Long live the NNI

The coordinating role of the National Nanotechnology Initiative will be essential for the development of research at the nanoscale in the next decades.

The National Nanotechnology Initiative (NNI) has been a driving force for the scientific community working on nanomaterials in the US and an inspiration for the launch of nanotechnology programmes elsewhere. Following a report by the Interagency Working Group on Nanotechnology presented in September 1999[1], President Clinton launched the NNI in a speech at the California Institute of Technology on 21 January 2000. On 3 December 2003, the NNI became law through the so called 21st Century Nanotechnology Research and Development Act, signed by President Bush[2].

Two points of the law that are worth noting were the establishment of a National Nanotechnology Coordination Office (NNCO), with the aim of acting as a point of contact between the federal agencies participating in the initiative, as well as between researchers funded by such agencies and the public, and the setting up of external reviews to both assess and shape the activities of the NNI.

The NNI has been acting as a tool to bring together scientists with different backgrounds though working at the nanoscale. This coordination has also resulted in the establishment of new nano-specialized experimental infrastructure and the optimized used of that already existing. Furthermore, the activities of the NNI have translated into the creation of excellence networks and centres in the US, such as the National Nanomanufacturing Network (NNN, https://www.internano.org/nnn) the Center for Sustainable Nanotechnology (CSN, https://susnano.wisc.edu), the National Nanotechnology Coordination Infrastructure (https://www.nnci.net) and the Nanosystems Engineering Research Center for Nanotechnology-Enabled Water Treatment (NEWT, https://www.newtcenter.org). Noteworthy are also the promotion of environmental health and safety studies, as outlined by Lisa Friedersdorf and colleagues in their Comment, and the extensive efforts on education and outreach by the NNCO.

During the past 15 years the NNI has evolved in shape and grown in size. The number of agencies participating in the initiative has grown from 5 to 33, and the NNI has received strong support from both Democratic and Republican administrations, with over US$1.4 billion in the President's budget request for 2020[3].

Despite all these activities, doubts are now rising regarding the appropriateness of the NNI existing the same way in the future. Indeed, the statement of call by the National Academies in preparation for the latest review that will conclude within the next few months explicitly mentions the necessity to consider whether the NNI should continue[4].

Paradoxically, the doubts on the appropriateness or necessity for the existence of the NNI are of opposite nature. Namely, some feel that nanotechnology has not delivered on applications as initially envisaged and efforts should therefore be addressed elsewhere. Others feel that the technology is now mature enough to be beyond the need of a wide coordinated effort.

On the achievement side, perhaps the most tangible example is the commercialization of quantum dot-enhanced displays for both TV screens and portable devices. This has been possible due to the combination of fundamental studies on the optical properties of quantum dots and of the improvements in their scalable synthesis. Nanomaterials have also been widely used as part of composite materials for coating and other mechanical applications and in electronic devices.

Commercial products aside, the properties of nanomaterials have provided a new and unique perspective on issues that had been considered solved or optimized. Take for instance lithium-ion batteries, subject of this year's Nobel Prize in Chemistry. Although not strictly for nanoscience work, the prize provides a nice glimpse into the pervasive influence that nanoscience investigations can have in other fields (in this case electrochemistry). The prize recognizes the development of commercial Li-ion batteries. The first battery used a carbonaceous anode instead of the dangerous, but on paper much more attractive, metallic lithium that was initially considered. Nowadays, thanks to the investigative tools that nanotechnology has developed over the years, we are able to understand why lithium metal was not a good choice; the reason is in the solid–electrolyte interface; the chemistry in this few-nanometre-thick layer controls the performances of the anode. Thanks to this nanoscale understanding, scientists are now increasingly reporting prototype batteries in which dendrite formation is prevented. The goal is to finally be able to use metallic lithium instead of graphite to boost the capacity of practical batteries and better meet the demand of future applications.

Progress on a fundamental level and even from commercial point of view is undeniable. This does not mean, however, that nanotechnology is fully established and that the research programmes in the field have exhausted their role. Just to give a few examples, from a fundamental perspective it is becoming obvious that more mechanistic insight into the interaction of nanomaterials with their environment is necessary for a range of applications, such as in medicine, in agriculture and to understand the environmental implications of nanomaterials.

The advancement of the sophisticated proof-of-concept devices developed in the past few years will require even more synergy between researchers and manufactures to enable large scale, reproducible synthesis of complex systems. It has also become obvious that large-scale manufacturing should occur in a sustainable way. This will require specific efforts towards the design and large-scale manufacturing of nanomaterials that are at the same time environmentally friendly and fit for purpose.

In principle, research at the nanoscale can be simply be incorporated into more generic programmes on materials science, physics, chemistry or engineering. But even just from the manuscripts that we receive and the papers that we see published elsewhere, we see nanotechnology developing more towards the applied landscape. The interdisciplinary character remains essential, but it risks being lost if we do not capitalize on it through the concerted efforts of programmes like the NNI. ❐

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