ASTROCHEMISTRY OF INTERSTELLAR CLOUDS:
II. MOLECULAR FORMATION IN A CONTRACTING CLOUD

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ABSTRACT

The chemistry of an 667 M_O interstellar cloud was studied using 142 reactions for 40 species during the contraction under self gravity in two steps. At first the **contraction is allowed without gas phase reactions untill** certain optical depth is reached. Secondly,at this optical depth the chemical reactions are started for sufficient cycles in a time dependant scheme till only very small additionally changes in the abundances occur. The so obtained relative abundances and coulmn densities for different species represent a continous function of the optical depths. The values arround τ_V=6.3 represent the observations for $H_2,H_2^+,H_3^+,OH,OH^+,CH,CH^+,CH_2,CH_2^+,CH_3^+$, H_2O and H_3O^+. The region of τ_V between 1 and 5 i.e of particle density between 4 10^2- 6 10^3 is the preferable formation place for the majority of molecules.

1-INTRODUCTION

Recent observational advances offer new opportunities for studying the interstellar gas under wide variety of previously inaccessible conditions. However most studies on the evolution of interstellar clouds have focused on either purely dynamical aspects or the interstellar chemistry,few articles have considered the coupling of dynamics and chemistry. In the present work a large number of physical processes have been considered in constructing a realistic model for the contraction of a spherically symmetric interstellar cloud intially of isothermal density distribution of central particle density $10^3$and temperature of 30K, **El Shalaby et al** (1983). We follow the formation and destruction processes of interstellar molecules at every of the 50 grid points within the cloud. The total fraction of any element in the gas form, relative to hydrogen equals the sum of its partial fractions in the different forms. The abundance of a molecule is then computed after every time step in a time dependant scheme. Applying this method during the contraction of an interstellar cloud enables us to get a detailed knowldege of the fractional

M. S. Vardya and S. P. Tarafdar (eds.), Astrochemistry, 273–274.

abundance of the different molecules at the different places and hence different densities, temperatures and optical depths of the cloud. As only an example we discuss here few molecules. Finally we give a summary of the conclusions. The full details of this work will be published elsewhere.

2-DISCUSSION

Most interstellar carbon exists as C, C^+, CO together with hydrocarbon molecules. Where $\tau_V \leq 1$, particle density $n_{\uparrow} 4\ 10^2\ cm^{-3}$, the radiation field is not attenuated very much and C^+ abundance is greater than those of C, CO, CH and CH^+. For $\tau_V \gg 1$, ($n \gg 4\ 10^2$), C predominates through neutralization of C^+. The C^+ relative abandance decreases sharply with carbon transfer in other neutral molecules such as CO and CH. CH is mainly formed by radiative and recombination reactions from CH_2^+ and CH_3^+. The formation of CH is necessary for the formation of the molecules $C_2H_n^+$. As CH^+ dissociates reasonably rapidly and because H_2 is rare at $\tau_V \ll 1$ the fractional abundance of heavier carbon hydrides and their ions remain small in spite of the second intial reaction $C^+ + H_2 \rightarrow CH_2^+ + h\nu$. With increasing H_2 and its destruction product CH_2^+, CH_3^+ is formed with large abundance. This in turn increases CH inwards via recombination reactions with increasing optical depth to approach the observed relative abundance of $3\ 10^{-8}$ for ζ Oph cloud, Black& Dalgarno (1977).

3-CONCLUSIONS

The main conclusions of this work are the following: (1)The observed relative coulmn densities of H_2, H_2^+, H_3^+, OH, OH^+, CH, CH^+, CH_2, CH_2^+, CH_3^+, H_2O and H_3^+ lie near the optical depth $\tau_V \approx 6.28$. (2)The different species reach their peak abundances at different places within the cloud depending on various parameters e.g.optical depth ,number of electrons,radiation field and density. (3)Most molecular formations occur at $\tau_V = 1 \rightarrow 5$. This corresponds to densities between $4\ 10^2$ and $6\ 10^2\ cm^{-3}$ which are representative for dark clouds. (4)The ionized molecules C_2^+, CH_3^+, CH_2^+, H_3O^+, H_2O^+, CH^+ have small relative abundances near the surface ($\tau_V < 1$). They reach maximum between $\tau_V > 1$ and $\tau_V \approx 4.5$. (5)The relative abundandance of H_3^+ reaches maximum of $5\ 10^{-2}$ at about $\tau_V \approx 0.9$ and decreases gradually inwards due to its consumption in the ion-molecule reactions. (6)The neutral molecules CH, CH_2, CH_3, HCO, C, O, CO, NO, H_2 increase generally towards the center of the cloud. (7)Most interstellar carbon is in the form C, C^+, CO together with hydrocarbon molecules in agreement with the observations of Morton et. al (1973). (8)Incomplete chemistry or inaccurate reaction rates may be the causes of differences between the observed and computed abundances of some species. Future work is planned with more reactions to test the sensitivity of abundances of different molecules to the reaction constants.

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