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Quantum nonlinear optics with polar J-aggregates in microcavities

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Abstract

© 2014 American Chemical Society. We predict that an ensemble of organic dye molecules with permanent electric dipole moments embedded in a microcavity can lead to strong optical nonlinearities at the single-photon level. The strong long-range electrostatic interaction between chromophores due to their permanent dipoles introduces the desired nonlinearity of the light-matter coupling in the microcavity. We develop a semiclassical model to obtain the absorption spectra of a weak probe field under the influence of strong exciton-photon coupling with the cavity field. Using realistic parameters, we demonstrate that a cavity field with an average photon number near unity can significantly modify the absorptive and dispersive response of the medium to a weak probe field at a different frequency. Finally, we show that the system is in the regime of cavity-induced transparency with a broad transparency window for dye dimers. We illustrate our findings using pseudoisocyanine chloride (PIC) J-aggregates in currently available optical microcavities. (Figure Presented).

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