Novel UV-C Emitting Phosphors for Hg Low Pressure Discharge Lamps

Jan-Niklas Keil, M.Sc., Mike Broxtermann, M.Sc., Prof. Dr. Thomas Jüstel
Münster University of Applied Sciences, Department of Chemical Engineering
Stegernaldstrasse 39, D-48565 Steinfurt, Germany
Corresponding authors: keil@fh-muenster.de and tj@fh-muenster.de

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Introduction
Water disinfection with UV-C radiation gets more and more important over the last 20 years. Hg-low-pressure discharge lamps are typically used as artificial UV-C sources. The main emission (85%) of these lamps lays at 254 nm, 12% lays at 185 nm (VUV-region) and 3% in the visible range of the electromagnetic spectrum. Therefore, the majority of the emitted radiation is UV-C light, which can be used directly for water disinfection. The 12% of VUV emission, become absorbed by water under formation of OH-radicals, already in small layer thicknesses. To increase the disinfection efficiency of Hg-low-pressure discharge lamps it is necessary to convert the emitted VUV-radiation into UV-C-radiation. Therefore phosphors are needed, which can be excited with 185 nm and emits radiation between 200 and 310 nm. In addition to disinfection purposes, UV-C radiation can also be used for so called “advanced oxidation processes” (AOP). AOP is a fast growing field in the area of water treatment, in which OH-radicals are used to break C-C and C-H bonds to decompose organic pollutants [1].

Processes inside the gas discharge
1. Emission of electrons: Cathode → e-
2. Excitation of Hg-atoms: Hg + e- → Hg^+ + e-
3. Relaxation of excited Hg-atoms: Hg^+ → Hg + hν

Prerequisites for potential UV-C emitting phosphors
- Suitable band gap (> 6 eV)
- High thermal, photo and chemical stability
- Redox stable activators
- High absorption cross section around 185 nm
- Emission band between 200 and 280 nm

Examples for suitable host materials and activators
Host materials: Activators:
- Phosphates - Bi
- Borates - Nd
- Aluminates - Bi^3+
- Silicates

Examples for the photoluminescence of UV-C emitting phosphors

Conclusions
Future work will deal with the more UV-C emitting phosphors. The herein presented phosphors are already known and multiple studies were dedicated to them.

Literature

Fig. 1: Hg-low pressure discharge lamp, general build-up and the process of UV generation

Fig. 2. Emission spectrum of a Hg-low pressure discharge lamp and a disinfection curve for B. subtilis (DIN 5031-10)

Fig. 3: Room temperature PLE, PL and reflectance spectra of YPO$_3$:Pr$^{3+}$

Fig. 4: Energy level diagram of YPO$_3$:Bi$^{3+}$ and YPO$_3$:Pr$^{3+}$ [1,4]

Fig. 5: Relative germicidal efficacy for B. subtilis according DIN 5031-10 and photoluminescence emission spectra of YPO$_3$:Bi$^{3+}$, YPO$_3$:Pr$^{3+}$ (850 nm)

Fig. 6: Overview energy distribution for a big disinfection device with and without phosphor conversion of the 185 nm line

Fig. 7: Water disinfection with UV-C radiation gets more and more important over the last 20 years. Hg-low-pressure discharge lamps are typically used as artificial UV-C sources. The main emission (85%) of these lamps lays at 254 nm, 12% lays at 185 nm (VUV-region) and 3% in the visible range of the electromagnetic spectrum.