Spectrochimica Acta, Vol. 43A, No. 2, p. 243, 1987.
Printed in Great Britain.

0584-8539/87 $3.00+0.00
Pergamon Journals Ltd.

An investigation of the end-products of CO_2 laser irradiation of ethene gas

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Ethene (ethylene) is an almost classical object of laser-induced chemistry [1] . At 950 cm^{-1} it possesses a strongly absorbing infrared spectral feature (ν_7).

In this preliminary study of the decomposition of ethene (C_2H_4) under the effect of strong infrared radiation from a CO_2 laser we have detected several decomposition products by infrared spectroscopy as a means of end-product analysis.

In the experiments described here ethene gas was allowed to enter a previously evacuated 10 cm infrared gas cell equipped by NaCl windows. The ethene pressure was 4.3 kPa and Ar gas was added as buffer to bring the total pressure to about 6 kPa. As infrared source a Coherent Everlase 525 cw high-power CO_2 laser (500 W) was used that could be operated at reduced power (50 W) in a pulsed mode at pulses of approx. 1 ms duration. The radiation was focussed by a Ge lens to the center of the sample cell. The estimated intensity at focus was in the range 10-30 MW pro square cm. In the present experiments about 6 kJ energy was sent through the sample. No light emission accompanied the absorption of laser radiation therefore probably no plasma was generated. The irradiated sample was transported to a high-resolution FTIR spectrometer (Nicolet 7199) and the infrared spectrum of the resulting gas mixture was measured at various spectral resolution levels.

The inspection of the infrared spectra of the initial ethene sample and the irradiated sample revealed the presence of C_2H_2 (acetylene), and also an amount of carbon monoxide and other products that could not be identified positively because of the overlapping strong absorptions from ethene. Therefore a standard feature of the Fourier-transform spectrometers was utilised, i.e. the spectrum of the initial ethene sample was "ratioed out" from the spectrum of the reaction mixture. This is basically equivalent to using a double-beam IR spectrometer. This way we obtained spectra that made it an easy matter to identify the characteristic rotational structure of the various bands belonging to acetylene, methane, formaldehyde and carbon monoxide.

As to the origin of the oxygen-containing products we can only speculate at this moment, but it seems likely that some water vapour or H_2O adsorbed on the inner wall of the infrared gas cell provided the necessary oxygen to form CO and CH_2O.

In the future we are planning specific CO_2 laser-chemical experiments controlling CO_2 frequency and pressure in a wider range. The present results show, however, that Fourier-transform spectroscopy is a widely usable and sensitive method for detecting end-products.

Acknowledgements

We would like to acknowledge the help given by the Tungsram Works at Budapest, Hungary in the way of providing access to their metallurgical CO_2 laser facilities. It was at the Bródy Laboratories in this firm where the initial phases of this research were carried out.

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