Nanoplastics – from basics to anaylsis

The Science of Microplastics Workshop

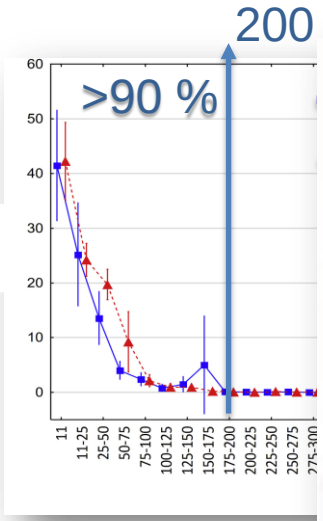
Woods Hole Ocean Institute, 16-18 October 2019

Michaela Meyns,

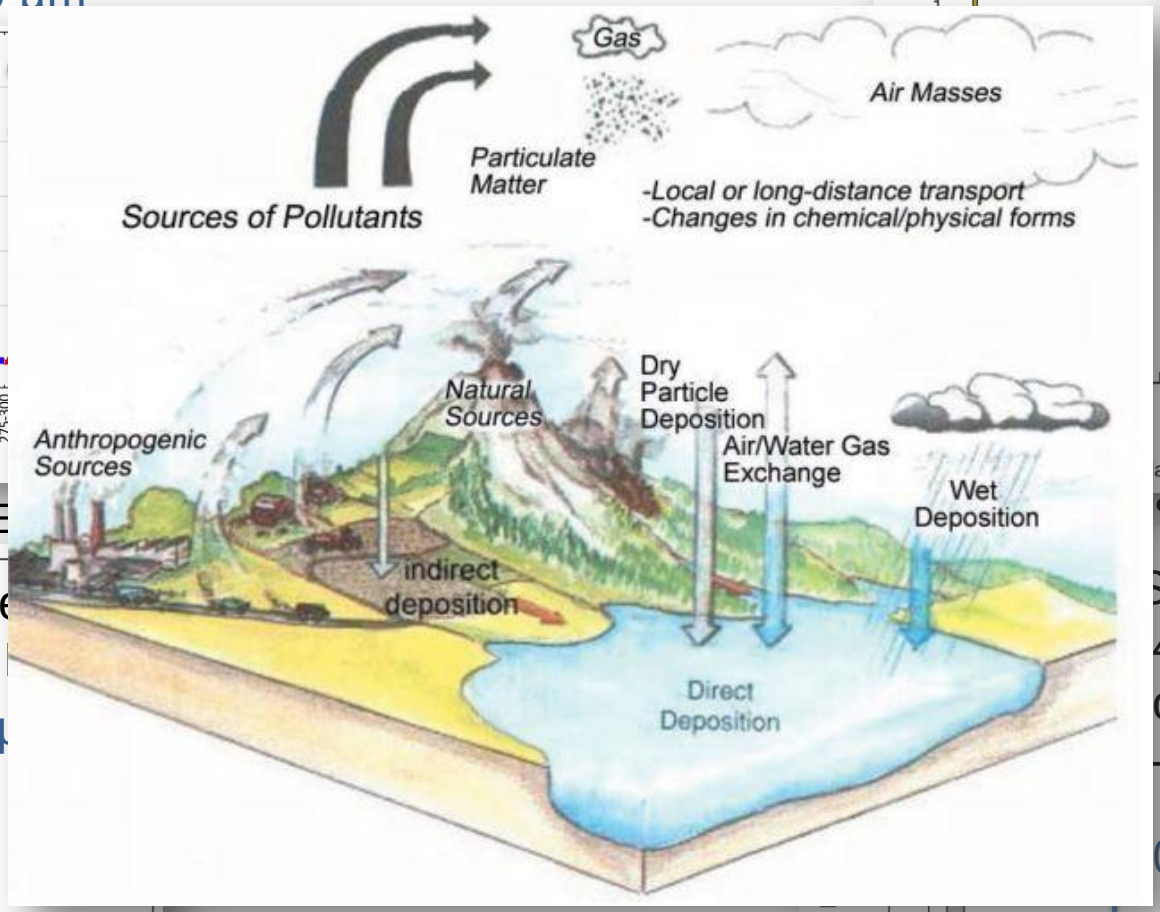
Alfred-Wegener-Institute Helmholtz Centre for Polar and Marine Research, Biologische Anstalt Helgoland

MP size distributions

North Sea: 0-1200 N/kg (L)

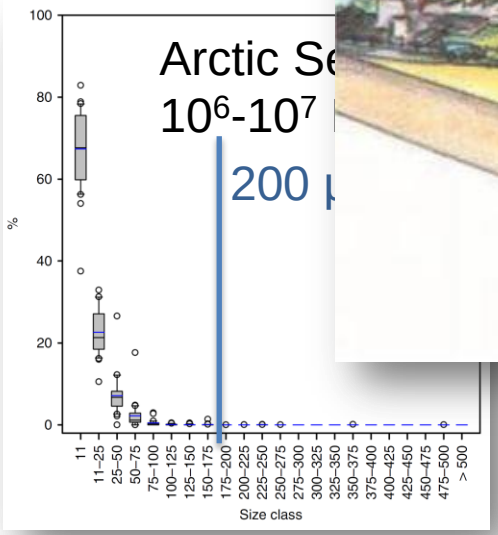


Lorenz *et al.* E



Fram Strait Deep Sea: 42-6595 N/kg

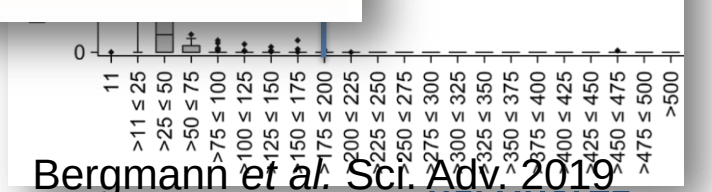
al. EST 2017



Peeken *et al.*
Nature Comm. 2018

Snow:
4 x10³ N/L
ow:
-154 ×10³ N/L

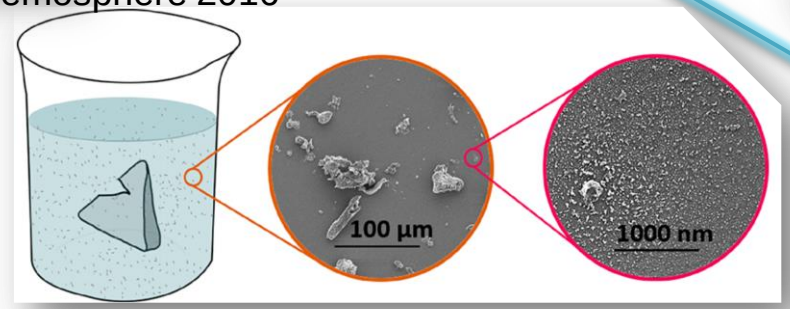
00 µm



Bergmann *et al.* Sci. Adv. 2019

Sizes and sources

Lambert, Wagner Chemosphere 2016



Hernandez EST 2019

Fragmentation, degradation: secondary plastics

macro

5 mm > MP > 1 µm

micro

UV

*

< 1 µm

nano

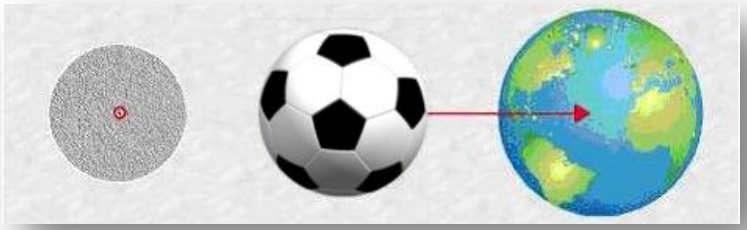
CH_4, CO_2, H_2O, …

Primary NP e.g.:

- side product of top-down MP production
- Medicine
- Additives e.g. in flowable products such as cements
- ….

