Stark Effect Measured by Microwave Fourier Transform Spectroscopy

W. Kasten, W. Stahl, and H. Dreizler

Abteilung Chemische Physik, Institut für Physikalische Chemie der Universität Kiel

Z. Naturforsch. **39a,** 511–512 (1984); received February 29, 1984

We present the test measurements with a Stark cell for Microwave Fourier Transform Spectroscopy, which is precise enough to improve the measurement of dipole moments.

Microwave Fourier Transform (MWFT) Spectroscopy has been proved to be a valuable tool for the investigation of rotational spectra of dipolar gases at low pressures [1]. We showed [2] that the measurement of the Stark effect is possible with this technique.

Because of the high resolution of MWFT spectroscopy a very homogeneous Stark field is necessary to avoid additional broadening. As a Stark field can be applied in a waveguide only by introduction of a septum, reflections of the microwave pulses necessary for the polarization of the gas occur at the septum ends.

Their influence on the spectrometer performance can be minimized if the ends of the septum are very near to the waveguide isolators enclosing the sample cell (see Fig. 1, part 19 of [3]). Since our first experiments we built and tested several cells. The last seems to be useful. It is an X-band cell with a length of 1.03 m and three septa inserted parallel to the broad side of the guide at equal distance. As the width of the waveguide $a = 22.86$ mm cannot be increased when higher modes should be avoided, the insertion of three septa (0.5 ± 0.003 mm* thick) is a way to make the ratio $r = w/d$ of septum width $w = 21$ mm to septum distance $d = 2.17 \pm 0.015$ mm** more favourable for a homogeneous Stark field. The septa are kept in position by Teflon spacers 10 mm long and 50 mm apart.

* Error taken from measurements with micrometers.
** Error calculated from septa and guide tolerances.

Reprint requests to Prof. Dr. H. Dreizler, Institut für Physikalische Chemie der Universität Kiel, Olshausenstr. 40, D-2300 Kiel.

The ends of the septa are formed as given in Fig. 1 of [4] to allow RF-transmission for other purposes. The center of the connector is 15 mm from the window.

Figure 1 gives a test measurement with carbonylsulfide, OCS. Measurements with a number of field strengths are given simultaneously. The shapes of the satellite at higher field strengths show that there is still a misalinement of the septa and/or tolerance of the septa and waveguide, which is estimated from the broadening of the satellite at 1404 V/cm to a mean value of 0.017 mm. This broadening effect seems to be larger than that resulting from the dephasing due to the inhomogeneous Stark field. The half width at half height of the satellite at 1404 V/cm is 260 kHz. This is about half of that we get with Stark spectroscopy.

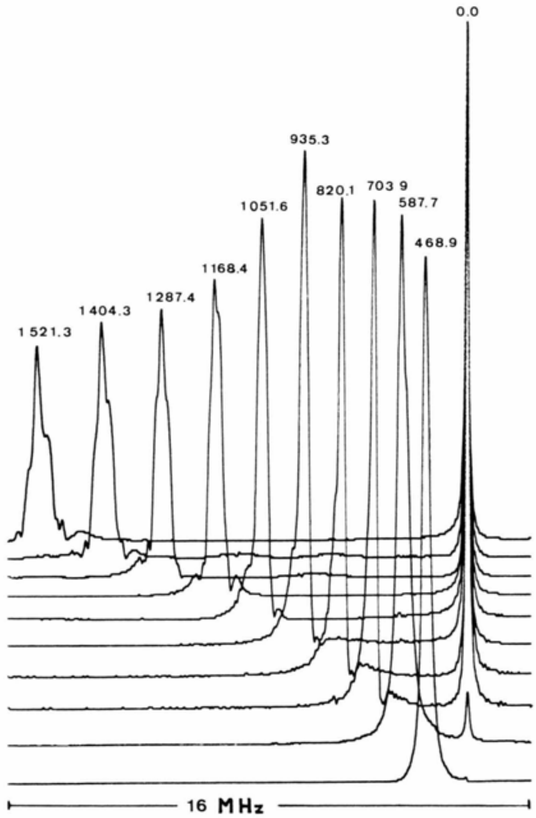

Fig. 1. Test measurements of the Stark effect of $J = 1-0$ transition of OCS with different field strengths [V/cm]. The frequency increases from right to left. 1 mTorr, 25 °C, 20 ns sample interval, $2 \cdot 2^{15} - 50 \cdot 2^{15}$ pulses, 1024 data points supplemented by 3072 zeros prior to Fourier transformation.

0340-4811 / 84 / 0500-0511 $ 01.3 0/0. – Please order a reprint rather than making your own copy.

We do not understand the appearance of the unshifted line at higher field strengths, as the space free of a Stark field is only 3% of the cell length.

Taking the value of de Leeuw and Dynamus [5] $\mu = 0.71512(3)$ D we calculate a septum distance of 2.135(4) mm near to the value determined from geometry.

We think that now MWFT-spectroscopy can also be used to determine dipole moments. Besides the higher resolution of MWFT-spectroscopy it is an additional advantage that only a DC-Stark field is employed. It is simpler to measure DC-voltages precisely and there are no bias problems as in MW Stark spectroscopy.

We thank the members of our group and especially Mr. H. Michaelis and Mr. H. Kähler of our workshop for help, the Deutsche Forschungsgemeinschaft and Fonds der Chemie for funds.

[1] For example: Dirk Hübner, Eckhard Fliege, and Dieter H. Sutter, Z. Naturforsch. **38a,** 1238 (1983) and other publications in Z. Naturforsch. **35a**–**38a** (1980–1983).
[2] G. Bestmann and H. Dreizler, Z. Naturforsch. **37a,** 615 (1982).
[3] G. Bestmann and H. Dreizler, Z. Naturforsch. **37a,** 58 (1982).
[4] H. Dreizler, W. Schrepp, and R. Schwarz, Z. Naturforsch. **34a,** 571 (1979).
[5] F. H. de Leeuw and A. Dynamus, Chem. Phys. Lett. **7,** 288 (1970).

Verantwortlich für den Inhalt: A. Klemm
Satz und Druck: Konrad Triltsch, Würzburg