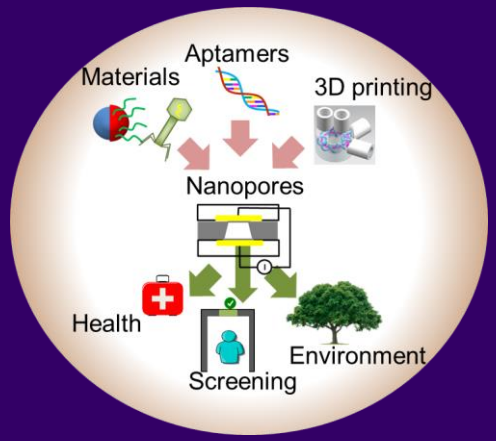
Loughborough University

Dr Mark Platt

RESISTIVE PULSE SENSORS FOR *BIOSENSORS*

SENIOR LECTURER
CHEMISTRY DEPARTMENT
LOUGHBOROUGH UNIVERSITY



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https://www.lboro.ac.uk/departments/chemistry/staff/academic-research/mark-platt/

“Lufbra”

Loughborough University

Introduction

NAMED
UNIVERSITY OF THE YEAR
Times and Sunday Times University Guide 2019

RANKED
5TH
IN THE 'TABLE OF TABLES' 2020
Times Higher Education

8th
COMPLETE UNIVERSITY GUIDE 2020

RANKED 4TH
GUARDIAN UNIVERSITY LEAGUE TABLE

Group

RATED FIVE STARS PLUS
for excellence
QS Stars

Nanomaterials for Sensing

Platt Group

Loughborough University

DNA – DNA
e.g. epigenetics, sequences

Metal Ions – DNA
e.g. Pb, Hg, Ca, Ni, Cu

DNA – Small Molecule
e.g. Pesticides, anticancer

Protein Corona – Nanoparticle
e.g. Serum, Plasma

DNA – Proteins
e.g. CRP, Cancer markers, cardiovascular

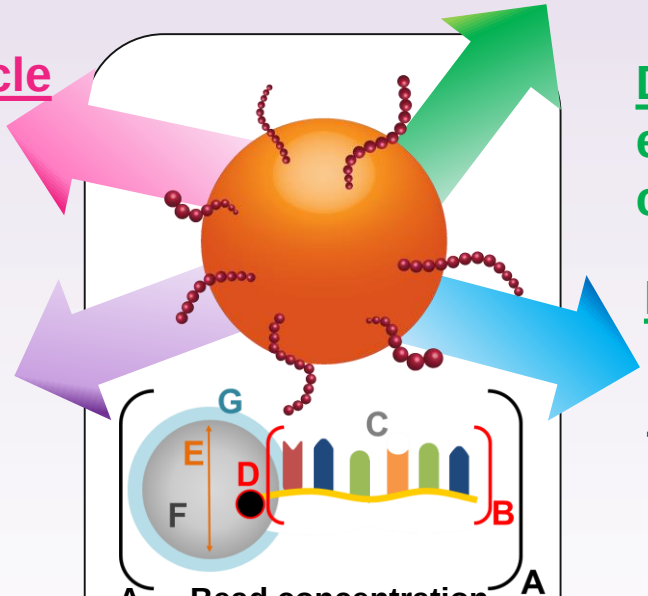
Nanoparticle Characterisation
e.g. Zeta potential, size, shape, concentration

DNA – Bacteria

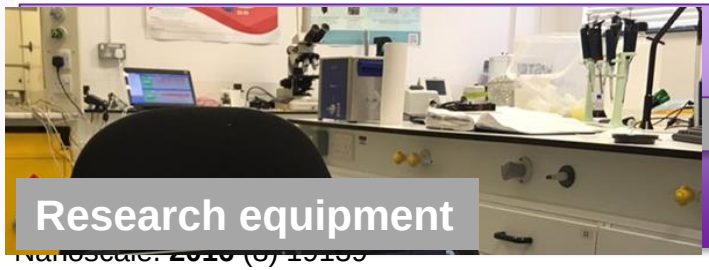
Peptide – Protein
e.g. CRP

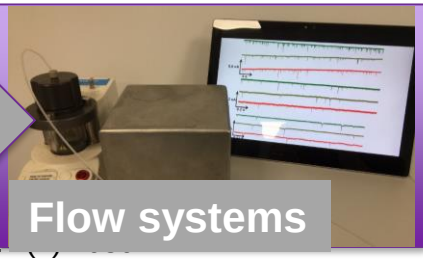
Microparticles
e.g. microplastics, bacteria, silica particles

Peptide – Metal ions
e.g. Ni, Cu, Fe.

