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Guest Editorial

The Importance of Interdisciplinary Science: When Chemistry Needs Physics

Introduction

Johnson Matthey has over 200 years of history, creating sustainable technologies, shaped around customers' needs. Our ambition is to research, develop and innovate solutions to make the world cleaner and healthier, today and for future generations. Much of the underpinning science behind these technologies relies on a knowledge of chemistry and its application. Like most successful organisations, Johnson Matthey reflects on the scientific capabilities that are key to developing these solutions today but also looks to the future to plan which capabilities will be required to meet future challenges and opportunities. Much of this learning comes from external insight by looking at what is happening both within the markets and scientific disciplines we are familiar with but also in parallel disciplines. Today, our core scientific capabilities can be grouped into nine key areas covering catalysis, characterisation and modelling, chemical synthesis, materials design and engineering, electrochemistry, platinum group metal and specialist metallurgy, process optimisation, product formulation, surface chemistry and coatings. Pulling these together forms a powerful toolbox to develop solutions for our customers' needs.

When looking beyond these capabilities, one useful 'lens' to look through is the overlap between scientific disciplines. For Johnson Matthey this might be to look at the interface between chemistry, one of our key underpinning strengths, and other sciences. For example, the interface between chemistry and physics; chemistry and biology or with other enablers such as the digital transformation that is enabling different ways of exploring science. Following this premise, *Johnson Matthey Technology Review* has devoted this issue to focus on physics and a future edition will look at biology.

Figure 1 shows how Johnson Matthey's core science capabilities today may overlap with physics and biology. Further insights can then be drawn by mapping how we apply these capabilities to provide customer solutions into our existing markets (pink text) or where they may be aligned with global drivers and world challenges. Such techniques can be a valuable tool to help discuss and identify opportunities and needs for an organisation.

Two areas increasingly dependent on capabilities bridging chemistry and physics are characterisation and modelling of materials and processes and the development of functional surfaces and coatings. These topics feature heavily in this edition of the *Johnson Matthey Technology Review*. For Johnson Matthey, characterisation and modelling are key capabilities to help develop new technology.

Characterisation, Modelling, Coatings and Surfaces

Characterisation provides insights into composition, structure and property-performance relationships at all length scales. The latter includes *in situ* and *operando* analysis, which is important to understanding how materials may respond in their intended application.

Modelling also encompasses all length scales and includes statistical, empirical and physical models. Modelling has been used for a long time in chemical engineering to design reactors, systems and processes. Examples include designing a new reactor for a chemical reaction, an aftertreatment system for a vehicle or a process flow sheet for recycling waste materials. More recently, advances in modelling are permitting chemists to be more predictive, to be able to design materials, reactions and their performance with far fewer experiments. For example, in this edition, the need for computational modelling methods to replace incremental experimental development to meet the need to design complex new advanced materials is explained (1).

The application of nuclear magnetic resonance (NMR) to characterising activated carbons leads

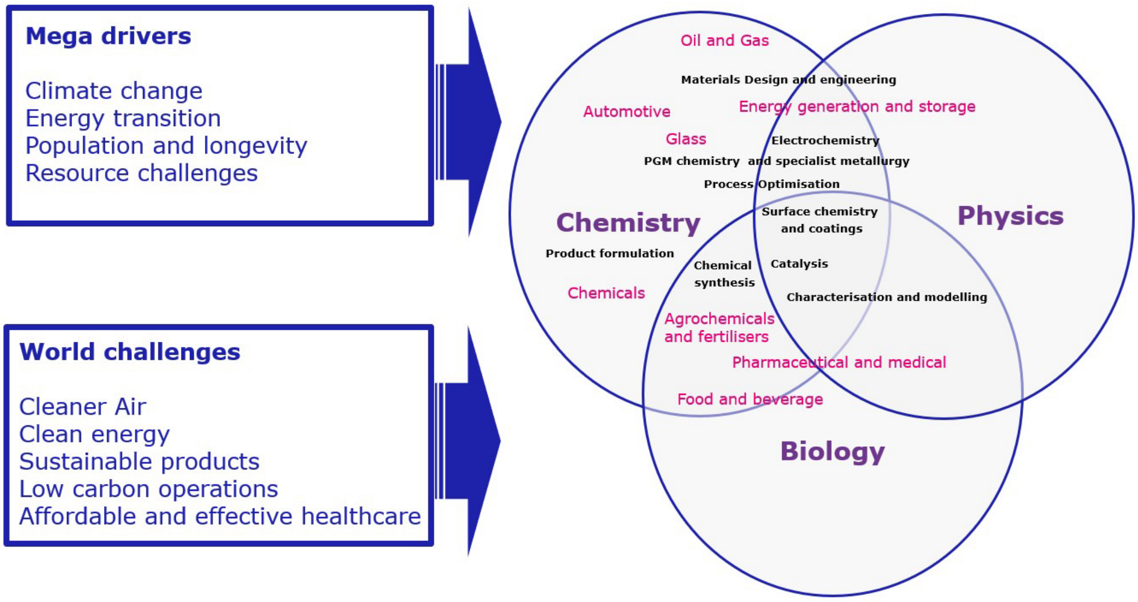

Fig. 1. Johnson Matthey's research and development (R&D) drivers and core capabilities

to insights into kinetic exchange of solvent molecules (2). The technique makes use of the magnetic shielding properties of the carbon structure to give insights into molecular level mechanisms which can give information to the chemist about where adsorbed species are in the material's structure. These techniques enable the industrial chemist to gain a better understanding of the materials being used which leads to faster development and better understood technology. Equally important is the fundamental understanding of new materials and their properties both at the atomic and molecular scales which in time can lead to advances in existing or new technology.

Coatings and surface properties is another area at the interface of chemistry and physics. Johnson Matthey has many examples of products which rely on the functionality of particles deposited onto a surface. Examples include precious and base metal catalysts, advanced energy materials and medical components. As the coating thickness reduces from micron to atomic, the chemist's traditional toolbox to deposit layers of formulated slurries, pastes and inks changes towards different deposition techniques such as chemical vapour deposition (CVD) and physical vapour deposition (PVD). The ability to design and deposit functional particles of a controlled size and shape onto a surface can find application in many disciplines such as transparent or reflective coatings, semiconductor devices, energy harvesting and sensing. Typically, these applications harness a combination of electronic, optical and chemical functionality. Further examples of applications in areas such as sensing, electronics and renewable energy are explored within this edition (3, 4).

Summary

Looking forward, global drivers such as climate change, the energy transition, population growth and longevity and resource challenges will drive the need for new technologies in areas such as more sustainable products, low carbon operations, clean energy and improved health and medical care. To meet these challenges chemists will increasingly need to reach out to adjacent disciplines to develop innovative solutions. In this edition of *Johnson Matthey Technology Review*, we welcome you to look at some of the advances in physics and explore how they are being used to drive forward R&D.

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