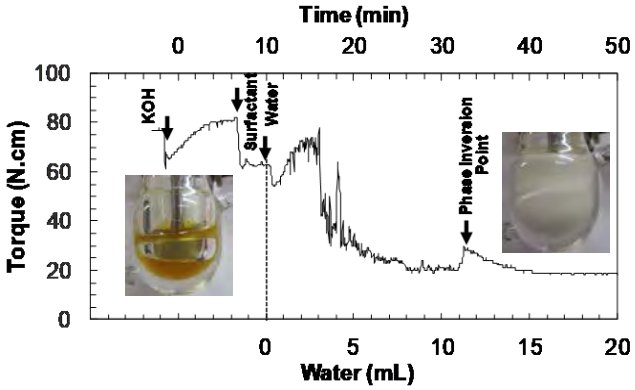

Figure 1. Torque of the BrijO20/isosorbide resin/0.01M $NaCl_{(aq)}$ system as function of the time and the water added to the neutralized viscous resin.

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Crude oil based WIII microemulsions of anionic/non-ionic surfactants determined by dynamic phase inversion scanning

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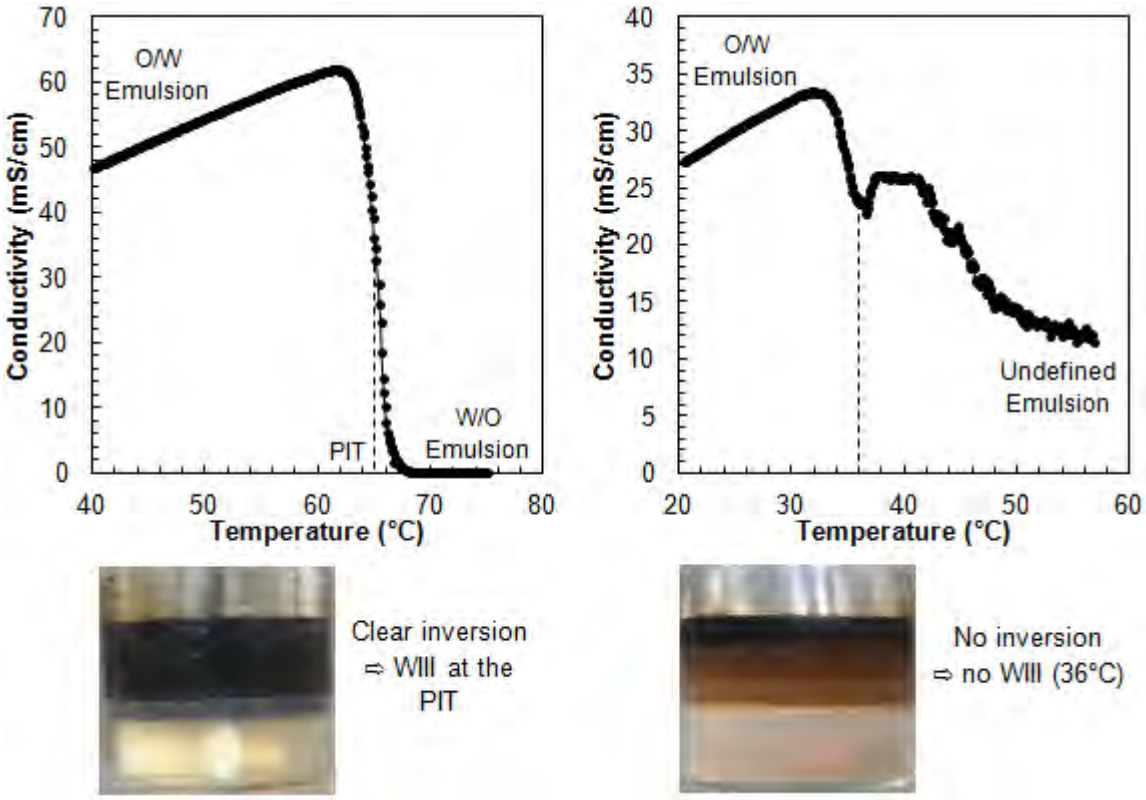
Since the introduction of the term "microemulsion" by Schulman in 1959, its formulation has become a promising area of interest for academics and industrials. Microemulsions are macroscopically anisotropic systems composed at least of oil, water and surfactant which are stable thermodynamically[1]. Besides of being stable, they have also an ultra-low interfacial tension (10^{-3} mN/m) when they form three phase behavior (WIII systems) and can be applied to different fields such as cosmetics, catalysis or enhanced oil recovery. Obtaining these systems, also called "optimal" formulation, is not trivial due to the large number of formulation parameters to consider. It depends not only of the amount and nature of surfactants added, but also of the aqueous phase salinity, the oil nature (EACN), temperature and pressure. "Optimal" formulations can be accurately predicted for pure oils from the semi-empirical HLD equation[2] but the prediction is much less reliable for more complicated oils such as crude oils. The attainment of the optimal formulation is traditionally carried out by time-consuming salinity scans with equilibrated formulations at a defined temperature to identify the best surfactant system for a given crude oil. This work highlights a new and fast method to determine these key parameters by detecting the "dynamic" Phase Inversion Temperature (PIT) of surfactant/crude oil/water systems. Considering the PIT shifts as well as the shape of conductivity-temperature profiles, it is possible to infer useful information such as precise crude oil EACN, Winsor III relation between salinity and temperature as well as the presence or not of WIII microemulsion related to the surfactant system used. The PIT allows also classifying pure and technical surfactants regarding their hydrophilic behavior using the PIT-slope method[3], which can be a useful tool to adapt the surfactant system to the crude oil considered.



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STUDY OF ORGANIC/INORGANIC SUSPENSIONS: THE CASE OF CEMENT SUSPENSIONS CONTAINING LATEXES.

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Cement can be considered as a reactive suspension that evolves over time. The addition of latex particles to the cement suspension has considerable benefits on adhesion and cement mechanical properties [1-2]. However, there is still a lack of knowledge concerning the link between the latex structure, the interaction of polymers with the mineral suspension and the mechanical property of this organic/inorganic nanocomposite. It is difficult to identify and characterize the relevant parameters that trigger the mechanical properties of cement and therefore to develop sufficiently well controlled materials.

Here we present a "step-by-step" physicochemical approach to studying the interactions between latex and cement suspensions. Commercial latexes are often sold as powders after a spray drying process during which mineral charges are added. The first step was to selectively remove these charges by an adapted centrifugation protocol which could distinguish the two types of particles. This process is efficient because most of the fillers can be removed from the commercial latex. The second step was to study the behavior of commercial cleaned latexes in the cement pore solution. During the third step we developed a method to quantify the latex/cement suspension interactions. Since the cement suspension is complex and reactive, we first carried out the study on a non-reactive system such as gypsum suspensions. The results shows the possibility of quantifying the amount of latex that “interacts” with gypsum and among them, we determined the proportion of irreversibly adsorbed latex. The first results put into evidence the strong attractive interaction between latex and gypsum. The next step will be to transpose this study to cement.

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On the effects of drop size distribution, dispersed phase volume fraction, and dispersed phase viscosity in emulsion rheology

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Rheological properties of emulsions are of considerable importance across different household products. For example, sensory evaluation of food emulsions such as mayonnaise and ice cream are related to their rheological properties. In this research, the rheological behaviour of oil-in-water (O/W) emulsions is studied over a broad range of drop size distributions, dispersed phase volume fraction and dispersed phase viscosity. High volume fraction emulsions were created using an in-line rotor-stator mixer, and then diluted to lower volume fractions. The drop size distribution of the highly concentrated emulsions does not change when subsequently diluted to the lower concentrations.

The yield stress of different high volume emulsions were measured using steady stress sweep and the viscosity could be modelled using Herschel-Bulkley type equation. The consistency index for different volume fractions was found to be predictable by a Krieger-Dougherty style model. The linear viscoelastic (LVE) range of each emulsion was determined with an amplitude sweep, followed by a frequency sweep and creep test to determine its long term stability and viscoelastic properties. Results showed that the emulsion rheology is strongly dependent on its Sauter mean diameter and dispersed phase volume fraction but not the dispersed phase viscosity.

DISSOLUTION OF SURFACTANT LAMELLAR PHASES

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Formulated products are an essential part of everyday life. They are available everyway we look from toothpaste to salad dressing and from motor oil to make up. These products seems different but they share common components like oil, water, particles and surfactants. Surfactants have some applications like stabilize emulsions and foams, adding lubricity to surfaces, including detergent properties besides other applications. Therefore, surfactant dissolution is important in formulated product preparation and in their applications.

The main goal of this study is to provide further insight into the surfactant dissolution process and to examine the effect of changing the degree of surfactant hydrophobicity on the dissolution process of surfactants. To achieve this goal dissipative particle dynamics (DPD) simulations are used. The initial surfactant system contained surfactant molecules in solvent at 80%, forming a lamellar phase. Each surfactant molecule was modelled as a chain of beads (AAABC) representing of a block of 3 C3HnF6–n groups (A beads) a block of two EO2 groups (B beads) and a SO3 - groups (C bead). The solvent particle is represented by a single sphere of (W) representing 4 molecules of water (H2O).

The initial lamellar phases produced under equilibrium simulations were placed next to a box of water beads. After relaxation, the lamellar phase was then allowed to dissolve into the water. Results showed that increasing the hydrophobicity of the surfactant made it more difficult for the water to penetrate into the lamellar phase. While increasing the hydrophilicity slightly increased the breakup time for the lamellar phase, when compared to the time of the lamellar phase breakup in the original system. Moreover, the dissolution of the surfactant with higher hydrophobicity produces micelles which are more elongated and worm-like in nature. In conclusion, surfactants with more hydrophobic tails take longer for the lamellar phase to break down and to dissolve fully into the box and hence effect their preparation and usage.

FORMULATION OF MIXED MOLECULAR/MACROMOLECULAR HYDROGELS BASED ON MODIFIED AMINOACIDS AND POLYSACCHARIDE

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Hydrogels find numerous applications in formulated products. Their rheological properties leading to liquid-like or solid-like mechanical behaviour according to external stress are key aspects for reaching targeted performances in operating conditions. Physical hydrogels rely on molecules or/and macromolecules interacting through low energy interactions (e.g. hydrogen bonds) and on physical entanglements between supra- or macromolecular species. Improving the control of the rheological properties requires more insight about the links between the molecular/supramolecular scale and the macroscopic physical properties. Thus it is of primary interest to characterize such hydrogels by combining spectroscopic and rheological techniques. In that work, a natural aminoacid, lysine, has been chemically modified for synthesizing three gelating compounds with similar structures and differing from each other by one or two functional groups. All three molecules were fully soluble in dimethylsulfoxide (DMSO) and gelled DMSO/H_2O mixtures with various compositions. Hydrogels could be produced by following a specific formulation procedure involving dialysis of DMSO/H_2O gels. Mechanical strength of the gels, thermal/mechanical reversibility, temperature of gel-sol transition as well as kinetics of gel formation were correlated to the chemical structure of the gelators as well as to the composition of solvent. The results of visual observation, rheological measurements and Raman spectra were compared (Figure 1). We demonstrated that subtle variations in the chemical structure of the gelator dramatically modified some properties like the time for gel formation (which varied between 10 and 5000 s) or thermal reversibility. The formulation pathway must be adapted to the gelling behaviour of each molecule. In addition a specific geometry was designed for rheological measurements. A non-ionic polysaccharide (dextran, $M_w \approx 400{,}000$ g.mol^{-1}) was added and the resulting modification of gel properties was investigated below and above its critical overlap concentration. According to the formulation of gels, their macroscopic properties could be adapted to specific applications.

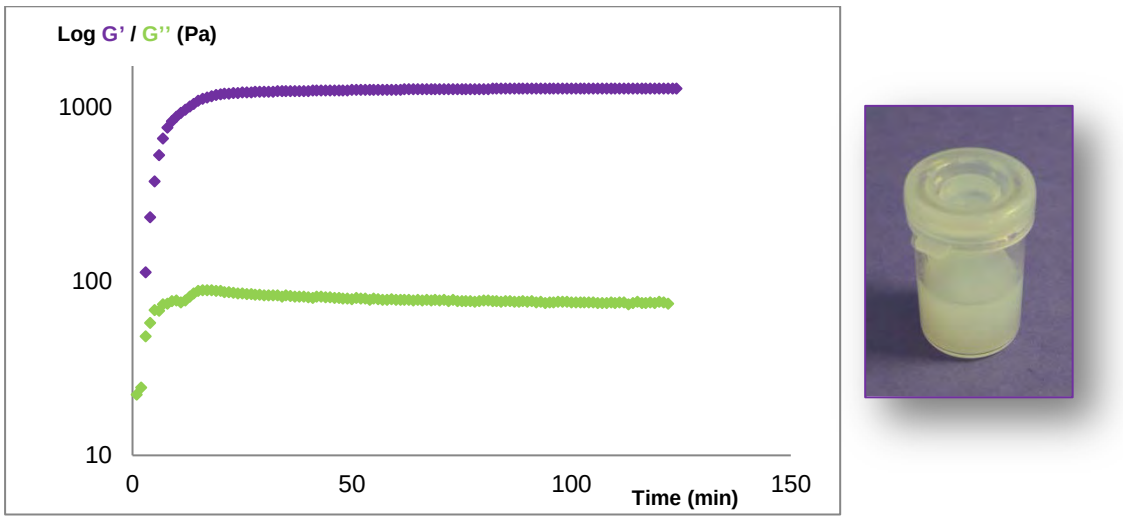

Figure 1: Left. Storage and loss modulus vs time for the gel formed by one lysine derivative (5 mg) in a mixture of DMSO (0.6 mL) and water (1.4 mL) at room temperature (stress : 1 Pa, ω : 10 rad/s). Right. Visual aspect of the gel after 1 day.

FORMULATION OF ENVIRONMENTALLY FRIENDLY COSMETIC CREAMS

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A cosmetic cream in semi-solid state is used as a barrier, moisturiser and carrier to protect, hydrate and deliver active ingredients to skin. These are generally formulated with water, oil and surfactant. 10-20 w/w% surfactants are normally involved in the formula, in order to emulsify and stabilize the thermodynamically metastable state. With the enhancement of public awareness of environmental pollution, considerable attention has been given to biological derived surface-active compounds instead of their counterparts of petroleum origin, due to their excellent surface activity and environmentally friendly properties.

Flow properties such as texture, consistency, greasiness, and stability of cosmetic creams directly determine the quality of products and the expectation of consumers to them. Rheological measurements are very useful in the development of consumer-satisfied products and optimisation of manufacturing process, where the flow and deformation behaviours of products can be revealed and predicted.

This project studies the effect of hand cream formulation with and without a biosurfactant on the product rheology. The base system contains cetyl alcohol (CA), glycerol monostearate (GM), and Sodium lauryl ether sulfate (SLES) with paraffin in water. Instead of the chemically synthesized surfactants, the cream was reformulated with Sophorolipid and Mannosylerythritol (MELs). In addition, vegetable derived oils were applied in replacement of mixed paraffin oils in the formulation. The products were analysed under steady state shear, dynamic oscillatory, and creep tests. Experimental results determined optimum rheological cream-like properties in products containing 4%wt SLES, 6%wt CA and 2%wt GM, and revealed that the product became less viscous and easier to flow when SLES concentration was increased. This is in part due to the surfactant structure, but also the paraffin droplet size achieved, analysed using a Mastersizer 3000. The average droplet size of the system with 2%wt SLES doubled that with 6%wt. Bio cream was successfully prepared with similar rheological properties comparable to the base system.

FORMULATION OF NANOTECHNOLOGIES FOR THE DELIVERY OF NUCLEIC ACIDS

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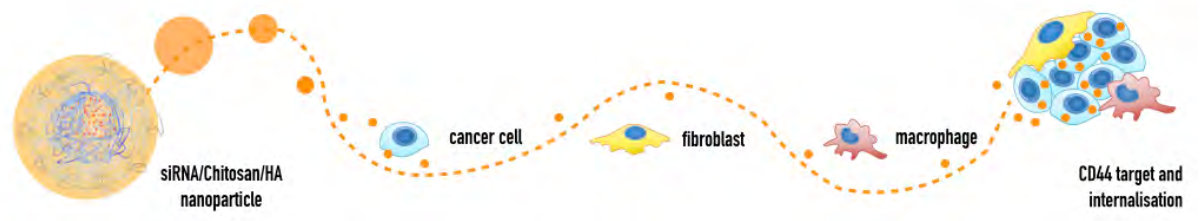
Over the past years, the delivery of small nucleic acid sequences in target cells using nanoparticles has been proven challenging. To improve the selectivity and delivery of anticancer therapeutics, and reduce side effects, it is necessary to design an effective strategy. Nanotechnologies can be engineered and formulated to enhance target-ligand interactions, promote internalization and intracellular release to effectively address the clinical need.

In the recent years, we have developed and optimised ternary nanocomplexes to deliver small nucleic acid sequences to cancer cells. Polycations varying in physicochemical properties were complexed with siRNA, or mRNA. Nanoparticles were decorated with hyaluronic acid (HA) to exploit the interaction with CD44-expressing cancer cells. We evaluated the role of chitosan macromolecular properties (e.g. molecular weight; degree of deacetylation) and correlate it with nanoparticle properties (e.g. complexation strength, nucleic acid protection, internalization rate).

The interaction between chitosans and siRNA showed protection of the cargo, regardless the chitosan used. Chitosans with higher deacetylation degree showed higher avidity towards encapsulated siRNA. Interestingly, such avidity of chitosan for RNA lead also to higher transfection efficiency. We further characterised the selected chitosan/HA formulation (higher transfection efficiency), and demonstrated that the decoration of nanoparticles with HA, not only promote the internalisation in CD44-expressing cancer cells, but also improved the stability and efficacy of siRNA transfection after storage (one-week, 4°C). We finally demonstrated nanoparticle internalization (flow cytometry), siRNA cytosolic release (confocal microscopy) and gene silencing (RT-qPCR) in CD44+/KRAS+ colorectal cancer cell line, HCT-116. Further we demonstrated that the uptake of HA-decorated nanoparticles in cancer cells is higher when co-cultured with fibroblasts and when tested under perfusion.

ACKNOWLEGMENTS: The authors acknowledge the support of AstraZeneca through the establishment of the NorthWest Centre for Advanced Drug Delivery (NoWCADD) at the University of Manchester, and the Innovate UK under project number 101710.



NEW ADDITIVES TO FULFILL THE REQUIREMENTS OF RELEASE COATING APPLICATIONS

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Nowadays, silicones coatings are more and more spread around the world thanks to their outstanding properties such as low glass transition temperature, low surface tension, high thermal stability, good water repellency and innocuity [1] [2]. Among all the applications, the release coating applications represents more than 50 billion square meter of release liners, mainly for label applications thanks to silicone's low Tg and surface tension and for food contact applications thanks to silicone innocuity [3].

As the world population increases, the demand of release liners based on silicone increases as well. The required increase of productivity is achieved by increasing the speed of coating machines. However, such increase of speed leads to some drawbacks such as formation of aerosol (misting), poor adherence of the silicone onto specific substrates, or foaming.

The challenge is thus to provide new additives fulfilling the requirements of the different market for release coating applications. In this presentation, it will be showcased a new anti-misting agent based on ionic compounds which decreases misting around the coating head [4], leading to safer and more reliable coating conditions. When silicone coatings are used on filmic substrates, the formulation plays an important role to achieve the right level of anchorage. New anchorage additives, specifically adapted for silicone emulsions or solventless silicone compositions, containing moreover less VOC than conventional additives, have been designed in order to promote adhesion of silicone coatings onto PET films [5]. Finally, by increasing the speed of paper machines producing bakery papers, it is important to control the runnability of the machine by controlling the foam. This can be achieved thanks to a specific anti-foam emulsion additive which improves greatly the processability leading to less spillage of silicone emulsions, more consistent quality of bakery papers, used every day by every one of you!