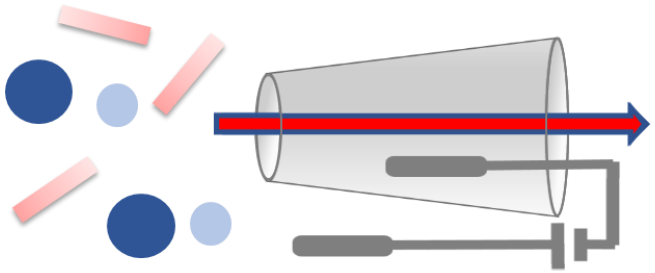


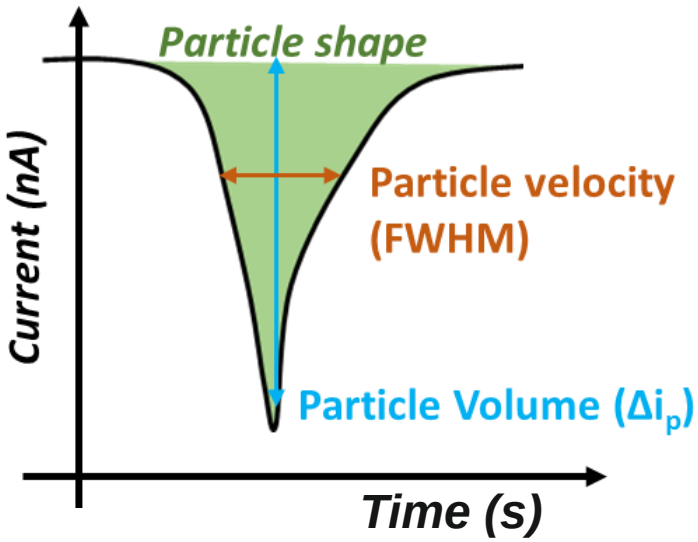
A. Bead concentration
B. Ligand density
C. Ligand (DNA/ Antibody)
D. Conjugation Chemistry
etc etc

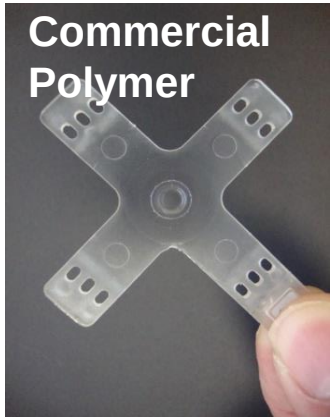


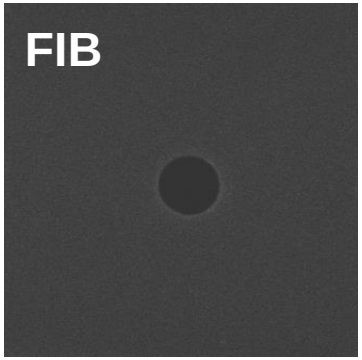


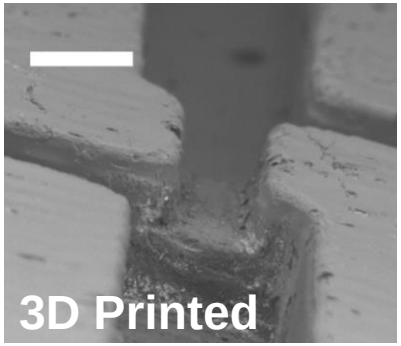
Resistive Pulse Sensors











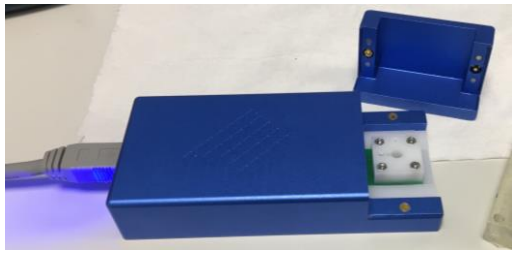
Δi_p = **Particle volume**

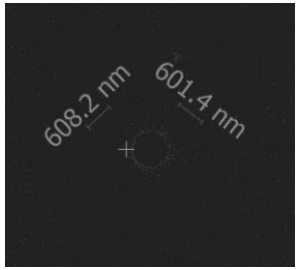
Peak Width = Particle velocity (zeta potential)

J = Pulse Frequency/ Rate (particles/ unit time)

Pulse shape = Particle/ Pore shape

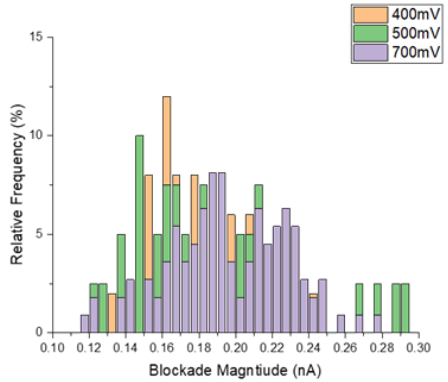
Testing Silicon nitride

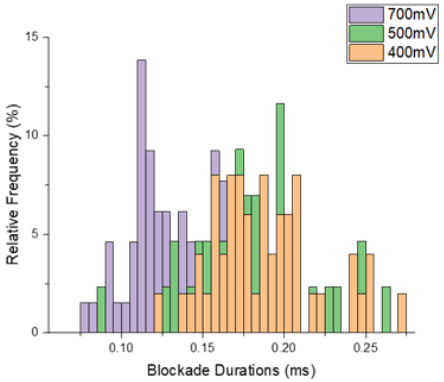


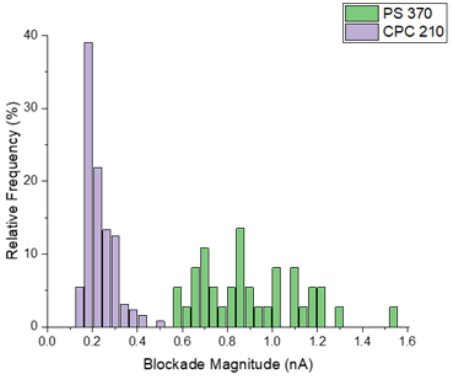


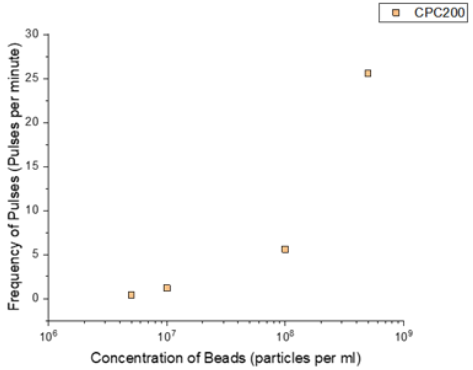
Pros
- Easy to fabricate (FIB)
- Testing for particles >100nm
- Size and concentration