* L. Roscher

Nanoparticles

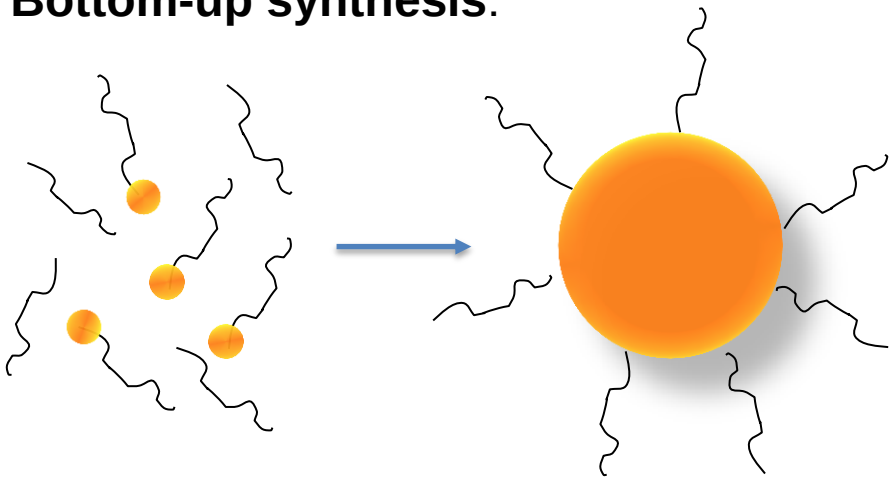


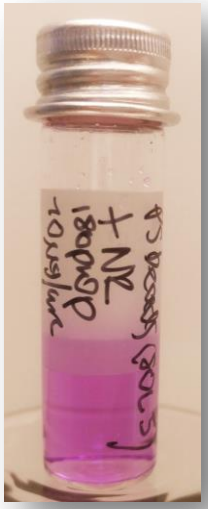
Adapted from www.idealcon.de/pic/nano1.jpg

c = 1 cm
A = 6 cm^2

d = 10 nm
A = 600 m^2

Bottom-up synthesis:





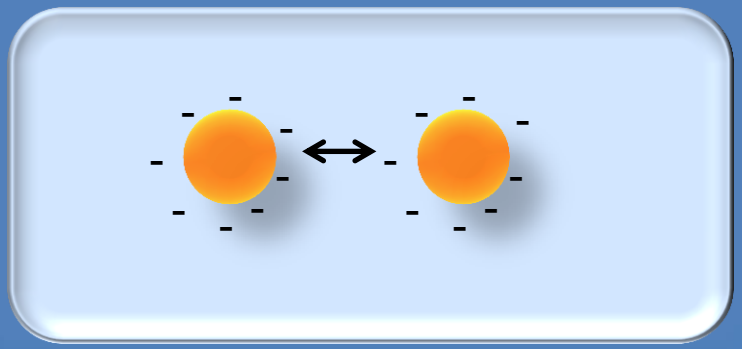
PS nano-beads

M. Veliu

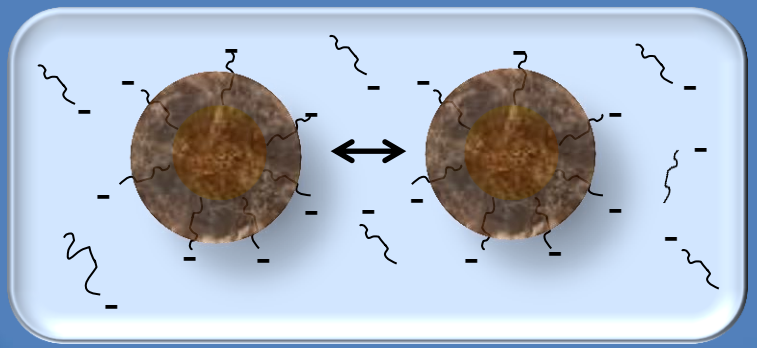
PE micro & nanobeads

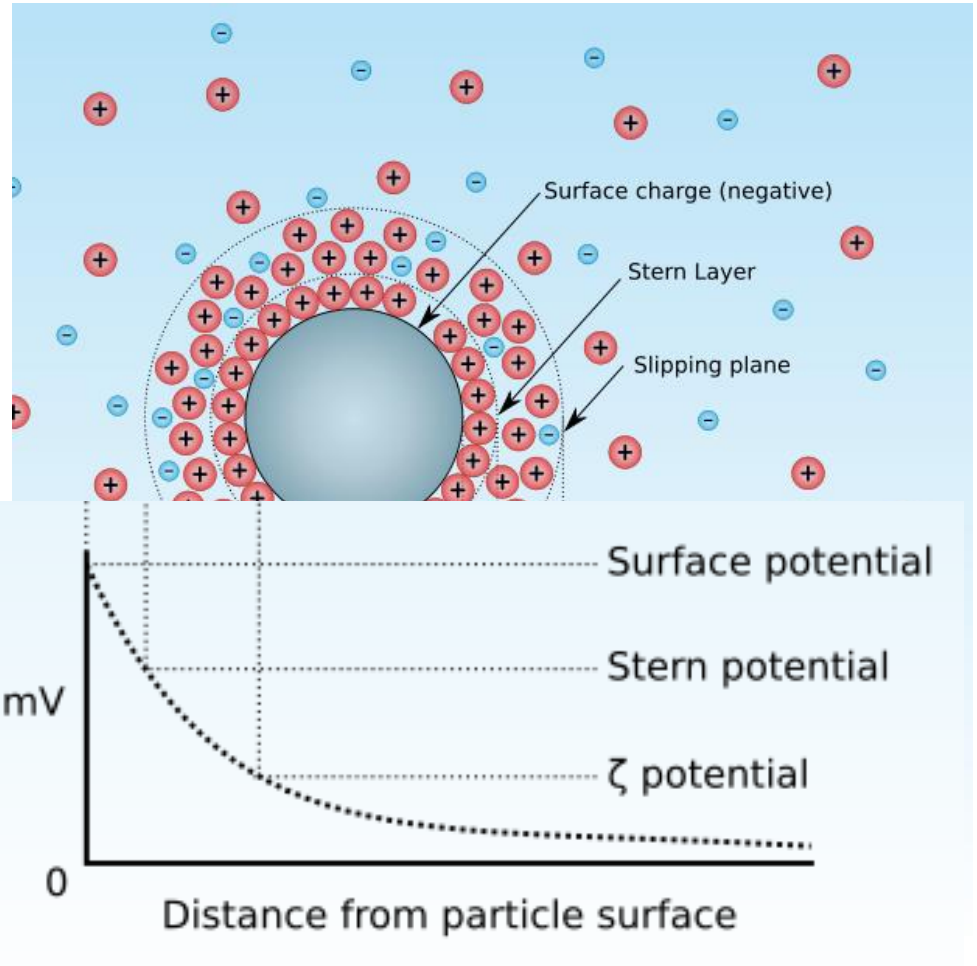
Stabilizing nanoparticles in water

Small inorganic ligands
Electrostatic stabilization



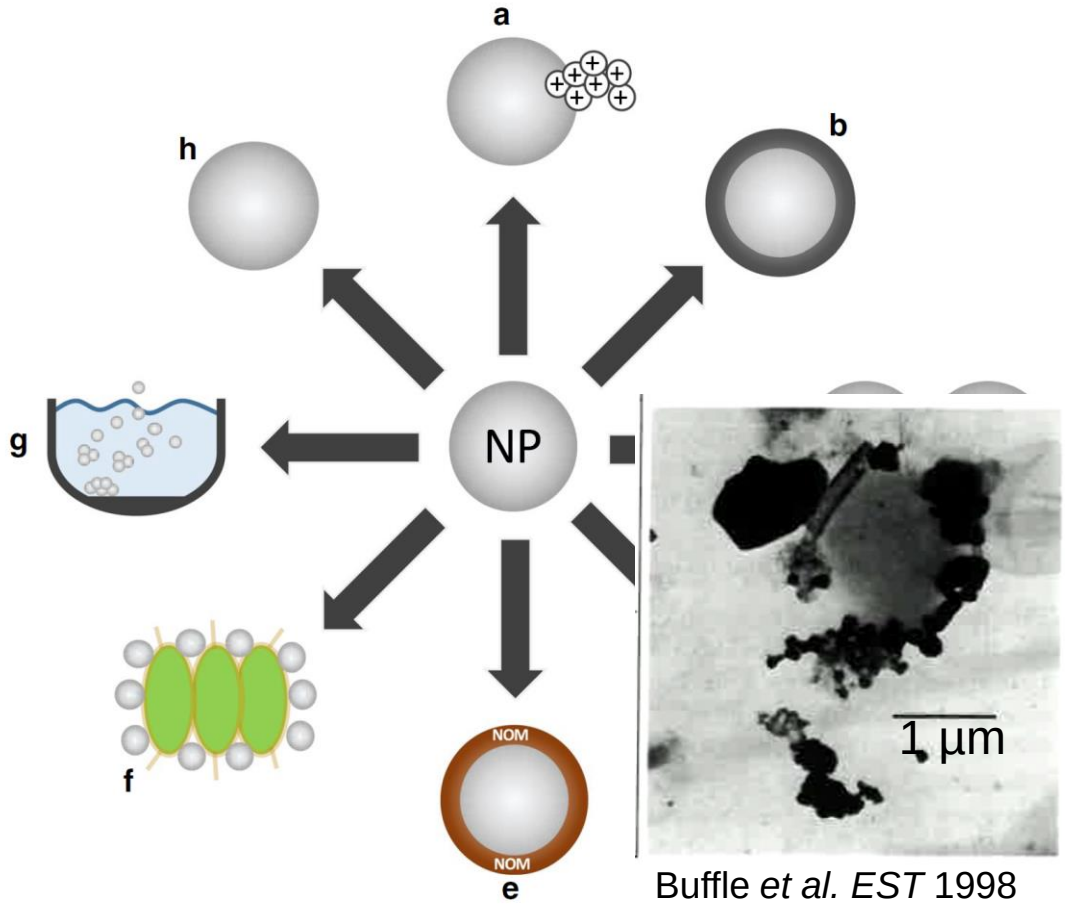
Long chain organic ligands
electro*steric* stabilization





https://commons.wikimedia.org/wiki/File:Diagram_of_zeta_potential_and_slipping_planeV2.svg

