NEUTRONS FOR SOCIETY

Chimet partners with Institut Laue-Langevin to find the best industrial catalysts

19 November 2018: Grenoble, France/ Arezzo, Tuscany – Chimet S.p.A. turns to the world's flagship centre for neutron science, the Institut Laue-Langevin (ILL) to develop the most effective catalysts for industrial processes, to enhance methods to produce widely used bulk and fine chemicals.

As presented at the UK Royal Society of Chemistry's prestigious Faraday Discussions, researchers at University of Torino and Institut Laue-Langevin (ILL) have used the latest innovations in neutrons to help identify better catalysts for industry. Used to speed up the rate of a chemical reaction, catalysts not only help make chemical processes more efficient in terms of activity, but also in term of selectivity. Choosing the right catalyst can translate into a market-differentiating product or process and can have a significant impact on energy use; with one third of the world's energy currently devoted to the chemicals industry.[1]

Catalysts can be used by industry to change a polluting chemical reaction to an environmentally friendly one, or to ensure a product has exactly the right features for end use. For instance, catalytic converters, used in vehicles across the world, efficiently convert harmful gases from combustion engines into less harmful ones. They can also be used to ensure medications are more efficient, by informing the development of active ingredients for better drugs. This research into catalysts remains extremely valuable, especially as it can lead to both time and cost-savings for companies, paving the way for better products and materials in future.

Drawing on advanced instruments for high energy neutron probing, as published in the world-renowned Discussions, the research analysed the microscopic characteristics of carbon supported platinum catalysts in unprecedented detail. Platinum on carbon catalysts are often used for hydrogenation reactions – where molecular hydrogen is used to hydrogenate (i.e. saturate) organic compounds. This process is important for the food, bulk chemical and health industries, which all draw on hydrogenation reactions to develop the best products for use.

With this knowledge to hand, the dedicated catalysis division of Chimet S.p.A. – a world-leading specialist in the recovery and refining of precious metals from waste in the industrial manufacturing process – will be able to perform more efficient reactions to support the development of active ingredients in drugs, helping to improve medications. The company uses the gold, palladium, platinum and other precious metals that come from the waste of electronic, photographic and pharmaceutical industries, to produce a series of fine grade metal catalysts with several applications.

Neutrons proved particularly compelling for this research because they allowed scientists to observe the dynamics of the hydrogen atoms involved in the reaction. Neutrons have the unique property that they do not damage the material under investigation, yet can penetrate deep into matter, and can also be used to analyse lighter elements such as hydrogen. This makes them an ideal probe for a variety of hydrogen based reactions – this is ideal to identify the exact characteristics needed to manipulate and use catalysts to their full advantage.

This research technique can also act as an excellent complementary technique for many other scientific methods and proves particularly compelling when combined with X-rays, which provided useful complementary information for fruitful investigation with neutrons. While X-rays only provide an indirect view of hydrogen in action, as the element is too light, the technique can be used to outline spectral features during a reaction, which can then be traced back to a specific hydrogen catalyst. Researchers at ILL have been keen to work closely with X-ray researchers to support future discoveries and in fact, another project highlighted at the recent Faraday Discussions, also conducted at ILL, used a combination of X-ray and neutron techniques in to characterise activated carbons used as hydrogenation catalysts.

[1] https://news.harvard.edu/gazette/story/2017/01/seeking-a-breakthrough-on-catalysts/

While Italy has not had its own nuclear source since the 1960s, ILL's world-class facilities and expertise have provided an important opportunity for Italian companies like Chimet to conduct neutron research and experiments. About 6% of all scientific visitors to ILL are Italian, with 24% of those welcomed through the Scientific Member countries. As a member country for over twenty years now, Italian academia and industry have accessed world-class instruments, expertise and education at the ILL. The country has a history of successful projects with ILL; from the University of Milan's work to map out the mechanisms of devastating diseases like Parkinson's and Alzheimer's using neutrons, to CAEN S.p.A.'s efforts to optimise its electronics and digital data acquisition systems.