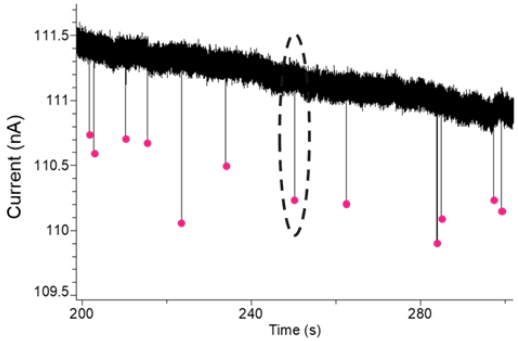
Cons
- Limited lifetime
  - <5 runs

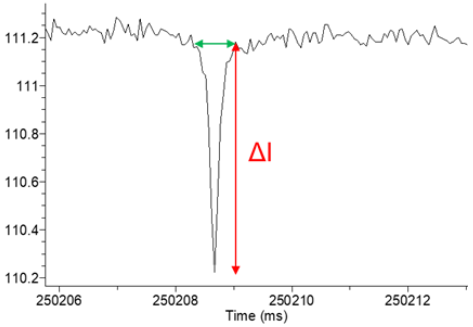




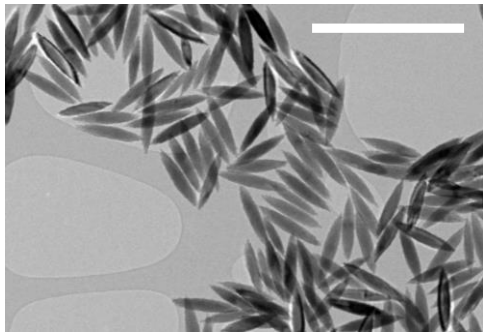


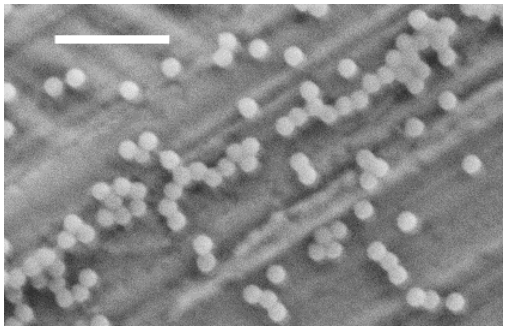




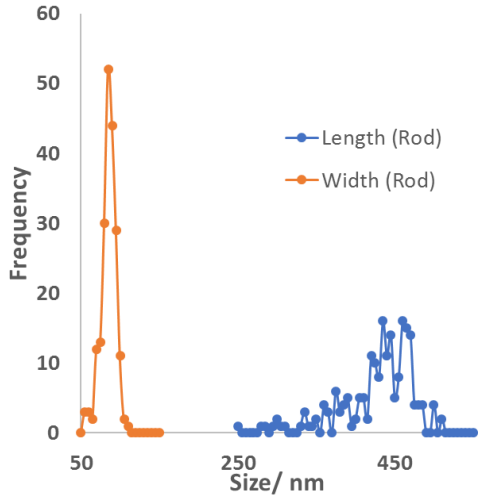


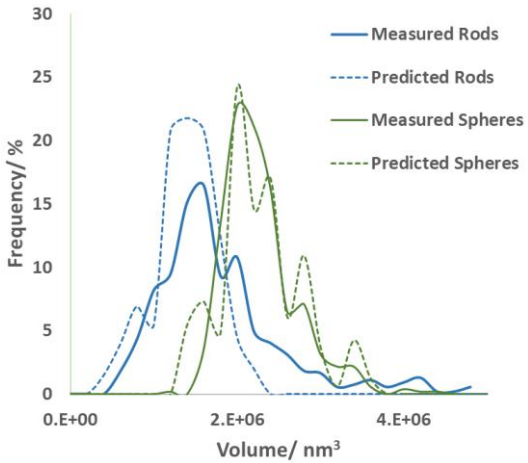
Shape analysis

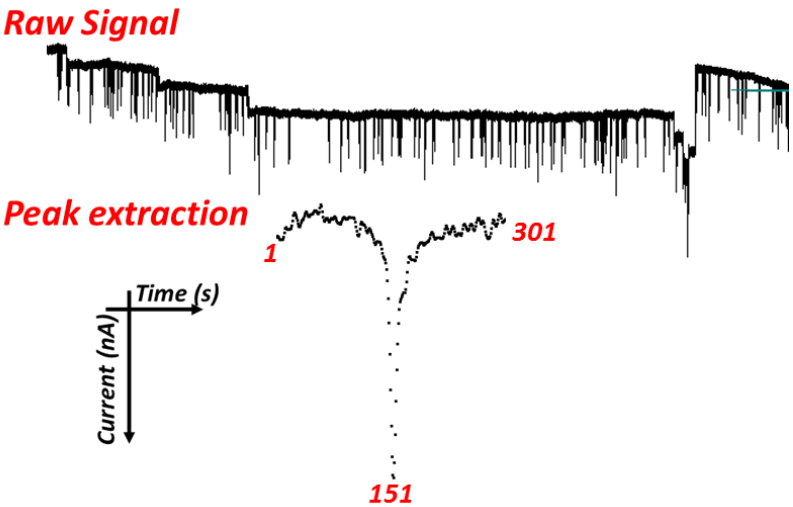