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PREDICTIVE SCIENCES AND HIGH THROUGHPUT SCREENING COMBINED FOR EFFICIENT FORMULATION DEVELOPMENTS

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VLCI, Amsterdam, Netherlands

The applied predictive formulation sciences, Hansen Solubility Parameters (HSP) and Hydrophilic Lipophilic Difference – Net Average Curvature (HLD-NAC) are very powerful to find matching ingredients, resulting in improved stability and efficacy of end-products. These models are applicable to solutions, dispersions and emulsions, which basically includes all types of formulated products. Although they have been applied for many years, there is still a limited use in formulation developments and ingredients thereof. The equations of these sciences require (practical) parameters of the ingredients and once generated, compatible ingredients can be predicted to develop and optimize specific formulations. The ingredient data generated from these models is predictive and sustainable: you can use them over and over, allowing to move away from trial-and-error and improve digitalization into product developments. A very efficient way to enhance the properties and reduce complexity, time and cost in the development of formulations or ingredients. When combined with High Throughput (HT) screening for automated, parallel and small-scale preparation of samples and end-products, further efficiency can be achieved. The predictive sciences and the required ingredient parameters will be explained via practical applications to showcase how this can lead to efficient product developments, even making incompatible ingredients compatible with the rest of the formulation. Also, how to further increase efficiency by means of HT screening will be explained and why this is needed to fill up the ingredient database for these predictive sciences.

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FORMULATION OF DELIVERY SYSTEMS FOR CAROTENOID-RICH EXTRACTS FROM MICROALGAE

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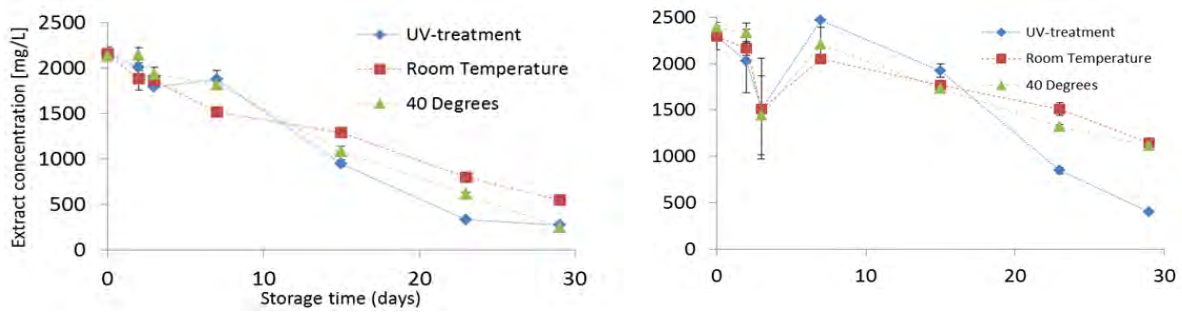
Abstract Text

High interest in dietary carotenoids stems from their antioxidant properties and ability to alleviate chronic diseases. However, carotenoids are very prone to oxidative degradation by a number of factors. The choice of delivery system used to incorporate hydrophobic carotenoids in aqueous matrices as well as the choice of ingredients and processing conditions will influence the chemical stability and eventual bioavailability of the carotenoids. Studies in the open literature report on the advantages of lipid nanoparticle dispersions over nanoemulsions in regards to their ability to protect single carotenoids against chemical degradation. However, it is uncertain whether such tendencies can be extrapolated to complex mixtures of carotenoids, such as those being produced during biorefinery separation processes. This aspect is addressed in the study described here where an extract from microalgae, containing approximately 30% w carotenoids (mostly β-carotene), was incorporated into o/w nanoemulsions and suspensions of nanostructured lipid carriers (NLC) prepared by means of high pressure microfluidisation. The physical stability of the delivery systems as well as the chemical stability of the carotenoids in these formulations under a different set of conditions was followed over time. Physical stability was assessed by monitoring variations in visual appearance and drop size distribution while chemical degradation of the carotenoids was followed by means of UV-vis spectrophotometry. Nanoemulsions and NLCs containing 0.25% of the extract and displaying good physical stability at room temperature over at least 2 weeks, were obtained with lecithin, medium chain triglycerides (MCT) as well as MCT /stearic acid and MCT/carnuba wax, respectively. Among these systems and contrary to what has been reported for single carotenoids, the nanoemulsion provided much better protection than the NLCs against carotenoid degradation. This finding is discussed in terms of the microstructure differences between NLCs particles and emulsion drops.

MCT/Stearic acid NLC MCT nano emulsion



Variations in carotenoid concentration in NLC and nanoemulsion formulations as a consequence of chemical degradation under different storage conditions.

AGEING OF SUSPENSIONS – CAN WE BETTER UNDERSTAND THEIR STABILITY AND DESIGN FORMULATIONS WITH IMPROVED STABILITY?

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Abstract

Suspension formulations are typically weak gels stabilised against gravitational separation by a mechanically rigid network. For many suspensions, this network is formed from particles with attractive interactions that reversibly aggregate. This reversibility is on one hand useful, since it allows the suspensions to flow when applied, for example as in paints, consumer products and crop protection flowables. However, on the other hand it can be detrimental to stability since it allows the network to age through the rearrangement over time of the particles in the network, and to ultimately fail and collapse under gravity.

To understand the ageing and failure processes, bespoke low invasive vane rheology and tracer particle tracking techniques have been used with model refractive index matched silicone oil emulsions, with attractive interactions to form weak reversible gels that show both the ageing and failure processes.

Low invasive rheology reveals how the network strength changes during the ageing process and unexpectedly reveals that the network strength increases with network age. However, at a particular age, the network strength rapidly decreases and the network and sample collapses. This raises an interesting quandary, since if the network is increasing in strength why does it collapse?

Complimentary particle tracking of tracer particles in ageing gel networks reveals the presence of localised intermittent flows within the sample prior to collapse, and at the point of collapse, chaotic flows that spread throughout the whole sample.

When combined this knowledge gives us a valuable understanding both for what information is required to predict the stability of suspensions, and also how to design formulations with improved stability. An example will be shown where added low density particles in combination with a low yield stress provide a solution to gravitational separation without the cost of high viscosities.

PIT-SLOPE, EACN AND COSMO-RS AS USEFUL EXPERIMENTAL AND THEORETICAL TOOLS TO PREDICT PROPERTIES AND RATIONALIZE SURFACTANT/OIL/WATER SYSTEMS

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Formulated systems are complex matrices with many ingredients, often incompatible, and likely to interact. To avoid a long and tedious traditional trial and error approach, it seems appropriate to have robust experimental and theoretical tools which will help in predicting, understanding and rationalizing the behavior of some components in order to be able, *in fine,* to establish relationships between chemical structures, physicochemical properties and functional properties. The CÏSCO research group of the University of Lille has been developing and using new experimental methods and conceptual tools for several years. We will illustrate, through concrete examples, the method that we named "PIT-slope" which is particularly robust for surfactants and additives to quantify their amphiphilicity (Fig.1A), the EACN (Equivalent Alkane Carbon Number) which provides a useful classification of perfumes and complex oils (Fig. 1B), and how it can be related to their solubilization in water, and finally, the COSMO-RS method which can predict some physicochemical properties of biosourced emollients in order to substitute silicones (Fig.1C).

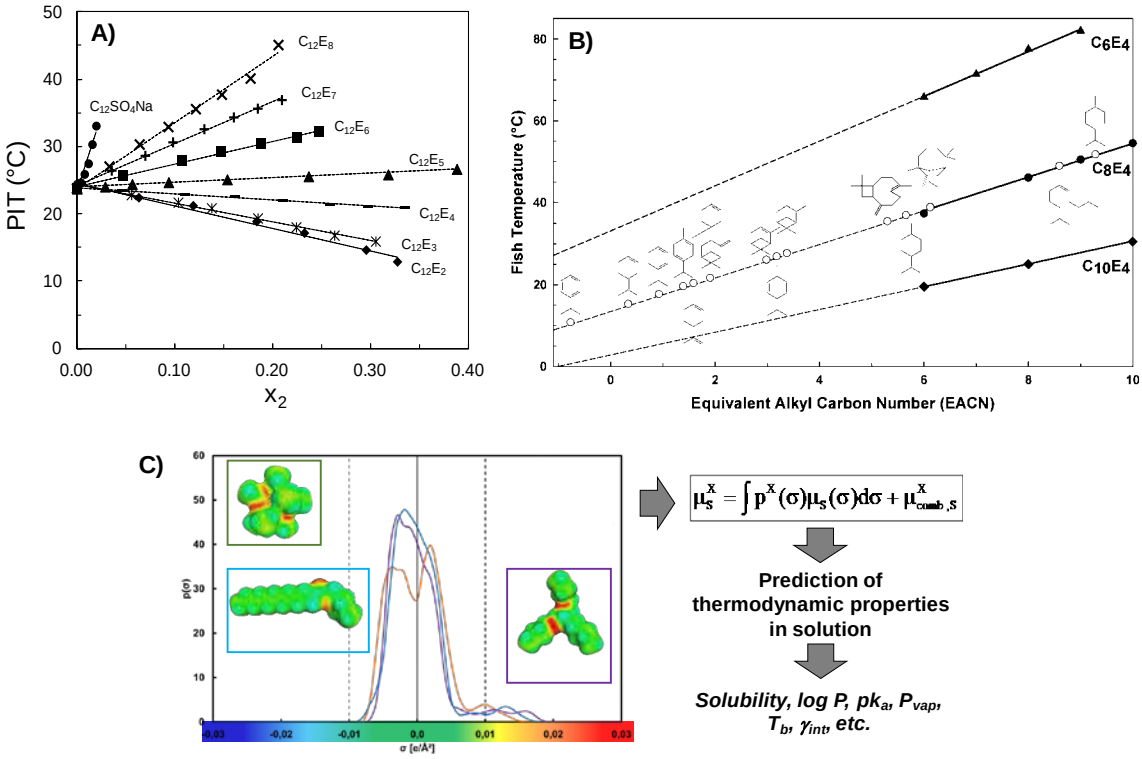

Figure 1. A) PIT-SLOPE method ofr the *classification of surfactants.* B) EACN scale for the *classification of terpenes.* C) COSMO-RS modelling for the *prediction of oils and surfactants properties.*

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ACCESSIBLE COMPUTER AIDED FORMULATION

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In civil and mechanical engineering, the design process is done almost entirely by computer. A long-held goal in formulated product design is to shift from an ad hoc labor-intensive and expensive process towards a more robust and adaptive computer aided formulation (CAF) paradigm. Recently, Formeric, have developed computational simulation methods and analytics to drive a radical change in speed of formulated product design for manufacturability and in-use performance. The goals of this work are enhanced de novo formulation design, shorter time to market, adaptive response to supply chain variability, and encouraging the adoption of formulation for sustainability. The ability to formulate virtually allows for acceleration of R&D processes, smoother development of new products, especially for high value manufacturing markets where growth arise from high R&D intensive efforts. These computer aided formulation tools are made possible by leveraging the latest cloud based platforms (e.g., AWS) methodologies. Our state-of-the-art computational models serve to advise the industrial chemist which formulations can be applied to produce products with the desired properties. In this talk we discuss the methods used in our CAF framework, highlighting successes and indicating where opportunities exist to develop the framework further. We present how the framework is being used to understand products in the fast-moving consumer goods and petrochemicals industries.

UNDERSTANDING CHEMOMECHANICAL INTERACTIONS DURING HARD SURFACE CLEANING PROCESSES

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The chemical function of detergents, has been carefully studied in the literature review, however, the chemical interactions with the surface that occurs during the cleaning process of hard surfaces, in combination with the mechanical interactions are still under investigation. So the purpose of this project is to understand the variables that affect cleaning and include them in models that will characterise this process.

To achieve the understanding of chemical and mechanical interaction during cleaning, the Mini Traction Machine (MTM) was used. The MTM is a tribometer that measures frictional properties of lubricated and unlubricated contacts. The main reason why this equipment was chosen, was to correlate cleaning rate with the friction applied during cleaning. For this purpose, tomato puree was placed on the discs and then in the oven (1h, 110oC). The mass of the burnt tomato was measured. The experiment was mainly examining the effect of different parameters such as normal load, speed, mass and concentration of surfactant.

The cleaning rate was steady throughout the whole cleaning process. The conclusions that can be extracted from the results are mainly about the effect of the different parameters in cleaning. The mass of tomato does not affect the cleaning rate. With an increase in load the cleaning rate is increasing as well, but the increase between 1 and 2.5 N is much larger than the increase between 2.5 and 5 N. By increasing the speed the cleaning rate is increasing as well. By adding a surfactant the cleaning rate seems mainly to stay constant. This probably happens because the detergents are adding lubrication to the system. The traction coefficient curves have similar behaviour in all cases.

Encapsulation of Water-in-Water (W/W) Emulsions inside Polyelectrolyte Capsules

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Water-in-water (W/W) emulsions are dispersions of one aqueous phase, forming droplets, into another aqueous phase [1-4]. These emulsions can be prepared in Aqueous Two-Phase Systems (ATPS), in which phase segregation occurs because of thermodynamic incompatibility between two hydrophilic components, mainly due to differences in hydration between the two water-soluble components [2,3]. Therefore, W/W emulsions can be prepared by applying agitation in aqueous biphasic systems, without oil and without surfactant. It is known that Water-in-Water emulsions can be stabilized by particles able to adsorb at the W/W interface [5], forming Pickering emulsions. These fat-free dispersions can be highly interesting for food and drug delivery applications.

In the present work, W/W emulsions were prepared using a highly charged anionic polyelectrolyte (either sodium alginate or sodium carboxymethyl cellulose, NaCMC), mixed in aqueous solution with a lowly charged globular protein (bovine serum albumin, BSA). These combinations of macromolecules showed phase separation, forming ATPS, and their phase behaviour was studied. BSA-in-alginate and BSA-in-NaCMC water-in-water emulsions were formed and characterized. Such emulsions showed to be relatively stable, which was attributed to the high viscosity of either alginate or NaCMC aqueous phases.

These W/W emulsions were introduced inside capsules, by dropping emulsions into a third aqueous solution, which contained a multivalent cation (Ca^{2+} or Fe^{3+}). The anionic polyelectrolytes (either alginate or NaCMC) formed ionic complexes with Ca^{2+} or Fe^{3+}, producing capsules that contained W/W emulsions in the interior. These capsules can have a smooth surface (made of polyelectrolyte-cation complexes) and a highly porous interior (formed by the presence of W/W emulsion droplets). Fig. 1 shows a scheme of capsules (a); the visual aspect of capsules formed with Fe^{3+} (b); and illustrative examples of Scanning Electron Microscopy images of capsules, (c) and (d). The porous structure of dried capsules (Fig. 1d) was characterized by nitrogen sorption, confirming the macroporous nature. These porous capsules might have interesting applications in encapsulation of active components (drugs, fragrances, etc.), and various possibilities are being evaluated.

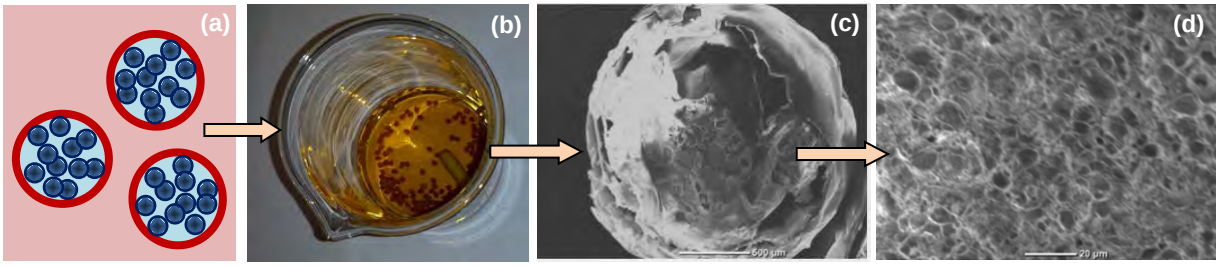

Fig. 1. (a) Scheme of encapsulated W/W emulsions; (b) Example of freshly formed capsules; (c) SEM image of a partly fractured capsule; and (d) Example of the macroporous interior of a freeze-dried capsule.

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LIQUID-LIQUID MIXING FACILITIES FOR DEVELOPMENT OF MODEL PREDICTIVE CONTROL FOR INDUSTRIAL SCALE-UP

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A research facility for liquid mixing at scales ranging from 1 to 1000 L was established by CPI in a joint project with the Universities of Birmingham, Edinburgh and Leeds. This state-of-the-art facility enables academics and industrialists to develop, prove, prototype and scale-up the next generation of products and optimise their process. The facility allows a deep understanding of mixing processes at small scale, utilising a range of process analytical technology (PAT) in conjunction with state-of-the-art software for real-time data analysis. The information gained at small scale is used to scale the process to 1000L and beyond, by combining the hardware with validated Computational Fluid Dynamics (CFD) models. This approach accelerates and de-risks the translation of laboratory innovations into new products and processes for commercial companies of all sizes, as well as significantly reducing the cost of scaling up. The hardware control and data fusion software (Perceptive Engineering) allows us to implement an advanced process control model for real-time prediction of formulation properties such as particle size and viscosity, and the detection of process abnormalities.

The new facility has two major functions:

1. Developing, validating and utilising new Process Analytics Technologies (PAT) and process analytics capabilities.
2. Understanding the universal principles of liquid formulation processing at different scales and building predictive models for scale-up.

We will present results validating a new on-line viscometer using a combination of CFD calculations and experiments. The setup was optimised for flow pattern and sensor coverage to ensure the highest level of accuracy and precision in the measurements. We will also present data optimising a model formulation process which demonstrates the capability of the facility. By combining a classic design of experiments approach with step-change experiments and PRBS, we were able to understand and optimise the process from bench scale to pilot plant scale.

STUDY OF THE DISPERSION BEHAVIOR OF AQUEOUS SUSPENSIONS OF TITANIA NANOPOWDER

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Titanium dioxide (TiO_2) is used for a wide range of applications in electronic, photocatalytic and electrochemical systems. The elaboration of ceramics based on titanium dioxide requires the preparation of stable concentrated suspension in which the dispersant enhances their colloidal stability. In this work, the effect of two kinds of dispersants (Tiron and dopamine) on the stability of TiO_2 suspensions was studied. Despite the chemical similarity between these two molecules, their effect on the surface chemistry of TiO_2 nanoparticles is different. Zeta potential, hydrodynamic size and rheological measurements were carried out in order to investigate the behavior of diluted and concentrated titania dispersion as function of dispersant ratio and suspension pH. It was proved that the viscosity of the titania dispersion is mainly governed by the nanoparticles size to which many parameters are involved. The studied dispersions were used to prepare granules, used in the ceramic elaboration process.

A SYSTEMS-BASED APPROACH TO DIGITAL DESIGN AND OPERATION IN THE FORMULATION OF PHARMACEUTICALS

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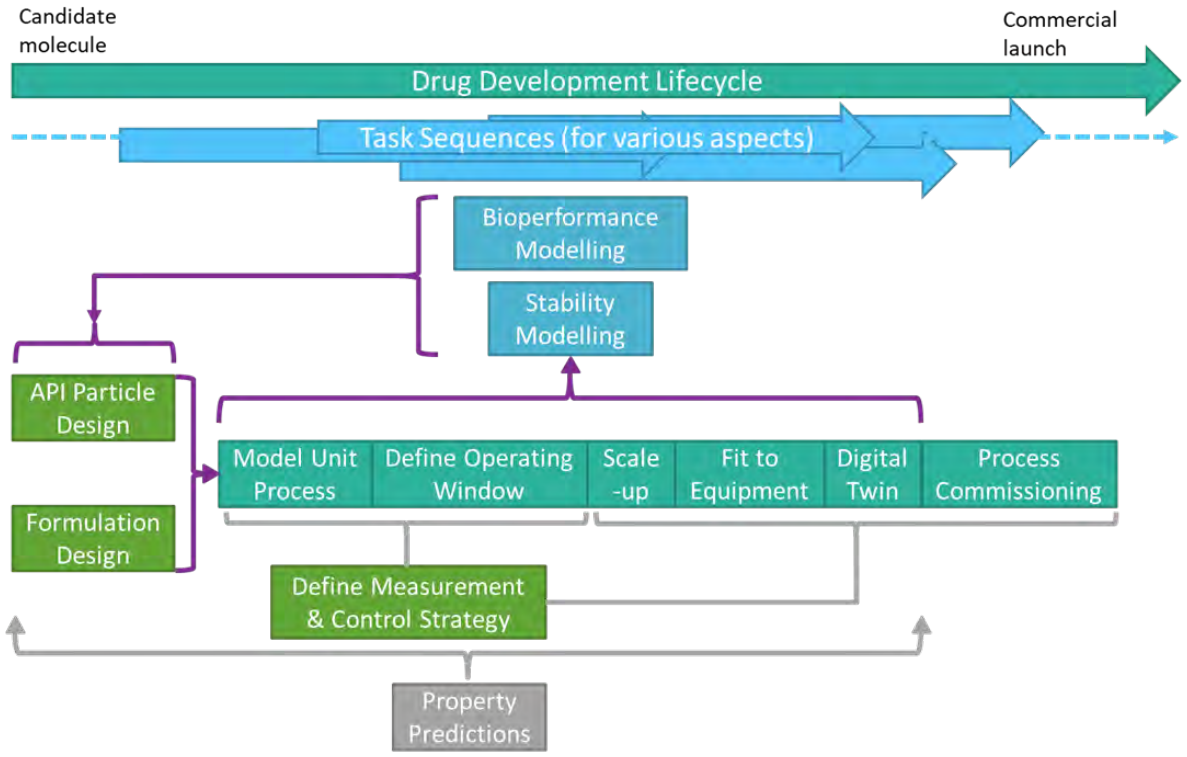
The formulation of drug products (e.g. tablets) requires the properties of the active pharmaceutical ingredient (API) particle and the excipients to be optimised along with the manufacturing process, to ensure that the requirements for product performance, stability and manufacturability are met.

