# Monte Carlo simulation to investigate the formation of various deuterated species on interstellar dusts

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High abundance of some abundant and simple interstellar species could be explained by considering the chemistry that occurs on interstellar dusts. Because of its simplicity, the rate equation method is widely used to study the surface chemistry. However, because the recombination efficiency for the formation of any surface species is highly dependent on various physical and chemical parameters, the Monte Carlo method is best suited for addressing the randomness of the processes. We carry out Monte-Carlo simulation to study deuterium enrichment of interstellar grain mantle under various physical conditions. We show that interstellar grain mantle would be heavily fractionated by deuterium. We carry out our simulation for a wide range of parameter space. Based on the effects of interstellar radiation fields, chemical composition of interstellar grain mantles are studied for the dense, translucent and diffuse clouds. From our simulation, it is revealed that in a dense cloud region, grain mantles would be heavily enriched by deuterated water and methanol. Water molecules would be heavily fractionated in a translucent cloud region and in a diffused cloud region, hardly a few monolayers of surface species would survive. Interstellar radiation fields and energetic particles plays significant roles in determining mantle compositions. To see the effects of various energetic particles, we allow our grain mantles to interact with various charged particles (such as $H^+$ and $Fe^+$ ). Stopping power and projected range of these charged particles on various target ices were studied to have an idea about the properties of these projectiles on various ices.

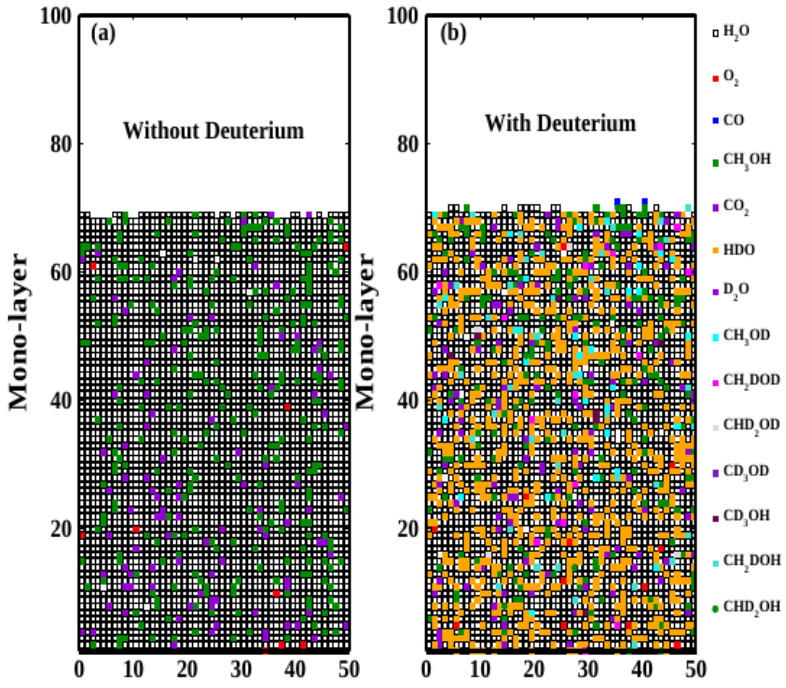


**Fig. 1. (a-b)** Composition of grain mantel with the (a) absence and (b) presence of deuterium.

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