



# New Technique for Analyzing Liquid Phase Involves in IR Diffusion Spectroscopy

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## DISCRPTION

The most common and widely used Infrared (IR) spectroscopy approach is absorption spectroscopy, which is mainly produced by Fourier Transform Infrared (FTIR) spectrometers and, more recently, by Quantum Cascade Laser (QCL)-based spectrometers. In general, direct absorption spectroscopy analyses the intensity losses that are wavelength dependent and occur after the contact of the light with the sample, particularly at its resonance frequencies. Direct intensity measurements, however, are susceptible to IR source instability as well as the IR detectors constrained dynamic ranges and sensitivities. Chemical bonds and functional groups experience fundamental vibrations when exposed to mid-infrared light. This spectrum range's spectroscopic techniques enable the non-destructive and label-free characterization and quantification of a variety of substances.

Dispersion spectroscopy comes with several advantages that can compete with and even surpass conventional absorption spectroscopy. Firstly, because here the measured quantity is the phase shift, it is decoupled from the intensity noise of the employed source. Secondly, the measured signal develops only in the presence of the analytic, otherwise it is zero. In addition, a linear relationship exists between the observed signal and the sample thickness and analytic concentration. The signal decomposes from its original maximum value, which corresponds to zero attenuation, in a linear manner for intensity measurements, in contrast (absorption). Dispersion spectroscopy of liquid-phase samples using an EC-QCL coupled to a Mach-Zehnder Interferometer (MZI) was first introduced in 2018. Successive works further advanced the experimental setup by increasing acquisition speed and improving thermal and mechanical stability as well as demonstrated applications to binary and complex mixtures of carbohydrates and proteins.

In this work, we present a detailed investigation of the broadband mid-IR dispersion sensing in liquids and the phase-locked interferometry detection used in the EC-QCL-MZI configuration. We empirically demonstrate the above-discussed benefits of dispersion sensing as well as its present limits. These results are based on theoretical considerations.

Experimental setup for mid-IR dispersion spectroscopy of liquids the analytical signal is the peso-mirror displacement signal from the force sensor position sensor output, which is proportional to changes in the sample's refractive index. The configuration gives changing between dispersion and absorption spectroscopy as the configuration. For quick and automatic switching between the two measuring modes, an automated beam shutter blocking one arm of the interferometer was used for this purpose, and it was synchronized using Lab View with the laser's scan trigger. In addition, for improved temperature control (22.5 °C) and stabilization of the setup's components and internal environment, all optical components are housed and mounted on a water-cooled breadboard in conjunction with a liquid cooling system.

Spectra acquisition the transmission cell's reference and sample channels were filled with reference solution (i.e., solvent) and sample solution, respectively, before the dispersion spectra were acquired. The process of continually adjusting the EC-QCL over the laser's spectral tuning range and observing the resulting piezo-displacement signal resulted in the acquisition of a dispersion spectrum. The phase shift or index of refraction, which is the signal examined in dispersion spectroscopy, is linearly proportional to the concentration. Therefore, beyond the scope of the Beer-Lambert equation, strongly absorbing or highly concentrated substances can be quantitatively evaluated using this method.

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