# Ammonia Poisoning in Low Temperature Fuel Cells

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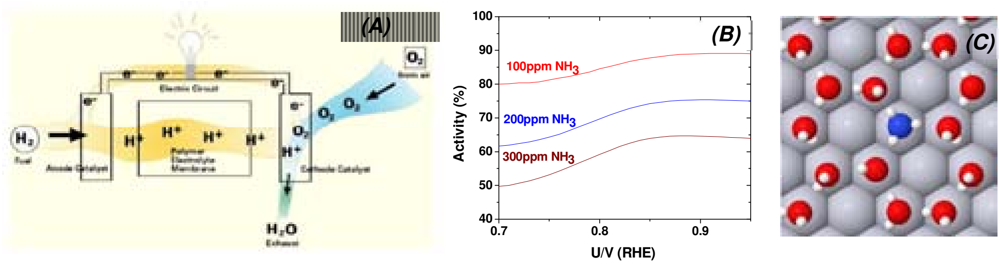
To slow global warming down it is of utmost importance to develop alternatives to fossil fuels that enable for a reduction of $CO_2$ levels. One of the possibilities for that ambitious –but absolutely necessary– goal is the use of fuel cells, devices that take energy from the conversion of hydrogen and oxygen into water (Fig. A), being a zero emissions source of energy. In particular, low temperature fuel cells would represent a non-polluting alternative for both stationary and automotive applications [1], but development is slowed down by difficulties in storing and transporting hydrogen. To overcome that challenge ammonia could be used as hydrogen carrier, taking advantage of an already existing infrastructure and an extensively studied synthesis [2]. However, any traces of ammonia on hydrogen derived from $NH_3$ will severely degrade the fuel cell performance to impractical levels [3].
Initial reports suggested that the cause of the performance decrease in the presence of ammonia was a membrane resistance increase, but more recent work established that these losses only account for a 10% of the total [3]. It remains as an open question whether the performance loss could be related to poisoning of the reactions occurring at the catalysts.
We studied the effect of ammonia on the catalysis of the hydrogen oxidation reaction (HOR) and oxygen reduction reaction (ORR) on a platinum catalyst using a rotating ring-disk electrode setup. While HOR was not affected by ammonia, strong poisoning occurred in the ORR (Fig. B), explaining the majority of the losses taking place in a fuel cell. On the basis of these observations, a theoretical model to give a microscopic interpretation was developed (Fig. C). The simulations revealed that the reason for the poisoning was ammonia blocking the platinum catalyst, which consequently stopped the desired ORR. Using the theoretical model, it was possible to screen through different catalysts and identify suitable candidates not showing ammonia poisoning effects. Such a catalyst was successfully tested experimentally, potentially leading to a patent. Additionally, we emphasized that the method used to mitigate ammonia poisoning can be generalized to other poisoning effects.




***(A)*** Schematic representation of an operating polymer electrolyte membrane fuel cell. ***(B)*** Platinum catalyst ORR activity decrease against applied potential for different ammonia concentrations. ***(C)*** Model of an ammonia molecule sitting on top of a platinum catalyst used in the theoretical calculations.

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[2] Klerke, A. et al. (2008). Ammonia for hydrogen storage: challenges and opportunities. *Energy and Environmental Science, 18,* 2304-2318
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