**The enhancement of third-order transient optical nonlinearity under strong light-matter coupling**
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**Abstract**

 Strong coupling of an optical mode with organic or inorganic materials paves the way for understanding the light-matter interactions. With the existence of this hybrid light-matter state, many properties of the material can be modified significantly[1](#_ENREF_1). Besides, recent studies also connected the hybrid light-matter states of specific organic materials with their nonlinear optical responses. For instance, the second harmonic generation[2](#_ENREF_2) and the third harmonic generation[3](#_ENREF_3), can be enhanced remarkably under strong coupling condition. However, the measurements in these works are only focused on some specific nonlinear optical phenomenons, this limits their generality in other nonlinear optical processes. In addition, the synthesis of those molecules is quite complicated, which precludes their practical application.

 In our work, by means of electronic strong coupling (ESC) and optical strong coupling (OSC), here the ESC is obtained by strongly couple the Frenkel excitons of J-aggregate cyanine molecules (TDBC) to an optical mode in a Fabry-Perot cavity, and the OSC is realized by couple the Mie resonances of the dielectric nanocavity to the epsilon-near-zero mode of an ultrathin indium tin oxide layer. We achieve enhancement of both nonlinear refractive index (*n*2) and nonlinear absorption coefficient (*β*) of the coupled systems for more than 2 orders of magnitude with respect to that of the uncoupled conditions. In addition, the temporal response of the coupled systems show a few hundreds of femtoseconds, which have promising applications in ultrafast optical switching and high speed data processing. These findings make them possible to study the effect of strong coupling on a series of *n*2, *β*-relatednonlinear optical phenomenons[4-6](#_ENREF_4).

**References:**

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