

Yicheng Wang

yicheng.wang@wetsus.nl

Motivation

UV radiation-based technologies (e.g. UV/H₂O₂, UV/O₃) have been developed to remove organic micropollutants (OMPs) from water. Especially, vacuum UV (VUV) radiation at 184.9nm has emerged as an option to eliminate even the most persistent chemicals, such as perfluoroalkyl and polyfluoroalkyl substances (PFAS)¹. Photons of 184.9nm are strongly absorbed by water, generating strong oxidants (e.g. HO·) and reductants (e.g. H· and e_{aq}⁻) for degradation of OMPs (Figure 2). Compared to conventional UV radiation-based technology, the VUV process is capable of *in situ* production of oxidants and reductants without additional chemicals. Current research on the VUV process focuses on interpreting the degradation kinetics and mechanisms of contaminants at a laboratory scale. The reaction kinetics of complex chemistry during the process are less studied. At Wetsus, we will combine kinetic modeling with experimental observation to better understand and utilize the VUV process.

Technological challenges

- Because of the high absorption coefficient of water, most of the 184.9nm photons are absorbed within the 5mm layer³. Generated radicals are consumed within μs scale. It is difficult to understand the complex mechanism and kinetics of direct photolysis and free radical-mediated degradation of OMPs with traditional experimental methods
- Different types of water, such as surface water and WWTP effluent, have various constituents. The effect of the water matrix on OMPs removal is not fully understood to support system scale-up

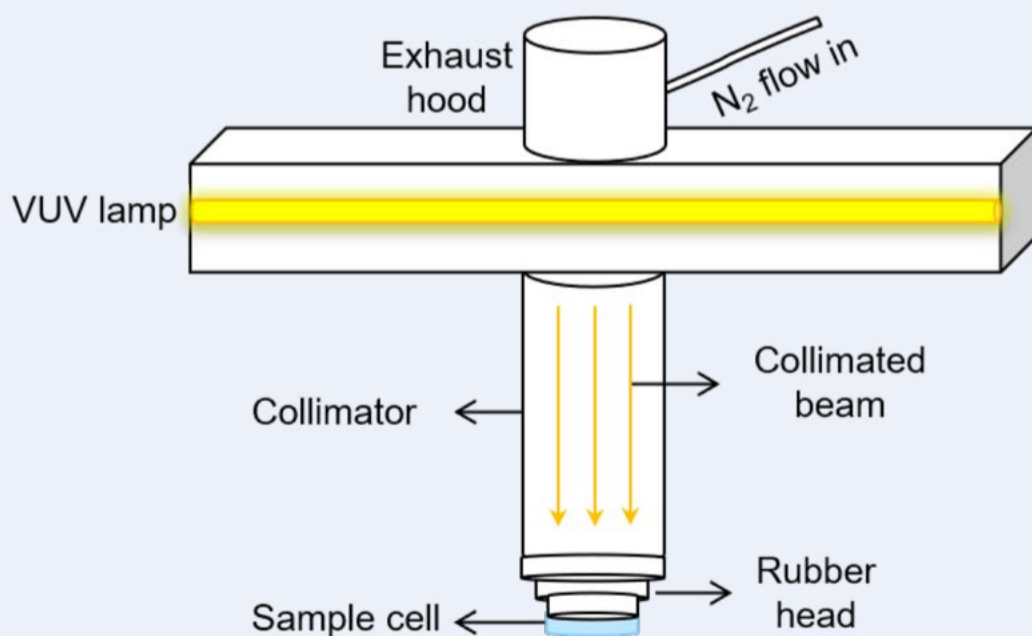


Fig 1. Schematics of the bench-scale (collimated beam) apparatus used in experiment.

