Hydrogen production from microwave plasma assisted methane conversion

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Hydrogen is often envisioned as the energy carrier and green fuel of the future. However, new energy efficient and greenhouse gas free production methods are needed to utilize hydrogen as energy carrier on larger scales. A promising production method is the pyrolysis of methane in a microwave plasma.

Here, we present a microwave plasma torch operated in an argon methane mixture (60 slm total flow rate, up to 35 % methane admixture) at atmospheric pressure. Microwaves with a frequency of 2.45 GHz and up to 6 kW of forward power are used to sustain the plasma. The plasma extents over a length of up to 60 cm and a diameter of about 1.2 cm. High resolution emission spectra are used to estimate the space resolved gas temperature from the rotational temperature of dicarbon. In the centre the plasma reaches temperatures of up to 4300 K. The main products are hydrogen (H_2), ethyne (C_2H_2), ethene (C_2H_4) and solid carbon. A continuous gas analyser with three nondispersive infrared sensors for the three hydrocarbons and one thermal conductivity sensor for hydrogen is used to analyse the product gas stream. The methane conversion increases linearly with the specific energy input per methane molecule (SEI). Increasing the methane admixture at constant SEI leads to an increased methane conversion. Methane conversions of up to 65 % are achieved. At low methane admixtures, the selectivity towards C_2H_2 is between 90 % and 100 % and the selectivity towards H_2 is about 70 %. With increasing methane admixture, the selectivity towards C_2H_2 drops to about 40 % while the selectivity towards H_2 increases up to 87 %. Increasing the SEI also leads to a decrease in selectivity towards C_2H_2 and an increase in selectivity towards H_2. The selectivity towards C_2H_4 is for the used conditions always below 20 % and also decreases with increasing SEI and methane admixture.