INTERSTELLAR MOLECULES ON DUST MANTLES

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Condensation temperatures of various interstellar molecules in dark clouds are calculated. Chemical reactions in dust mantles are discussed.

1. CONDENSATION TEMPERATURES IN DARK CLOUDS

Gaseous molecules in dark clouds show more variety and are more concentrated than those in diffuse clouds. Under these conditions the condensation of interstellar molecules on the dust surfaces can occur. We have calculated the condensation temperature of various interstellar molecules (Table 1) using the Clapeyron-Clausius equation. S or L means extrapolation from the data at vapor pressures of 1 Torr and 10 Torr in the solid state(S) or the liquid state(L); other values were calculated using an evaporation heat assumed from Trouton's rule. As the calculated values are given for pure substances, condensation must occur at higher temperatures due to the low vapor pressure of solid solutions.

In Table 1 the molecules can be separated into two groups at 20 - 30 K. One group is condensed in the dust mantles and the other group containing CH_4, CO, N_2, and H_2 is gaseous.

2. REACTIONS IN DUST MANTLES

At temperatures below 100 K in dust mantles the usual chemical reactions having activation energies about 50 kJ/mol will have rates with time scales of 10^8 years. However during star formation the temperature becomes high and chemical reactions in dust mantles may occur. Two types of reactions attract notice. One type is the reaction of the main components of dust mantles such as H_2, HCN and NH_3. This mixture is famous among researchers into the origin of life because it produced glycine, alanine, other amino acids, bases of nucleic acids and urea.[3,4]

Another type of reaction is that between water ice and polyynes.

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Polyynes react with water to form various compounds having —C—O, >C=O, —C—H, —C—C (—O—), as demonstrated by NMR and IR spectra in the laboratory. There is therefore a possibility of the production of sugars from interstellar molecules.

TABLE 1

Molecule	Abundance[1] 10^{-x}	Condensation Temperature (K) 10^3/cc	10^5/cc	10^7/cc
H_2NCHO	10	93.4	98.8	105.0 L
H_2O [2]	5	84.8	90.1	97.2 S
HCOOH	10	81.3	85.8	90.7 S
CH_3COOH	(10)	79.7	84.1	89.0
H_2CS	10	73.0	78.0	84.0
CH_3OH	7	65.1	69.4	74.2 L
HCN	6	64.5	68.9	73.9 S
H_2NCN	9	63.0	68.0	73.6
CH_3CH_2OH	10	63.4	67.2	71.4 L
CH_3CH_2CN	10	57.9	61.4	65.4 L
SO_2	7	55.2	58.7	62.6 S
CH_3CN	(9)	55.0	58.5	62.5 L
NH_3	6	52.6	56.1	60.0 S
CH_3OCHO	10	49.8	52.8	56.2 L
CH_3CHO	10	47.9	50.8	54.1 L
(CO_2)	(6)	45.5	48.6	52.1 S
CH_3NH_2	10	45.2	47.9	51.1 L
H_2CO	8	41.6	44.5	47.7 L
(C_2H_2)	(6)	41.2	44.1	47.3 S
CH_3CCH	9	37.9	40.7	43.8
OCS	8	37.2	39.7	42.6 L
CH_3OCH_3	10	36.8	39.1	41.7 L
H_2S	8	36.6	39.0	41.7 S
CH_4	(6)	16.9	18.0	19.5 S
CO	4	14.8	16.1	17.5 S
(N_2)	(6)	12.1	12.9	13.9 S
H_2	0	2.6	2.9	3.2

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