HOW WELL DO WE UNDERSTAND THE CHEMISTRY IN HOT MOLECULAR CORES?

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Unlike the chemistry of cold cores of dense interstellar clouds, the chemistry of hot molecular cores appears to require three temporal phases: a cold phase, during which both gas-phase and grain-surface chemistry occur, a warming-up phase, as high-mass star formation occurs nearby and grain mantles are evaporated, and a warm phase, when gas-phase chemistry converts the evaporated species into a variety of other molecules. The most important molecule evaporating from grain mantles is thought to be methanol, which acts as a precursor for a variety of more complex organic molecules. Although this picture is not a quantitative one, it has been generally accepted despite a lack of laboratory kinetic evidence.

We have looked in detail at the reaction pathways generally believed to produce methyl formate ($HCOOCH_3$), a well-known and copious emitter of rotational spectral lines in hot cores, with a large collaboration involving experimentalists, quantum chemists, and astrochemists. In this collaboration, three different experimental groups (Hanscom Air Force Base, Waterloo, Oslo) have looked at specific ion-molecule reactions leading from methanol and other precursors to methyl formate. The results obtained have been utilized in a detailed chemical model of hot cores. Our conclusion is that no process we have investigated can produce enough methyl formate to agree with its observed abundance. We then conclude that hot core chemistry remains mysterious.