GRAIN SURFACE FORMATION OF METHYL FORMATE IN THE WARM-UP PHASE OF HOT MOLECULAR CORES

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Until recently, the methyl formate detected in hot molecular cores in interstellar clouds was thought to originate from gas phase chemistry. However, recent theoretical work (Horn et al. 2004) has shown that there is a large potential barrier to the reaction between protonated methanol and formaldehyde which was thought to form protonated methyl formate. In addition to this, experimental results suggest that the recombination reaction of this precursor molecule with electrons should have only a very weak channel producing methyl formate. Other possible gas phase mechanisms were suggested by Horn et al. (2004), however, none were successful at the typical hot core temperature of 100 K.

Most hot core chemical models consider only the hot period itself, or use a step-change in temperature. Here we consider a more detailed model of hot core evolution, invoking a warm-up phase of order 10^5 years, over which the gas phase and grain surface chemistry are closely coupled. As the temperature gradually ramps up from 10 K to 200 K, the heavier radicals on the grain surfaces become more mobile, whilst the lighter species (which usually dominate surface reactions) are quickly evaporated. This allows these larger building blocks to react together before they too are desorbed into the gas.

We introduce 3 new surface reactions (Allen & Robinson, 1977) into the OSU gas-grain chemical code, allowing for the formation of methyl formate ($HCOOCH_3$), dimethyl ether (CH_3OCH_3) and formic acid (HCOOH). We also use the gas phase reactions introduced in Horn et al. (2004), adopting more refined rates. The gradual warm-up of the gas and dust grains produces a strongly coupled chemistry which cannot be reproduced by the typical step-wise warm-up.

We find that ample methyl formate is produced, providing a good match with observed abundances. We suggest that the formation of other large molecules detected in hot cores may also require surface chemistry along with a gradual increase in temperature.