Platinum performs well in operating fuel cells, better than any other pure metal.

Just over two years ago, I wrote an article on the subject of platinum and its use in low temperature fuel cells. At that time the price of platinum was rising steadily and had reached its highest point since before the global financial crisis. It therefore came as no surprise that the subject of substituting platinum with cheaper materials was a hot topic. Since then platinum has decreased in price by around 20% and this drop has taken place despite the destabilising pressures in the South African mining industry which have not gone away, such as threats of strike action and shortages in electricity supply. With the imminent release of fuel cell electric vehicles in the coming years how much does the cost of platinum affect the cost of fuel cells and what is being done about it?

All of the world’s major automakers have pledged to release fuel cell vehicles in some form during the next few years. Some are more advanced than others with Hyundai already rolling vehicles off the production line and into the hands of eager customers around the world. Toyota will be unveiling its production-ready fuel cell vehicle during the November 2013 Tokyo Motor Show and other manufacturers, like Daimler, are not far behind. But what is the cost of platinum compared to the cost of the vehicles themselves? Well, early prototype fuel cell vehicles cost millions to build, not because the fuel cell itself cost millions of dollars, but because they were hand-built one-off prototypes and not able to leverage economies of scale. Even at the high platinum loadings present on these early vehicles, in excess of 100 g, it would only have amounted to a minimal percentage of total vehicle cost.

Fuel cell technology has moved on a long way since those times however, with Toyota announcing recently that the latest iteration of its fuel cell has reduced platinum loadings to around 30 g. It has published a target sale price of $50,000 for its fuel cell vehicle, and calculating the value of platinum at today’s prices reveals the metal would contribute to less than 3% of the total vehicle cost.
Definitely a significant component, but it doesn’t represent a prohibitive cost by any means. Comparing Toyota’s 30g to current light-duty diesel catalysts fitted to equivalent class cars in Europe, modern fuel cells only contain around four to five times more. Fuel cell technology is continually advancing too, with improvements in nanotechnology allowing for reductions in metal loading without a loss of performance or durability.

According to the DoE, the amount of platinum in PEM fuel cells has decreased by around 80% during the past decade. This trend is expected to continue, albeit at a reduced rate with smaller incremental improvements. I don’t doubt that one day platinum loadings can equal or indeed be lower than in conventional internal combustion engine (ICE) vehicles. The ever-tightening legislation applied to ICE vehicles around the world provides continual support for precious metal loadings since generally improvements in catalyst technology are nullified by more stringent emissions limits. This trade-off is not an issue in fuel cell electric vehicles because they are already zero-emissions vehicles and so any improvement in electrocatalyst design which allows a reduction in metal content will do just that, and lower cost at the same time; platinum can also be efficiently recycled from fuel cell systems.

The potentially bigger question of whether platinum can be replaced in PEM and direct methanol fuel cells is one which researchers around the world continually strive to answer. News releases announcing cheap replacement materials for platinum must be read with care however because a large array of alternative materials can be made to outperform platinum if the test conditions are right and so some claims can be misleading; these comparative test conditions do not always reflect the operational environment within a typical fuel cell in some instances testing materials under alkaline conditions and then comparing the results to PEM fuel cells which operate under acidic conditions.

A recent review on the subject, published in the journal Platinum Metals Review, provides an insight into why platinum performs so well in fuel cell electrochemistry and explains the different failure mechanisms which thus far have prevented other materials from being used. The images at the top of this article were taken from that review and show how platinum is the most active and stable material available for the reactions on the cathode side of the fuel cell. While it was written for a technical audience, the article is still approachable for those who are searching for a relatively simple explanation of why platinum dominates the choice of material for this technology. The review also provides an insight into alternatives to pure metal, such as using alloys or other, more complex materials which can increase performance by an order of magnitude or more. It also contains links to research on non-platinum materials, but the authors state that “none are likely to represent viable options in the near- or mid-term”.

So a lot has happened since my last article on this subject, but as I said two years ago, developments have taken the direction of reducing and optimising platinum use, rather than substituting it – which, in my opinion, is a much harder thing to achieve. Automotive manufacturers know how low they must drive platinum loadings in order for the cost of the fuel cell system to be commercially viable and are clearly continuing to work towards that goal. Their advances over the coming years, especially in the areas of automation and volume manufacturing, will also be beneficial to other users of PEM fuel cells who will be able to take advantage of cheaper, more durable systems in other applications. I look forward to the day when the platinum content (and therefore cost) of an automotive fuel cell is equivalent to that of a diesel catalytic converter, and then we can worry about other issues, like supporting infrastructure development and marketing the technology to customers.

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