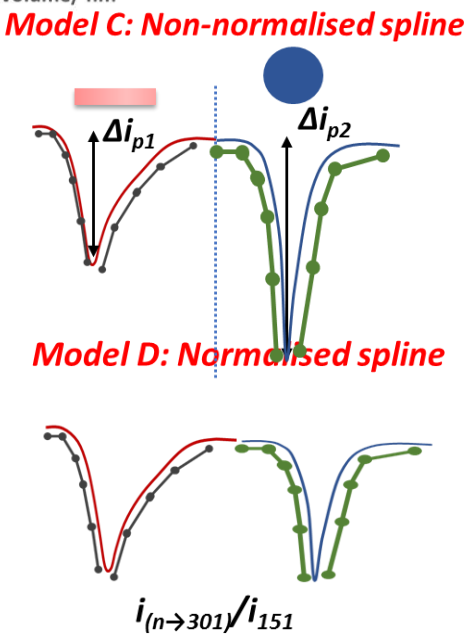


Jenna Bowen – Cardiff University



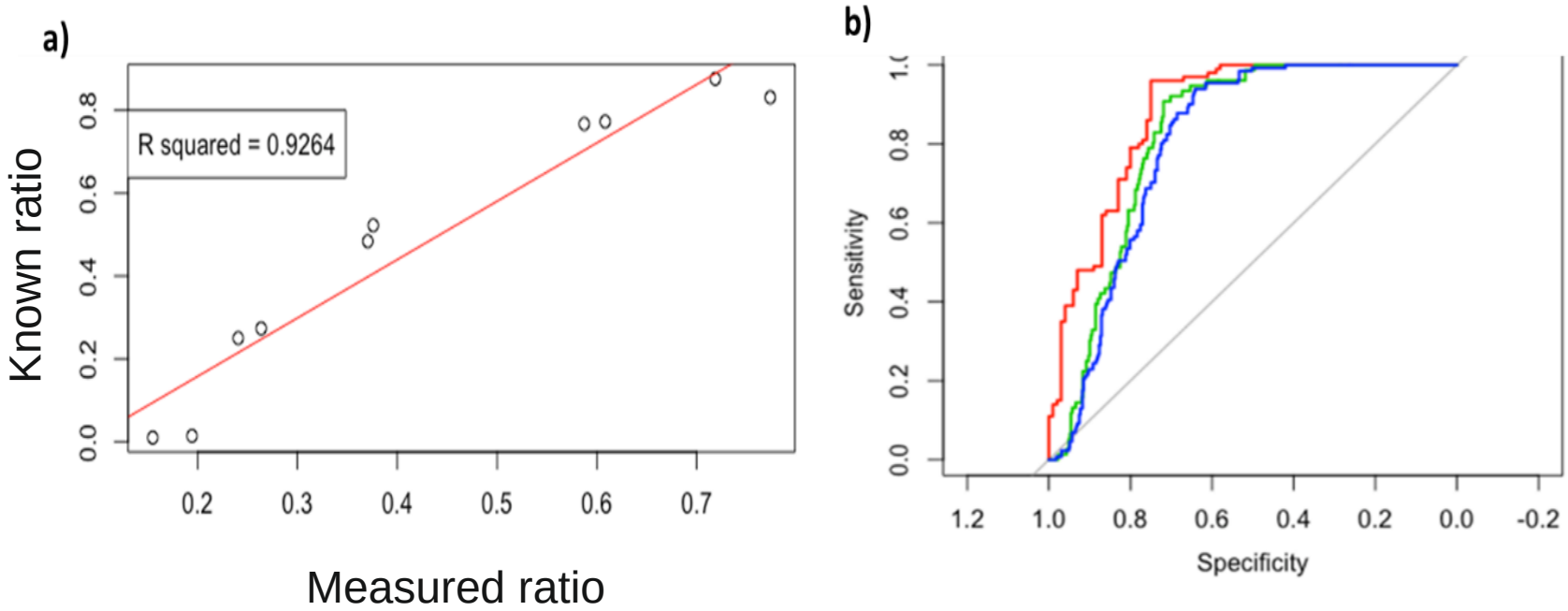






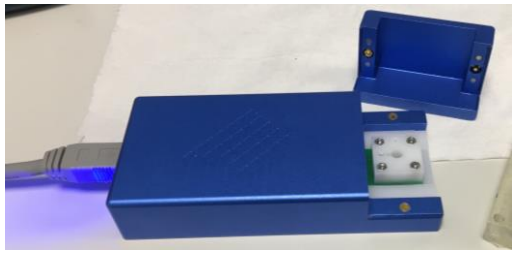
Nanoscale, 2020,**12**, 262-270

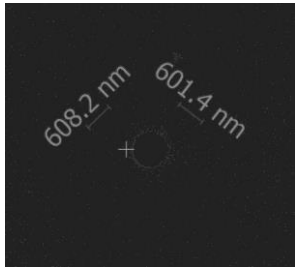
Shape analysis

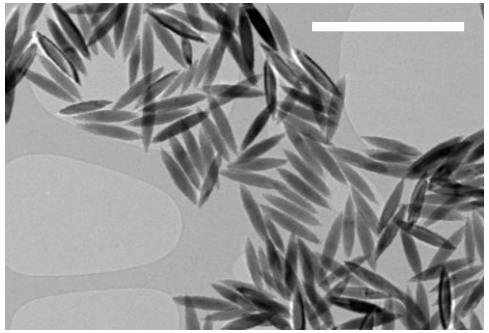


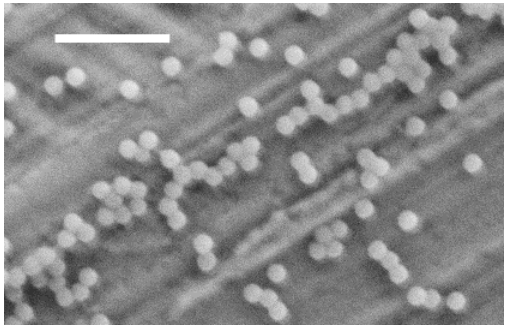
