Fundamental Insights into Advanced Functional Carbon-based Materials as Fe-N-C Electrocatalysts for the Oxygen Reduction Reaction

The commonly-used platinum catalyst is prohibitively expensive and accounts for about 40% of the total cost of a fuel cell system. Replacing it with high-performance non-precious catalysts will render clean fuel cell technology much more competitive compared to high-emission conventional power conversion technologies used in the automotive industry and at power plants. Dr Stephen Lyth (Kyushu University) and I (Dr Mohammed Ismail from the University of Sheffield) have joined forces through a collaborative research travel grant sponsored by the Royal Society and Japan Society for the Promotion of Science (JSPS), namely the International Exchanges Scheme (~£40,000). We are developing cheap carbon foam, doped with nitrogen and iron, a catalyst which has demonstrated comparable performance to that of the platinum catalyst.

The grant has been instrumental in realising a number of milestones in terms of refining the developed catalyst and the method to synthesise it. Namely, a scalable, cheaper, safer and more effective method was developed to produce the proposed catalyst; it, compared to the old methods, improves the current density and results in a fivefold increase in the surface area of the catalyst. Further, the multiscale and multiphysics modelling framework, developed at Sheffield, has been further improved to allow for more flexibility in terms of the investigation of structure of the heterogeneous catalysts.

In addition to mutual research visits, I and Stephen organised five workshops, which were held alternately at Sheffield and Kyushu and often attended by internationally recognisable experts in the field, to disseminate the outcomes of the project; these have been mostly disseminated in the form of two articles published/to be published in high-impact journals. To further widen the scope of our collaboration, Stephen and I have recently submitted a H2020 project application. If successful, the proposed project will set the foundations for intensive collaboration between 9 world leading European and 2 Japanese institutions and organizations in the area of carbon capture and utilisation. Also, we plan to apply for the upcoming round of the International Exchanges Scheme next year in order to intensify the collaboration on jointly developed non-precious catalysts and/or some promising cellulose based membranes used in fuel cells.

Dr Mohammed Ismail, Florence Lee (a PhD student from Sheffield University who made two research visits to Kyushu as part of the project) and Dr Stephen Lyth stand in the labs at Kyushu University.

Dr Mohammed Ismail presenting at the Energy Week Conference 2019 at Kyushu University.