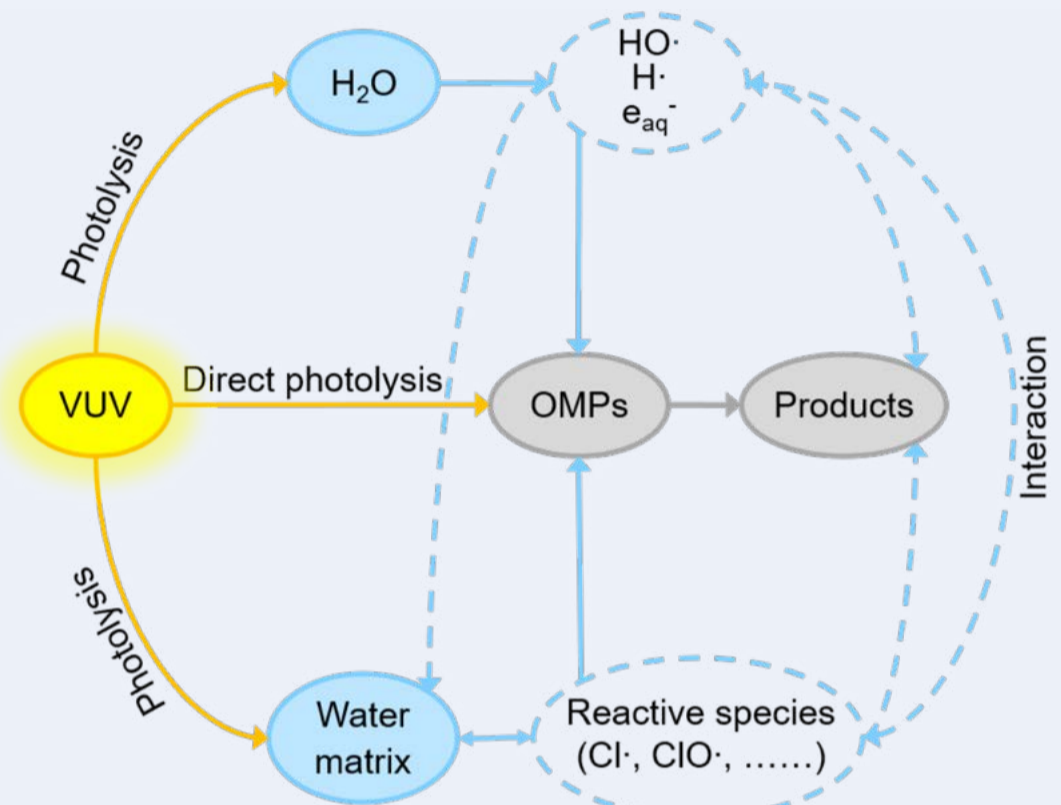


Fig 2. Simplified diagram of vacuum UV process in the water sample².

- In the presence of dissolved organic matter and dissolved inorganic constituents (e.g. halides), undesired by-products would be formed while OMPs degradation would slow down

Research goals

- Evaluate the role of OMPs direct photolysis at 184.9nm on their overall degradation in the VUV process
- Predict the impact of water matrix constituents (primarily dissolved organic matter and chloride) on the VUV process performance
- Elucidate the PFAS degradation with the VUV process, develop a kinetic model and validate it against the experimental data collected from bench-scale tests (Figure 1)
- Examine the VUV process in combination with chemical solutes (e.g. sulfite) as a means of enhancing the PFAS degradation via additional H· and e_{aq}⁻ generation

References

- [1] Li, F., Duan, J., Tian, S., Ji, H., Zhu, Y., Wei, Z., & Zhao, D. (2020). Short-chain per-and polyfluoroalkyl substances in aquatic systems: Occurrence, impacts and treatment. *Chemical Engineering Journal*, 380, 122506.
- [2] Xie, P., Yue, S., Ding, J., Wan, Y., Li, X., Ma, J., & Wang, Z. (2018). Degradation of organic pollutants by Vacuum-Ultraviolet (VUV): kinetic model and efficiency. *Water research*, 133, 69-78.
- [3] Furatian, L. (2017). The use of 185 nm radiation for drinking water treatment (Doctoral dissertation, University of British Columbia).