# Noble metal catalysts for plasma-assisted oxidation of methane

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***Highlights***

- Plasma alone showed significant methane conversion.
- Methane conversion increased with increase in plasma power.
- Methane was mostly converted into carbon monoxide in plasma alone experiments.
- The presence of catalyst improved the selectivity of carbon dioxide.

## 1. Introduction

Methane ($CH_4$) is a potent greenhouse gas and converting methane to carbon dioxide is a promising strategy. Nevertheless, the catalytic oxidation of methane to $CO_2$ requires elevated temperature (above 400°C) to activate the strong carbon-hydrogen (C-H) bonds, making it energy intensive[1]. Non-thermal plasma employs electrical energy to generate highly energetic electrons and reactive species, initiating diverse chemical reactions at ambient conditions, making it a suitable solution for methane oxidation[2]. However, cold plasma itself lacks selectivity and may lead to the formation of undesirable by-products[2,3]. Hence, the incorporation of a catalyst within the reactor can induce a synergistic effect, enhancing the selectivity of desired products[3].

## 2. Methods

The primary objective of this study was to explore the catalytic properties of various noble metals, namely Pt, Pd, and Cu, supported on γ-$Al_2O_3$ and $NH_4$-ZSM-5, synthesized by the impregnation method. The study evaluated the oxidation efficiency of 1% $CH_4$ in air and the product selectivity of different catalysts under similar conditions in a Dielectric Barrier Discharge (DBD) plasma reactor. To assess the impact of plasma on the investigated catalysts, several characterization techniques were employed, including $N_2$ physisorption, $H_2$ chemisorption, XRD, and SEM.

## 3. Results and discussion

Plasma exhibited significant methane conversion across varying plasma power. The conversion of methane increased with increase in plasma power. The presence of catalyst reduced the methane conversion. Notably, 1% Pd/$Al_2O_3$ and 1% Cu/$Al_2O_3$ catalysts emerged as the most active, surpassing methane conversion achieved by pure γ-$Al_2O_3$ support. Remarkably, the presence of noble metal catalysts improved the selectivity towards $CO_2$. At 30 W, none of the catalysts displayed selectivity towards CO. Palladium catalysts showcased remarkable consistency with above 90% selectivity towards $CO_2$ across all plasma power levels. The formation of other products, including $N_2O$ and $NO_x$ (NO and $NO_2$) was observed across all plasma power levels.

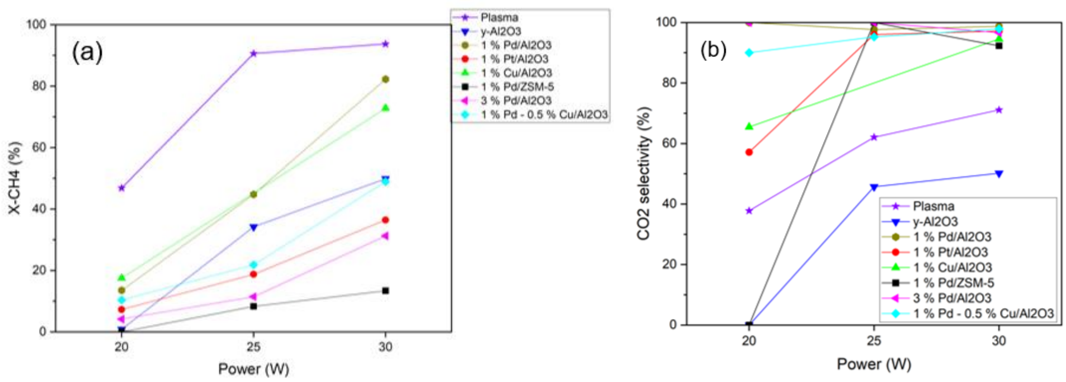


**Figure 1.** Effect of catalysts at different plasma power on (a) Conversion of methane (b) $CO_2$ selectivity.

## 4. Conclusions

The complete oxidation of methane can be accomplished through a plasma-catalyst system. While plasma alone demonstrates substantial methane conversion, it tends to generate undesired byproducts, such as carbon monoxide (CO). The integration of noble metal catalysts facilitates the complete oxidation of methane, enhancing the selectivity towards carbon dioxide ($CO_2$). The synergy between plasma and catalyst significantly elevates the selectivity for the desired product, $CO_2$, compared to the sole use of plasma.

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***Keywords***

methane oxidation; non-thermal plasma; palladium, alumina