Ie, 91% of spherical particles are identified by just their shape data as spheres, and 72% of rod particles are identified by just their shape data as rods.

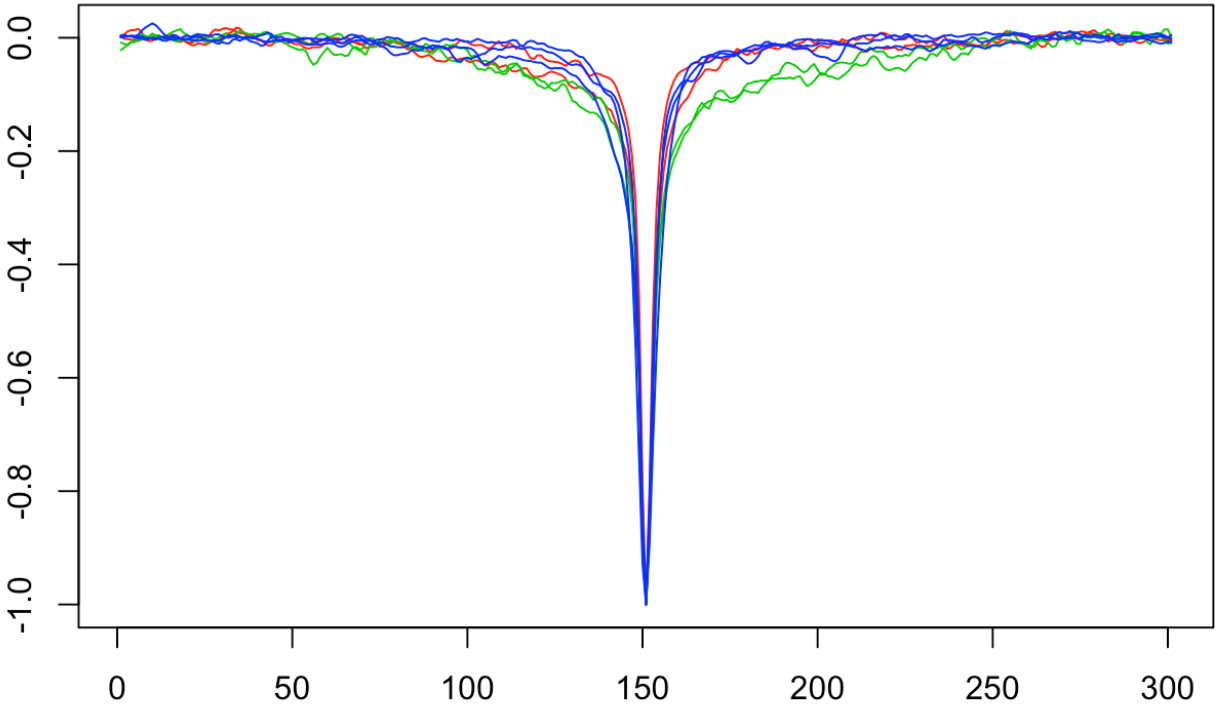
Shape analysis - SiN







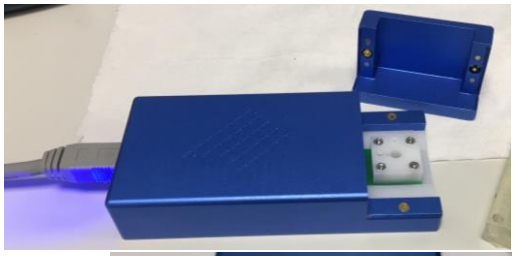


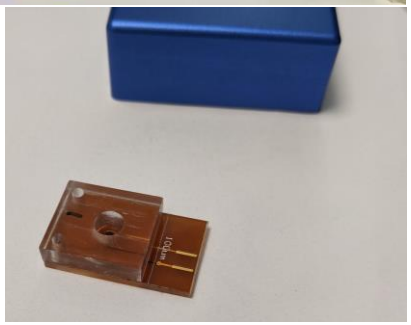


- Size and concentration
- AND Shape classification

- Optimising the data extraction.

