Lehrstuhl für Analytische Chemie & Wasserchemie
Institut für Wasserchemie (Raman- & REM-Gruppe)
TUM School of Natural Sciences (Dep. Chemie)
Technische Universität München

Interdisciplinary Project

Topic:

Further Development of *TUM-ParticleTyper2* Software –
Optimization of image processing for micro- and nanoplastics analysis

Scientific Background

Reliable analysis of microplastics (plastic particles in the size range of 1 µm – 1 mm) and nanoplastics (<1 µm) in environmental and food samples is a prerequisite for studying their potential hazard for the environment and human health.[1] Knowledge of numbers, size distributions and polymer type for particles and fibers is particularly relevant in this respect. Raman microspectroscopy can identify particles down to below 1 µm in diameter (and even below, down to approx. 300 nm). The core of *TUM-ParticleTyper 2* – open-source software developed in our group –[2,3] is a fully automated procedure to analyze microplastics across the entire size range. This software implements the theoretical approaches of *random window sampling* and *on-the-fly* confidence interval estimation during ongoing measurements.[4] It also includes image processing of the microscope pictures to recognize, morphologically characterize and quantify plastic particles and fiber. An approach to adaptive de-agglomeration has been implemented.[3]
Further development to recognize even smaller particles including nanoplastics makes it necessary to improve the image processing for recognition, accurate determination of particle size and deagglomeration.

Requirements

Basic knowledge of **image recognition** and programming skills with **Python** (e.g. numpy, pandas, cv2) are preferred. Version control is performed with GitLab.

Tasks

- Recognition of particles below 1 µm in diameter (e.g., with cv2.ADAPTIVE_THRESH_GAUSSIAN_C)
- Optimization of deagglomeration process
- Reduction of ‘halo’ around particles to improve size evaluation
- (Improvement of particle classification variables (random-forest-algorithm) if interested in machine learning)

Associated Lectures/ Courses

We suggest considering the course titled "Automating and Visualizing Laboratory Processes and Data" (CH0505). This course explores the convergence of chemistry and data science, particularly from a chemical perspective. It covers various topics, including chemometric analyses, data assessment for analytical chemistry experiments, and the creation of laboratory robots. Alternatively, participants can opt for different lectures like "Analytical Chemistry" for CIW (CH0860) or for BWL (0107) students. We are open to suggestions of other lectures fitting with the project.

Begin date & Location

As soon as possible. Work can be done remotely or in Garching (Department of Chemistry). The written report and the IDP can be done in German or English.

Please contact Isabel Jüngling (isabel.juengling@tum.de) and PD Dr. Natalia P. Ivleva (natalia.ivleva@tum.de) if you are interested.

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Learn more about our group https://www.ch.nat.tum.de/hydrochemistry/raman-sem/

References

(1) Ivleva, N. P. Chemical Analysis of Microplastics and Nanoplastics: Challenges, Advanced Methods, and Perspectives. *Chemical reviews* **2021.** DOI: 10.1021/acs.chemrev.1c00178. Published Online: Aug. 26, 2021.

(2) Esch, E. von der; Kohles, A. J.; Anger, P. M.; Hoppe, R.; Niessner, R.; Elsner, M.; Ivleva, N. P. TUM-ParticleTyper: A detection and quantification tool for automated analysis of (Microplastic) particles and fibers. *PLOS One* **2020**, *15* (6), e0234766. DOI: 10.1371/journal.pone.0234766.

(3) Jacob, O.; Ramírez-Piñero, A.; Elsner, M.; Ivleva, N. P. TUM-ParticleTyper 2: automated quantitative analysis of (microplastic) particles and fibers down to 1 Formula: see textm by Raman microspectroscopy. *Analytical and bioanalytical chemistry* **2023.** DOI: 10.1007/s00216-023-04712-9. Published Online: Jun. 8, 2023.

(4) Schwaferts, C.; Schwaferts, P.; Esch, E. von der; Elsner, M.; Ivleva, N. P. Which particles to select, and if yes, how many? : Subsampling methods for Raman microspectroscopic analysis of very small microplastic. *Analytical and bioanalytical chemistry* **2021.** DOI: 10.1007/s00216-021-03326-3. Published Online: May. 12, 2021.