Comparison of the efficiency of Vacuum-UV light sources in water treatment: low-pressure mercury-vapour lamp versus Xe* excimer lamp

Luca Farkas[1], **Tünde Alapi**[1]

[1]*University of Szeged, Faculty of Science and Informatics, Department of Inorganic and Analytical Chemistry, Szeged, Dóm square 7.*

Corresponding author: fluca@chem.u-szeged.hu

Adequate quality of water is essential to the appropriate quality of life. Due to the water cycle, many toxic compounds, that are difficult to biodegrade, appear in surface waters and drinking water bases. The conventional biological water treatment is a very effective and economically feasible process, but sometimes it is not able to eliminate completely the toxic organic pollutants having a low concentration. These harmful substances can cause serious ecological problems, and also responsible for many public health problems. Consequently, it is important to investigate and develop additive water treatment processes. Advanced Oxidation Processes are a variety of chemical, photochemical, and electrochemical processes that are based on the production of reactive species, especially HO•, and can be used for elimination of organic matter. VUV photolysis, one of these methods, is based on high-energy (wavelength <200 nm) radiation, which is able to cause the dissociation of water molecules and produce HO• and H•. The aim of this study to compare the efficiency of two VUV light sources: low pressure mercury vapour and excimer lamp. The low-pressure mercury vapour (LPM) lamp emits both 185 nm VUV and 254 nm UV photons, while excimer lamp emits only 172 nm VUV photons. A characteristic difference between the two light sources is that while 185 nm of light is absorbed in the 11 nm thick layer of water, a fraction of mm (0.04 mm) is sufficient to absorb 172 nm photons.

Results: The effect of dissolved O_2, the effect of the initial concentration of coumarin (model organic substance) on its transformation rate, and on the formation rate of its hydroxylated products, and the effect of HO• scavenger were determined and compared using both light sources. The recombination of HO• and HO_2•/O_2•- in pure water result in the formation of H_2O_2. Although the photon flux of 172 nm photons was five times higher than that of 185 nm photons, 40 times higher H_2O_2 concentration was measured in O_2 saturated water using 172 nm VUV light compared to the 185 nm light irradiated one. At the same time, the initial transformation rate of coumarin was only 5 times higher and practically independent on the dissolved O_2 concentration. The effect of methanol as HO• scavenger, demonstrated the relative contribution of HO• initiated reaction to the transformation of coumarin and formation of its hydroxylated product in both cases.

Conclusions: Comparing the aqueous solutions irradiated with VUV light at 185 and 172 nm, we found that the extreme inhomogeneity of the irradiated water at 172 nm greatly influences the quantum efficiency of organic matter conversion.

Acknowledgements: This publication was supported by the János Bolyai Research Scholarship of the Hungarian Academy of Sciences, and new national excellence program of the Ministry for Innovation and Technology (ÚNKP-20-3-SZTE-459 and ÚNKP-20-5-SZTE-639). The authors thanks the financial support from the project Hungarian Scientific Research Fund (NKFI contract number FK132742)

Keywords: AOP, VUV photolysis, hydroxyl-radical