Polyamide





- 100 μm pores
- Rapid data capture
- Characterised particles
  - 10 μm

- Applications in food/ drink/ cosmetics/ algae

Plastic Teabags Release Billions of Microparticles and Nanoparticles into Tea

Laura M. Hernandez, Elvis Genbo Xu, Hans C. E. Larsson, Rui Tahara, Vimal B. Maisuria and Nathalie Tufenkji*

Cite this: *Environ. Sci. Technol.* 2019, 53, 21, 12300-12310
Publication Date: September 25, 2019
https://doi.org/10.1021/acs.est.9b02540
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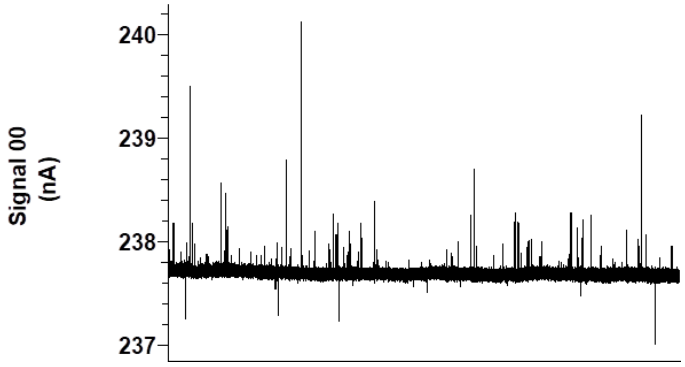
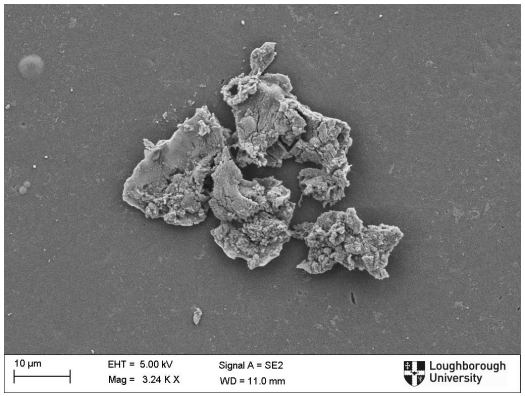
SUBJECTS Polymer particles, Beverages, Plastics,

Environmental Science & Technology

Abstract

The increasing presence of micro- and nano-sized plastics in the environment and food chain is of growing concern. Although mindful consumers are promoting the reduction of single-use plastics, some manufacturers are creating new plastic packaging to replace traditional paper uses, such as plastic teabags. The objective of this study was to determine whether plastic teabags could release microplastics and/or nanoplastics during a typical steeping process. We show that steeping a single plastic teabag at brewing temperature (95 °C) releases approximately 11.6 billion microplastics and 3.1 billion nanoplastics into a single cup of the beverage. The composition of the released particles is matched to the original teabags (nylon and polyethylene terephthalate) using Fourier-transform infrared spectroscopy (FTIR) and X-ray photoelectron spectroscopy (XPS). The levels of nylon and polyethylene terephthalate particles released from the teabag packaging are several orders of

