METAL-ORGANIC FRAMEWORKS FOR PHOTOCATALYTIC DEGRADATION OF DYES

Pokhorukov D.A.[1,2], **Griaznova O.Yu.**[1, 2, 3], **Gorin D.A.**[3], **Deyev S.M.** [1, 2]

[1] *Shemyakin-Ovchinnikov Institute of bioorganic chemistry, Moscow, Russia*
[2] *National Research Nuclear University MEPhI, Moscow, Russia*
[3] *Skolkovo Institute of Science and Technology, Moscow, Russia*
yvileapsis@gmail.com

Metal-organic frameworks (MOFs) are a class of hybrid porous materials consisting of metal nodes and organic ligands structured into a crystal lattice. MOFs are highly porous on a structural level, being able to entrap molecules within their crystal lattice, which combined with their ability to produce reactive oxygen species (ROS) through photocatalytic activity makes them a promising adsorbent and filtration agent for various organic and inorganic pollutants, as well as a prospective material for photodynamic therapy. [1]

The mechanism of ROS generation by MOFs is quite typical for semi-conductor materials — after absorbing photons of energy larger than the bandgap formed by ligands and metallic nodes, an electron-hole pair is created and the charge migrates to the highly developed surface of the MOF. There, an electron reduction of oxygen to superoxide radical and hole oxidation of water to hydroxyl radicals occur. These reactive oxygen species then proceed to attack organic molecules, cleaving bonds and mineralizing them into CO2, water and simple ions, effectively destroying original compound. [2,3]

Despite there being a number of works on visible-light photocatalytic activity of MOFs, most focus on solar light-driven catalysis and optimization of MOFs to such conditions. An alternative approach using lasers to induce photocatalysis offers several advantages. These include clear separation of effects of ROS on the dye from direct impact of the light, ability to detect even subtle photocatalytic ability of nanoparticles, and precise control over the laser's intensity and power, allowing for a comparison of catalytic effects across different photon wavelengths.

The aim of this work was to compare MOF nanoparticles of the same crystalline structure and different metal ions in their ability to degrade organic dyes in a water solution. To this end, MIL-101 (Al), MIL-101 (Cr), MIL-101 (Fe), as well as UiO-66 (Zr), UiO-66 (Ce), and UiO-66 (Hf) have been synthesized and characterized using dynamic light scattering, UV-vis spectroscopy, scanning-electron microscopy and X-ray crystallography. To study MOF-induced photocatalytic degradation Rhodamine B solution was subjected to laser irradiation of wavelengths of 450 nm, 532 nm, 650 nm, 808 nm in presence of synthesized nanoparticles, and absorbance spectra were analyzed.

The work was supported by the Ministry of Science and Higher Education of the Russian Federation, agreement no. 075-15-2024-536.

[1] Ni, K., Lan, G., & Lin, W, Nanoscale Metal–Organic frameworks generate reactive oxygen species for cancer therapy, ACS Central Science, 6(6), 861–868, (2020).

[2] Wang, Y., Zhang, N., Wang, R., et al, Bimetallic UiO-66-NH2(Zr–Hf) synergistic photocatalytic and piezoelectric effects for the degradation of rhodamine B, Dalton Transactions, 52(29), 10079–10088, (2023).

[3] Wang, Q., Gao, Q., Al-Enizi, A. M., et al, Recent advances in MOF-based photocatalysis: environmental remediation under visible light, Inorganic Chemistry Frontiers, 7(2), 300–339, (2019).