Fate of nanoparticles in water

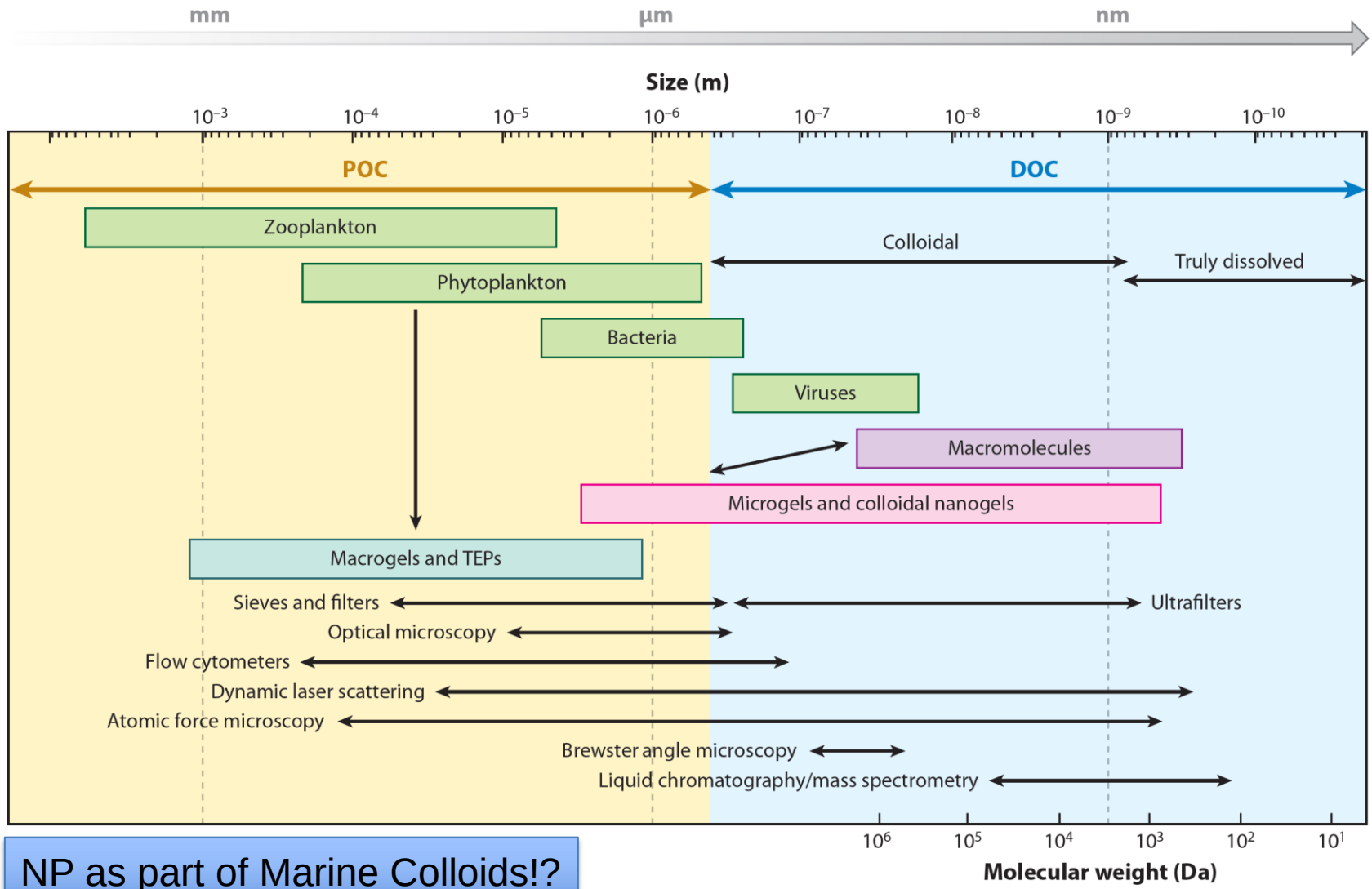


Buffle *et al. EST* 1998

Fig. 2 Interactions and fate of NP in the environment considering (a) dissolution, (b) sulfidation, (c) homo-aggregation, (d) hetero-aggregation, (e) coating with NOM, (f) NP adsorption on biological surfaces, (g) sedimentation/deposition, and (h) persistence

Bundschuh *et al. Environ Sci Eur* **2018**, *30,* 6.

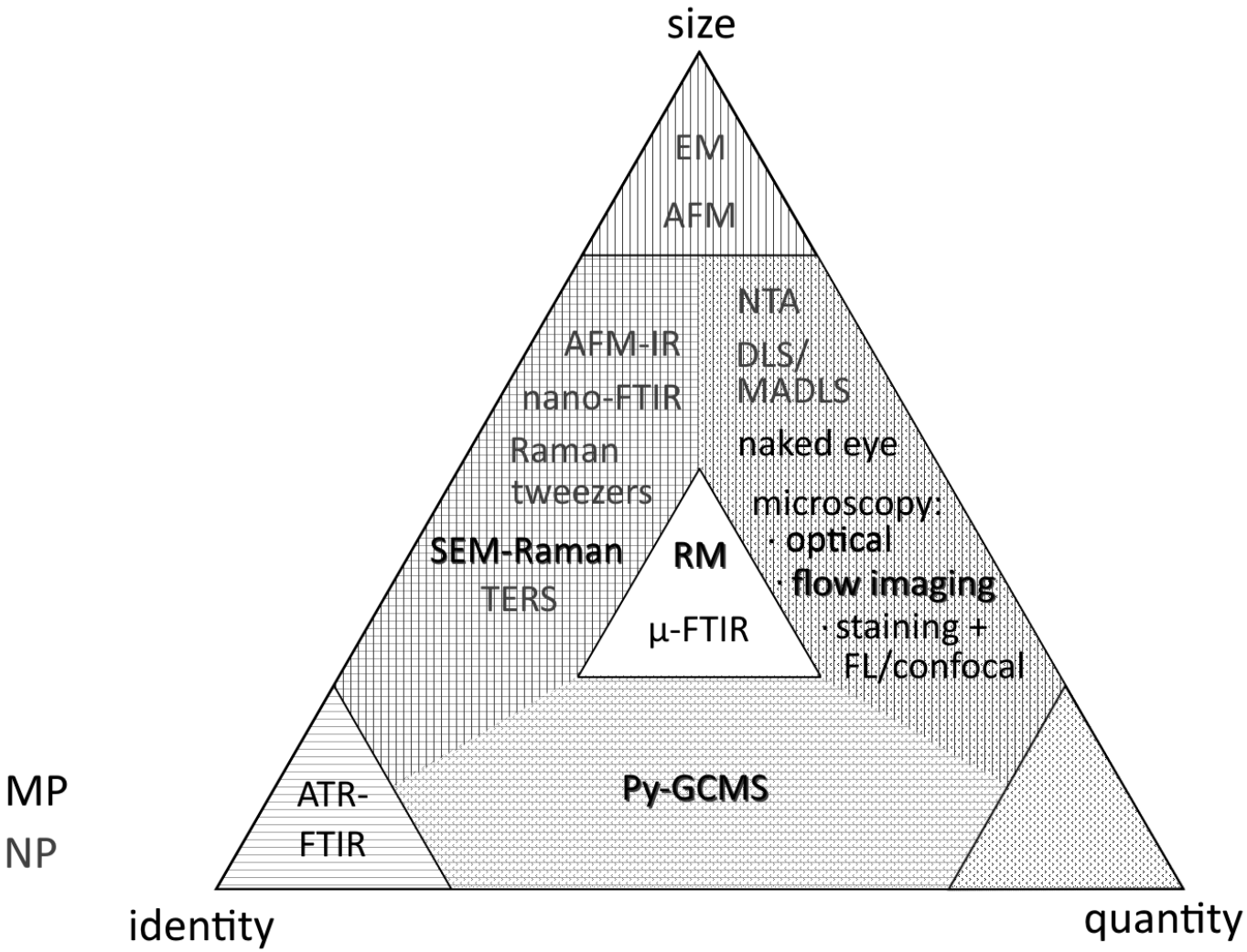
Environmental nano fraction



NP as part of Marine Colloids!?
Santschi *Marine Chem.* 2018

Verdugo *Annu Rev Mar Sci* **2012**, 4375.

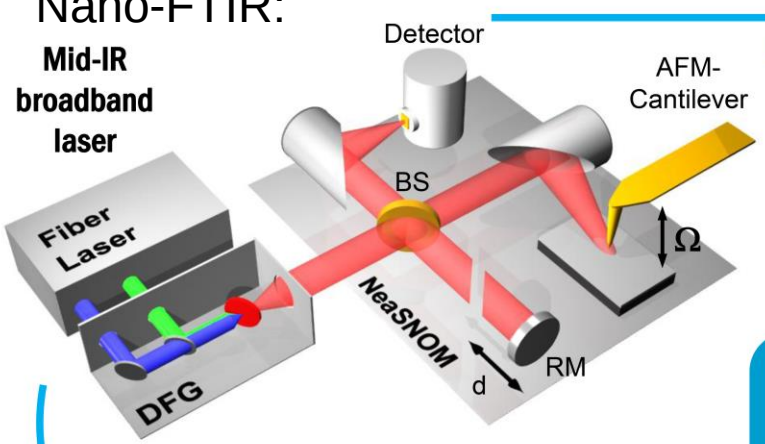
Detection

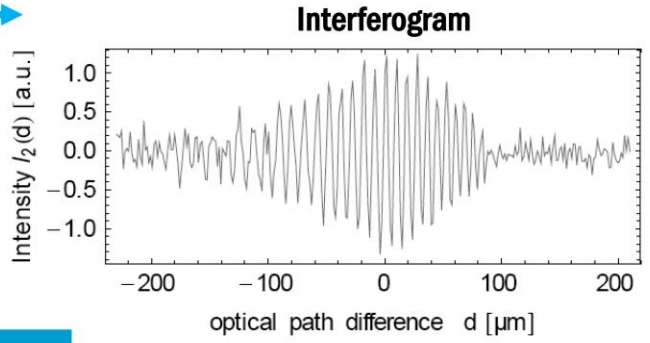


under revision *Applied Spectroscopy*

Nano-FTIR

Nano-FTIR:

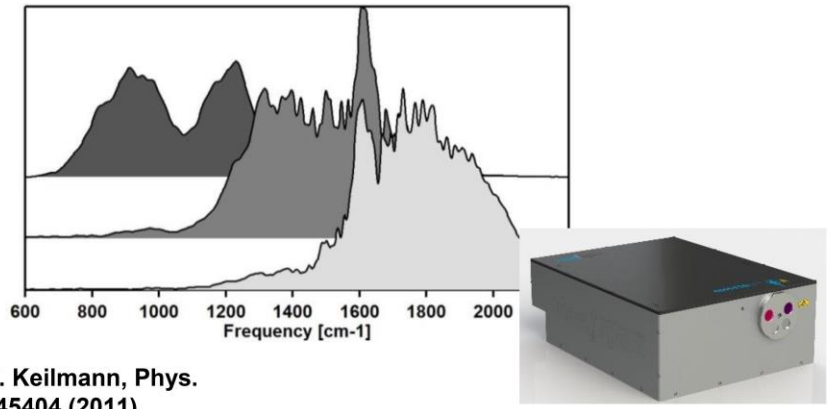




nano-FTIR provides Reflectance & Absorption spectra

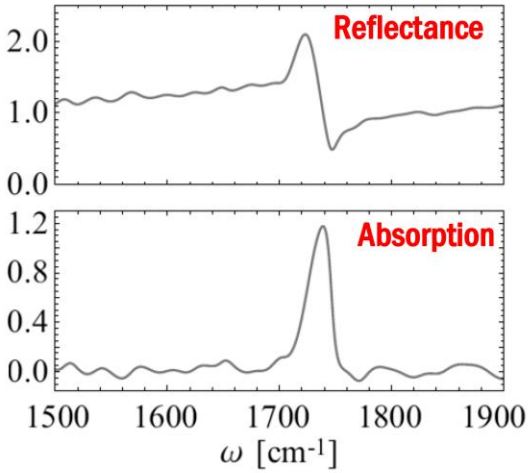
FFT

nano-FTIR laser output spectra



S. Amarie, F. Keilmann, Phys. Rev. B 83, 045404 (2011)

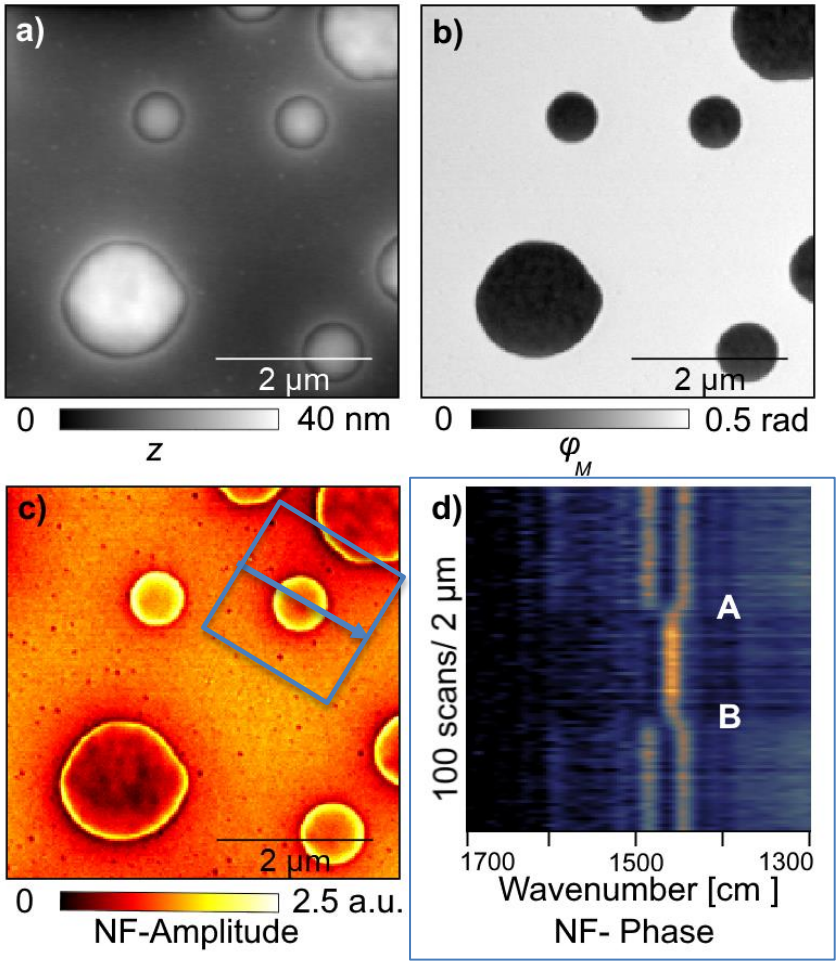
nano-FTIR spectra of PMMA

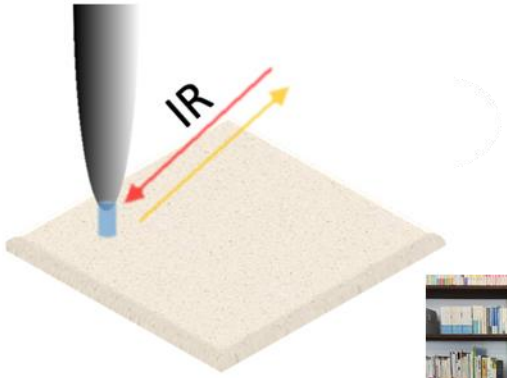


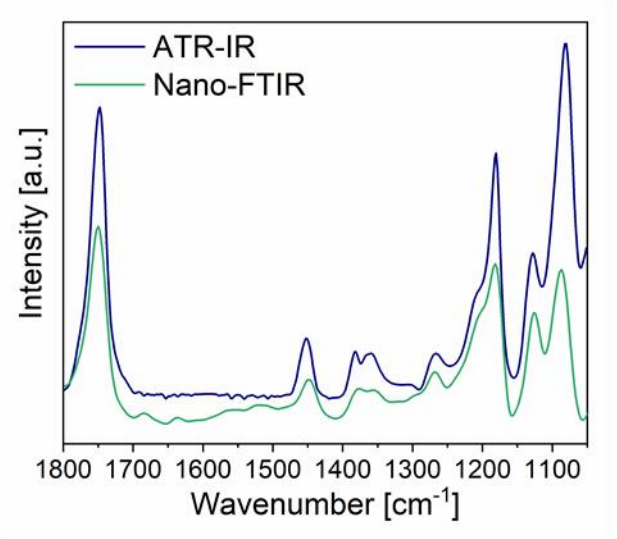
IR-sSNOM: Tunable single line laser

© Andreas Huber, neaspec

Nano-FTIR polymer identification







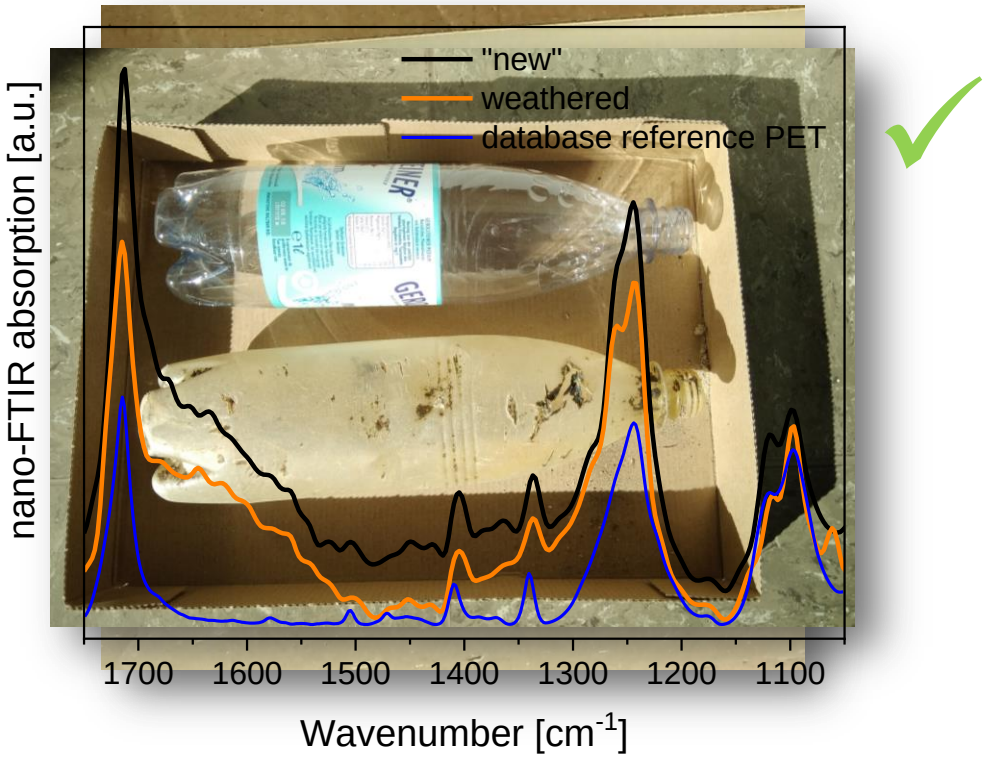
Vector norm.
1st derivative
(rubber band corr.)°

