Unveiling the role of the catalyst support in silver-enhanced plasma ammonia synthesis

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Plasma catalysis is an emerging research area that aims to combine the speed and selectivity of catalysis with non-thermal plasma's ability to promote high-energy chemistry at mild conditions. However, plasma catalysis needs a deeper understanding of its fundamental mechanisms, as evidenced by the differing results reported in the literature regarding the true synergy between plasma and the catalytic material [1]. Unlike thermal catalysis, in plasma catalysis, dissociation also occurs in the gas phase, and the presence of the electric field, charged particles, and radicals can lead to different pathways unique to the specific environment [2]. In addition, complex chemical and physical interactions arise among the catalyst support, the catalyst, and the discharge that are not well understood.

Adding a catalyst does not necessarily improve the plasma's activity, and in some cases, it can be detrimental to performance. In most plasma catalysis studies, the procedure for preparing the catalyst (and the catalyst support) is not standardized, making it problematic to understand and reproduce the experiments. In this contribution, we examine the plasma-catalytic ammonia synthesis process to gain insights into the role of support preparation [3]. We chose silver as the active material, and alumina beads and alumina monoliths as supports for a dielectric barrier discharge and a nanosecond repetitively pulsed discharge, respectively. To reveal the influence of the support preparation process, we use bare alumina beads as a reference group. These beads underwent the same preparation steps as the silver-impregnated beads (drying, impregnation with or without stirring, and calcination), except that silver was not added. The same procedure has been applied to monoliths of γ-Al2O3 on α-Al2O3, except that monoliths do not require stirring. We found that the catalyst support significantly affects the ammonia production. In particular, the treatment of the support required to load the catalyst strongly impacts ammonia production, as demonstrated by the comparison between treated and untreated support. This difference can be attributed to the combination of stirring (for beads) and the heat treatment that the supports undergo during preparation. The addition of silver, which is not active in thermal catalysis, enhances ammonia production when loaded on the supports in both discharges relative to the performance of the appropriate reference group.

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