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Application of Zeolite Nanoparticles in Biomedical Optics

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Abstract : Recently nanoparticles (NPs) have been introduced in biomedicine as effective agents for cancer-targeted drug delivery and noninvasive tissue imaging. The most important requirements to these agents are their non-toxicity, biocompatibility and stability. In view of these criteria, the zeolite (ZL) nanoparticles (NPs) may be considered as perfect candidates for biomedical applications. ZLs are crystalline aluminosilicates consisting of oxygen-sharing SiO4 and AlO4 tetrahedral groups united by common vertices in three-dimensional framework and containing pores with diameters from 0.3 to 1.2 nm. Generally, the behavior and physical properties of ZLs are studied by SEM, X-ray spectroscopy, and AFM, whereas optical spectroscopic and microscopic approaches are not effective enough, because of strong scattering in common ZL bulk materials and powders. The light scattering can be reduced by using of ZL NPs. ZL NPs have large external surface area, high dispersibility in both aqueous and organic solutions, high photo- and thermal stability, and exceptional ability to adsorb various molecules and atoms in their nanopores. In this report, using multiphoton microscopy and nonlinear spectroscopy, we investigate nonlinear optical properties of clinoptilolite type of ZL micro- and nanoparticles with average diameters of 2200 nm and 240 nm, correspondingly. Multiphoton imaging is achieved using a laser scanning microscope system (LSM 510 META, Zeiss, Germany) coupled to a femtosecond titanium:sapphire laser (repetition rate- 80 MHz, pulse duration-120 fs, radiation wavelength- 720-820 nm) (Tsunami, Spectra-Physics, CA). Two Zeiss, Plan-Neofluar objectives (air immersion 20×/NA 0.5 and water immersion 40×/NA 1.2) are used for imaging. For the detection of the nonlinear response, we use two detection channels with 380-400 nm and 435-700 nm spectral bandwidths. We demonstrate that ZL micro- and nanoparticles can produce nonlinear optical response under the near-infrared femtosecond laser excitation. The interaction of hypericine, chlorin e6 and other dyes with ZL NPs and their photodynamic activity is investigated. Particularly, multiphoton imaging shows that individual ZL NPs particles adsorb Zn-tetraporphyrin molecules, but do not adsorb fluorescein molecules. In addition, nonlinear spectral properties of ZL NPs in native biotissues are studied. Nonlinear microscopy and spectroscopy may open new perspectives in the research and application of ZL NP in biomedicine, and the results may help to introduce novel approaches into the clinical environment.

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