Digital Design combines research insight and qualitative and quantitative mechanistic modelling to provide links between raw materials, manufacturing processes and product performance to deliver the needs of the patient. Work carried out under a major UK-based design, manufacture and supply chain collaboration has defined a system for Digital Design and Operation for drug products and their manufacturing processes. Through a dedicated technical facilitation process, the members of the ADDoPT (Advanced Digital Design of Pharmaceutical Therapeutics) consortium have developed an Information Flow for digital design and manufacture of formulated drug products.

ADDoPT partners have worked both to advance the current state of the art in process modelling and control for pharmaceutical processes, and to combine and integrate these developments using a systems framework-based approach. The process encompassed: identification of current best practice and areas for development through interviews with industrial partners; definition of the requirements for the Information Flow; and generation of an architecture for a Digital Design Guide for Pharmaceutical Manufacture capable of meeting these requirements.

The Information Flow has been implemented as an interactive flowchart. Using E-Learning software has facilitated the layering of information from high level overview down to increased depth and detail, and provides a web-enabled output, ideal for dissemination. The generic information flow developed is a template upon which individual organisational needs can be customised, and similar digital information flows will be applicable outside the pharma sector.



RISE Rapid Substitution Tool: A quick screening tool for finding environmentally friendly, cheep and readily available solvents

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RISE Rapid Substitution Tool is a quick and easy to use tool created to facilitate the identification of environmentally friendly, cheap and readily available solvents when designing, reformulating or exchanging toxic chemicals in a product.

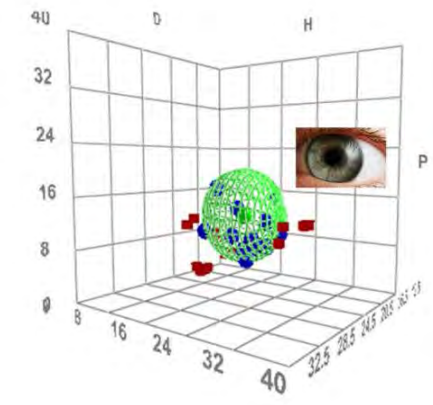
The tool contains searchable data on the following information: 1) price for commodity solvents; 2) odor/smell properties from several online databases; 3) safety/hazard data from Swedish, EU and USA agencies; 4) RISE internally developed method for in-silico prediction of eye irritation; as well as 5) physico-chemical properties of the enquired solvent. The tool can be efficiently combined with the Hansen Solubility Parameters in Practice (HSPiP) software to accelerate the substitution work. To demonstrate the power of this tool the substitution of a model solvent, xylene, will be showcased. Xylene is a toxic solvent for which a cheep and safe replacement is needed.

The advantage of this tool is that it combines numerous databases in one and enables to screen for a wide range of parameters in just one search. Thus, the best alternative solvents that fulfils the required properties can be quickly identified, which allows fast decision-making in the reformulation process.

Price

Odor

Toxicology data



Eye Irritation data

STABILIZATION OF PICKERING EMULSIONS BY BIODEGRADABLE PLGA NANOPARTICLES: INTERFACIAL STRUCTURE

Albert C[1], Huang N[1], Tsapis N[1], Geiger S[1,2], Rosilio V[1], Mekhloufi G[1], Chapron D[1], Robin B[1], Beladjine M[1], Nicolas V[3], Fattal E[1], Agnely F[1]

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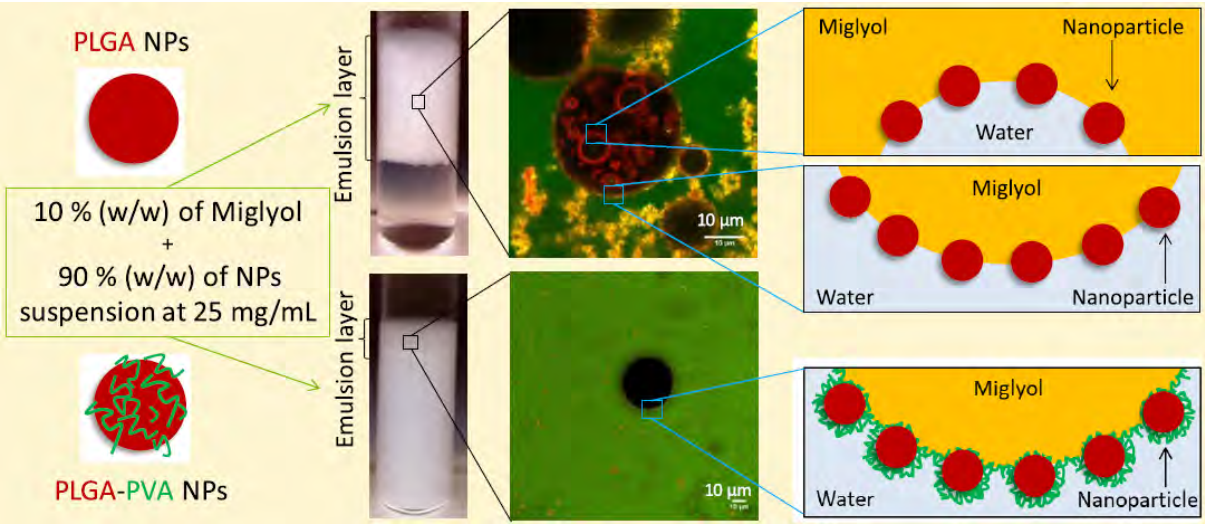
What happens at an interface stabilized by PLGA nanoparticles? We formulated Pickering emulsions stabilized by biodegradable and biocompatible poly(lactic-co-glycolic acid) (PLGA) nanoparticles (NP). We performed a physicochemical comparison of two types of emulsions: the first one stabilized by bare PLGA NP, i.e. PLGA NP without surfactants or any other polymer than PLGA, and the second one by sterically-stabilized PLGA-poly(vinyl alcohol) (PVA) NP, i.e. PLGA NP with PVA as NP stabilizers. Polymer stabilizers such as PVA are very commonly used to prepared PLGA NP. Both emulsions had medium chain triglycerides as the oil phase, at a ratio of 10% w/w. Using bottle-test, dynamic light scattering, confocal microscopy and interfacial analysis, we observed that the emulsions demonstrated very different structures at macroscopic, microscopic, and interfacial scales, depending on the type of NP used. Indeed, the emulsion layer was significantly thicker when using PLGA NP rather than PLGA-PVA NP. This was attributed to the formation and coexistence of multiple water-in-oil-in-water (W/O/W) and simple oil-in-water (O/ W) droplets, using a single step of emulsification, whereas simple O/W emulsions were obtained with PLGA-PVA NP. The latter NP were more hydrophilic than bare PLGA NP because of the presence of PVA at their surface. Moreover, PLGA NP only slightly lowered the oil/water interfacial tension whereas the decrease was more pronounced with PLGA-PVA NP. The role of PVA is paramount: PVA chains at the PLGA-PVA NP surface could probably partially desorb from the NP and adsorb at the interface, inducing the interfacial tension decrease. This work has direct implications in the formulation of Pickering emulsions and stresses the paramount influence of the physicochemical nature of the NP surface into the stabilization of these systems.

Reference: Albert C et al., Langmuir 2018, 34 (46), 13935-13945. DOI: 10.1021/acs.langmuir.8b02558



PARTICLE MIGRATION IN INKJET-PRINTED DROPLETS

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The evaporation of sessile droplets is of great importance to a range of applications from biosensors to graphics printing and crop spraying to printed electronics. Inkjet printing technology is particularly powerful as a method of selectively depositing functional materials with typical inks being complex formulations comprised of solvents, pigments, humectants and surfactants. Therefore a predictive understanding of formulations is necessary in order to achieve desired morphologies and avoid widely reported non-uniform morphologies.[1] Composition or temperature gradients across the liquid-vapour interface have been shown to induce Marangoni flows which can redistribute suspended material to avoid such ring-stains,[2] however studies have mainly taken place on microlitre droplets in which buoyancy-driven convection can feature.[3]

Here we report experiments in which dark-field optical microscopy coupled with high-speed cameras is used to trace the trajectories of light-scattering tracer particles to investigate internal flows through particle image velocimetry. Solutal Marangoni flows are generated in a selection of initially low viscosity solvent mixtures and solutions however at these smaller length-scales different morphologies are observed. Instead of obtaining uniform deposits, particles are seen to migrate across flow streamlines[4] to collect in central groups in ethanol-water mixtures, ethylene glycol-water mixtures and sucrose, lactose, sodium chloride and sodium nitrate solutions, demonstrating the prevalence of particle migration in a disparate range of chemical systems. A weak particle-size dependence to the migration is noted and a diffusiophoretic mechanism of migration in response to composition gradients is proposed.

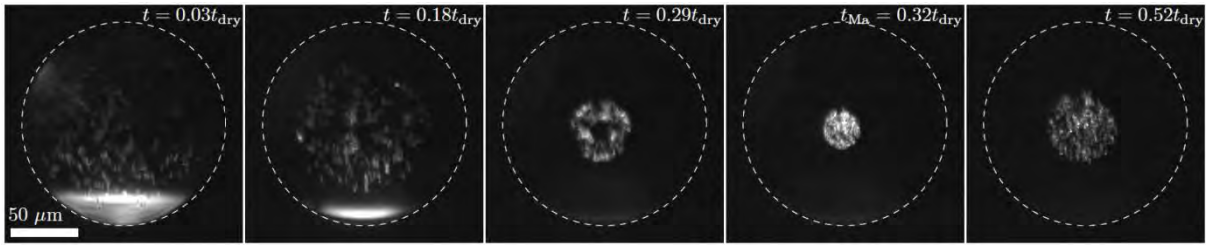

Figure 1. Particle migration towards the centre of an evaporating 50:50%v ethanol-water droplet. The dashed line is the position of the contact line. t_{Ma} is the time when the Marangoni flows ended while t_{dry} = 2.4 s.

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SCALE-UP OF NARROW DISPERSITY EMULSIONS FOR HIGH VOLUME MANUFACTURING AGAINST DEMANDING REQUIREMENTS

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Abstract Text

Homogenisation techniques have traditionally been used to generate emulsions but have drawbacks of high energy use and reduced stability through a lack of process control. Alternative methods to form superior emulsions have been investigated. Membrane emulsification has historically been limited to scale lab-scale operations, but recent developments have led to scalable systems specifically designed for aseptic applications, such as pharma, as well as more general industrial use.

One such membrane emulsification system is reported. The system contains no moving parts and generates uniform droplets using a continuous single pass, making the system suitable for highly sensitive and demanding processes in the pharmaceutical, cosmetic and food industries. The system is shown to be highly capable in large-scale production of emulsions, with a rate of production in the range 20 - 200L/Hr. Oil-in-water emulsions, across a range of droplet sizes with median diameters 20 - 100µm, were produced to demonstrate the equipment's flexibility. A model encapsulation system has been demonstrated to highlight the potential for continuous production of low-dispersity encapsulates. Samples produced have a droplet size coefficient of variation of below 15%. A high dispersed phase concentration of up to and beyond 40% has been achieved in a single pass, further demonstrating the potential for translation to highly efficient continuous manufacturing processes.

A narrow droplet size distribution results in a more stable emulsion. This emulsion, through different chemistries, has been converted into microcapsules and other forms of delivery systems with superior performance in mechanical stability, uniformity of dose and rate of diffusion.

This presentation will demonstrate the benefits of membrane emulsification to achieve size control and stability benefits. The associated cost savings of significant waste reduction and low energy usage will also demonstrate this technology can improve yields and enhance product performance through a low-cost sustainable process.

CHITOSAN/CARBOXYMETHYL CELLULOSE-STABILIZED POLY(LACTIDE-*CO*-GLYCOLIDE) PARTICLES AS BIO-BASED DRUG DELIVERY CARRIERS

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Poly(lactide-*co*-glycolide) (PLGA) colloidal particles stabilized by an electrostatic complex of two oppositely charged polysaccharides, chitosan (CS, cationic) and carboxymethyl cellulose (CMC, anionic), have been successfully prepared following a two-step procedure. In the first step, an oil-in-water emulsion was prepared by dispersing a solution of PLGA in dichloromethane into a mixture of CS and CMC in water. Dichloromethane was then evaporated from the emulsion, leading to the formation of a suspension of CS/CMC-covered PLGA particles. It has been shown that CS and CMC contents affected not only the characteristics but also the stability of resulting PLGA particles. Stable CS/CMC-covered PLGA particles had diameters between 480 and 700 nm, when prepared with convenient CS (150 to 450 ppm) and CMC (50 to 150 ppm) concentrations in the aqueous phase. Turbidity measurements demonstrated that CS/CMC-covered PLGA particles exhibited colloidal stability over a wider pH range as compared to PLGA particles covered by CS alone. Curcumin (CUR), a hydrophobic model drug, was encapsulated into the particles at the maximum of 10% by weight of PLGA so as to remain in the domain of complete miscibility as established by dynamic scanning calorimetry. The efficiency of encapsulation of CUR into CS/CMC-covered PLGA particles was found to be 99.6%. When using electrostatic complex of CS/CMC for covering PLGA particle the pH sensitivity of the kinetics of release of CUR was modified as compared to that observed with CS-covered particles. CS/CMC-covered PLGA particles exhibited delayed of CUR release in mildly acidic conditions and faster release in neutral and basic conditions. Thus, these bio-based particles have a potential to be further investigated as pH-sensitive drug carriers.

FORMULATION OF DUAL COMPONENT SOLID DRUG NANOPARTICLES FOR IMPROVED ORAL BIOAVAILABILITY OF DARUNAVIR AND RITONAVIR

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Many active pharmaceutical ingredients (API) exhibit poor aqueous solubility, which can often impact on the bioavailability of the drug when taken as a therapy. Recently, a strategy for formulating antiretroviral drugs into solid drug nanoparticles (SDNs) has been presented, with the resulting products exhibiting enhanced oral pharmacokinetics (PK). Preparation of these nanoparticles relies on an emulsion-templated freeze-drying method to screen different polymers and surfactants, with the drug dissolved in an organic phase and water soluble polymers and surfactants present in the aqueous phase. Once ideal excipients are identified and studied for reproducibility, stability and pharmacological behaviour, the method can be translated to spray-drying for scale-up and manufacture. Antiretroviral drugs are often taken in combinations as part of a HIV drug regimen which act on multiple viral targets. This is known as highly active antiretroviral therapy (HAART) and often involves antiretroviral drugs being administered with ritonavir, known to boost the half-life of certain antiretrovirals.

We have adopted the solid drug nanoparticle strategy with the anti-retroviral drugs Darunavir (DRV) and Ritonavir (RTV) to prepare dual component SDNs to combine two APIs into one nanoparticle-containing powder feedstock. *In vitro* pharmacological testing isolated the best performing formulation by determining the apparent permeability of the SDNs across Caco-2 and triple culture monolayers, whilst *in vivo* studies established its steady state pharmacokinetic profile. Steady-state multiple-dosing studies determined, using an initial loading dose followed by a 50 % lower maintenance dose, that there is potential for considerable dose reduction without compromising PK exposure. This data provides preclinical demonstration of the world's first DRV/RTV fixed-dose-combination formulation with a potential for dose reduction of both DRV and RTV whilst maintaining drug concentrations in the therapeutic window. The scale-up of the best SDN candidate by spray-drying has provided the manufacturing scale necessary to potentially pursue first in human clinical evaluation.

AUTOMATED SYSTEM TO ASSESS STABILITY OF COMPLEX FORMULATIONS AT MACRO SCALE

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Abstract:

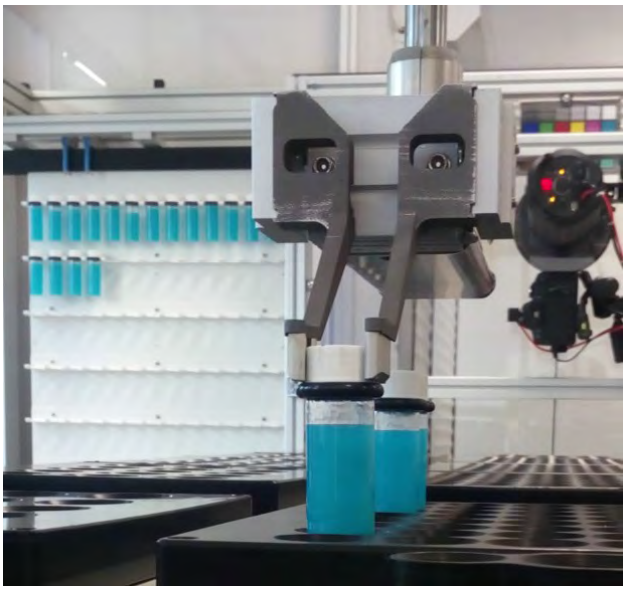
Liquid formulations are some of the fastest growing product forms, anticipating sustainability and consumer preference trends. They often display complex rheology behavior and a broad spectrum of physical and chemical properties.

The stability of formulations (such as dispersions, emulsions, etc.) is increasingly challenging with the widening of global market conditions. However, the methods to predict product stability have not evolved at the pace of technological progress. They are largely based on visual inspection of products performed over extended time periods. These approaches are time-consuming, labour-intensive, require large quantities of products and the obtained data are not conducive to predictive modelling of stability. In many projects, they are limiting the pace of innovation.

While the generation of formulations through automated systems is now well-known and applied in the industrial R&D, our project aimed to answer the clear need for a better understanding of the physico-chemical interactions and the long-term evolution of the formulated products at an accelerated pace.

Combining automation expertise, stability know-how and high-throughput methodologies, we developed a unique fully automated platform to assess the stability of liquid formulations. The platform is designed to age samples and test properties 24/24 and 7 days per week under limited supervision. On the actual system, rheology, pH, digital imaging and turbidity can be measured at any time on a formulation to evaluate its stability and follow the evolution of its physico-chemical properties. Incubators are present on the system to accelerate ageing process or trigger instabilities by applying elevated or low temperatures.

Based on a modular architecture, the unique system opens a new field in predictive modelling of stability for all type of formulations. Its capacity, going up to 1600 samples, together with intensive characterizations are used to generate a large database on stability data and feed machine learning systems.



Central robot of the stability platform handling samples on the automated system combining ageing and characterization

DEPOSITION OF FUNCTIONAL ACTIVES ON TEXTILE SURFACES

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Functional actives is a term that is widely used in the fabric care industry and it refers to substances that can deposit on a substrate providing beneficial properties. It is known in the literature that the deposition profile of an active can vary depending on the nature of the material, the delivery system, the substrate, the presence of competitive phenomena, pH, temperature and ionic strength [1, 2].

The aim of this work is to gain mechanistic understanding on the on-fabric deposition of hydrophobic actives during a washing cycle and the development of a representative deposition model.

Detecting the deposition of actives depends on the chemical structure of the active. During this research, a range of analytical techniques was utilized, namely UV-Vis spectroscopy, streaming potential and particle size measurements to assess bulk properties and surface-active behaviour. Single surfactant systems allow for better deposition and retention of an insoluble, hydrophobic molecule than mixed surfactant systems (Figure 1) due to the higher critical micelle concentration of the system (CMC) (~20-50ppm vs ~7ppm) [3]. Absence of micelles cannot lead to the solubilisation of the active, whereas plethora of micelles seems to be inhibiting the deposition. Efficient deposition occurs with surfactant concentrations close to the CMC. Furthermore, positively charged carriers such as Zwitterionic in its cationic form, will allow for better deposition due to the electrostatic forces between the fabric and surfactant micelles. In some cases, active adsorption is enhanced by water hardness due to calcium bridging between the micelles and the cotton fibres. From this study it was concluded that the deposition of hydrophobic actives depends on numerous factors such as: the CMC of the system, emulsifying capacity of the surfactant for the given active, presence of ions, charge, pH and substrate type. The impact of each of these factors is assessed single variably.

