Hydrogen Mitigation: Passive Autocatalytic Recombiners Using Catalysts Based on Graphene Hydrophobic Coatings

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In the context of discussions surrounding the hydrogen economy, particularly its green aspects, ensuring safety in the production and storage of hydrogen is paramount. This is especially crucial when hydrogen mixes with air, comprising between 6% and 30% in volume, as it poses potential risks of explosions. A proven method to mitigate these dangers is the utilization of Passive Autocatalytic Recombiners (PARs). These devices facilitate the recombination of hydrogen with oxygen on active catalytic surfaces, leading to the generation of water vapour and heat [1], reducing significantly the risk of explosions. PARs are typically composed of materials like stainless steel, alumina, and silica, which support active catalytic elements such as platinum or palladium. To combat catalyst deactivation resulting from water accumulation, researchers have explored the use of hydrophobic materials [2], among which graphene stands out. Recent studies have demonstrated that graphene could be successfully applied directly on surface, [3], using a non-thermal plasma system. This method resulted in the production of a material with few layers and hexagonal structural defects, making it attractive due to its simplicity, low cost, and scalability. In this sense, graphene is a promising option fto be applied as hydrophobic coating in catalysts for PARs. This work investigated the formation of films of graphenoid materials doped with platinum or palladium on a sintered porous metal filter in a single step. X-ray diffraction experiments revealed high amorficity, with percentages of approximately 49.6% and 60.0% for materials containing platinum or palladium, respectively. The D1/G band ratios were 2.9 and 1.6 for materials with platinum or palladium, indicating the presence of structural defects. Contact angle measurements demonstrated strong hydrophobicity for both materials, with values of 124° and 119°, respectively. Catalytic tests showed that the palladium-based converter was able to remove 17% of the injected hydrogen, while the material containing platinum achieved a removal of around 23%, confirming the effectiveness of these coatings in converting hydrogen into water. The experimental results indicated that coating porous steel filters with graphene doped with catalytic metals represents a promising strategy to ensure safety and efficiency in converting hydrogen into green energy systems. This approach has significant implications for sustainability and corporate social responsibility practices.

References

[1] V. Shepelin, D. Koshmanov, E. Chepelin, Nuclear Tec,, 178, (2012) 29-38.
[2] W. Yu, X. Yu, S.-T. Tu, P. Tian, Int.J. Hydrogen Energy, 42, (2017) 14829-14840.
[3] P.V.R. Gomes, N.F.B. Azeredo, L.M.S. Garcia, et al., Appl.Mat. Today, 29 (2022), 2100.

Figures

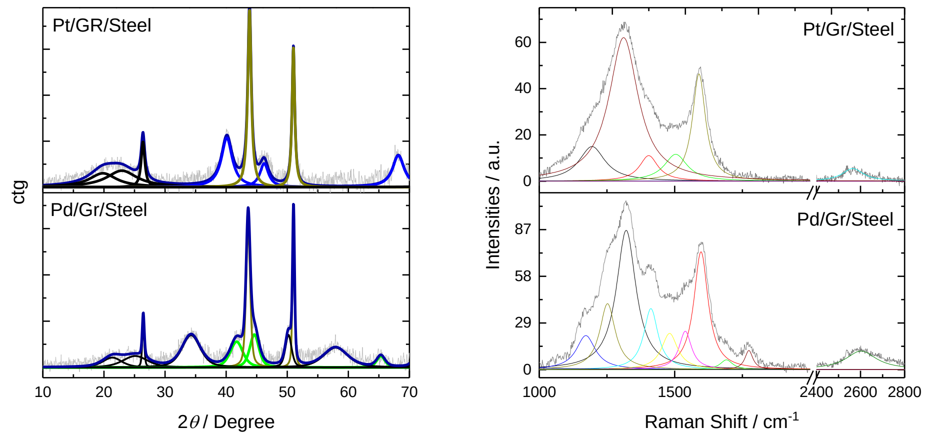

Figure 1: XRD pattern and Raman spectra of noble metals/graphene/sintered porous steel filter.