Unravelling the limitations of ammonia synthesis by non-thermal plasma

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Ammonia synthesis by means of atmospheric pressure non-thermal plasmas is thought to be a feasible alternative to the Haber Bosch process. Nevertheless, and although many plasma devoted research groups are now working on this topic,[1-3] energy efficiencies and chemical yields are still under those provided by the classical method.

In this work we analyse the ammonia synthesis process in a ferroelectric packed-bed reactor, paying special attention to the factors that hinder higher nitrogen conversions and better energy performances. Between them, the occurrence of the reverse reaction (it is, destruction of ammonia by the plasma after being formed) and inefficient exchange reactions (ammonia can exchange H atoms with H_2 molecules in the plasma bulk or –OH groups at the surfaces) could play an important role. With the aim of quantifying the occurrence of those energy wasting processes, we apply an isotope labelled technique. By using different reactive gases (composed by NH_3, H_2, N_2, D_2 or their mixtures) and varying their residence time in the plasma reactor we have obtained valuable information about reaction mechanisms. Our results point to an important proportion of decomposed ammonia, that alternatively can be seen as a hydrogen production process, and a high number of H↔H inefficient exchanges. Furthermore, this methodology allows us to quantify, for the first time up to our knowledge, the relative amount of processes taking place in the plasma bulk or at the ferroelectric surface.

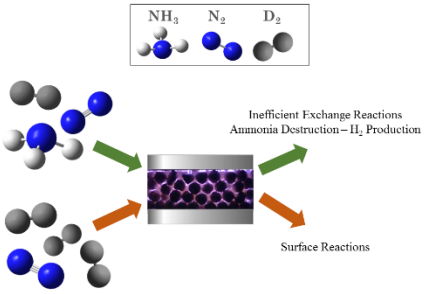

Figure 1. Sketch of the analyzed processes.

References: [1]. J. Hong, S. Prawer and A.B. Murphy. ACS Sustainable Chem. Eng. 6 (2018) 15-31. **[2].** Y. Gorbanev, E. Vervloessem, A. Nikiforov and A. Bogaerts. ACS Sustainable Chem. Eng. 2020, 8, 7, 2996–3004. [**3].** Navascués, P.; Obrero-Pérez, J.M.; Cotrino, J.; Gonzalez-Elipe, A. R.; Gómez-Ramírez, A. ACS Sustainable Chemistry & Engineering. 2020, 8, 14855–14866.

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