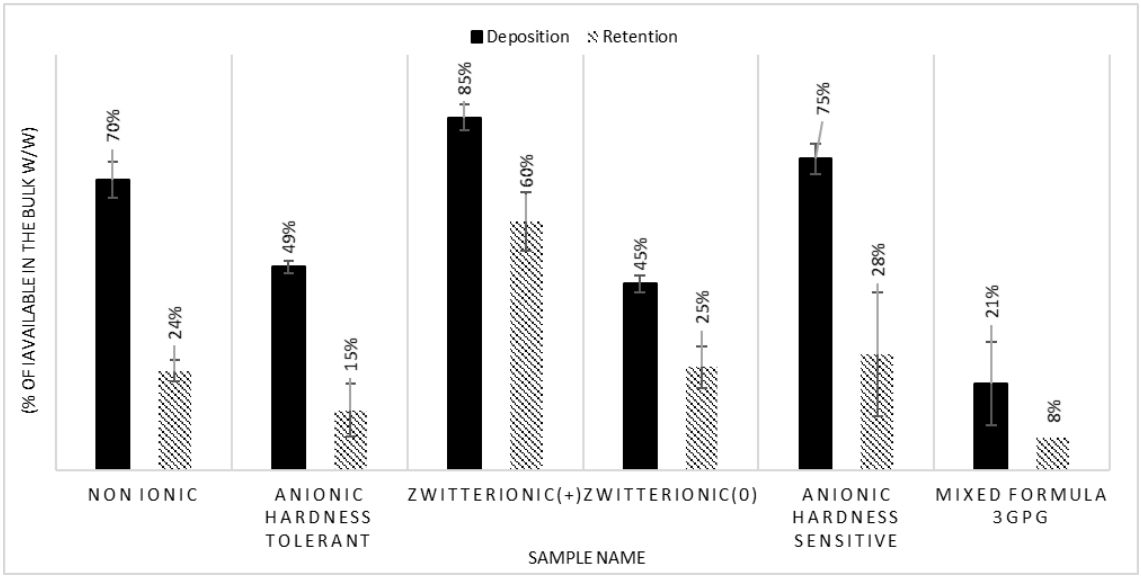

Figure 1. Deposition of a small hydrophobic active on cotton with different surfactant systems, as assessed via UV-Vis.

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Lab scale methodology to measure formulation losses due to rain

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Keywords

"rainfastness", "microscopy", "formulation"

Abstract

Formulation can play a key role in maximizing the delivery of an agrochemical active ingredient to the target site and preventing losses from it. In this contribution we share developments in state of the art for characterising the rainfastness of a formulation. In particular we compare results from fluorescently labelled deposits on *vicia faba* leaf surfaces and demonstrate a high through-put lab-scale methodology which is predicative of performance in a full scale raintower without the need for liquid chromatography and mass spectrometry analysis.

Methodology

Leaves were fixed to glass-slides and 0.2 µL droplets of fluorescently labeled PVA (0.4% w/w) or a model fluorescent active ingredient (Azoxystrobin) were placed on the adaxial leaf surface and allowed to dry. The deposit was imaged under a fluorescent microscope (Leica MZ10 F, fitted with an 'ET GFP' filter, camera and fibre optic light source) and then washed either by 1 mL of DI water from a burette or by a full-scale raintower to simulate rain.

The deposit was sequentially imaged and washed and the resulting mages were processed using ImageJ software to determine the coverage of the fluorescent polymer/model compound deposit.

Results and Discussion

The raintower and novel lab washing methods correlate well thus enabling use of the lab-scale method as a tool study the impact of co-formulants on deposit formation. Here the dependence of rainfastness on the molecular weight and crystalinity of PVA is presented and the new methodology used to show Chitosan is a particularly good example of a rainfastness adjuvant.

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COMPUTER SIMULATIONS OF SODIUM LAURETH SULPHATE WORMLIKE MICELLES

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Wormlike micelles (WLM) can be formed by surfactant systems at moderate concentrations and are found in personal care products. WLMs are long, flexible structures that share many features with traditional polymeric systems, but an important difference is that they can break and reform. This similarity to polymers forms the basis of a theoretical description developed by Cates and co-workers[1] that relates the microscale structure to the macroscopic properties. One key parameter is the scission free energy, E_{sci}, that is, the change in free energy upon breaking a cylindrical micelle into two hemispherical caps (see Figure 1). This can be directly related to the mean micelle length and the viscosity.

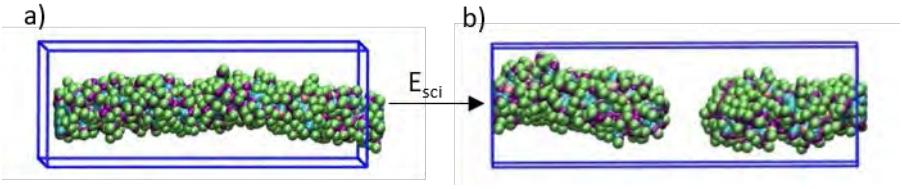

Figure 1 The scission free energy (E_{sci}) is the change in energy from breaking a wormlike micelle (a) into two wormlike micelles with hemispherical caps (b).

Here we use Dissipative Particle Dynamics simulations to calculate E_{sci} for WLMs of sodium laureth sulphate (SLES), a key ingredient in many personal care products via the protocol developed by Wang ***et al*** [2]. Briefly, we simulate an infinitely long micelle and calculate E_{sci} using umbrella sampling. From these simulations we are investigating how the salt concentration and surfactant attributes (head group size, alkyl tail length) affect E_{sci}. We find that E_{sci} increases with increasing salt content indicating longer micelles are present, in agreement with previous literature results[2]. However, upon increasing the alkyl chain length from C12 to C16, a 4-fold increase in E_{sci} and a qualitatively different potential of mean force is observed.

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Novel xanthan amphiphilic derivatives for stabilizing surfactant-free O/W emulsions

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The use of low molecular weight surfactants is more and more criticized due to many disadvantages related to toxicological and environmental considerations. Therefore, a number of new strategies are being investigated to prepare stable emulsions, including the use of particles (known as "Pickering" approach [1,2]) or macromolecular species [3].

In this later case, macromolecular surfactants have been developed during the last decades, most being synthetics while the nowadays demand of natural ones is considerably growing. Thus, polysaccharides derivatives may be interesting candidates to stabilize oil-in-water emulsions and to control their rheological properties. Among others, xanthan gum is the most used due to its outstanding thickening properties of aqueous solutions. However, because of its poor interfacial properties, it requires the addition of an emulsifier to disperse and stabilize the oil droplets. Thus, octyl residues were grafted onto the backbone of xanthan to confer amphiphilic properties [4].

The objective of the present work is to study and understand the phenomenon involved in the stability of oil-in-water emulsions containing amphiphilic xanthan. To this end, Oil-in-Water (O/W) emulsions containing no molecular surfactant but amphiphilic xanthan with different grafting densities have been studied and compared. As expected, amphiphilic xanthan allowed obtaining stable O/W. Nevertheless, a bulk-interface partition of xanthan amphiphilic derivative was evidenced depending on the grafting density.

These results clearly demonstrate the high potential for hydrophobically modified xanthan as emulsion's stabilizer.

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ENCAPSULATION IN DOUBLE EMULSIONS - FUNDAMENTAL ANALYSIS OF STABILITY

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Double emulsions show great potentials for the encapsulation of hydrophilic components such as enzymes, vitamins, or crop protection agents. Thereby, the active ingredient is formulated in a water phase (W_1), which is emulsified in the oil phase (O) protecting the active. The inner emulsion is again emulsified in the outer water phase (W_2) for different aqueous applications in cosmetic, food or agricultural industries. Due to stability issues, only a few products based on double emulsions are currently available on the market. For instance, during storage, the inner water phase and consequently the active ingredient is lost in most systems. Underlying instability mechanisms like coalescence and diffusion, however, are still not completely understood and need further analysis.

Regarding stability, the selection of the emulsifier systems is important and is therefore discussed in detail, as part of this study. To stabilize the inner water droplet (W_1) a hydrophobic emulsifier is needed. Additionally, the W_1/O-droplets need to be stabilized by a hydrophilic emulsifier. Concerning coalescence between the inner and the outer water phase not only the type and the concentration of emulsifier is important, but also the interaction between the hydrophobic and hydrophilic emulsifier. For example, very small amounts of a hydrophilic emulsifier stabilizing the W_1/O-droplets lead to interfacial instability and coalescence of inner W_1-droplets.

Innovative analytical approaches are adapted or further developed to determine and describe instability mechanisms and corresponding influencing parameters. To investigate coalescence and diffusion, single drops are analysed by imaging techniques. Nonlinear spectroscopy is used to describe the interfacial properties of emulsions, focusing especially on the structure and alignment of emulsifier molecules. Next to that, the distribution of the emulsifier molecules is determined via molecular modelling. The aim of the work is the identification of structure/property-relationships in double emulsions to select appropriate formulation and process conditions for making stable (W_1/O/W_2)-emulsions.

DEVELOPMENT OF A SURFACE ENHANCED RAMAN SCATTERING METHOD FOR THE QUANTIFICATION OF BACTERIA: APPLICATION TO THE CHARACTERIZATION OF PROBIOTICS ENCAPSULATED IN MICROSPHERES

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Probiotics are increasingly used to improve, maintain or restore homeostasis of the gut microbiota. For these purposes, they are administrated to human via various pharmaceutical formulations improving their stability and preservation, such as lyophilized powder in capsules or microparticle-based delivery systems. The development of such dosage forms requires a reliable quantification method of the bacteria to determine formulation characteristics such as encapsulation efficiency, release kinetics or microorganism viability. The conventional counting method using plating and culturing is the most straightforward and widely used method for these purposes, but it appears tedious and time consuming (requiring at least 24h).

Conventional Raman spectroscopy appears as an interesting alternative method by providing many advantages, in particular easy and rapid sample preparation, rapid analysis in aqueous matrices (biological fluids, tissues or food matrices) and also the acquisition of spectral data characteristics of the bacteria. However, this technique is limited by the weakness of the inelastic light scattering phenomena, thus requiring the use of highly concentrated samples. Therefore, Surface Enhanced Raman Scattering (SERS) technique, allowing to provide a high enhancement of Raman scattering from molecules adsorbed on a nanostructured noble metal surface (silver, gold), was investigated for the characterization of bacteria. The developed SERS method allowed, within 30 min, the quantification of probiotic *Lactobacillus rhamnosus GG* (LGG) suspended in water over a concentration range consistent with pharmaceutical applications (Figure. 1). LGG were then encapsulated in spray-dried microspheres. The encapsulation efficiency was determined by both the SERS and the conventional counting methods indicating that the developed analytical procedure should be very useful for the characterization of probiotics-based pharmaceutical formulations. The SERS method was also successfully used in combination with chemometric techniques i) to highlight LGG modifications induced by applying deleterious process conditions (solvent, shear stress…) and ii) to discriminate different bacterial strains (Figure. 1).

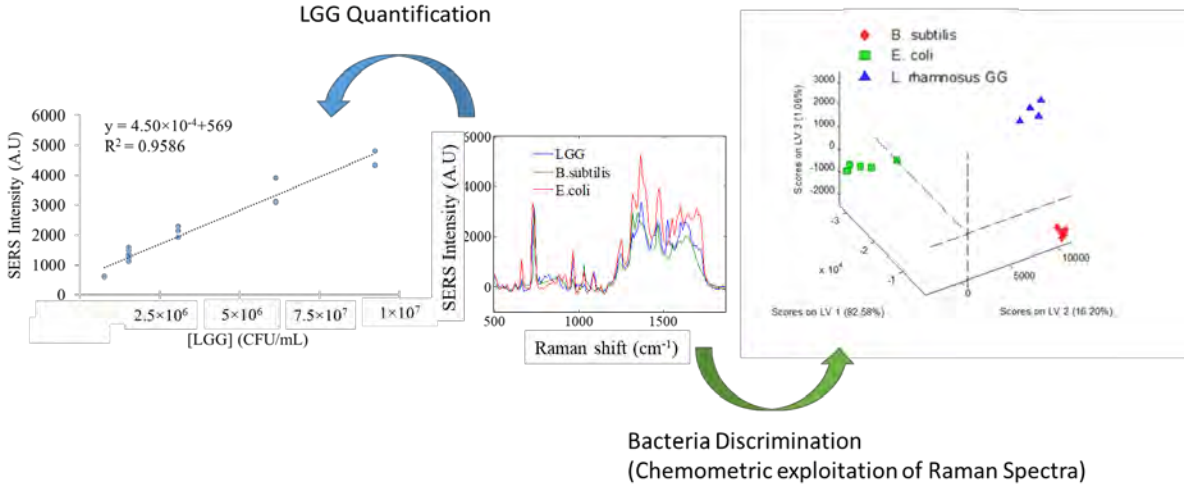

Figure. 1 Quantification and discrimination of bacteria from Raman SERS spectra

PREDICTING THE DROPLET SIZE DISTRIBUTION OF EMULSIONS PRODUCED IN A SONOLATOR

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The Sonolator is a type of high pressure homogeniser used to produce formulated products such as emulsions. The droplet size distribution (DSD) is an important characteristic of an emulsified product since it determines both product quality and stability. It this study, oil/water emulsions were created using the Sonolator and the resultant DSDs measured using the Malvern Mastersizer 3000. The flow rate through the Sonolator orifice and the size of the orifice were altered to investigate their effect on the DSD. The viscosity and the concentration of oil was also varied from 10 cSt to 2760 cSt and 1% to 10 % wt/wt respectively. The oil used was Silicon Oil. All emulsions contained 0.1% surfactant (SLES). The results showed that the drop size decreased with flow rate or pressure across the orifice and increased with SiOil viscosity. The DSDs were predominantly bi-modal, with each part of the DSD being log-normal. The DSD of each emulsion could therefore be modelled using the sum of two-lognormal distributions. The mode of the daughter droplets can be predicted fairly well using theory. The volume fraction of the satellite droplets was found to be a function of the pressure across the orifice and also the dispersed phase viscosity. The blade of the Sonolator, which is supposed to contribute to the droplet break-up via cavitation, was found to have no effect on the DSD. Neither did the volume fraction of SiOil. The correlation developed in this study using both the experimental data and theory allows us to accurately predict the entire DSD of emulsions produced in a Sonolator. We are therefore able to more easily tune the stability and quality of our emulsified product without having to use trial-and-error.

FORMULATION OF ENZYMES FOR INDUSTRIAL APPLICATIONS

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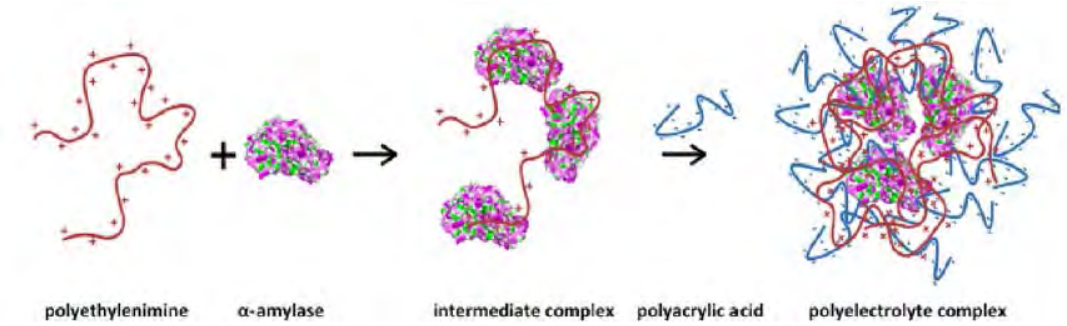
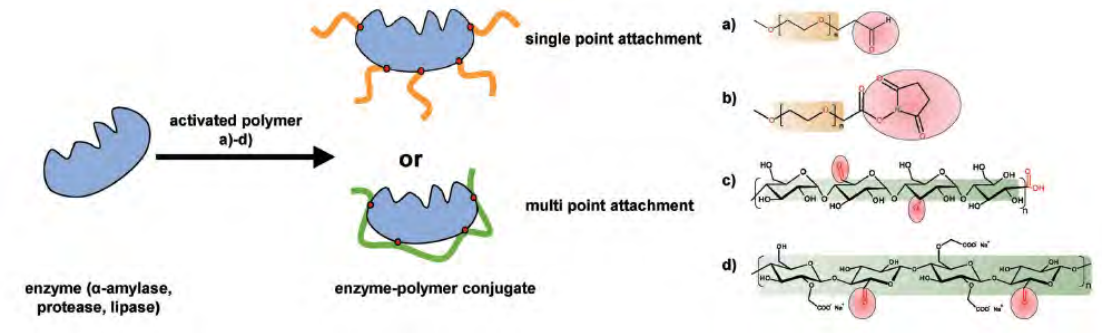
Industrial enzymes are an attractive market with high annual growth. They are key performance enablers for food & feed applications and for detergent formulations in the laundry area. New methods and appropriate enzyme formulation approaches are of crucial importance to protect enzymes against environmental influences. In addition to the established phytases and proteases, BASF will focus on the formulation of different enzyme classes as well. Fundamental knowledge is necessary to formulate enzymes without any loss of enzyme activity which is directly connected to the performance and subsequently to the margin of the product.

We will present two different strategies to formulate enzymes. Both approaches provide stabilization and activity in applications using enzymes with activities greater than average. Using contrary charged polyelectrolytes like polyacrylic acid and polyethylenimine, polyelectrolyte complexes (PECs) are formed *in-situ* around enzymes. α-amylase immobilized in such a polyelectrolyte complex shows an increased stability at low pH values. Within the second strategy, enzymes are covalently linked to polymers. Such enzyme-polymer conjugates are synthesized with various polymers – PEG as well as polysaccharide based – and with three different enzymes. The thermal stability in general and the enzyme shelf life in a standard detergent formulation is enhanced significantly for the conjugated enzymes. The colloidal and physico-chemical stability was characterized in terms of size, size distribution, electro-kinetic potential, and morphology. The thermodynamic parameters of interactions in solution were analyzed by calorimetry. Enzyme shelf life was checked by specific enzyme test assays and showed promising results regarding their potential in stabilizing enzymes.



Preparation of polyelectrolyte complexes with encapsulated a-amylase.



Enzyme modification with four different polymers: a) mPEG-aldehyde, b) mPEG-N-hydroxysuccinimide ester, c) maltodextrine aldehyde, and d) carboxymethyl cellulose aldehyde. The red circles indicate the functional group reactive toward covalent coupling with the enzyme's amino group.

CROSSING THE VALLEY OF DEATH: THE FUNDAMENTAL SCALE-UP PROBLEM

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Taking early stage research and development work and turning it into a viable commercial product is so difficult that this stage in the development process has been termed the valley of death. This is when the vast majority of new technologies, processes and companies fail, and it is the stage in the process that CPI's Process Technology Team specialise in.

Through helping multiple customers across a range of industries with process development, scale-up and commercialisation, we have gained a unique insight into the problem of navigating the valley of death. We understand why failure is so ubiquitous at this stage of the development process, and the best approaches and strategies to use to mitigate the potential risks.

In this presentation we will distil some of the key lessons we have learned by explaining why new technology developments are most likely to fail in the valley of death, and examine one of the main causes of failure: process scale-up.

While scaling up a chemical process in the formulation industry seems like a unique problem, it is actually just a symptom of a much more ubiquitous and fundamental problem that exists throughout nature and across all industries, including: chemical, business and even software. Through examples and case studies we will explain what the fundamental scale-up problem is, why it exists and how it applies to the formulation industry.

Advanced Control in Powder Processing (Through Modelling and Continuous Processing) to Deliver Novel Formulations

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A research facility for processing powders across the scales relevant to the formulation industries has been delivered as a joint project between CPI and a number of adademic and industrial partners (including AstraZeneca, GSK and the Universities of Edinburgh and Sheffield). This state-of-the-art facility hosts a number of different powder processing capabilities and includes the applicaiton of multi-scale models to enable industrialists and academics to develop, prove, prototype and scale-up the next generation of products and optimise their processes. The facility as a whole allows a deep understanding of powder processes from gram to tonne scales utilising a range of process analytical technology (PAT) such as Raman, Near IR and particle size and shape analysis.