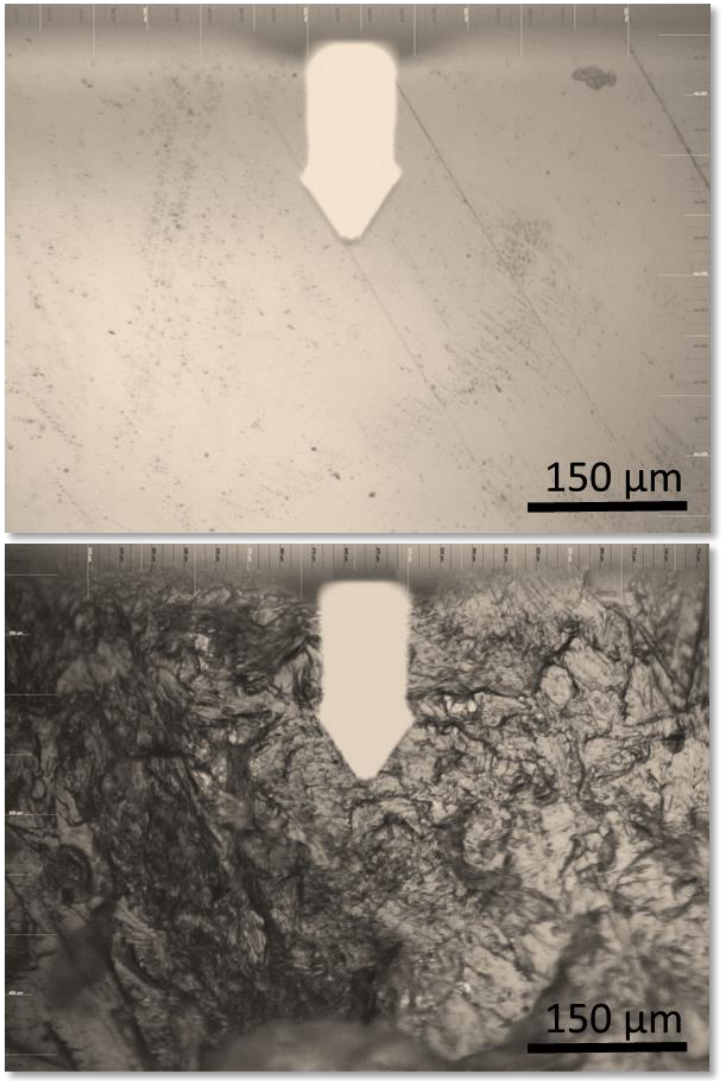
Resolution of 10 cm^{-1}, 6:45 min

Analytical Methods 2019

°Primpke Anal. Methods 2017

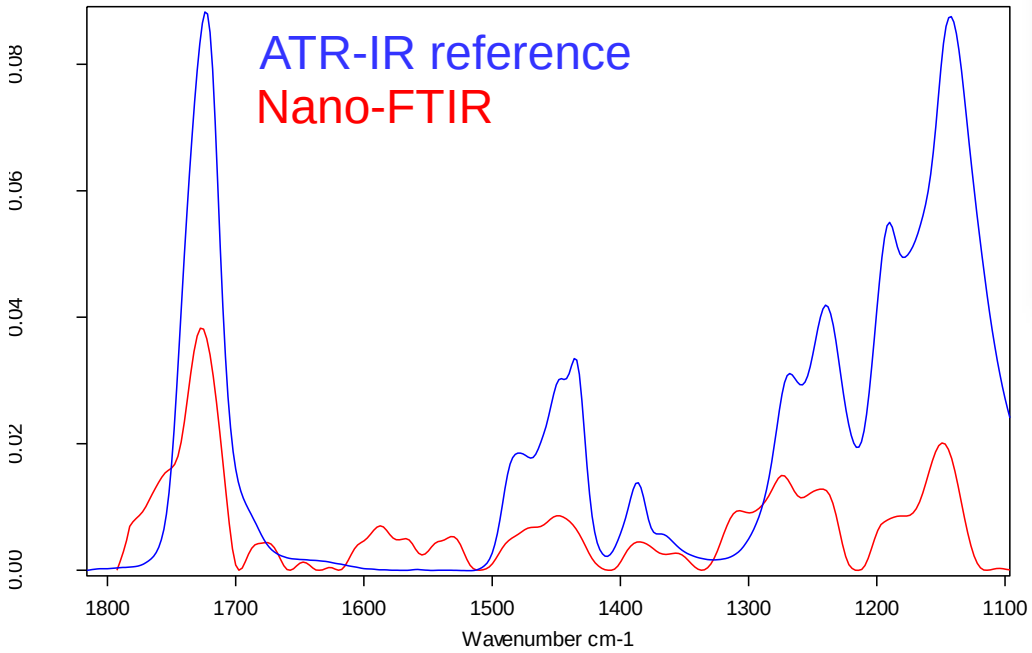
Weathered sample



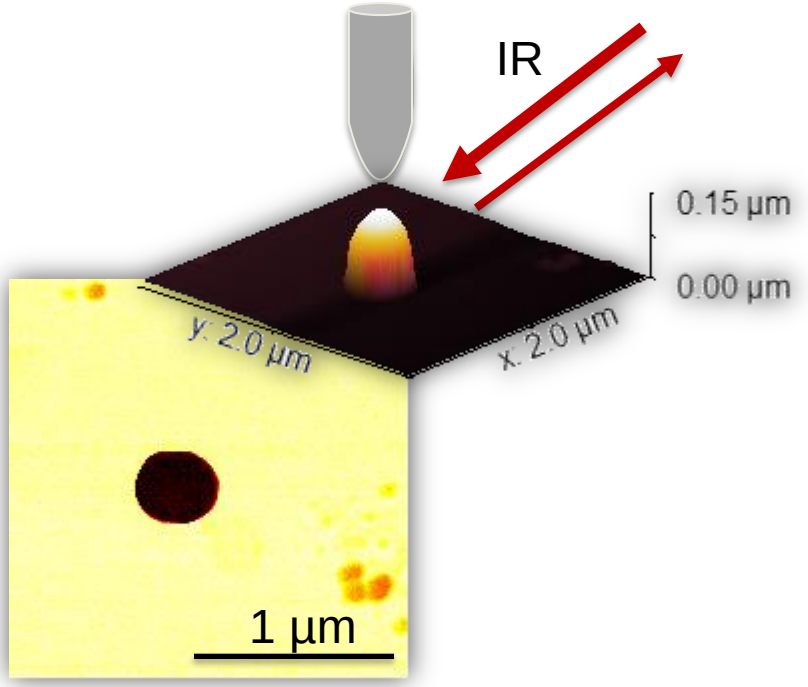


Analytical Methods 2019

Single particle identification



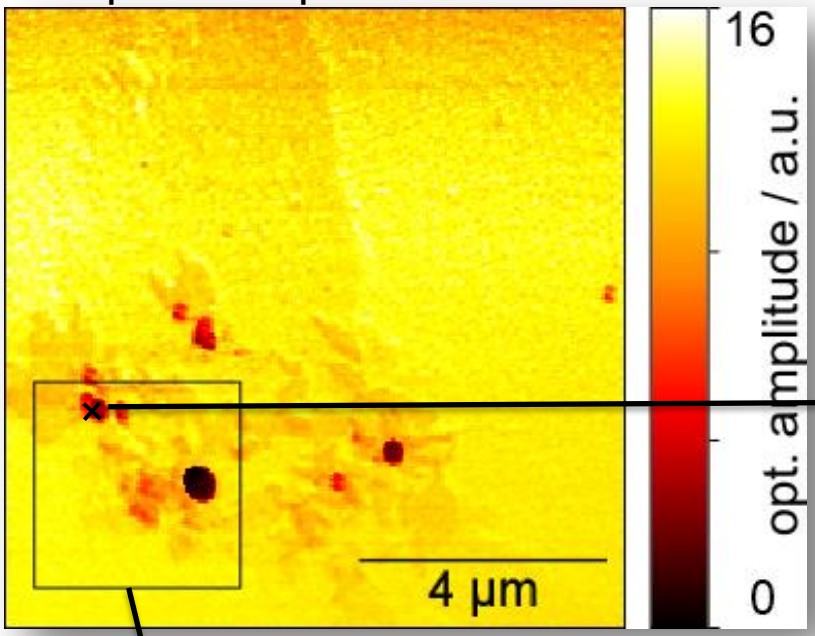
