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MATRIX ISOLATION AS A TOOL FOR STUDYING INTERSTELLAR CHEMICAL REACTIONS

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Since the identification of the OH radical as an interstellar species (Barrett and Lilly, 1957), over 50 molecular species have been identified as interstellar denizens. While identification of new species appears straightforward, an explanation for their mechanisms of formation is not. While most astronomers concede that "large" bodies like interstellar dust grains are necessary for adsorption of molecules and their energies of reactions (Watson and Salpeter, 1972; Allen and Robinson, 1975), many of the mechanistic steps are unknown and speculative.

We propose that data from matrix isolation experiments involving the reactions of refractory materials (especially C, Si, and Fe atoms and clusters) with small molecules (mainly H_2, H_2O, CO, CO_2, and O_2) are particularly applicable to explaining mechanistic details of likely interstellar chemical reactions. In many cases, matrix isolation techniques are the sole method of studying such reactions; also in many cases, complexations and bond rearrangements yield molecules never before observed. The study of these reactions thus provides a logical basis for the mechanisms of interstellar reactions.

Table 1 shows a list of reactions studied in our laboratory that would simulate interstellar chemical reactions. These reactions were studied using FTIR-matrix isolation techniques. This Table does not represent an exhaustive list of reactions studied; we only include reactions of species having astronomical interest. We do point out, however, that the preponderance of reactive pathways shown here hints that true interstellar space is certainly a "soup" of chemical species, about which much is still unknown.

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TABLE 1

REACTION	REFERENCE
$C + CO \longrightarrow C_2O$	Ortman, 1987
$C_2 + CO \longrightarrow C_3O$	
$C_3 + CO \longrightarrow C_4O$	
$C_3 + H_2O \longrightarrow C_3\cdots H_2O$	
400 nm $\big\downarrow$	
$HO{-}C{\equiv}C{-}C{-}H \xrightarrow{UV}$ propynal	
$C + O_2 \longrightarrow CO_2$	
$C + 2\,O_2 \longrightarrow CO + O_3$	
$C_3 + O_2 \longrightarrow C_3\cdots O_2$	
400 nm $\big\downarrow$	
$C_3O + O \longrightarrow CO_2 + C_2$	
$C + H_2 \not\longrightarrow CH_2$ (evidence of barrier: Harding, 1983)	
$C_2 + H_2 \longrightarrow C_2H_2$	
$Si + H_2 \longrightarrow SiH_2$	Fredin, 1985
$Si + H_2O \longrightarrow HSiOH$	Kafafi, 1982
$Si + HF \longrightarrow HSiF$	Kafafi, 1982
$Fe + HX \longrightarrow HFeX$ ($X = CH_3, NH_2, OH, F$)	Kauffman, 1981