This PAT in combination with mechanistic models and Advanced Process Control (APC) accelerates and de-risks the translation of laboratory innovations into new products and processes for commercial companies of all sizes, as well as significantly reducing the cost of scaling up. The hardware control and data fusion software (Perceptive Engineering) allow us to implement an advanced process control model for real-time prediction of formulation properties; by monitoring process parameters.

We will present results detailing the practical implementation of PAT tools into continuous pharmaceutical processing for wet granulation along with the use of mechanistic models in this work. Further powder processing capability will be described detailing how to implement the use of PAT sensors to enable understanding and control in powder formulation.

CHARACTERIZATION OF COMMERCIAL PHARMACEUTICAL TABLETS AND MODEL BINARY MIXTURES TOWARD AN IMPROVED UNDERSTANDING OF TREATMENT EFFICIENCY

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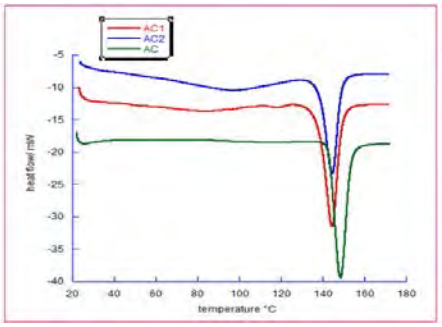
Pharmaceutical tablets are an important class of formulated forms of active pharmaceutical ingredients (API). The control and optimization of their therapeutic efficiency is thus a fundamental challenge for pharmaceutical industries. This efficiency is influenced both by the interactions between ingredients (API, excipients...) and the manufacturing process (milling, granulation, compression, storage…) which can alter various important characteristics (polymorphism, solvatation, dehydration, crystalline/amorphous conversion…). Taking into account the number of ingredients and unit operations involved in the manufacturing process of pharmaceutical tablets, systematic studies are required to gain insight into main factors responsible for the efficiency of treatments.

In that work, the followed methodology comprised analyses of commercial tablets together with characterisation of model mixtures prepared in the laboratory, i.e. involving a limited number of ingredients and not submitted to any potentially degrading manufacturing operations. Various commercial tablets containing β-blockers, acebutolol and carvedilol, as well as different model binary mixtures of API with various excipients and antioxidants were analyzed using several experimental techniques. The obtained data provided valuable information about the samples regarding their compositions (using nuclear magnetic resonance and high performance liquid chromatography), their morphology (using differential scanning calorimetry, DSC, Figure 1, and X-ray diffraction), their thermal stability (themogravimetric analysis) and the binary interactions between ingredients (using infrared spectroscopy).

The importance of the nature of the excipient as well as the conditions of manufacturing was revealed through the detection of partial API degradation.



Pure AC and different tablets	T_{onset} °C
AC	143
AC1 (princeps)	137
AC2 (generic)	139

Figure 1: DSC thermograms of pure acebutolol (AC) and two commercial tablets (AC1 and AC2).

LABEL-FREE CHARACTERISATION OF BIOLOGICAL DRUGS IN PLASMA

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Abstract Text

The effects of immunogenicity are only detectable and measured after phase II trials and in rare cases after phase I trials. The major causes for immunogenetic reactions are in some cases related to the drug product and various modifications thereof but it can also be related to the patient and to the dosing of the drug product. Issues with both safety and efficacy can be related to anti-drug antibodies (ADA) arising after administration of biological drugs to patients.

By using Asymmetric-Flow Field Flow Fractionation (AF4), in-depth characterisation of both monomer and higher aggregated form of antibodies can be accomplished and this can studied on patient basis allowing more in-depth knowledge of drug behaviour in the individual patient.

Using the AF4 methodology in combination with label-free technologies allows us to distinguish between monomers and higher aggregates in complex tissues such as plasma, blood and cerebrospinal fluid (CSF). We also believe that this combination of technologies allows for a track and trace system setup in order to study drug dissolution from complex carrier systems such as viral capsids, nanoparticles and liposomes. The system not only allows the study of drug-drug interactions but also drug-target and drug-particle interaction.

This allows investigation of several of the causes leading to immunogenicity such as aggregation, degradation, and modification. By using this ex vivo sampling methodology, we believe that problems leading to immunogenetic reactions can be studied in human tissues in pre-clinical settings before putting patient at risk at various stages during dosing regiments.

PARTICLE LEACHING FROM POLYMERIC COATINGS

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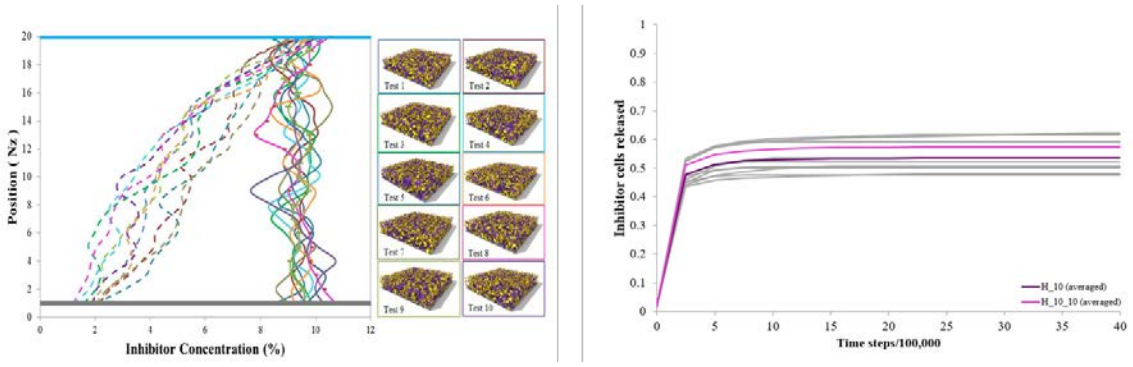
Understanding the microstructure of polymeric coatings used for active corrosion protection and the leaching mechanism of corrosion inhibitors can provide the tools to develop more environmentally friendly, sustainable and effective coatings. In this work, we used a combined experimental and simulation approach to first identify the main features that affect the corrosion protection to then develop a model that will allow exploring the parameter space to develop better understanding on the structure-property relationships and inform formulator of the desirable features in the coating. As an example, we focus on the leaching rate of inhibitors from coatings, using lithium carbonate as the model corrosion inhibitor. We show that Celular Automata simulations are able to describe the leaching from coatings and we explore the effect of different features, such as pigment volume concentration, solubility rate, and coating heterogeneity. Figure 1 shows an example of a collection of model coatings with 10% volume concentration of inhibitors, and the reproducibility of the structural properties as well as the release profiles.



(a) (b)

Fig. 1. (a) Reproducibility of composition profile of inhibitor particles in a model polymeric coating, where the inhibitor concentration is 10% where the solid lines represent the total concentration and the dashed lines the concentration corresponding to the percolated inhibitor particles; and (b) is the calculated inhibitor release profile for the individual coatings (grey), a coating formed by two thinner layers of the same composition (pink) and the average release profile (purple).

Back to Programme

Utilising modelling approaches for the scale up of spray dryers

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Spray drying is used to form particles from droplets (clear liquid or a suspension of particles) in a hot gas stream. There is recent and renewed interest in this technology within the pharmaceutical industry as it presents a way to co-formulate active pharmaceutical (APIs) with excipients [1]. By manipulating drying conditions (gas temperature, relative humidity, ratio of gas flow rate to liquid/suspension flow rate) spray drying also allows tuning the external shape, apparent density, etc. of the particulate product [1][5]. However, reproducing properties of a dried solid at a different scale presents numerous challenges and requires well-considered scale up methodologies [4].

For a long time, scale-up requirements have been based on experience and rule of thumbs, however such methods are not always reliable and can lead to unsuccessful scale-up operations. As such, better tools are required to minimise uncertainties [3]. To accomplish this, models that link drying conditions with the particle morphology obtained on the basis of a single droplet can be combined with droplet and gas flow trajectories obtained, e.g., from computational fluid dynamics [4]. This represents a platform for process scale up, as it links the process with product quality and component performance. By developing a clear picture of the effect of process variables on powder properties and through mathematical modelling, it is possible to identify key variables that will affect process drying behaviour and powder quality and hence achieve similar product quality on different scale. In the end, the drying behaviour and powder quality (for example, size distribution and moisture content) determines the residence time and hence, scale of a spray dryer [2][3].

In this work, we combine an extensive experimental and mechanistic modelling methodology to predict the drying behaviour and final particle size of single droplets. We utilise an acoustic levitator approach to mimic drying conditions in a typical spray dryer. We further develop a mathematical framework by solving conservation equations to describe the evolution of the continuous and discrete phases, in addition to equations describing external mass and energy transport. The solution to the conservation equations yield critical particle properties such as shell formation time, particle size and moisture content required to meet scale up demands. Finally, we elucidate on important properties that must be considered during scaling-up operations and others that need less stringent control.

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Studying Microstructure of Coatings to Understand Formulation Effects on Function

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Organic coatings are complex formulated systems which need to provide multiple functions in the liquid state, while drying and finally as coatings. Formulation attempts to optimise all these functions, new insights from micro-structural characterisation of coatings is providing new approaches to formulation, as highlighted in these two different coating systems.

Formulation additives are essential in waterborne direct-to-metal (DTM) coatings for attainment of coherent and visible defect-free film formation to prevent premature failures. However, difficulties in selecting the appropriate additive package often leads to time-consuming experimentation based on 'trial-and-error' approaches. In this work, scanning electron microscopy (SEM) and atomic force microscope infrared spectroscopy (AFM-IR) techniques were used to elucidate the additive-induced microstructural changes under corrosive environments, and perform nanoscale chemical functionality mapping to investigate the long-term coating deterioration mechanisms. This knowledge provides deeper insight into the relationships between binder/additive structures, film morphologies and the associated anticorrosive properties.

Fundamental understanding of organic coating microstructure, may hold the key to understand failure mechanism in intact coatings. AFM-IR is a technique which allows microstructural characterization of organic coatings by mapping their infrared absorptions. Studies on crosslinked polyesters for food-contact applications conducted using this technique reveal intriguing results on sub-micron heterogeneity and phase separation.

CONTROLLED SUPERSATURATION: ASSESSING THE USE OF EXCIPIENTS IN FORMULATION TO ENHANCE IN VIVO EXPOSURE FOR PRECLINICAL STUDIES

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Solubility together with permeability are one of the most important parameters to achieve required concentration of the compound in systemic circulation for achieving bioavailability. In combating of poor solubility of drug, the ability to achieve and maintain the supersaturation of drug is substantial. The supersaturated concentration of compound is significantly above its intrinsic solubility. Thus, supersaturation presents the driving force for drug absorption to the blood circulation. The achievement and the maintenance of supersaturation is crucial and offers an opportunity for formulation experts to significantly enhance exposure by maintaining the solubility and prolonging the duration of the supersaturation phase.

Several excipients have been shown to be effective in this context (see Figure 1), however their effect is highly dependent on the compound. This poster describes a new screening approach of determination of the extent and duration of supersaturation in the presence of various excipients using a solvent quench method. This gives the formulation expert precise control over the pH and drug: excipient ratio for each experiment allowing rapid identification of the most effective excipient using a low amount of compound in the formulation development process. Moreover, selected excipients were used in vehicles in preparation of microsuspensions and further tested *in vitro*. Particle size distribution and dissolution rate were determined to support the decision of excipients used *in vivo* studies.

The supersaturation study provides the useful information about the behavior of compound in solution, which replicates fluids in GI track, in a presence of different excipients and can significantly affect the exposure of compound.

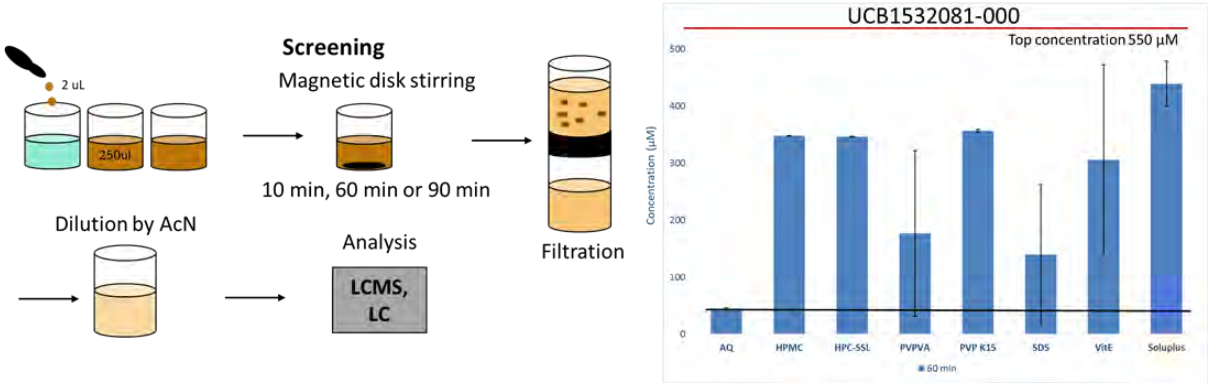

Figure 1 – Schema of Supersaturation screening and the effect of different excipients on the concentration in the solution for UCB1532081-000.

DEPOSITION OF SOLID FABRIC ENHANCERS DURING CLOTHES DRYING: DYNAMICS OF ARTICLE MOTION

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Dryer sheets are used to deliver a solid fabric enhancer, SFE, to fabrics during tumble drying. To improve dryer sheet formulations a mechanistic understanding of SFE transfer to fabrics is required. Fabric and dryer sheet motion within the dryer drum will influence deposition. This work looks into the nature and frequency of collisions between articles to allow bench scale reproduction of interactions.

As the dryer is an opaque system Positron Emission Particle Tracking, PEPT, was chosen to study motion. This technique allows the location of a positron emitting tracer particle to be detected within a system accurately, multiple times per second. The particle was glued to fabrics and dryer sheets and tracked at pseudo steady state for up to an hour. Results were processed to produce occupancy and time averaged velocity profiles.

For all conditions investigated fabrics were found to be cateracting. A bed forms in the drum base and is lifted up the drum wall before fabrics detach and fall through the free space. Above the bed a stagnant region of slow-moving fabrics forms, but both articles spend little time here. While fabrics and dryer sheets were seen to follow the same velocity profiles, dryer sheets were more likely to travel close to the drum wall and detach later. Increasing moisture content was shown to have little effect on the velocity profile but led to a more compressed bed forming, with articles travelling closer to the drum wall. Increased volume fractions limited fabric motion in the falling region, decreasing velocity here.

The dynamics of fabric and dryer sheet motion within a tumble dryer have been characterised using PEPT. Differences in motion show both impacts and abrasive contacts occur. These will be reproduced in future work to further the understanding of SFE deposition.

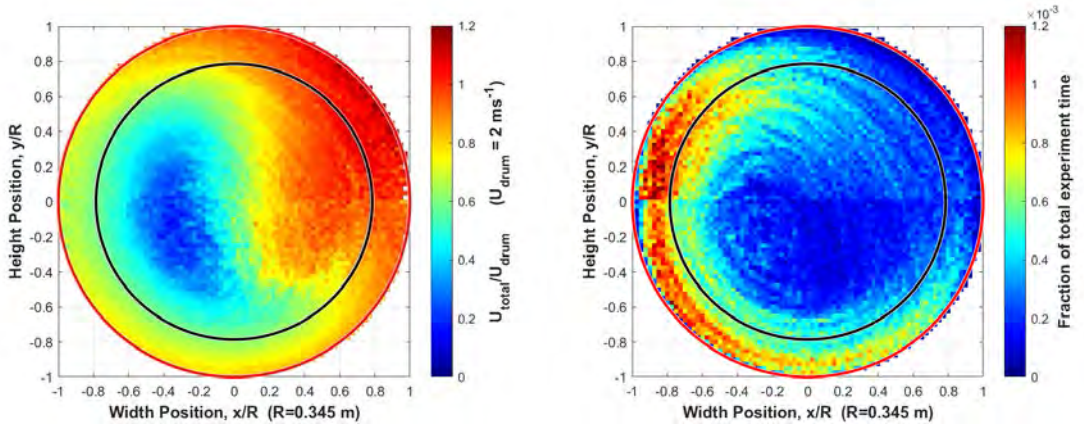

Figure 1. Eularian velocity (left) and occupancy (right) profiles for a fabric sheet in 4.5 kg load of 50x50 cm dry cotton fabric sheets

Synthesis of Fluorescent-Tagged Polymers

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Abstract

New MMA-PAH copolymers were prepared with a view to their use as stabilisers for aqueous graphene dispersions, for surface functionalisation of 2D-materials and for the synthesis of Janus, 2D-materials. A variety of perylene- and pyrene-containing copolymers were prepared by radical copolymerization of 5-(perylen-3-yl)pent-4-yn-1-yl methacrylate (Perylene-C5-MA), 1-pyrenemethyl methacrylate (PyMMA), 2-Acrylamido-2-methylpropane sulfonic acid (AMPS) and 2-(2-Bromoisobutyryloxy) ethyl methacrylate (BIEM). Following the successful synthesis of these copolymers a study of their interaction with 2D-materials has now been initiated.

Salt-tolerance of ethoxy or propoxylated anionic surfactants: Rationalization of the enhancing effect of non-ionic groups

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Anionic and non-ionic surfactants are widely used in end-use products, but their functional properties are generally weakened and eventually lost in hard water or high salinity media. Actually, most of the aqueous solutions of anionic surfactants are not salt-tolerant and precipitate in the presence of high concentration mono- or di- valent cations. However, many applications areas such as detergency, personal care or petroleum extraction require surfactants that are salt-tolerant in a wide temperature range[1]. A synergistic effect has been pointed out by mixing anionic surfactants with ethoxylated non-ionic surfactants, increasing the resistance to the salt addition. These results have guided the design of non-ionic/anionic hybrids surfactants in the hope of cumulating the strong hydrophilicity of anionic polar head and the salt resistance of ethylene oxide groups. The salt resistance to NaCl and $CaCl_2$ of several surfactants is evaluated at 5% wt. as shown in figure 1.[2]

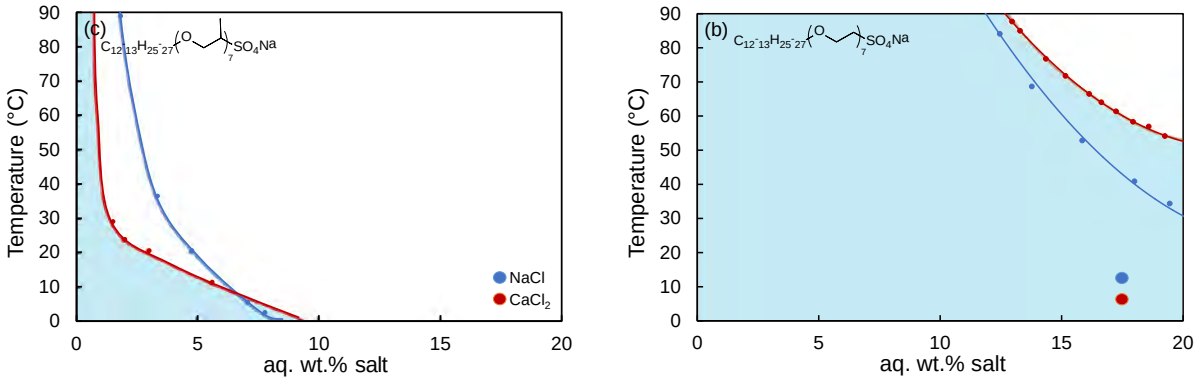

Figure 1. Influence of NaCl (●) and $CaCl_2$ (●) on the cloud point of ethoxylated and propoxylated sulfates at 5 wt.% . **a)** C_{12}-E_7-SO_4Na, **(b)** C_{12}-PO_7-SO_4Na. Blue area indicates the zone in which the surfactant is completely soluble into the aqueous solution of $CaCl_2$.

Comparing three C_{12}-sulfates group *i.e* SDS, C_{12}-EO_7-SO_4Na and C_{12}-PO_7-SO_4Na we observed that the salt tolerance is higher with the hydrophilic ethoxy groups than with the propoxy ones, however in both cases the Krafft temperature is vanished. This result is not intuitive since it is known that propoxy groups are slightly hydrophobic. However, the propoxy groups increases the entropy in the micelles and do not promote the precipitation phenomena. In the case of ethoxylated sulfates, the more the EO groups content in the hybrid surfactant, the higher the amount of salt needed to make the phase separation appearing, whereas the reverse trend is observed when increasing the PO groups. Alkyl ethoxy carboxylates hybrid surfactants are more salt resistant than alkyl ethoxy sulfates.

