Methane production from H_2+CO_2 reaction without solid phase catalysis

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ABSTRACT

An open important challenge in the research field of possible strategies using low cost or renewable energy is to design and develop a heterogeneous/homogeneous catalysis processes reusing waste CO_2 to produce methane in a circular economy scheme [1]. For such a purpose is crucial to realize an optimized yield methanation stage in which hydrogen reacts with carbon dioxide to produce methane and steam water. Currently, the methanation process used in laboratory prototype apparatuses, as Progeo 20kw [1], is based on the well known Sabatier reaction

$$CO_2 + 4\ H_2 \rightarrow CH_4 + 2\ H_2O$$

performed at high pressure (2-3 atm) and high temperature (200-300°C) with the use of a solid phase catalyst (nickel, ruthenium, or alumina).

The present contribution aims to find new efficient methanation pathways in order to avoid the use of the solid phase catalysis, exploring alternative reaction mechanisms involving the CO_2 hydrogenation through a plasma generation by electrical discharges on a CO_2+H_2 gas mixture. In order to realize this aim, the authors can employ their long expertise in modeling molecular processes (hydrogen generation, gas phase processes, molecular dynamics simulations) and in fully characterize the microscopic dynamics of elementary reactions by the experimental determination of all main kinetic parameters as rate constants, cross sections, intermolecular potentials, structure, and energy of the transition state, and related reaction pathways. Furthermore, they can conduct high resolution experiments in a single collision condition, by using crossed molecular beam apparatuses, and studying plasma induced gas phase reactions both by microwave and RF discharges [2], and by synchrotron radiation [3-5]. Such experiments are performed using the ARPES (Angle Resolved PhotoEmission Spectroscopy) end station at the GasPhase Beamline of the Elettra Synchrotron Radiation Facility (Trieste) [6,7], and the PIES (Penning Ionization Electron Spectroscopy) crossed molecular beams apparatus of the Perugia University [8,9].

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