A future generation of Italian neutron scientists are also in training via ILL's close connection with the Italian Society for Neutron Spectroscopy (SISN). The Introductory School and Advanced Schools are underway to help ensure that a pipeline of future neutron scientists are equipped with the latest techniques to take full advantage of the resources available at ILL in years to come, ready to make discoveries that will change the world for the better.

Helmut Schober, Director, ILL, said "ILL has a long history supporting research that helps the chemical industry improving their catalytic processes. It is an honour for this project to be recognised by the distinguished Royal Society of Chemistry Faraday Discussions. This particular project highlights the enormous potential of neutron spectroscopy for studying chemical processes. The unprecedented sensitivity was made possible by the progress in instrumentation achieved through our latest modernisation programme."

"Collaboration between our world-leading neutron facility and industry has allowed for a wide range of scientific challenges to be realised, with over half of all work conducted at ILL being applications focused, and as such, contributing to efforts to develop greener energy solutions, better health and improved technology."

Andrea Piovano, Research Scientist, Spectroscopy Group, ILL, said, "This experiment was possible due to significant developments in neutron inelastic scattering techniques, which allow for the dynamics of the hydrogen involved in the reaction to be analysed to an unprecedented level of sensitivity. With a focus on platinum as a catalyst, this study has helped to highlight how the element acts in the hydrogen environment and its difference from other noble metals – paving the way for further investigation into the use of metal particles as the basis for a wide range of catalysts."

Riccardo Pellegrini, R&D Scientist, Chimet S.p.A., said, "The work conducted at the ILL has been extremely important for the advancement of our techniques at Chimet, including those supporting the development of more efficient drugs. It has helped us to improve our understanding of the microscopic interactions at play when a catalyst is put into action and in turn will help us to conduct more efficient reactions in future, with a better choice of catalysts to hand for the substances they will be combined with. This will save both time and money in the final industrial application process."

Dr Susan Weatherby, Programme Manager for the Faraday Discussion meetings: "The importance of international speakers and contributors at the Faraday Discussion series of meetings cannot be overstated. Well over half of meeting delegates are typically from outside of the UK, with a third coming from Europe. Faraday Discussion meetings are held all over the world, including one in Italy in recent years, and Italian chemists, have enriched the discussions across many different scientific disciplines."

The LAGRANGE instrument at ILL, a high resolution filter spectrometer, was used in this study. You can find out more about LAGRANGE here: https://www.ill.eu/in1-taslagrange

Looking for the active hydrogen species in a 5wt% Pt/C catalyst: a challenge for Inelastic Neutron Scattering, M. Carosso, A. Lazzarini, A. Piovano, R. Pellegrini, S. Morandi, M. Manzoli, J. G. Vitillo, M. Jimenez Ruiz, C. Lamberti, E. Groppo.

A comprehensive approach to investigate the structural and surface properties of activated carbons and related Pd-based catalysts, A. Lazzarini, A. Piovano, R Pellegrini, G. Leofanti, G, Agostini, S. Rudic, M.R. Chierotti, R. Gobetto, A. Battiato, G. Spoto, A Zecchina, C. Lamberti and E. Groppo.

About ILL – the Institut Laue-Langevin (ILL) is an international research centre based in Grenoble, France. Funded by France, Germany and the United Kingdom, in partnership with 10 other European countries, it has led the world in neutron-scattering science and technology for almost 40 years. ILL operates one of the most intense neutron sources in the world, feeding beams of neutrons to a suite of 40 high-performance instruments. Research conducted at ILL covers a wide range of disciplines such as biology, (green) chemistry, materials science, condensed matter physics, as well as fundamental and nuclear physics. Within the framework of FILL2030 (a project funded by the European Union's Horizon 2020 research and innovation programme under grant agreement No 731096), the ILL is designing its new business model to support the neutron users community with optimised services and financial resilience beyond 2030. https://www.ill.eu/

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