Formation pathways of complex organic molecules: $OH^{\cdot}$projectile colliding with methanol ice mantle $(CH_3OH)_{10}$

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Abstract
In this article, we simulated the collisions of an OH• projectile impacting on a methanol cluster formed by ten units of methanol to mimic an ice mantle (CH3OH)10. The chemical processes occurring after the impact were studied through Born-Oppenheimer (ab-initio) molecular dynamics. We focus on collisions with initial kinetic impact energy of 10-22 eV, where the richest chemistry happens. We report the formation mechanisms of stable complex organic molecules (COMs) such as methoxymethanol CH3OCH2OH, formic acid HCOOH, formyl radical HCO, formaldehyde H2CO and its elusive HCOH isomer. We show that CH2(OH)2, •CH2OH or +CH2OH are key intermediates to generate H2CO and other COMs. We compare the outcomes using OH• with those using OH- projectiles. These processes are likely relevant to the production of COMs in astrophysical environments. We discuss its formation mechanism and the astrophysical implications of these chemical pathways in star-forming regions.

Author keywords
Astrochemistry
Dust
Extinction
ISM: atoms
ISM: molecules
Molecular processes