Strong Light-Matter Interaction and its Consequences on Molecular Photophysics

MANUEL HERTZOG

UNIVERSITY OF GOTHENBURG

Institutionen för kemi och molekylärbiologi
Naturvetenskapliga fakulteten
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Abstract

Strong light-matter interaction offers the possibility to modify chemical and physical properties of molecules by modifying their photonic environment, resulting in the creation of hybrid light-matter states, known as polaritons. The field of polaritonic chemistry using microfluidic cavities is in its infancy, and developing methods to increase the coupling strength are necessary to maximise the effects of polaritonic states. Moreover, exploring the effect of strong coupling on photophysical properties is necessary.

This thesis covers the design, characterisation and modeling of strongly coupled systems, with the aim of studying photophysical properties and developing methods to increase the total coupling strength between light and matter. Using FT-IR spectroscopy and numerical modeling, an increase of 50% of the coupling strength is reported by aligning the molecular transition dipole moment inside a cavity. Additionally, another method is introduced using artificial plasmonic molecules which increases the coupling strength of a nitrile absorption band by almost an order of magnitude. Furthermore, this thesis shows that upscaling microfluidic cavities is possible without affecting the coupling strength. Finally, selective manipulation of excited states in the strong coupling regime are demonstrated.

This dissertation is an exploratory study of several aspects of strong light-matter coupling paving the way to a new chemistry, and new approaches in material sciences.

Keywords: Strong coupling, Vibropolariton, Polaritonic chemistry