УДК 538.975

Laser-Induced Structural Modification of Metal-Organic Frameworks Using Second Harmonic (515 nm) Femtosecond Laser Pulses

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Introduction. Metal-organic frameworks (MOFs) have emerged as versatile materials with tailored porosity and tunable optical properties, attracting interest in fields ranging from catalysis to photonics [1]. Their sensitivity to external stimuli, particularly laser irradiation, opens avenues for structural modifications that enhance their optical and electronic performance. This study investigates the laser-induced modifications of MOFs under second harmonic (515 nm) femtosecond laser pulses. The short pulse duration and high peak intensity of femtosecond lasers provide unique conditions for precise material modifications without excessive thermal effects. The focus is on assessing how laser parameters influence the structural integrity, optical behavior, and photonic potential of MOFs.

Main Part. We conducted experiments using 515 nm femtosecond laser pulses (pulse duration = 224 fs) to induce controlled modifications in a copper-based MOF. The samples were deposited on plain quartz substrates and subjected to varying laser parameters, including fluence and pulse frequency. To analyze the structural, chemical, and optical changes post-irradiation, we utilized a range of characterization techniques.

Microscope spectrophotometry was employed to measure reflection (R) and transmission (T), from which the refractive index (n) and extinction coefficient (k) were calculated. Scanning electron microscopy (SEM) provided detailed insights into surface morphology, while the real and imaginary parts of the dielectric function were derived to further understand the optical response of the MOF under different laser conditions. The results highlight how laser-induced modifications can be precisely controlled to achieve specific optical and structural changes in MOFs. Our research delves into the nuances of how different wavelengths and intensities, characteristic of UV and IR lasers, uniquely interact with and alter the MOF structure and its optical properties [2].

An important aspect of this inquiry is identifying the ablation and modification thresholds of HKUST-1 under diverse laser irradiation scenarios [3,4]. Discerning these thresholds is paramount in understanding the limits of laser parameter tuning that can instigate alterations in the MOF's structure and properties, without causing significant material degradation or loss. This exploration is crucial in advancing our understanding of the resilience and adaptability of HKUST-1 MOFs under varied photonic influences, thereby broadening their potential applications in photonics and material science.

Conclusion. The study demonstrates that second harmonic femtosecond laser pulses provide an effective tool for tailoring the structural and optical properties of MOFs. The ability to control modifications by fine-tuning laser parameters offers new prospects for integrating MOFs into photonic devices. This study contributes significantly to the expanding knowledge base regarding the interaction of MOFs with laser irradiation, highlighting its potential in novel applications and material modifications.

References.

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