PROPANE CONVERSION IN DBD: EXPERIMENTS AND MODELLING

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Abstract. This work presents a comparison between a modeling and experimental results of the propane conversion using a Dielectric Barrier Discharges (DBD) reactor. Propane was diluted in dry or in wet air at atmospheric pressure. We shown previously that to set a DBD reactor in an oven heated at 800K led to a decrease of the energetic cost saving a high propane conversion rate. Thus, the propane conversion in a pulsed-DBD can be simulated using a chemical kinetic mechanism with successive elementary plug-flow reactors to simulate our DBD. Actives species (O, OH, H) play a major role to initiate the conversion.

1. INTRODUCTION

Non-thermal plasma discharges are intensively studied to convert Volatile Organic Compounds (VOCs') diluted in air at atmospheric pressure since many years ago. Previously, we presented effects of the temperature and of the water vapor in air on the propane conversion and produced species [1,2]. We shown that a heating until 800 K led to a decrease of the energetic cost injected keeping a high conversion rate [2]. In this article, a modeling of the propane converted in CO and CO_2 (the two main produced carbon species) in a pulsed DBD reactor was performed with a good agreement from a combustion mechanism at 800 K. Chemistry processes implied in the propane decomposition in our non-thermal plasma can be explained from kinetic mechanisms where H, O atoms and OH radical are produced by streamers.

2. EXPERIMENTAL SET-UP AND MODELING PARAMETERS

2.1. Experimental apparatus

The experimental plasma reactor used in this work was previously described [1-3]. Geometry of the reactor was a wire to cylinder DBD type. The plasma reactor was set in an oven where the temperature was 800K. Previously [2], we observed that to heat the plasma reactor from 300 K to 800 K led to a high decrease of the energetic cost and reduced the amounts of the by-products [2]. The inlet gas mixture composition was propane (1100 ppm) in dry air or in water saturated air (called wet air conditions). Gas mixture was injected through mass flow controllers and the total flow rate, Q, was maintained at 1000 sccm. Energy density, Ed, injected in the plasma reactor was expressed from: $Ed=(Ep.f)/Q$, where Ep was the discharge pulse energy, f was the pulse repetition rate and Q was the total flow rate of the inlet gas mixture.

2.2. Modeling

In a DBD, each streamer is supposed to produce given amounts of active species (O, OH, H) from O_2 and H_2O decomposition by electronic impact (eqs 1, 2):

$$O_2 + e^- \rightarrow 2\,O + e^- \qquad \text{(eq.1)}$$

$$H_2O + e^- \rightarrow OH + H + e^- \qquad \text{(eq.2)}$$

DBD reactor was modelled using a successive number of elementary plug-flow reactors. Streamers effects were simulated by injection of specific amounts of active species (O, OH and H) in each