Research Project #6

Hydrogen Transparency: Bridging Isotopic Forensics and Next-Generation Energy Solutions (ICE-3 & INW-3)

Hydrogen is a key solution for decarbonizing industry and meeting climate targets, but its environmental impact varies widely depending on the feedstock [1]—such as water, biomass, natural gas, or coal. Ensuring transparency and preventing greenwashing require robust methods to trace and quantify emissions. Advanced analytical techniques, including mass spectrometry and isotopic analysis, provide critical insights into production pathways and associated carbon footprints. Here, we merge techniques from air quality research on tracing and quantifying pollutant sources with the advancement of next-generation, climate-friendly energy carriers, which support the transition toward a resource-efficient, greenhouse gas–neutral industrial landscape. By analyzing the isotopic signatures of organic trace components in methanol, a hydrogen-based fuel, the project will reveal the raw materials and processes underlying its production. The findings will inform the design of a transparent and reliable certification framework for hydrogen and hydrogen-based fuels, enabling the widespread adoption of low-emission hydrogen across industrial and consumer applications.

Tasks of the PhD project are:

- developing and optimizing compound-specific stable carbon isotope measurement methodologies for trace organic compounds in methanol, including chromatographic separation, concentration, and detection
- characterizing isotopic fingerprints of methanol derived from various feedstocks and quantifying raw material contributions. This involves calibrating reference materials against international standards to ensure high-precision, traceable isotope measurements
- Integrating complementary gas chromatographic and mass spectrometric techniques to link molecular-level analyses at ICE-3 with mean compositional characterizations at INW-3
- applying isotopic diagnostics to verify the origin and production methods of methanol, supporting the development of a robust hydrogen-carrier fuel certification scheme

We offer:

- an inspiring, interdisciplinary research environment within an international team
- access to a top-tier scientific setting with state-of-the-art laboratories and technological facilities
- opportunities to present at international conferences
- personalized supervision and mentorship through an excellent supervisor-to-student ratio

Location of the HITEC Fellow	Forschungszentrum Jülich, Institute of Climate and Energy Systems - Troposphere (ICE-3), Director: Prof. Dr. Anke Nölscher https://www.fz-juelich.de/en/ice/ice-3
Partners of the HITEC Project	Forschungszentrum Jülich, Institute for a Sustainable Hydrogen Economy – Reaction Engineering for Chemical Hydrogen Storage (INW-3), Director: Prof. Dr. Peter Wasserscheid https://www.fz-juelich.de/de/inw/unsere-bereiche/inw-3, https://hch2.de/en/
Specific **requirements**	MSc degree (or equivalent) in chemistry, physics, or atmospheric science with at least a “good” overall grade; strong experimental skills; experience in physical chemistry and/or isotope mass spectrometry is advantageous. Ability to work in international teams and proficiency in spoken and written English are required.
For **project specific** questions please **contact**	Dr. Iulia Gensch, ICE-3, i.gensch@fz-juelich.de

[1] International Energy Agency (2025) Global Hydrogen Review 2025. Paris: IEA. Available at: https://www.iea.org/reports/global-hydrogen-review-2025 (accessed November 10th, 2025)
[2] Gensch, I., Kiendler-Scharr, A. & Rudolph, J., 2014. Isotope ratio studies of atmospheric organic compounds: Principles, methods, applications and potential. Int. J. Mass Spectrom., 365–366, pp.206–221. https://doi.org/10.1016/j.ijms.2014.02.004