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CGRP ANTAGONIST PEPTIDE'S FORMULATION IN CHITOSAN MICROPARTICLES

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AIM: to develop a dry powder, mucoadhesive drug carrier for the nasal administration of small peptide CGRP (calcitonin gene-related peptide) antagonists to treat migraine.

METHODS: A truncated version of CGRP was synthesised using SPPS. Peptide-containing microparticles (MP) were prepared by spray drying peptide (1%) and low molecular weight (LMW) chitosan (2%) from a solution of 0.5% acetic acid using a Büchi B-290 spray dryer. Moisture content was determined by thermogravimetric analysis. The morphology and MP diameter was observed using scanning electron microscopy. Average particle diameter was calculated measuring 100 particles for each sample.

To assess the release of the peptide, Three MPs samples (10 mg) were suspended in 1 mL of deionised water and mixed (20 rpm, 37˚C, 24 h) and centrifuged (13200 rpm for 10 min). The supernatant was analysed by RP-HPLC, utilising the unloaded MPs as blanks.

Peptide stability was investigated using human serum. Aqueous peptide stock solution (2 mg/mL) was added to 25% pooled aqueous human serum and incubated at 37˚C. At specific time intervals samples were precipitated (6% TCA), centrifuged (13,200 rpm, 2 min) and the supernatants were analysed using an RP-HPLC.

RESULTS: LMW chitosan was selected due to its biocompatibility, mucoadhesiveness and non-toxicity. Chitosan MPs containing 5mg of peptide in 0.5 g LMW Chitosan were prepared with a 45% yield. The water content of the powder was 8.2%. Microparticles were spherical with an average diameter of 10.7 µm. In water, 70% of the peptide was released over 24 h. The stability of the peptide over 30 minutes was analysed by RP-HPLC and LC-MS indicating a percentage degradation of 43%.

CONCLUSIONS: Chitosan microparticles loaded with peptide were successfully prepared by spray drying, achieving a size suitable for nasal delivery.

NUMERICAL STUDY OF INKJET PRINTING OF WEAKLY VISCOELASTIC INKS

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Inkjet printing is being increasingly used for novel applications, such as 3D printing and printed electric circuits. New formulations of inks under development are often non-Newtonian fluids, which exhibit viscoelastic and shear thinning properties. In order to design and optimise printing processes for these complex inks, the stability of the ink jets and the dynamics of droplet formation must be understood, predictable and controllable at different conditions. The study of drop formation on non-Newtonian inks is still limited [1].

In this work, a Computational Fluid Dynamics model has been developed and used to study jet breakup of complex fluids and understanding the effect of relevant non-dimensional numbers on the dynamics of droplet formation. The rheologic constitutive models used are the Upper-Convective Maxwell Model and the Oldroyd-B model. Simulations of Newtonian fluids have also been performed, in order to see the effect of added viscoelasticity and allow for a direct comparison.

The results of Drop-on-Demand (DOD) printing were compared to results from the literature for Newtonian DOD printing. Additionally, the impact of viscoelasticity on drop formation and different pulse times has also been studied. Continuous Inkjet (CIJ) printing simulations have also been done to study how the different parameter contribute to jet breakup and drop formation without any inlet velocity modulation. By doing so, the parameters ideal for printing viscoelastic inks are defined and can be used in the future to predict the printability of new complex materials.

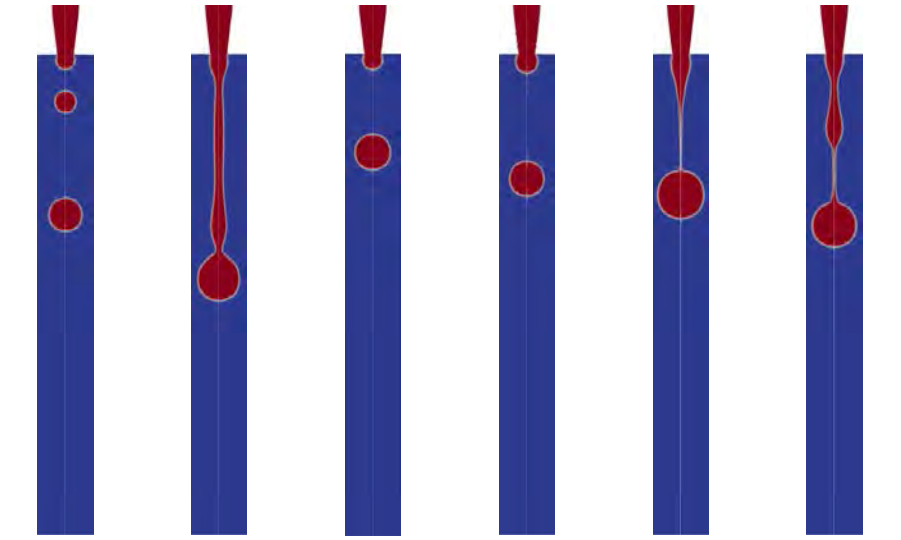

Figure 1 Drop formation a Re=25 and Oh=0.30, for the same flow time.

TUNING THE RHEOLOGY OF HYDROPHOBIC MATERIALS IN AQUEOUS SYSTEMS USING RESPONSIVE SURFACTANTS

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Robocasting is an additive manufacturing technique whereby formulations are extruded through a fine nozzle to create self-supporting 3D structures. To ensure successful printing, said formulations must display specific rheological behaviours that depend on the application. The printability of soft materials can be quantitatively described with relatively simple oscillatory tests in a rotational rheometer using three parameters: the stiffness of the network at rest (G_{LVR}'), the solid-to-liquid transition point, σ_f, and the flow transition index, which relates the flow and yield stresses ($FTI = \sigma_f/\sigma_y$).[1]

Printable formulations of ceramics and 2D materials incorporating a variety of rheological modifiers are well known.[2,3] One such modifier, known as branched co-polymer surfactant (BCS, $PEGMA_5/MAA_{95}$-$EGDMA_{10}$-DDT_{10}), displays intrinsic pH responsiveness due to the incorporation of MAA monomers. Below the pKa of MAA, hydrogen bonds form between neighbouring groups - a pseudo-gel is formed, and the structure transitions to a shear-thinning, viscoelastic solid.[4] Conversely, aqueous formulations comprised of hydrophobic compounds remain poorly investigated due the difficulty in finding appropriate modifiers.

Herein, we present preliminary results on the use of BCS as a modifier for hydrophobic materials using charcoal as a standard. Initial studies have shown that BCS is an ineffective additive and requires optimisation – sedimentation was observed in all formulations tested, regardless of BCS wt/v%, while foaming in solutions with more than 2 wt/v% BCS suggests that BCS is not well adhered to the charcoal. Furthermore, said formulations never reach the “printability threshold” where the G_{LVR}' exceeds 10 kPa under any of the conditions tested. Thus, we also detail the synthesis of BCS derivatives incorporating other chain transfer agents like benzyl mercaptan and naphthalenethiol, which we predict will stabilise charcoal more effectively via additional π-π stacking interactions, the effect of which will be evident in the G_{LVR}', the σ_f and the FTI.

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COSMO-BACKFITTING AS A PROMISING IN SILICO TOOL TO CHARACTERIZE UNDEFINED POLYMERS: ILLUSTRATION OF THE CONCEPT ON THE SOLUBILISATION OF CELLULOSE ACETATE

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Cellulose acetates derived from the renewable cellulose can be used, *inter alia*, to produce membranes by an inexpensive and simple process[1]. The solvents currently used for this process, such as cyclohexane or NMP, are volatile organic compounds and/or harmful to the environment or human health. Since there is a growing demand for more sustainable processes, an effective strategy to find safe and bio-based solvents able to solubilize this polymer is desirable[1].

The COSMO-RS theory (Conductor-like Screening Model for Real Solvents) provides a purely theoretical and computational method for the prediction of solubilities. The chemical potential (μ_S^X) of a solute X in a solvent S is calculated by statistical thermodynamics and quantum chemistry without experimental input (eq. 1). For this purpose, the molecular surface of a molecule is divided into interacting segments whose screening charge densities (σ) can be represented in the so-called σ-profile (p^X) (Fig. 1). The σ-potential (μ_S) describes the affinity of a system to a surface of polarity σ and the combinatorial term ($\mu_{C,S}^X$) considers the effects of size and shape. Solvents, in which the polymer has a low chemical potential, are predicted to be good solvents[2–4].

$$\mu_S^X = \mu_{C,S}^X + \int p^X(\sigma)\mu_s(\sigma) \qquad (1)$$

In order to avoid time-consuming quantum chemical calculations, COSMO-backfitting can also be used to generate a σ-profile, and thus calculate properties, using the fragmentation approach (COSMOfrag). In this approach, the σ-profile of the polymer is a composition of already pre-calculated σ-profiles from a database of 170 000 molecules (Fig. 1,2) Experimentally determined solubilities can be used as references otherwise only relative solubilities are calculated[5,6].

We used both COSMO-RS (via COSMOtherm software) and COSMO-backfitting (via COSMOquick software) to predict the solubility of cellulose acetate DS 2.5 (Degree Substitution). By comparing the predictions with our experimental results, we observed that both approaches are able to predict effective solvents quite well. However, the molecule's structure is not required for the calculations using COSMO-backfitting. Therefore, it's particularly useful for undefined polymer structures, even when they have a broad distribution of molar masses. Further, several non-toxic biosolvents of the polymers could be highlighted.

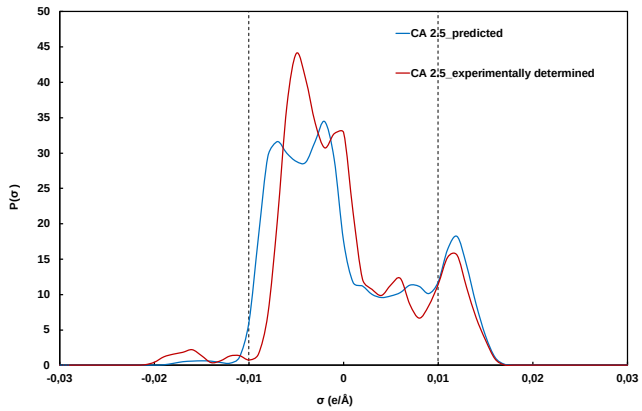

Figure 1: σ-profiles of cellulose acetate DS 2.5 predicted by COSMOtherm (blue curve) and experimentally determined solubility (red curve).

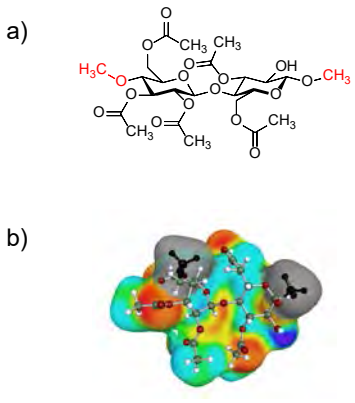

Figure 2: Structure (a) and σ-surface (b) of cellulose acetate DS 2.5.

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DEVELOPMENT OF ENTERIC POLYMER BASED MICROSPHERES BY SPRAY-DRYING FOR COLONIC DELIVERY OF *LACTOBACILLUS RHAMNOSUS GG*

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Probiotics are widely used in encapsulation systems in order to improve their stability and preservation against adverse environmental conditions related to oral administration (i.e. acidic pH in the stomach, bile salts in the small intestine) while ensuring their release, preferably in the colon. Various colonic delivery systems were developed using different strategies such as time-dependent, pH-dependent or bacterially triggered delivery systems. Eudragit® S100 is an anionic copolymer, based on methacrylic acid and methyl methacrylate, with enteric property and frequently used for the design of pH-dependent colonic delivery systems. However, its use as a polymer for microparticle formulation usually involves the use of organic solvents inappropriate for the encapsulation of living cells.

In this study pH-responsive Eudragit® S100 microparticles were developed for the encapsulation of *Lactobacillus rhamnosus GG* (LGG) using an aqueous-based spray-drying approach (Figure. 1), and thereby avoiding the use of organic solvents. One of the main drawbacks of the spray-drying is the thermal and dehydration stress imposed on bacteria, which are the major causes of cell inactivation. The use of thermoprotectant such as mannitol and trehalose allowed to increase the survival ratio from 3% to more than 50 %, using the selected and optimized parameters of the spray-drying process. The viability of encapsulated LGG were then determined during storage and incubation in simulated gastric conditions. Encapsulated LGG showed a great stability during storage with less than 1 log reduction after 1 month thanks to the low residual moisture content (1.5-3%) achieved in presence of the protectant (versus 9% without protectant). Concerning resistance in acidic conditions, free LGG showed a dramatic loss in viability after their incubation in acidic environment since no viable cell was detectable after 1h exposure. In contrast, only 1.5 log reduction was observed for encapsulated LGG after 2 h exposure in simulated gastric conditions.

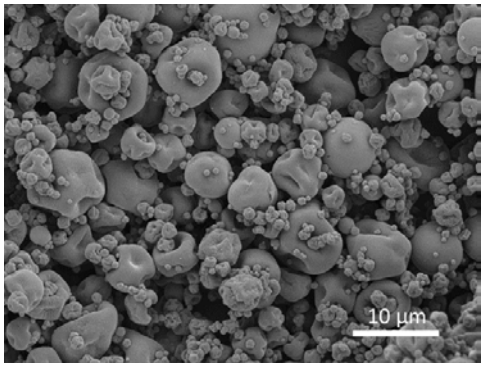

Figure. 1 SEM image of spray-dried microparticles

METHODS FOR INVESTIGATING DISSOLUTION IN SURFACTANT SOLUTIONS

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Surfactants are present in many everyday products such as detergents and shampoos. Under certain conditions, surfactants will aggregate into different structures in solution. These different structures alter the rheology of the solution, and the exact structure formed is concentration dependant. This poses an interesting situation in which the rheology changes as the material dissolves. This research uses different simulation techniques to investigate both equilibrium phase behaviour, as well as the dissolution process. Most research focuses on understanding equilibrium behaviour, and non-equilibrium processes have been much less studied and are not as well understood.

Small scale modelling of the ‘clustering’ behaviour of surfactant molecules in solution helps us to understand the effects of the small scale on the rheology of the material. This poster will focus on the use of Lattice Monte Carlo (LMC) and Dissipative Particle Dynamics (DPD) methods. Both methods model molecules as a chain of 'beads'. LMC confines these beads to a lattice structure, whereas DPD is an off-lattice mesoscopic simulation technique which involves a set of particles moving in continuous space. While LMC can only be used to study the equilibrium behaviour of solutions, DPD can be used to study the dissolution process as well. This poster will compare the two methods, and show how DPD can be used to study the movement of surfactant molecules into an aqueous solution.

Incorporating small scale dissolution phenomena into large scale models, for example via multi-scale CFD approaches, is challenging and has received little attention in the literature. This is largely due to challenges capturing small scale phenomenon in a large scale simulation. One of the aims of this research is to investigate the feasibility of a coupled DPD-CFD model. This poster will discuss how such a model is implemented, and outline how a DPD-CFD model could work.

POSTER WITHDRAWN

Lipid-based nanoformulations as delivery systems for new and improved drug molecules

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Abstract Text

In medicine today, many diseases are faced with promising basic research results with respect to new and improved drug molecules. Development of treatment is however hampered by effective delivery of the drugs. The focus of the present work is on lipid-based formulations, such as liposomes, lipidic nanocapsules, solid lipid nanoparticles and lipid complexes, as delivery systems for conventional and new drug molecules as well as for antimicrobial peptides. Lipid formulations can be used for several delivery routes; nevertheless, the work herein focuses on topical applications, and on delivery to the eyes and lungs. To be able to use lipid formulations as drug delivery systems the formulations need to be applicable in a clinical setting. Optimization for drug loading efficiency, drug release, physical and chemical stability, manufacturing process (including scalability for clinical studies), environmental impact and cost are aspects that need to be considered during formulation development. Key results from two large collaborative projects were RISE is a major partner will be presented, namely FORMAMP and transMed. The objective is that these formulation studies will pave the way for further development for every day therapeutic use in patients.

Acknowledgements

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FORMAMP is funded by the European Union’s Seventh Framework Programme (FP7/2007-2013) under grant agreement no 604182.

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CEFOTAXIME-LOADED CHITOSAN NANOPARTICLES TO OVERCOME ANTIBIOTIC-RESISTANCE

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The complex membrane structure of Gram-negative bacteria presents a considerable barrier to the entry and action of anti-infective agents, and is partly responsible for mediating the growing level of Gram negative resistance to antibiotics. Nanotechnology can be considered as an effective solution to enhance anti-infective trafficking across the bacterial cell envelope. Carriers made of chitosan (CHT) have attracted interest due to the biodegradable and biocompatible nature of this material, as well as its intrinsic antimicrobial activity.
The aim of this study was to manufacture blank and loaded chitosan nanoparticles (CHT NPs) containing cefotaxime, a third-generation cephalosporin antibiotic, using the NanoAssemblr™ bench-top instrument. This is an innovative, microfluidics-based platform for the production of particulate delivery systems. To prepare CHT NPs, chitosan and TPP (tripolyphosphate), were dissolved in 1% acetic acid and distilled water respectively at desired concentrations. Taguchi design L18 orthogonal array, constructed through Minitab 16 Statistical Software®, was used to determine the optimum blank formulation in terms of size, PDI (polydispersity index) and charge. Different amounts of cefotaxime were added to the TPP and chitosan solution to manufacture cefotaxime-loaded CHT NPs followed by characterization in terms of size and PDI. Encapsulation efficiency (EE%) of loaded-NPs was measured using HPLC. Results indicated particle sizes of less than 100 nm and a low PDI for the blank formulation, with no significant differences for the cefotaxime-loaded NPs. EE% of cefotaxime within nanoparticles ranged from approximately 5%, when the smallest amount of drug was added to CHT solution, to approximately 15% when the highest amount of drug was added to the TPP solution. The study showed that CHT NPs can be easily manufactured in the nanometer size range using microfluidics technology. Moreover, it is possible to encapsulate cefotaxime within nanocarriers, allowing the manufacture of nanoparticles in a fast and reproducible way.

The EC4SafeNano PROJECT AND THE CASE STUDY OF SURFACE CHEMICAL TRANSFORMATIONS OF NANO-TiO_2 SAMPLES UPON AGEING

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A central challenge to ensure the sustainable production and use of nanotechnologies is to understand and effectively control the risks along the industrial innovation value chain. Knowledge about nanotechnology processes and nanosafety issues (hazards, fate, risk...) is growing rapidly but the effective use of this knowledge for risk management by market actors is lagging behind.

EC4SafeNano (*European Centre for Risk Management and Safe Innovation in Nanomaterials and Nanotechnologies)* promotes a harmonized vision of expertise in risk assessment and management for the public and private sectors to enable the safe development and commercialization of nanotechnology.

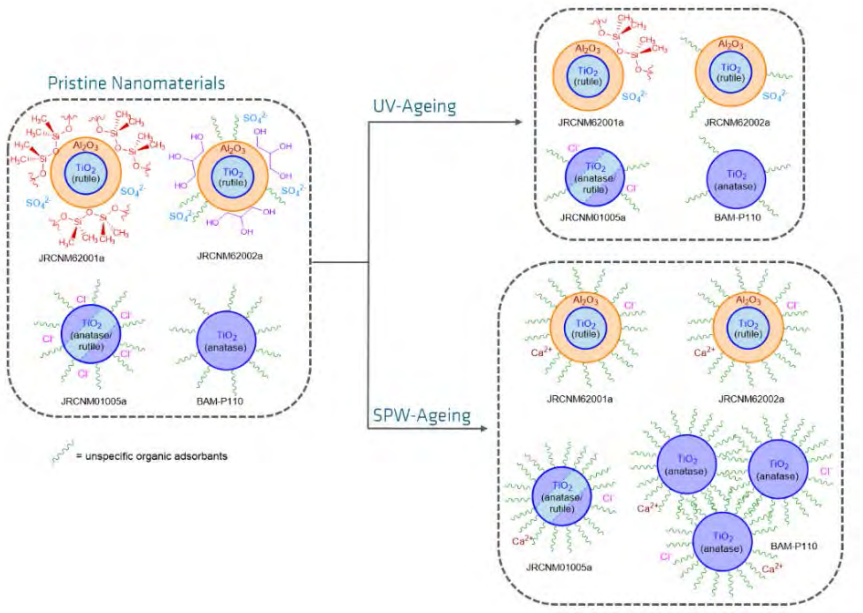
EC4SafeNano is operated together by major European risk institutes with the support of numerous associated partners, gathering all stakeholders involved in Nanomaterials and Nanotechnologies (regulators, industry, society, research, service providers...).

