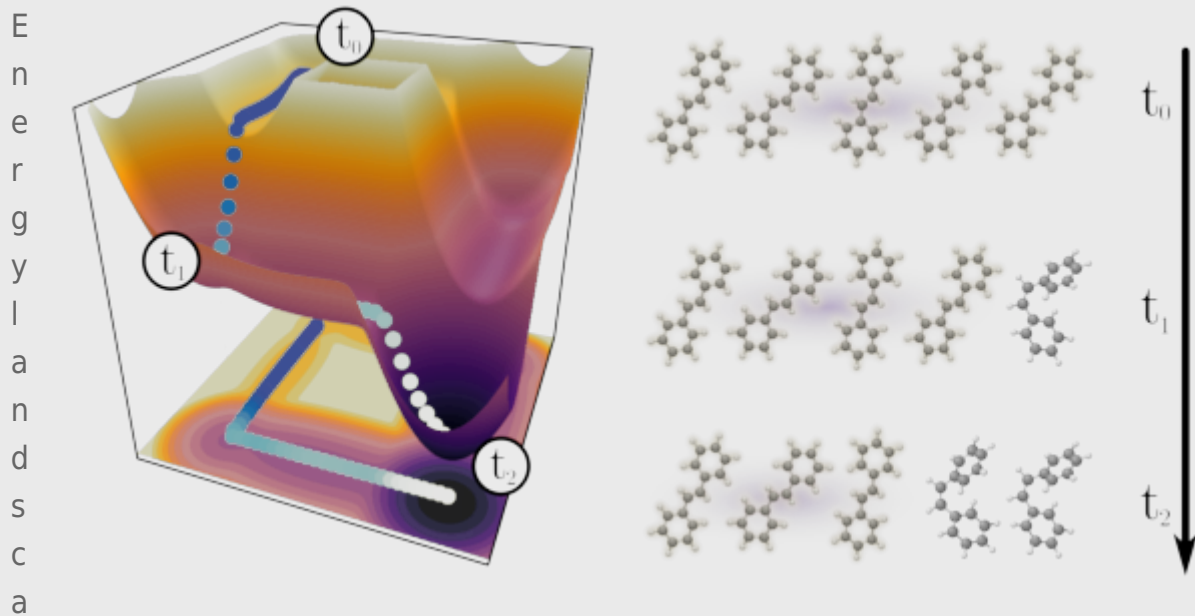


## Triggering Many Molecular Reactions With a Single Photon



pe that governs the chemical reaction of two molecules after the system absorbs one single photon. At the first reaction step  $t_0$  the system consists of five molecules strongly interacting with the electromagnetic vacuum. At the second reaction step  $t_1$  the system has evolved and one molecule has isomerized. In the strong coupling regime this process continues with more steps in which one molecule isomerizes after another.

Article: published in [Physical Review Letters](#) by Javier Galego, [Francisco J. Garcia-Vidal](#), and [Johannes Feist](#), IFIMAC researchers and members of the Department of Theoretical Condensed Matter Physics.

**P**hotoisomerization is a chemical process in which the nuclear structure of an organic molecule is modified after absorption of one photon. It is of great importance to many fundamental processes in nature such as photosynthesis and human vision, and constitutes a great tool for technological applications such as optical switches and solar energy storage. In conventional photochemistry the behaviour of these reactions is ruled by the Stark-Einstein law: only one molecule undergoes a reaction per absorbed photon.

In a recent study published in [Physical Review Letters](#), a theory group from Department of Theoretical Condensed Matter Physics and the [Condensed Matter Physics Center](#) (IFIMAC) at the [Universidad Autónoma de Madrid](#) has proven the possibility of overcoming the Stark-Einstein law in specific situations by taking advantage of the quantum electrodynamic phenomenon of light-matter strong coupling. This realization could have important applications in solar energy storage, where molecules under normal conditions efficiently absorb solar energy and store it for long times. Strong

coupling could allow the release of the stored energy of the whole system on demand by using only one single photon.

In the strong light-matter coupling regime the characteristics of each component are mixed and the system develops new states called polaritons, which can show modifications in both the material and chemical properties of the system. In this work the researchers show the possibility of taking advantage of this new “polaritonic chemistry” to open new reaction pathways otherwise forbidden in conventional chemistry. They consider organic molecules proposed for solar energy storage purposes, which have a 50% probability of inducing a useful reaction when absorbing a photon. They show that by putting these molecules in the strong coupling regime, it is possible to entangle the degrees of freedom that describe the reaction of each individual molecule. This way, absorbing a photon causes one molecule to react after another, inducing a stepwise chain reaction for many molecules. Therefore, by using strong coupling it is possible to trigger a reaction of thousands of molecules using only one photon.

This work is another example of the great potential of polaritonic chemistry, of great interest for both fundamental and applied reasons. In particular it is noteworthy how this developing field brings together chemistry and quantum electrodynamics. While in standard chemical reactions light and molecules are separated and have distinct roles, polaritonic chemistry calls for a redefinition of the molecule, and enables novel and exotic chemical processes, even finding ways to defy the well-established laws of conventional photochemistry. [[Full article](#)]