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ASTROPHYSICALLY RELEVANT REACTIONS OF C_n (n = 1-3) WITH IONS: EXPERIMENTS IN ION TRAPS

IGOR SAVIĆ

Department of Physics, Faculty of Science, University of Novi Sad, Trg Dositeja Obradovića 4, 21000 Novi Sad, Serbia and Montenegro
E–mail: savke@uns.ns.ac.yu

Many chemical models have been developed for describing the formation and destruction of molecules in different regions of the interstellar medium (ISM). Due to their possible complexity, the number of processes included in a model has to be restricted, in order to numerically solve the problem. Therefore, relevant and selected data from experimental and theoretical astrochemistry are needed. Especially, dedicated measurements performed under astrophysically relevant conditions are of crucial importance.

Ions play an extremely important role in the formation of molecules at low temperatures. The reasons for this are that, in general, their reactions have no barriers and the reactions are often fast.

Since carbon containing molecules play an extremely important role in physical and chemical evolution of the ISM, detailed and systematic studies on formation and destruction of carbon containing molecules are needed.

Using ion-trapping technique, selected laboratory experiments on ionmolecule reactions of astrophysical interest have been performed and results are presented in PhD thesis "*Formation of Small Hydrocarbon Ions Under Inter- and Circumstellar Conditions: Experiments in Ion Traps*" (Savić, 2004).

In one part of the thesis, results of detailed investigations of reactions of C_3^+, C_3H^+ and $C_3H_3^+$ ions with H_2 and HD between 15 K and room temperature are presented. Results, obtained using a Variable Temperature 22Pole Trap machine, include many observed interesting reactions like reactive collisions, deuteration and radiative association (Savić, 2004; Savięt al., 2005a; Savić and Gerlich, 2005).

In the other part of the thesis, it is described how the neutral carbon beam source have been integrated into an ion trapping apparatus allowing for the first time studies on reactions between neutral carbon atoms, and small neutral carbon molecules from one side and ions from other side. First results are also presented.

Here, only a brief description of experimental setup combining the ion-trapping technique with effusive neutral carbon beam (CRET machine) and results of reactions between D_3^+ and hot C_n will be presented (Savić, 2004; Savić et al., 2005b).

The CRET machine and measurement sequence is fully described in the (Savić, 2004 and Čermák et al., 2002). CRET is an iontrapping machine that combines the trapping technique with a beam of neutral carbon atoms and molecules. The machine consists of a carbon vaporization source, an electron bombardment ion source, ring electrode radiofrequency ion trap (RET) and singleion mass analyzer. The primary ions are produced by electron impact directly in the trap. They are stored for a given reaction time and during this time exposed to the carbon beam. After this, content of the trap is extracted, mass selected and counted. Immediately after this, the flux of the carbon beam is monitored to correct for drifts of the carbon source.

The interaction of stored D_3^+ with hot C_n (n = 1 3) have been studied and measured reaction rate coefficients are summarized in table 1.

Table 1: Measured reaction rate coefficients for reaction $D_3^+ + C_n$ (Savić, 2004; Savić et al., 2005b):

Reaction	k / 10^{-10} cm^{3}s^{-1}	
	This work	UMIST*
$D_3^+ + C_3 \rightarrow C_3D^+ + D_2$	7.3	14.7
$D_3^+ + C_2 \rightarrow C_2D^+ + D_2$	5.7	13.4
$D_3^+ + C_2 \rightarrow C_2D_2^+ + D$	1.0	
$D_3^+ + C \rightarrow CD^+ + D_2$	4.7	15.5
$D_3^+ + C \rightarrow CD_2^+ + D$	2.2	
$D_3^+ + C \rightarrow CD_3^+$	0.4	

* The UMIST values (Le Teuff et al. 2000) which are included into the database only for H_3^+, have been converted by accounting for the reduced mass

From table 1 can be seen that D^+ transfer dominates over all other exothermic product channels and that measured reaction rate coefficients for formation of C_nD^+ are almost a factor two smaller than values presently used in astrophysical models. First results on growth of pure carbon chains via associative reactions $C_m^+ + C_n$ indicate that these reactions are slower than is generally assumed in models. The details on these results can be found in (Savić, 2004 and Savić et al., 2005b).

More work is needed to prepare a better beam of carbon atoms and molecules with a well defined temperature and to achieve higher number densities in the trap.

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