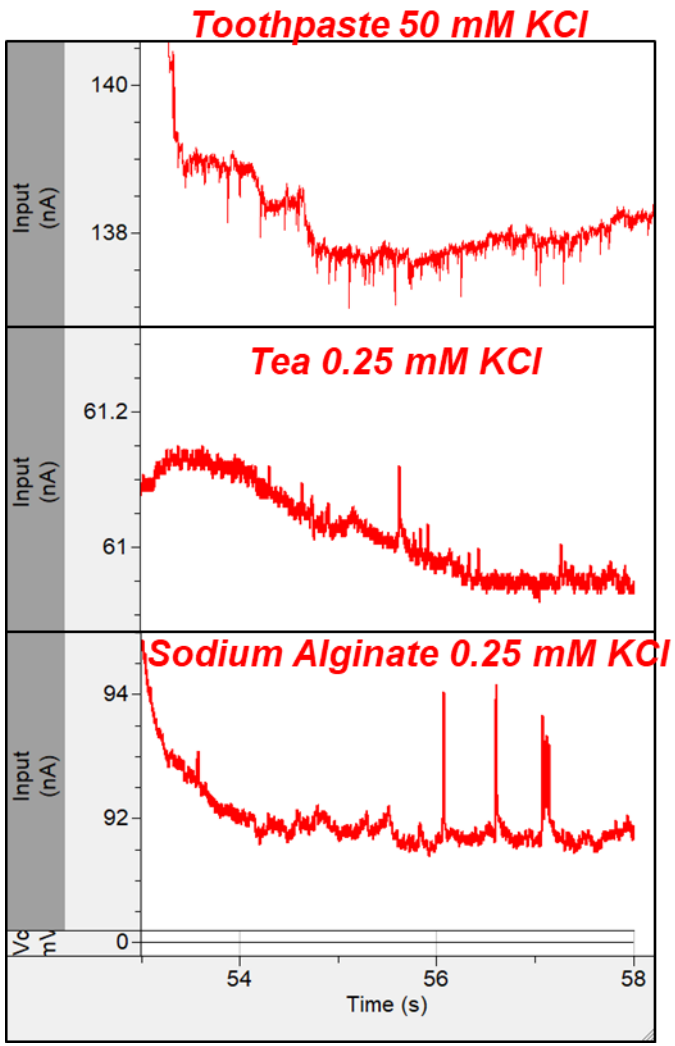


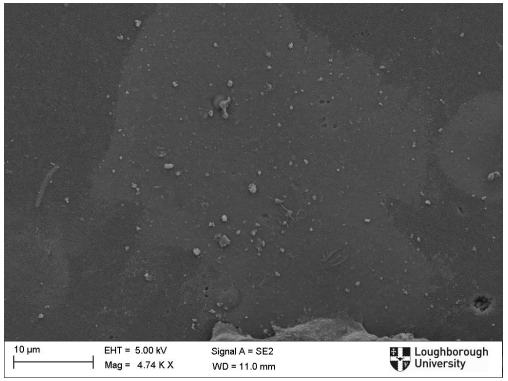


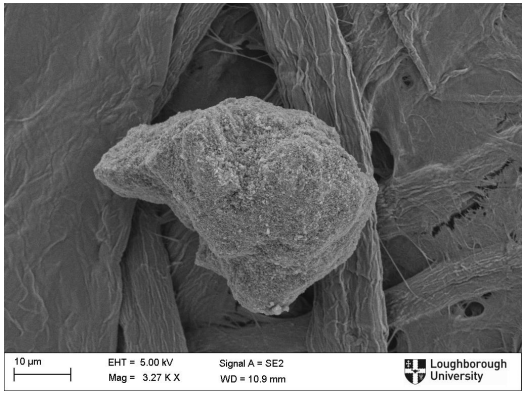
Polyamide

- 100 μm pores
- Rapid data capture
- Characterised particles
  - 10 μm

- Applications in food/ drink/ cosmetics/ algae
- *Chemical information in the direction of the pulse?*



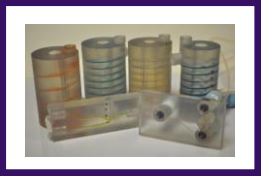




Resistive Pulse Analysis of Microgel Deformation During Nanopore Translocation

Deric A. Holden[†], Grant Hendrickson[‡], L. Andrew Lyon[*‡] and Henry S. White[*†]

J. Phys. Chem. C 2011, 115, 7, 2999-3004



Flow RPS sensors

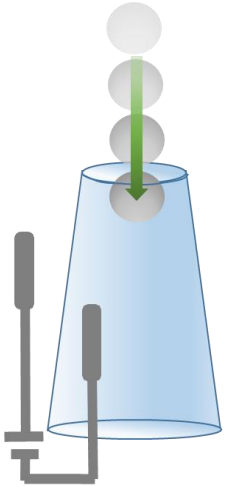
Loughborough University

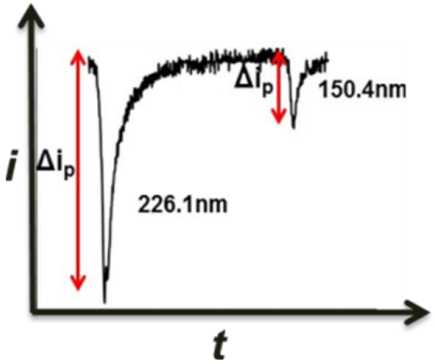
Fluidic Technologies

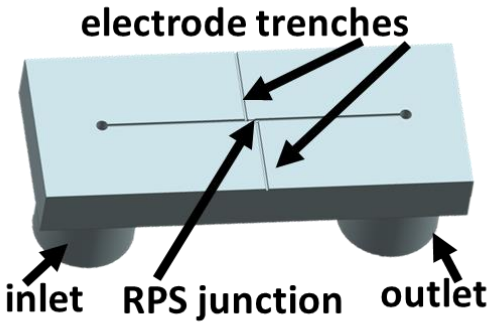
Δi_p = Particle volume

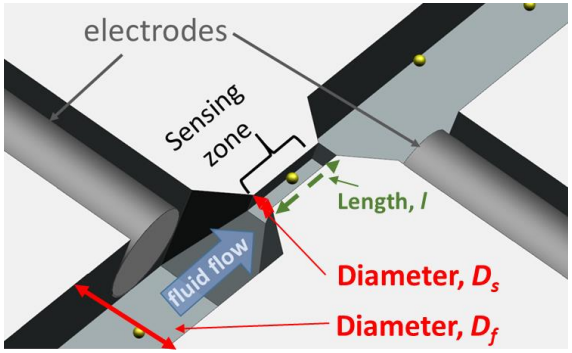
J = Pulse Frequency/ Rate (particles/ unit time)

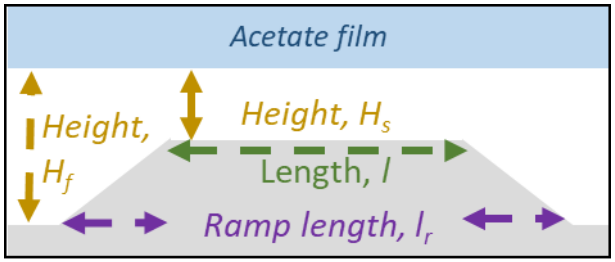
Peak Width = Particle velocity (Flow Rate or Zeta potential)

