MATERIALS MASTERY

EXTRACTING THE BEST FROM RARE EARTH ELEMENTS AND BEYOND

With a focus on nanomaterials and rare earth elements, materials scientists at Peking University (PKU) develop functional materials for a broad range of applications, from optoelectronics to energy and catalysis. Their significant breakthroughs have seen PKU's ranking rise to the top 1‰ globally in materials science, according to the Essential Science Indicators (ESI).

PKU has several leading lights in rare earth materials. Chemistry professor, Xu Guangxian, a member of the Chinese Academy of Sciences (CAS), established the theory of rare earth cascade extraction and devised the vital equations. His work improved the separation of rare earth from multi-component mixtures, allowing for a wider application. For his achievements, Xu was awarded China's State Supreme Scientific and Technological Award in 2008.

Another CAS member, Gao Song, proposed the concept of rare earth-based single-ion magnet and molecular qubit, which laid a foundation for the use of rare earth molecular magnets in quantum computing. The PKU team under CAS member, Huang Chunhui, solved the thermal stability problem for rare earth-based, organic, light-emitting materials, which led to more luminous LEDs made of rare earth complexes. CAS member, Yan Chunhua, led a team that established the controllable preparation methodology for rare earth nanomaterials, which are used in biological imaging and advanced catalytic materials.

In carbon nanomaterials, PKU research teams, including those led by CAS member Liu Zhongfan, chemistry professors Zhang Jin and Li Yan, have established controllable preparation methodologies for carbon nanotubes, graphene and graphyne, a one-atom-thick carbon material categorized as a cousin of graphene. They hope their synthesis technology will be integral to future breakthroughs. To meet the different needs for material properties in various applications, PKU researchers have prepared 'graded' carbon nanomaterials by gradually adjusting the composition and structure to achieve properties for specific functions. Single-walled carbon nanotubes with controlled conductive properties, and wafer-sized single-crystal graphene are among the technologies for making high-performance electronic materials.

Their research results, published in *Nature* and other high-quality journals, have promoted understanding of the industrial transformation of carbon nanomaterials. To further boost the research and development of graphene-related technologies and their applications, PKU has recently established the Beijing Graphene Institute in partnership with the Beijing municipal government and industrial partners.

PKU's energy materials researchers work on novel materials and their application for energy harvesting, conversion and storage. An example of their success is in the industrialization of lithium-ion (Li-ion) batteries. A PKU professor, Xia Dingguo, discovered a new type of cathode material — the main component for Li-ion batteries, which displays high capacity from anionic redox reactions. Using hierarchical nanostructures, another professor, Hou Yanglong, built a high-performance lithium-sulphur battery.

Success in energy conversion is typified by the invention of a novel thin-film based on carbon nanomaterials. The work, led by Cao Anyuan and Zhou Huanping, allows flexible solar cells with high efficiency and high stability at low cost. Other teams, such as those led by PKU professors, Guo Shaojun, Zou Ruqiang and Zhang Yanfeng, have developed preparation methodologies for novel hierarchical nanomaterials and heterostructure materials, which show significantly improved electro-catalytic performance.

Research by PKU engineering professors Yang Huai and Yu Haifeng has also led to new applications of liquid crystal materials for optical/thermal energy conversion and storage, contributing to novel energy conservation technologies. ■