Polymethylmethacrylat (PMMA) 150 nm

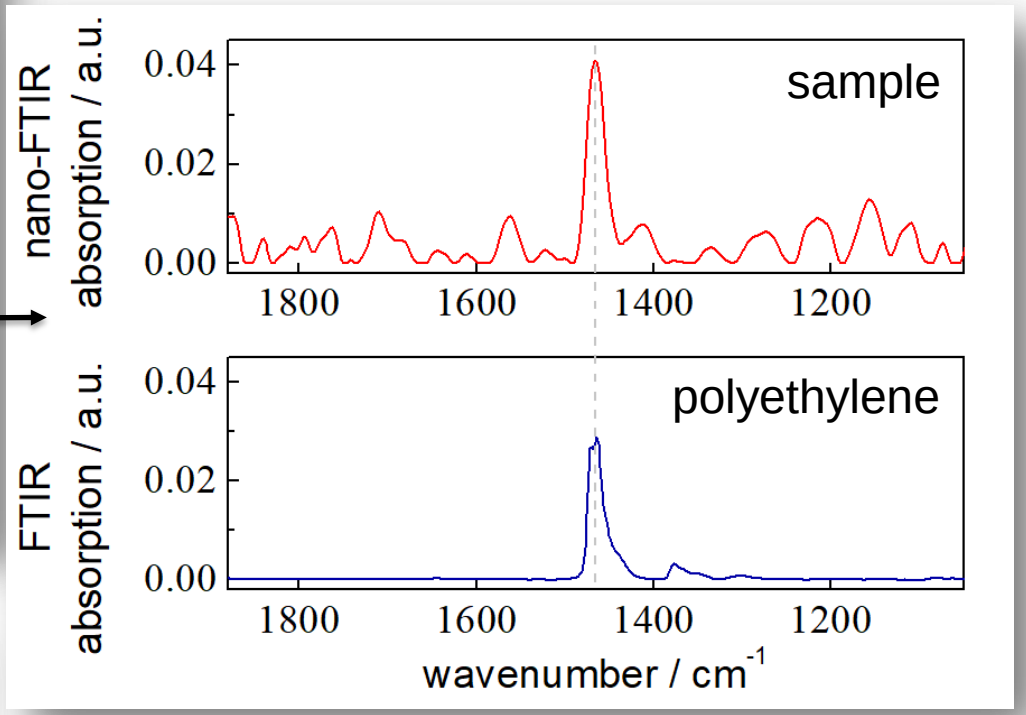


Substanz	12
Kurzzeichen	PMMA
Hersteller	Universität Bayreuth
Form (Pulver, Pellet, Folie, Stü	pellet
Farbe	clear
Messmethode	ATR
Eintrag Nr.	233
Bibliotheksname	BASEMAN_AUTOMATED.S01
Bibliotheksbeschreibung	Finale Bibliothekt für die automatische Auswe
Copyright	Sebastian Primpke

