Interstellar ices as witnesses of star formation: selective deuteration of water and organic molecules unveiled

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Observations of star forming environments revealed that the abundances of some deuterated interstellar molecules are markedly larger than the cosmic D/H ratio of 10-5. Possible reasons for this pointed to grain surface chemistry. How- ever, organic molecules and water, which are both ice constituents, do not enjoy the same deuteration. For example, deuterated formaldehyde is very abundant in comets and star forming regions, while deuterated water rarely is. In this article, we explain this selective deuteration by following the formation of ices (using the rate equation method) in translucent clouds, as well as their evolu- tion as the cloud collapses to form a star. Ices start with the deposition of gas phase CO and O onto dust grains. While reaction of oxygen with atoms (H or D) or molecules (H2) yields H2O (HDO), CO only reacts with atoms (H and D) to form H2CO (HDCO, D2CO). As a result, the deuteration of formaldehyde is sensitive to the gas D/H ratio as the cloud undergoes gravitational collapse, while the deuteration of water strongly depends on the dust temperature at the time of ice formation. These results reproduce well the deuterium fractionation of formaldehyde observed in comets and star forming regions and can explain the wide spread of deuterium fractionation of water observed in these environments.

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