In a case study the surface chemical transformations upon 2 different ageing procedures (long-term UV irradiation or swimming pool water) of a representative set of titanium dioxide nanoparticles has been investigated. The materials have been analyzed by various analytical techniques. Each method addresses different aspects of the complex endpoint surface chemistry. The multi technique approach allows evaluation of the capabilities and limitations of the applied methods regarding their suitability to address the endpoint surface chemistry and their sensitivity to identify even small surface chemical transformations.

Results:

- To obtain a comprehensive picture, it is insufficient to concentrate on a single analysis technique.
- By using time-of-flight secondary ion mass spectrometry (ToF-SIMS) in combination with principal component analysis (PCA) it was possible to identify even subtle changes in the surface chemistry of the investigated materials.
- A general trend that was observed for the UV-aged samples is the decrease of organic material on the nanomaterial surface.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 723623



Schematic visualization of the surface chemical transformation caused by UV-weathering and swimming pool water (SPW) ageing.

ANTI-FOULING MEMBRANES USING GRAPHENE OXIDE

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Abstract

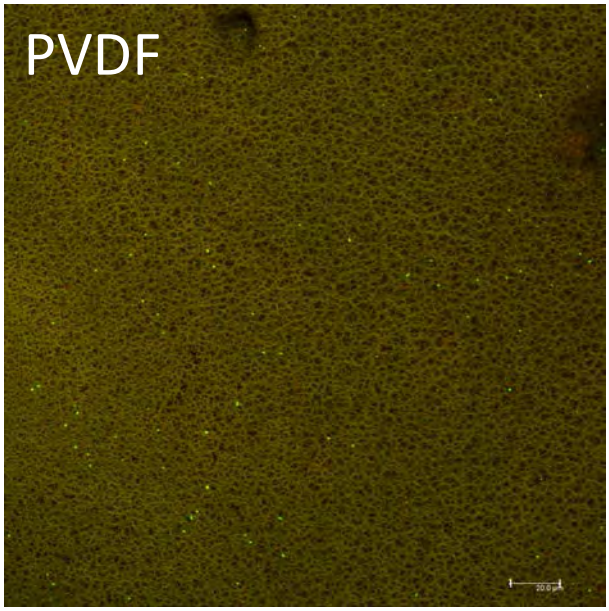
Anti-(bio)fouling is of major interest in many application areas. In the membrane industry it is associated with downtime, use of water and cleaning chemicals and reduction in membrane life.

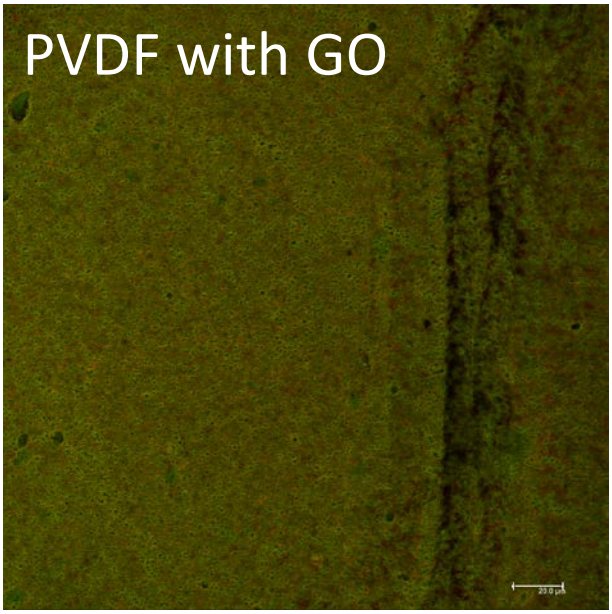
Graphene oxide has been found to have antifouling properties. A new generation of membranes with anti-fouling capability of membranes for water treatment applications has been described using up to 1 wt% of graphene oxide (GO) during the fabrication of the polymer membrane. The membranes have increased hydrophilicity, optimized pore size and mechanical properties, as well as negative Z-potential to reject major fouling component including extracellular polymeric substances (EPS) [1], and microorganisms [2].

In our study we have been investigating 4 different GO or GO derivatives, as well as 2 different types of dispersant/spacers for the GO.

By varying the ratio of GO and dispersant we have found the most promising ratio which we have used for making membranes with different amount of PVDF, aiming at a mean pore size of 0.25 µm. It was shown that the streaming potential for the different membranes was negative above pH 2.5, and decreased with higher pH. The PVDF is highly negatively charged in itself, thus addition of GO or related materials is not important for the charge of these PVDF membranes.

The anti-fouling tests using a confocal laser scanning microscope show that PVDF with GO has less live bacteria on the membrane surface after 6 days exposure of *Pseudomonas aeruginosa, than the PVDF reference*. Below: Live bacteria are shown in green and dead bacteria are shown in red. The membrane appears in yellow/green.





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POSTER WITHDRAWN

POSTER WITHDRAWN

Accelerating Chemical Formulation and Providing insights Using Computational Methods

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Formulation is a vital field of chemical research and development, responsible for the generation of consumer products from raw chemical constituents. The process of chemical formulation has rarely been the focus of computational chemistry efforts. Computational chemistry has instead been focused at the early stage screening and molecular design, where it has had a notable impact in the past decade. Our work begins to apply computational chemistry applications to problems pertinent to formulation chemistry.

Our work to date, has focused on the generation of reusable computational analogues of common experimental procedures. These computational experiments aim to provide predictions and insights to experimental formulation chemists, in an effort to help guide the best use of experimental resources.

We present, several examples of such computational experiments which utilize a simulation method known as Dissipative Particle Dynamics (DPD). These computational experiments span: predicting phase separations, simulating micellar aggregation and partition coefficient predictions. We also address the issue of suitable parameterization of these simulation methods. We apply a data driven parameterization, accelerated by the application of machine learning, prior to our simulations. This ensures we are representing the physics and chemistry of the systems as accurately as possible within the constraints of the simulations.

IN SILICO DESIGN OF NANOPARTICLES FOR TRANDERMAL DRUG DELIVERY APPLICATIONS

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Background: Human skin provides ample opportunities for various healthcare and personal care application. However, developing strategies for these applications are challenging as human skin provides a natural barrier to body and prevent permeation of foreign substances and chemical materials. The reason being skin's densely packed layered structure, which acts as a protective barrier preventing the inflow of any external species. Thus, to ensure the permeation of active components through, it is required to breach the outermost layer of epidermis known as stratum corneum.

Objective: In-silico design of nanoparticles of various shape, size, surface chemistry and surface pattern which can breach the barrier provided by the skin's top layer, stratum corneum.

Methods: The SC layer has to be breached out in a controlled manner to deliver therapeutics through it. Nanoparticles are convenient vehicles for transdermal drug delivery due to their reversible barrier breaching mechanism [1-3]. A computer simulations based (*in-silico*) approach backed by few experiments could speed up the nanoparticle formulation design process.
At first, we have developed an *in-silico* skin model based on the multiscale modeling framework linking atomistic-molecular-mesoscale to macroscale to study molecular transport across the Stratum Corneum (SC) [4-5]. At molecular level, atomistic and coarse grained molecular dynamics simulations are performed. Nanoparticles of various size [6], surface chemistry [7] and surface pattern [8] are built using Monte Carlo simulation. These nanoparticles are further *in-silico* tested on coarse grained skin SC lipid layer model via prolonged molecular dynamics simulations.

Results: Figure 1A, shows the permeability of gold nanoparticle of various sizes. The permeability decreases with increase in size. The observations are in line with several experiments carried out on real skin samples (*in-vitro*) [9]. Hence, based on the application (desired skin permeability), the size can be tuned and design *in-silico*. Further, these nanoparticles can be coated with various ligands changing their surface properties (charges) significantly. Figure 1B shows the snapshots of simulations carried on skin model in presence of gold nanoparticles coated with various ligands making them neutral, catatonic and anionic. The results show that charged nanoparticles are adsorbed on the surface of the skin while neutral molecules easily cross the skin barrier. These observations are in line with the results obtained through several *in-vitro* permeation experiments carried out on real skin samples [9, 10]. Fig 1C shows one such design case, where nanoparticle of various surface pattern are simulated along with skin lipid layer model. Out of these, only three nanoparticles, having uniform distribution of 1:0, 2:1 and 1:2 (hydrophobic: hydrophilic) beads were able to cross the skin barrier. Experimentally, it has been shown that nanoparticles, having 2:1 (hydrophobic: hydrophilic) uniform distribution of ligand over their surface, were able to breach the plasma membrane significantly [11]. Hence, these nanoparticles could be used for delivering therapeutics through skin.

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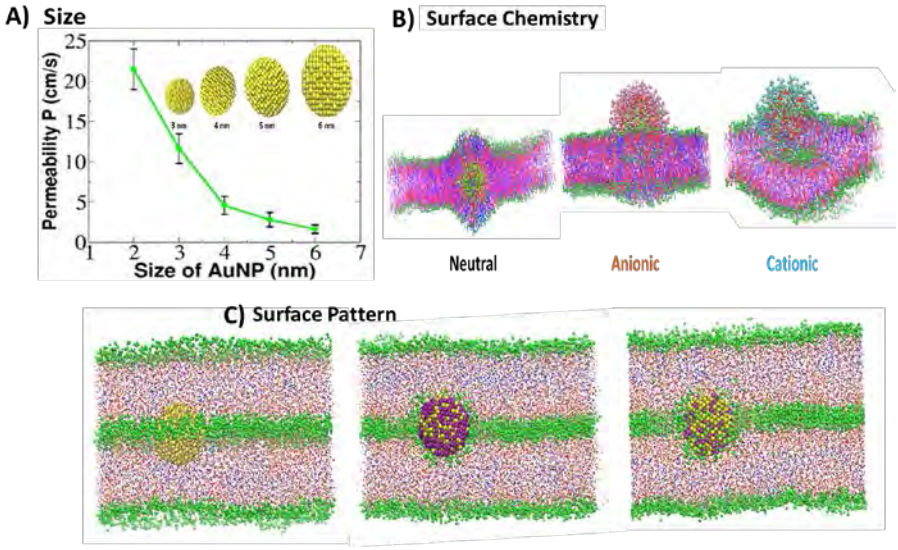

Figure 1. A) Effect of gold nanoparticle size on its skin permeability (Adapted with permission from Gupta and Rai [6] Copyright (2016) American Chemical Society). B) Effect of surface charge on skin permeation of surface coated gold nanoparticle (Images are reproduced from Gupta and Rai [7]). The skin lipids are shown in red, blue and green color. C) Effect of surface chemistry on skin permeation of nanoparticle (Images are reproduced from Gupta and Rai [8] by permission of The Royal Society of Chemistry). The green beads shows the head group of skin models. The yellow and magenta color represent hydrophobic and hydrophilic bead respectively.

TRIBOLOGICAL PROPERTIES OF POLY(IONIC LIQUID) BRUSHES IN ORGANIC AND AQUEOUS MEDIA

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There are few publications evaluating polymer brushes in two types of solvent, such as organic and aqueous solvents, and there are even fewer papers evaluating surface grafted poly(ionic liquids) for its ability to reduce friction. This study evaluates the friction reducing capabilities of an Imidazolium based poly(ionic liquid) brush grafted onto a silicon wafer using surface initiated atomic radical transfer polymerisation (ATRP) against borosilicate glass in both dodecane and water. The samples were tested as a function of the polymerisation time as well as changing functional groups on the Poly(ionic liquid).

Using a macroscopic tribometer the friction coefficient was measured as a function of polymerisation time as shown in Figure 1 and a reduction of friction was seen in both dodecane and water, though the reduction in friction exhibited in dodecane was more significant than that in water. This implies that the surface grafted poly(ionic liquid) brushes could be well solvated by both aqueous and organic solvents. Atomic force microscopy imaging was carried out in water to view the morphology of the film in the aqueous solvent to examine why a more minor reduction of friction is seen. Some brush like features are seen for the samples with polymerisation times of 5 h and 9 h and 7 h but not polymerisation times of 3 h which matches with the friction coefficient seen in water.

To further verify these observations force curves with a borosilicate glass colloidal particle will be carried out to assess the 'pull-off' adhesion force of these samples and how they relate to friction coefficient. Also, imaging of the samples in dodecane should be carried out to compare that with the water imaging and see if that can explain differences seen in friction coefficient.

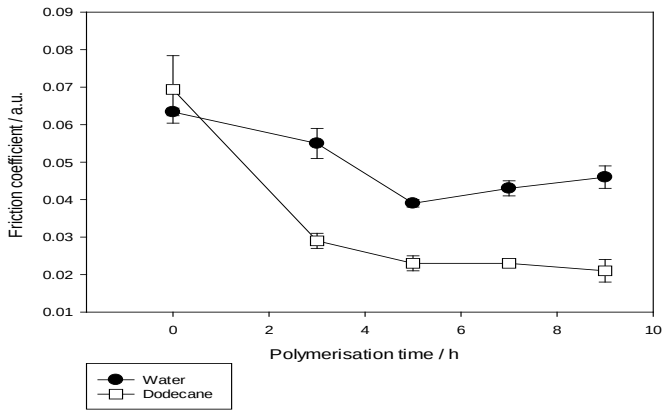

Figure 1- Graph plotting the friction coefficient measured between the PIL brush samples and a borosilicate glass sphere with a normal load of 100 g and a sliding speed of 0.5 mm s^{-1}.

BIAXIAL NEMATICS OF HARD CUBOIDS IN AN EXTERNAL FIELD

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Colloids are biphasic systems consisting of particles dispersed in another medium. When these dispersions have anisotropic shapes, they can self-assemble into liquid crystalline (LC) phases. In this research, we are interested in the biaxial nematic phase (N_B), an elusive phase that is foreseen to be a promising candidate in the engineering of next generation liquid crystal displays (LCDs). In equilibrium, board-like colloids cannot form the N_B phase in monodisperse [1,2] and bidisperse systems [3]. However, theory [4] and experiment [5] have suggested that significant size dispersity may enhance its stability. Previously, the N_B phase has been observed experimentally in systems of board-like particles through magnetic field application [5]. This experimental finding unveiled an important phenomenon about the N_B phase: that we can stabilise it with an external field. Motivated by the experimental finding, we attempt a computational study on the phase behaviour of board-like particles in an external field.

By Monte Carlo simulation, we modelled the phase behaviour of colloidal board-like particles when subjected to an external field. By varying shape anisotropy and field strength, we constructed phase diagrams for fields applied to the isotropic (I) and uniaxial nematic (N_U) phases. We coupled the external field to the intermediate axis of our particles and were able to observe, from initially I and N_U phases, the formation of weak and strong N_B phases. At the self-dual shape, very weak fields are able to spark direct I-N_B and N_U-N_B phase transitions; other shapes required stronger fields. In line with theoretical predications [6], the self-dual shape is shown to promote phase biaxiality in our system. This finding paves the way to exploit low-energy N_B phase transitions through the self-dual shape. Currently, work is being done to study the reorientation dynamics of these phase transitions using dynamic Monte Carlo simulations [7].

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COMPLEX MORPHOLOGIES FROM SELF-ASSEMBLY OF BLOCK-COPOLYMERS IN BINARY SOLVENTS

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Novel routes for the synthesis of hierarchical porous materials have recently highlighted the relevance of methacrylate-based copolymers, which in mixtures of selective and common solvents are able to spontaneously self-assemble into colloidal size aggregates such as vesicles or more complex mesophases including polymeric nanospheres with bicontinuous internal structure (BPNs) [1]. Nevertheless, the phase behaviour of this family of structure directing agents is only partially understood [1]. In this regard, computer simulations can be effective to provide a clear insight into the physical laws governing the associated kinetics and equilibrium. Motivated by their essential role in the preparation of complex self-assembled morphologies, we have developed transferable and computationally efficient coarse-grained (CG) models that reproduce the behaviour of a family of methacrylate-based copolymers in aqueous and organic solutions, melts and interfaces [2]. The CG potential derivation is based on a hybrid thermodynamic-structural approach which incorporates macroscopic and atomistic-level information. The target properties in the parameterisation are those that govern the self-association mechanism (i.e. interfacial tension, chain conformational entropy and excluded volume repulsive interactions [3]).

By direct molecular simulation, using our CG models, we obtain phase diagrams of methacrylate-based copolymers in mixtures of THF and water (Figure 1), which act as common and selective solvents, respectively. In particular, we focus on the morphological transformations of self-assembled aggregates as a function of the selective/common solvent ratio, polymer concentration and chain architecture. Our results demonstrate that in addition to chain related properties, solvent correlations play a fundamental role on determining and stabilising the polymer structures.

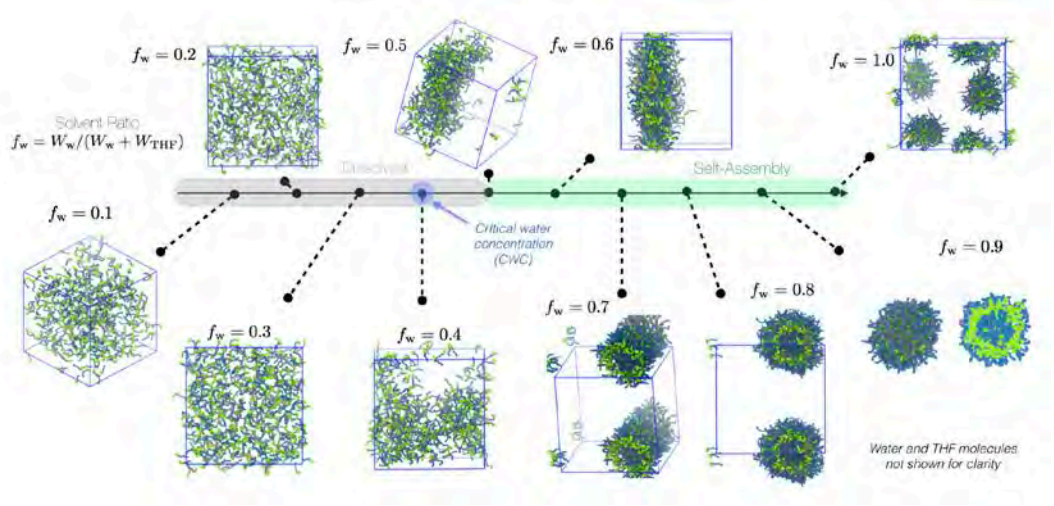

Figure 1. Morphological phase diagram of PEO6-b-PBMA4 at 10wt% in mixtures of water and THF for different solvent ratio (fw). In the simulation snapshots the PBMA and PEO blocks correspond to green and blue beads, respectively.

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ENHANCED DYNAMICS OF GLYCEROL IN GAMMA-ALUMINA NANOPORES

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Equilibrium and transport properties of fluids are deeply affected under 2D or 3D confinement [1]. Knowledge of molecular level properties of confined systems is especially relevant in a wide spectrum of technological applications, including catalysis, oil recovery and membrane separations [2]. Of special interest is the case of viscous glass-forming liquids in mesoporous materials, where a deeper understanding of the physics of the fluid under confinement, based on relationships between structure and mobility, is required in order to fully understand thermodynamic and kinetic properties [3]. Particle-based simulations can provide a detailed insight into this multifaceted problem [4], which is dramatically determined by the complex nature of inter-molecular interactions. In this work, we present results from classical Molecular Dynamics (MD) simulations of condensed interfacial-Glycerol on Gamma-Alumina. Model systems of slit-shaped pores at different degree of saturation are studied. The heterogeneity imposed by the presence of the solid surface is analysed in terms of the dynamic and structural properties of the liquid in the proximity of the interface and sufficiently far from it. In particular, spatial ordering of Glycerol into quasi-discrete molecular layers is observed and the confinement is also seen to influence the relaxation dynamics as a result of the slowing down of the average molecular motion (translational and rotational) at the solid-liquid interface. In the case of slit-shaped pore geometries at full saturation, this results in an overall decrease of the molecular self-diffusion when compared to the unperturbed bulk fluid at the same density. Interestingly, an accelerated dynamics is detected for the outermost layers of glycerol molecules in the unsaturated pores. Such a behaviour could explain the enhanced self-diffusion of Glycerol on Gamma-Alumina that has been reported in recent experimental observations [5].

