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New Rate Constants of Hydrogenation on Interstellar Grains and their Astrophysical Implications

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Abstract. For the gas-grain chemical models the surface reactions and their rate constants are essential, in particular to the hydrogenation rates. The high observed abundances observed for some large organic molecules such as H_2CO and CH_3OH in the interstellar medium (ISM) amaze astrochemists and lead their attention to think about the possible mechanisms of their formation and destruction through different types of chemical models. Among the problems astrochemists face in constructing these chemical models are the rate constants of the reactions especially those occur on grain surfaces. Awad et al. (2005) derived and estimated, theoretically, new rate constants for the hydrogenation process of CO molecules on grain surfaces to produce directly CH_3OH. In their calculations they rely on the experimental results of Watanabe et al. (2003). The new estimated rate constants were one to two orders of magnitude higher than those used previously in other models (e.g., Hasegawa et al. 1992). In the present work, we investigated the implications of these new rate constants on the production rate and the abundances of H_2CO and CH_3OH. We have used two different pseudo-time-dependent gas-grain chemical models, which evolve under fixed physical conditions. In these models we have applied both the old and new routes and rates for hydrogenation. Our results implied that the impact of these new rates and routes for CH_3OH formation are divided into two main parts: a direct effect on the abundances of H_2CO and CH_3OH species and an indirect one on other species such as H_2O, CH_4 and NH_3 in both gas- and solid-phases. The comparison between our results of the two models and the observations of the dense cloud TMC-1 shows a good agreement.

Keywords. astrochemistry, ISM: molecules, molecular processes