Part II

Introduction

The starting point for this work was the dataset obtained during the optical longterm-monitoring program of comet C/1995 O1 Hale-Bopp [Rauer *et al.*, 1997, 2002]. Observations started in April 1996 and ended nearly 5 years later in January 2001 covering a heliocentric distance range from 4.6-2.8 AU pre-perihelion and from 2.9-12.8 AU post-perihelion. It was the longest campaign ever observing a single comet in the optical wavelengths range so far. This huge dataset had to be reduced and analyzed. During a first analysis using the Haser model a number of scientifically interesting questions arose, which had to be analyzed further in more detailed studies. One of these was especially interesting: the formation of C_2 and C_3 in a cometary coma.

C_2 has been the first constituent of the coma to be found by spectroscopy observations. This was done already in 1864 by Giovanni Donati [1864] in comet Tempel (1864 II) and independently in 1867 by Sir William Huggins [1867] in comet Winnecke (1867 II). Both identified the emissions by comparing the cometary spectra with flame spectra. They also observed a group of lines near 4050 Å, but it took more than eighty years until Douglas [1951] identified these lines as C_3 emissions. For more than a century C_2 remained without an observed parent molecule. A number of parent molecules had been proposed, namely acetylene C_2H_2 and ethane C_2H_6 for C_2 [Jackson, 1976] and propyne or its isomeric form allene C_3H_4 for C_3 [Stief *et al.*, 1972]. Finally in 1996 emissions of C_2H_2 and C_2H_6 have been detected in comets Hyakutake and Hale-Bopp [Tokunaga *et al.*, 1996; Brooke *et al.*, 1996; Mumma *et al.*, 1996]. C_3 is up to the present without an observed parent molecule.

The main aim of this study is to analyse the formation of C_2 and C_3 in a cometary coma at large heliocentric distances. As Crovisier and Encrenaz [2000] pointed out in their book on comets: C_2 has been an orphan for nearly a century. To stay in this picture, this work will help to link the 'orphan' with its heritage by providing a family tree and will attempt to identify the ancestor of C_3. In this work a chemical reaction network is presented capable of explaining the formation of C_2 and C_3 assuming C_2H_2, C_2H_6 and C_3H_4 as their parent molecules. Such a formation model allows to derive abundances for these parent molecules from data obtained with optical spectroscopy at heliocentric distances $r_h \geq 3$ AU. Up to now C_2H_2 and C_2H_6 has only been measured by infrared observations at heliocentric distance $r_h \leq 3$ AU [Dello Russo *et al.*, 2001]. Thus this model can greatly extend the heliocentric distance range over which hydrocarbons can be studied in the coma of comet Hale-Bopp. Based on the production rates for C_2H_2, C_2H_6 and C_3H_4 abundances ratios will be derived for heliocentric distances $r_h \geq 3$ AU. Especially the ratio to CO at these large heliocentric distances can give some important indications on the volatility of the C_2 and C_3 parent molecules.

This work consists of three main parts. The first part is an introduction to the areas of cometary science touched in this study. Its intention is to give a short introduction in each topic. A more detailed discussion is given only for issues closely related to this study. The second part presents the dataset obtained during the optical longterm monitoring program of comet Hale-Bopp [Rauer *et al.*, 1997, 2002], describes the data reduction and presents a first analysis using the Haser model. The third part finally presents the analysis of the formation of C_2 and C_3 and the derived formation model. Using this model abundances for C_2H_2, C_2H_6 and C_3H_4 at heliocentric distances greater than 2.86 AU have been derived.

This part is closed by a discussion on the implications for the formation region of comet Hale-Bopp.