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CROSS-OVER IN THE DYNAMICS OF POLYMER CONFINED BETWEEN TWO LIQUIDS OF DIFFERENT VISCOSITY

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The study of structural and dynamical properties of polymers at liquid/liquid interfaces is crucial to understand technological and biological systems. Polymers are indeed confined at liquid interfaces in many industrial processes, such as liquid/liquid extractions, solvent displacement methods, or emulsifications, and also in biological applications, such as drug nanocarriers. Depending on the relative solubility of the polymer chains, they can dissolve in one of the two solvents or reside at the interface. In the latter case the polymers adsorbed at the interface minimize the interfacial free energy of the system, behaving as active molecules [1]. By performing molecular dynamics simulations, we characterized the dynamics of polymer chains with different molecular weights, entrapped at the interface between two immiscible liquids of different viscosity (Figure 1). We showed that increasing the viscosity of one of the two liquids the dynamic behaviour of the chain changes from a Zimm-like dynamics typical of dilute polymer solutions, to a Rouse-like dynamics where hydrodynamic interactions are screened [2].

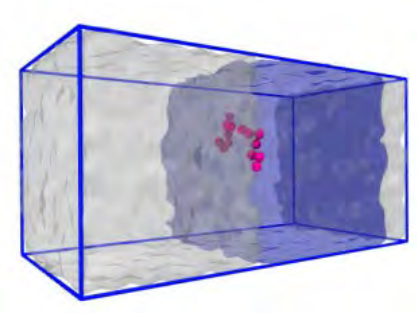

Figure 1 - Schematic representation of a polymer chain at the interface between two immiscible liquids of different viscosity.

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COARSE-GRAINED MOLECULAR DYNAMICS SIMULATIONS OF POLYMER-SOLID INTERFACES IN NANOCOMPOSITES

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The adsorption and dynamics of polymer chains on solid surfaces play an important role in many applications, especially in polymer nanocomposites, where inorganic fillers such as carbon black are dispersed in the polymer matrix to improve composite mechanical and rheological properties. The effect that the presence of such particles has on the macroscopic properties of the material is directly linked to the polymer/filler interfacial area and the chemical nature of the particles [1]. However the molecular mechanisms by which these properties are modified are not entirely clear. This lack of understanding is mainly due to the complexity of the experimental characterization and of the material itself which often contains polymer chains with large distribution of molecular weight, particles of different sizes and geometry and different type of additives including small organic molecules which act as plasticizers [1, 2]. In this work we develop a Coarse-Grained (CG) model for graphite/PI nanocomposite, which is in this instance considered as a model for the surface of carbon-black fillers. To do that we employ the Kremer-Grest (KG) PI model developed by Svaneborg et al. [3] and implement a new efficient way to optimize the parameters for PI and graphitic surface. By performing molecular dynamics simulations we study the effect of the solid surface on the conformation of the adsorbed polymer chains (Figure 1) and the entanglement density. Finally we investigate the behaviour of the adsorbed chains in the presence of plasticizers which are added to modify the glass transition temperature of the polymer.

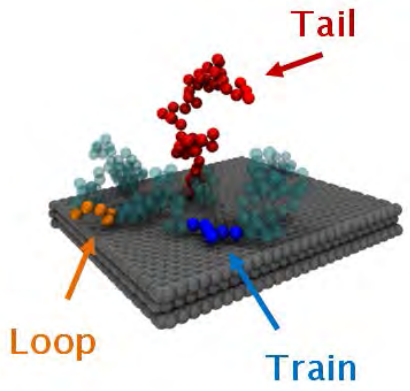

Figure 1 – Schematic representation of a polyisoprene chain adsorbed on graphite

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Predicting adsorption selectivity of ethane and ethylene in carbon slit pores: a comparison between Monte Carlo simulations and direct numerical integration

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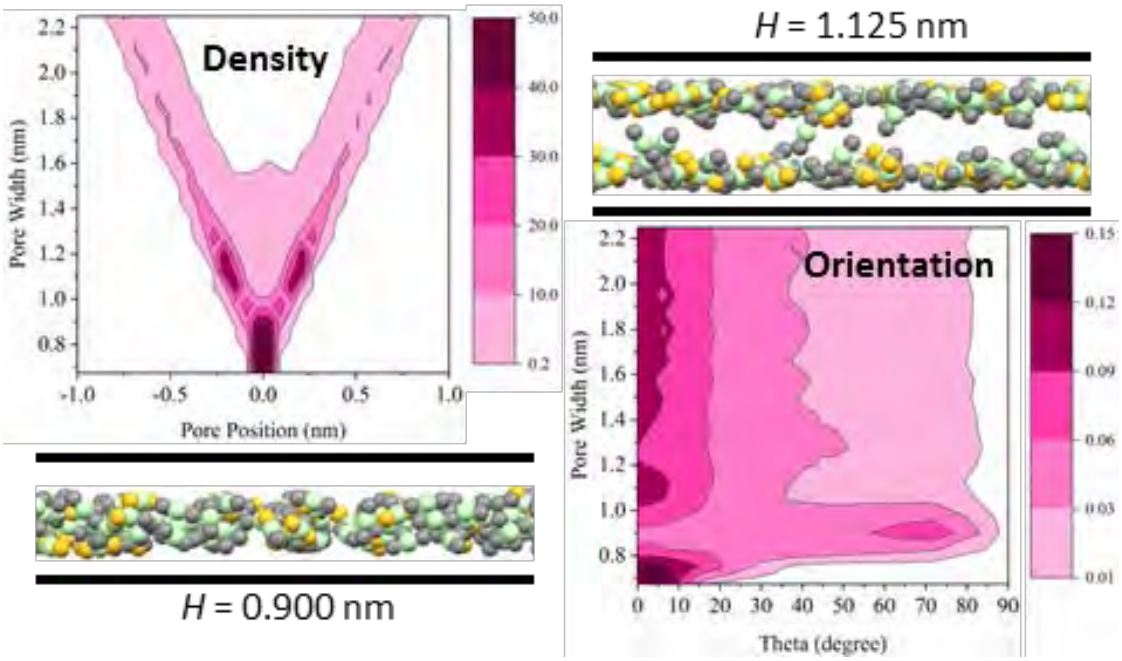
Understanding the behaviour of fluids in confinement is essential to predict adsorption selectivity and develop adsorbents that can address challenging separations, such as ethane/ethylene mixtures [1]. In this work we show that adsorption selectivity for an ethane/ethylene mixture can be predicted from direct numerical integration of the solid-fluid interaction potential because fluid-fluid interactions are negligible when compared to solid-fluid interactions, and adsorption sites are indistinguishable in pure component and mixture simulations. We present a comprehensive analysis of the density and orientation distributions in the pores as a function of pore size and pressure, providing tools that can be used for the design of 2D materials for the selective adsorption of gases.



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TURBULENT FLOW SIMULATION OF DISPERSION MICROSYSTEM WITH CUMULANT LATTICE BOLTZMANN METHOD

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Micro-systems minimize required quantities and make processes economically efficient and environmentally friendly. A desirable size of each drug component can help physicians to improve the patient's health effectively. A micro-machined disperser is an efficient way to break-up large agglomerates into suitable small-sized ones. This motivates to analyze a complex micro-system used for dispersion. The disperser generates stresses (shear, elongational, turbulent flow) inside micro channel geometries designed to break-up nanoparticle agglomerates. The advancement in computational fluid dynamics (CFD) theory and in high performance computing able us to study orifice flow with a high-fidelity CFD method. Cumulant lattice Boltzmann method (LBM) is used to study the dispersion micro-orifice [1,2]. The agglomerates are modelled as tracer particles with mass and drag coefficient. They record the history of the stresses and the relative velocity of the agglomerates with respect to the fluid. The tracer particles are implemented in a massively parallel multi-resolution lattice Boltzmann framework. The simulation of the disperser is validated against PIV and flow rate measurements [3]. The drag coefficients of the agglomerates are obtained by detailed simulations of synthetic agglomerates in simple shear flow, elongational flow, and rotational flow. An empirical relation between the drag coefficient and the number of primary particles in the agglomerate and its fractal dimensions is found and used in the tracer simulation of the disperser. Maximal strain, exposure time to a certain strain, and relative velocity of the particles with respect to the surrounding fluid are measured. The distribution of the maximum strain rate seen by an agglomerate can be condensed into a simple exponential cumulative probability distribution.

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Towards The Development of a QSAR Approach to High Concentration Graphene and Reduced graphene Oxide Dispersions Exfoliation

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The stable dispersion of graphene in polar solvents such as water requires the use of stabiliser molecules. Desirable properties of such dispersions include low excess stabiliser content, high graphene concentration and large flake size. Polyaromatic sulphonic acid salts have shown promise in meeting these criteria, adsorbing onto graphene through π-π interaction. In our study, we present a series of perylene, pyrene and triphenylene monofunctional amphiphilic molecules with different alkyl and alkynyl chain lengths between the ionic head and polyaromatic core have been synthesised and systematically tested on the *in-situ* reduction and stabilisation of graphene oxide. The effect of spacer and core both influence the final concentration of these materials, with perylene core groups showing the highest efficiency. Combination of this with an unsaturated alkynyl chain and sulphonic acid salt, produces quantitative yields of 100% monolayer aqueous reduced graphene oxide dispersions with no reduction in flake size. The application of this material for inkjet printing and elastomeric composites is also shown.

Synthesis of Fluorescent-Tagged Polymers

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Abstract

New MMA-PAH copolymers were prepared with a view to their use as stabilisers for aqueous graphene dispersions, for surface functionalisation of 2D-materials and for the synthesis of Janus, 2D-materials. A variety of perylene- and pyrene-containing copolymers were prepared by radical copolymerization of 5-(perylen-3-yl)pent-4-yn-1-yl methacrylate (Perylene-C5-MA), 1-pyrenemethyl methacrylate (PyMMA), 2-Acrylamido-2-methylpropane sulfonic acid (AMPS) and 2-(2-Bromoisobutyryloxy) ethyl methacrylate (BIEM). Following the successful synthesis of these copolymers a study of their interaction with 2D-materials has now been initiated.

PREPARATION OF PHOSPHATE-FUNCTIONAL CORE-SHELL POLYMER LATEXES AND INVESTIGATION INTO THEIR USE IN PROTECTIVE COATINGS

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Due to increasing concerns on the environmental impact of volatile organic compounds (VOCs), there has been a reduction in the use of solvent-borne coatings over the past decade. As a result, the use of low VOC/VOC-free waterborne coatings, or emulsion paints, has increased, especially in the decorative market. Phosphate-containing polymers have been shown to be effective, 'green' corrosion inhibitors in solvent-borne and epoxy coatings.[1, 3] They are able to improve adhesion to metal substrates and corrosion performance.[1, 3] The targeted inclusion of functional groups, such as fluorine and phosphate, in the shell of a core-shell latex dispersion has been achieved using seeded emulsion polymerisation.[4-6] In this poster, the influence of phosphate groups on the water uptake of the free and metal-bound films of a series of poly(styrene-co-butyl acrylate-co-phosphated methacrylate) latexes, prepared via semi-continuous seeded emulsion polymerisation. Latex dispersions with high solid contents (30 wt. %) were prepared with shell thicknesses in the range 25-75 nm and phosphate monomer contents of 0–7 wt. %. All polymerisations exceeded 95 % monomer conversion and final particle diameters were in the range of 189-275 nm. The latex series were cast at 30 °C to ensure good film formation on HDPE (for free films), aluminium or carbon-steel. The film formation of the latexes was confirmed using AFM to observe film structure. These films were subjected to Dynamic Vapour Sorption (DVS) analysis and bulk water uptake to probe the effect of the hydrophilic phosphate groups on the water uptake. Control particles containing methacrylic acid and ß-carboxyethyl acrylate were used as comparison. Although the films are relatively hydrophilic, we intend to determine whether the inclusion of the phosphate functionality has an overall positive impact on the protection imparted by films prepared from these latexes.

PICKERING EMULSIONS USING A FUMED SILICA AND A SILICA SOL – THE EFFECT OF MICROFLUIDIZATION

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Abstract Text

The ability of colloidal silica to stabilize nano-oil-in-water emulsions prepared using a Microfluidizer® has been demonstrated by Persson, K.H., Blute, I.A., Mira, I.C., Gustafsson, J. Creation of well-defined particle stabilized oil-in-water nanoemulsions, 2014, Colloids and Surfaces A: Physicochemical and Engineering Aspects, 459, pp. 48-57.

As vast amount of work has been performed and reported on fumed silica-stabilized emulsions, we wanted to investigate the limiting emulsion droplet size that can be obtained with these by means of emulsification via microfluidization in a Microfluidizer®.

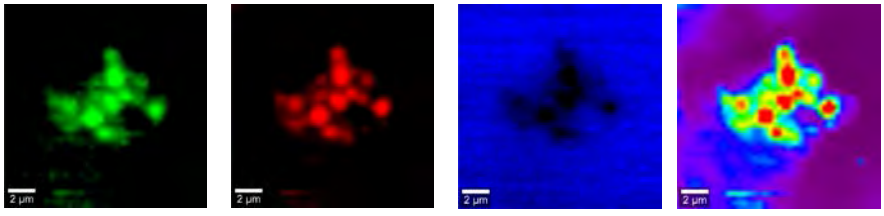
In our work we used fumed silica with 80%SiOH and a primary particle diameter of 25-30 nm. Fumed silica is known to partially fuse into larger 'aggregates'. A colloidal silica Levasil CC301 (7 nm particle diameter) was used as benchmark.

The results show that both fumed and colloidal silica particles stabilize squalene-in-water emulsions with 10% w oil . Emulsions produced with Levasil CC301 were characterized by a droplet size of 0.092 µm (volume mean diameter) . No variations in droplet size were observed for at least a month (previous work indicates that these type of emulsions remain stable for years).

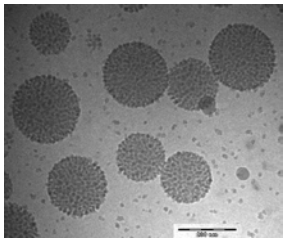
However, while the fumed silica also stabilize 10% squalene-in-water emulsions, the mean droplet size of these emulsions is larger (2-10 µm), and the droplets grow in size with time. Using less oil (5%) and pre-dispersing the fumed silica in the Microfluidizer® results in more stable emulsions. This emulsion initially has a bimodal droplet size distribution but the droplets coalesce (or agglomerate) resulting in an emulsion with stable droplet size of 3-20 µm. This droplet size was constant between 1 week and 1 month.

In summary, while the fumed silica is good for stabilization of emulsions with droplets sizes larger than 2 µm, it is not suitable for stabilization of nano-oil-in-water emulsions. Surface-modified colloidal silica performs very well as stabilizers of nano-oil-in-water-emulsions.

Silica Squalene Water Combined



Confocal Raman Microscopy images of the 10%w squalene emulsion stabilized with fumed silica. The images show (from left to right) the location of: silica, squalene, water and all the components at once. Scale bar: 2 µm.



CRYO-TEM of 5% oil nano emulsion stabilized with colloidal silica. The scale bar is 200 nm.

MOLECULAR MIGRATION IN POLY(VINYL ALCOHOL) MIXTURES

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Introducing additives such as plasticisers into polymer materials is a common way to enhance their mechanical properties while retaining the inherent advantages of these materials. Although characteristics are improved upon modification with additives, unintended changes in materials' structure (e.g. blooming or segregation) due to guest molecule migration may occur. As a result, these systems can exhibit long term non-equilibrium characteristics, potentially affecting their operational life cycle. Current scientific theories cannot fully explain these phenomena. Therefore, developing a molecular understanding within these systems may result in enhanced, environmentally friendly products with improved performance and shelf life.

This work aims to understand the migration characteristics of small molecules one such complex polymer mixture - poly(vinyl alcohol) (PVA) packaging materials that are in contact with concentrated detergent. Thin PVA films containing glycerol, surfactants of various headgroup chemistry, and Rhodamine B (RhB) as a fluorescent tracer were examined using Fluorescence Recovery After Photobleaching (FRAP) and Fluorescence Correlation Spectroscopy (FCS). It was found that the migration is determined by both molecular arrangement within the film and the magnitude of inter-species molecular interactions. Glycerol initially improved the flexibility of PVA but imposed steric inhibition once the concentration exceeded 44 wt% (Fig. 1a-c). Furthermore, surfactants reduced the diffusivity of RhB in PVA matrix in both thin films and bulk solutions. Steric inhibition effects explain this phenomenon in compositions doped with non-ionic surfactant (Fig. 1d), however, for films containing cationic or anionic surfactant, molecular interactions and consequent change in diffusivity of RhB are the likely explanation (Fig. 1e).

Using thin polymer films as a proxy for industrial formulations, we revealed fundamental migration mechanisms within these materials. Both molecular arrangement and molecular interactions control the migration at the macroscopic scale, therefore, this simplified system can be used to create a set of design rules for commercial polymer film products.

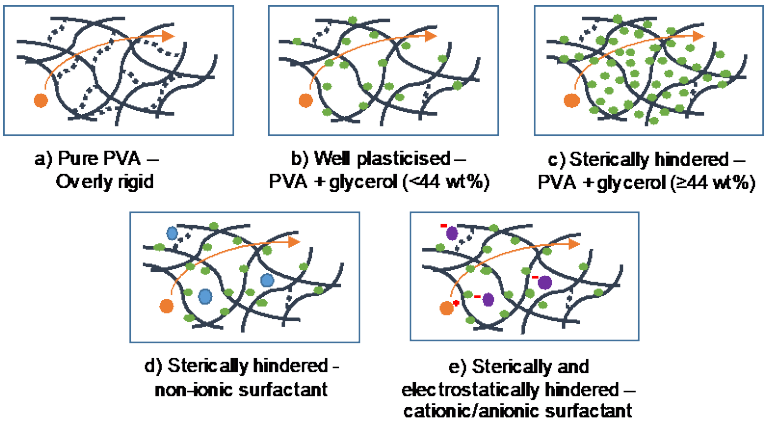

Fig. 1. Scheme of factors controlling RhB (orange sphere) diffusion through a polymer matrix (lines). Dashed lines – PVA-PVA hydrogen bonding, green spheres – glycerol, blue spheres – nonionic surfactant, purple spheres – anionic surfactant.

Monday 24th June		Tuesday 25th June		Wednesday 26th June		Thursday 27th June	
		09:00-9:45	Prof Ijeoma F. Uchegbu: Nanotechnology and the differentiated medicine	09:00-9:45	Dr Valeria Garbin: Formulations by Design: Towards a Mechanistic Understanding of Oleofoam stability	09:00-10:00	C2: Novel Characterisation of Formulations III / C9: Emulsions and Suspensions III
		09:45-10:45	C2: Novel Characterisation of Formulations I / C9: Formulation of Pharmaceuticals and Biologicals I	09:45-10:45	C2: Formulation of Nanomaterials I / C9: Emulsions and Suspensions I	10:00-10:30	Coffee
		10:45-11:15	Coffee	10:45-11:15	Coffee	10:30-11:15	Prof Ricky Wildman: Formulation for 3D Printing
		11:15-12:15	C2: Novel Characterisation of Formulations II / C9: Formulation of Pharmaceuticals and Biologicals II	11:15-12:15	C2: Formulation of Nanomaterials II / C9: Emulsions and Suspensions II	11:15-12:00	Future Formulation Activities
		12:15-13:00	Exhibitor and Sponsor Presentations	12:15-13:00	Overview of Thursday's visits		Conference ending
		13:00-14:00	Lunch	13:00-14:00	Lunch	12:00-13:00	Lunch
			Posters	14:00-14:45	Dr Anna Fureby and Dr Jacob Sloth Overgaard: Particle formation in drying processes - from single particles to full scale	12:30-16:00	Post conference visits
14:00-14:15	Welcome	14:00-15.45					
14:15-15:00	Prof Ian Kinlock: Formulation of low dimension carbon particles for composites and supercapacitor applications			14:45-16:05	C2: Formulation Processing and Scaleup / C9: Innovative Coatings and Films		
15:00-16:00	C2: Advances in Dispersed systems / C9: Novel Formulation Development	15:45-16:30	Dr Véronique Schmitt: Elaboration and time stability study of capsules made of double emulsions	16:05-17:00	Coffee & Networking		
16:00-16.30	Flash posters	16:30-17:00	2030 Roadmap for the European Formulation Industries				
16:30-18:00	Welcome reception and posters	17:00-19:00	AceForm Workshop / iFormulate Workshop	19:00	Dinner		