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Origin of Titan and the clathration processes in the solar nebula

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We present an evolutionary turbulent model of the Saturn's subnebula consistent with the recent core accretion formation models of the giant planet. Using the thermodynamic conditions of our model, we calculate the evolution of the CO_2:CO:CH_4 and N_2:NH_3 molar mixing ratios in the subnebula. We thus show that the carbon and nitrogen homogeneous gas-phase chemistry is inhibited in the subnebula. We also consider the role played by Fischer-Tropsch catalysis in the gas-phase conversions of CO and CO_2 into CH_4. We demonstrate that, even if a catalytically active zone is likely to exist in the early Saturn's subnebula, it does not alter the composition of volatiles ultimately trapped in the forming solids. Assuming solar abundances for elements in the solar nebula gas-phase, we show that planetesimals that contributed to the formation of Titan were formed from hydrates, clathrate hydrates and pure condensates. In order to reproduce the observational constraints (deficiency of primordial noble gas and CO) derived by the Huygens probe mission in its atmosphere, we argue that Titan was formed from planetesimals produced in the solar nebula and partially vaporized in the balmy and early Saturn's subnebula. We note that, even if most of noble gases can be eliminated during the formation of Titan via this mechanism, tiny amounts of these species may remain trapped in clathrate hydrates of methane incorporated in the planetesimals accreted by Titan. We then discuss the processes that, added to our formation scenario, might explain the origin of the deficiency of noble gases observed in the atmosphere of Titan.