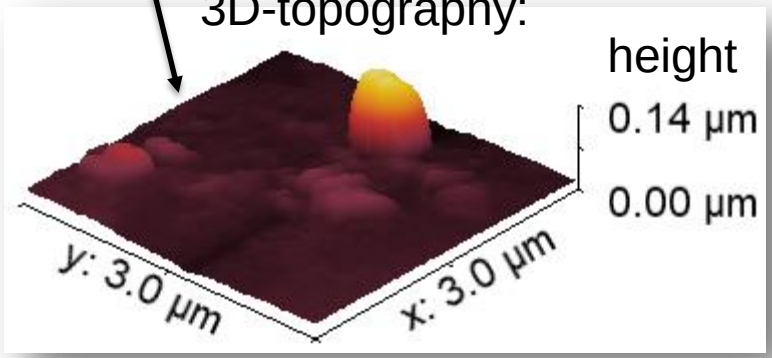
Environmental particles

Optical amplitude scan:

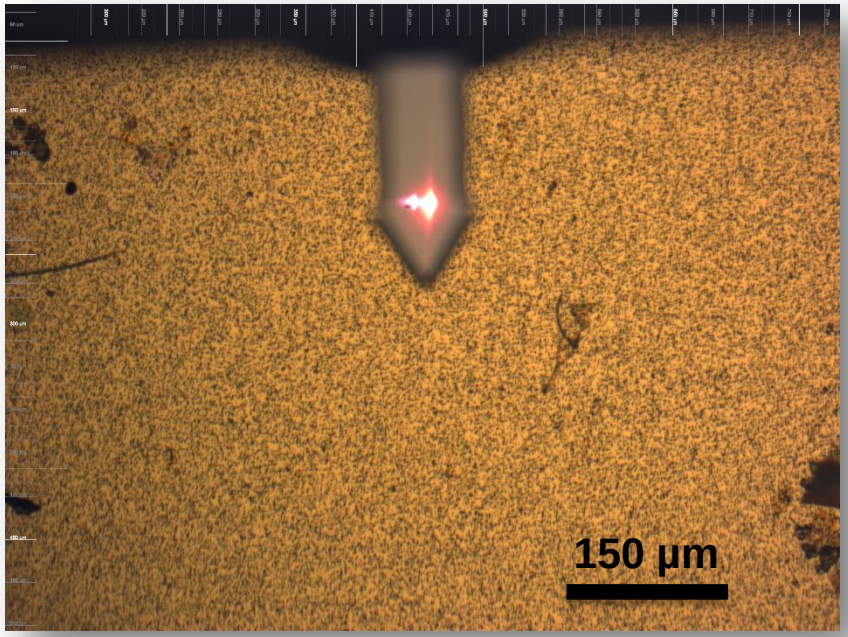




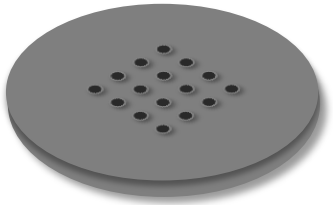
3D-topography:



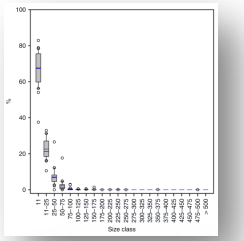
Substrates



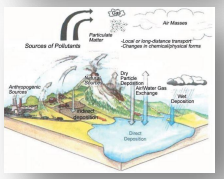
- Nanopores
- Relocating spots
- Inert surface



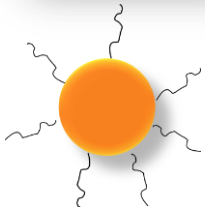
Conclusions



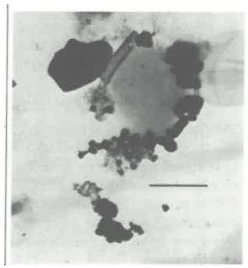
- 500 µm fraction not representative
- > 80 % < 100 µm



Longe range transport: water, ice, air

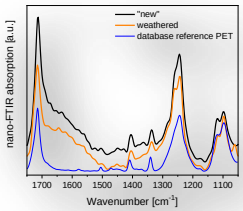


Surface and proper models matter

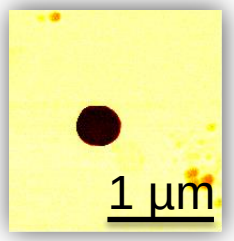


Nanoplastics (< 1µm) part of colloidal fraction!?

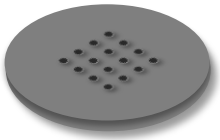
Size, shape and identity!



Nano-FTIR: Identification of new and weathered plastics



Nanoplastics: Identification of single particles possible



Si membranes: < 300 nm pores, intermethod comparison

Future Tasks

- Imaging nanoplastics and their formation in environment: What to look for and where?
- Composition of „the“ nano fraction
- Quantify
- impacts on health: NP in relation to other colloids
- Apply more interdisciplinary/-field approaches: What can be learned from research on other colloids? Are nanoplastics a class of their own?

SETAC Europe May 2020 Dublin

Looking forward to your abstracts:

Analysis of Microplastics and Nanoplastics – From Harmonisable Protocols and Data Treatment to the Peculiarities of the Environmental Nanofraction

Co-chairs: Michaela Meyns, Natalia P. Ivleva, Sebastian Primpke

Contributions should cover one or more of:

1. sample preparation: requirements for different matrices, filter materials, detection limits
2. analysis of number/size or mass and combining techniques
3. solutions for analytical challenges: tire materials, paint particles
4. small MPs (1 – 10 µm)
5. spectroscopic data: Software tools, databases, artificial intelligence approaches
6. analysis pipelines applicable for monitoring
7. design and application of relevant reference MPs and NPs for validation
8. lessons learned: nanoparticle analysis in environmental samples
9. the future of MP and NP analysis: Promising techniques, tools and developments

Acknowledgements

- Microbial ecology AWI Helgoland

Dr. Gunnar Gerdts

Dr. Antje Wichels

Dr. Sebastian Primpke

MSc. Saskia Finckh

Medina Veliu

Microbial ecology group

- AWI Bremerhaven

Dr. Ilka Peeken

- Neaspec

Dr. Andreas Huber

- Funding

- “Size is important”, wt.sh, Germany
- BASEMAN, Defining the baselines and standards for microplastics analyses in European waters, BMBF

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