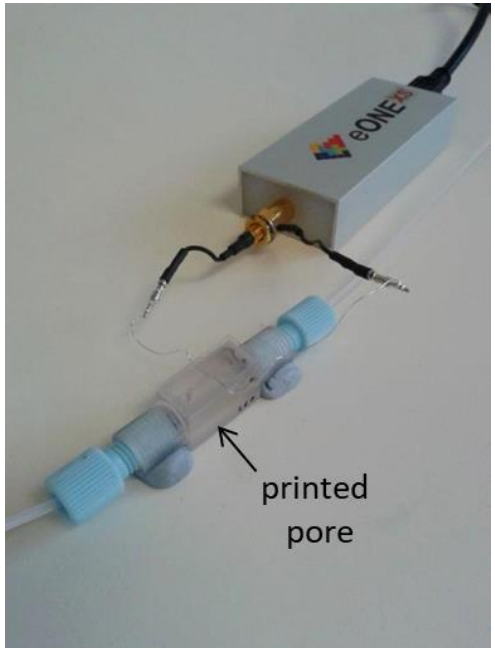












Anal. Chem. 2019, 91, 4, 2947-2954

Flow RPS sensors

Platt Group

Loughborough University

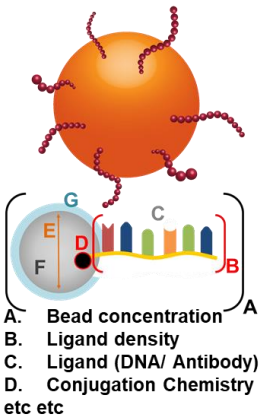
- 100 µm pores
- Flow rates > 1mL/min
- Characterised particles
  - 2 µm

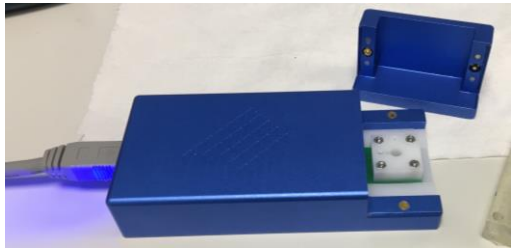
- Applications in food/ drink/ cosmetics/ algae
- *Chemical information in the direction of the pulse?*

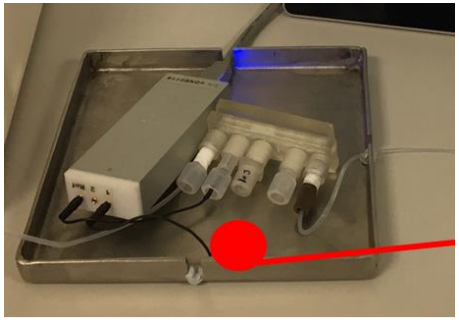
0.25 mM KCl		
Sample	**No of Conductive**	**No of Resistive**
Tea bag 1	250	47
Tea bag 1	163	44
Tea bag 2	128	1
Tea bag 2	95	1
50 mM KCl		
Tea bag 1	2	103
Tea bag 2	152	148

0.25 mM KCl		
Sample	No of Conductive	No of Resistive
Toothpaste	270	0
Toothpaste	180	0
Toothpaste	206	0
50 mM KCl		
Toothpaste	2	3
Toothpaste	1	6
Toothpaste	1	9
100 mM KCl		
Toothpaste	2	75
Toothpaste	3	48
Toothpaste	2	28

Nanopore reader







- SiN is ok – But we are still working out our SOP's
  - Shape information is being developed
- The larger pores are very easy to use
- Capable of some very weird and wonderful samples
  - Chemical information within the pulses?

Flow

- Higher count rates
- Combined multiples RPS sensors in one easy to manufacture chip, SiN, Glass pippete, polymer pores

Thank You.

elements
enabling technologies for Life Science

Loughborough University

Group

Research Associate
Emma Blundell
Graduate Students;
Imogen Heaton
Rhush Maugi
Marcus Pollard
MSc;
Nigel Lucas
Sofia Satia
MChem
Bernie Gamble
Hayden Salway

Alumni
Emily Billinge
William Rowe
Chen Hu
Laura Mayne
Suchanuch Sachdev
Sarah Hampson
Matthew Healey

Collaborators

Steve Christie - Loughborough University
David Bunka – Aptamer Group
Andreas Dietzel - Technische Universität Braunschweig
Georg Garnweitner - Technische Universität Braunschweig
Jenna Bowen – Cardiff University
Brian O'Farrell – Altratech
Brett Kralj – National Nuclear Laboratory
Sivakumaran Muttuswamy – Peterborough City Hospital
Zuzanna Siwy - UC Irvine
Robert Vogel - University of Queensland
Eugenie Hunsicker – Loughborough University

EPSRC
Engineering and Physical Sciences Research Council

MARIE CURIE ACTIONS

THE FRAMEWORK PROGRAMME FOR RESEARCH AND INNOVATION
HORIZON 2020

CDT-EI
EPSRC CENTRE for Doctoral Training in Embedded Intelligence

ROYAL SOCIETY OF CHEMISTRY

NDA
Nuclear Decommissioning Authority

NIHR Leicester-Loughborough Diet, Lifestyle and Physical Activity Biomedical Research Unit

NHS
National Institute for Health Research

TOXI TRIAGE

ISR
INSTITUTE FOR SPORTS RESEARCH

iZON science