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The Research Front on Molecular Logic

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When I had to identify a topic of high current interest and broad relevance for my first Research Front as an Associate Editor (Commissioning) of this Journal, molecular logic came immediately to my mind. Indeed, the study of the logic implications of the physico-chemical behaviour of molecules introduces new concepts in the field of chemistry and stimulates the ingenuity of researchers engaged in the bottom-up approach to nanodevices.

Investigations on 'intelligent' molecules capable of elaborating signals are mainly motivated by the development of novel paradigms for information processing that go beyond silicon-based technology. Such paradigms could lead, one day, to the realization of radically new devices with extremely small size, low power consumption, and unprecedented performances. The rational basis for this research stems from the fact that in living organisms information is transported, elaborated, and stored by molecular or ionic substrates.[1,2] Although the components of a molecular computer will not necessarily have to operate in ways analogous to those of microelectronic circuits, several efforts have been devoted to the design, synthesis, and characterization of chemical systems that mimic the operation of semiconductor logic gates.[3–8]

Clearly, the development of chemical computers[9] that can rival with current solid-state devices in terms of computing power is a very ambitious objective even for basic research. However, recent work showed that molecular logic devices could be interesting for specific applications in fields such as diagnostics,[10] medicine,[11] and materials science.[12] In fact, there are problems that not only can be solved by simple computations that are at hand for current molecular processors, but also need to be addressed in places where a silicon-based computer cannot go (e.g. inside a cell or in a membrane).[13,14]

This Research Front is intended to give you a flavour of this exciting and rapidly growing research area. In his opening lead essay, A. P. de Silva, the founding father of the field,[15] identifies the main avenues for its future development. The short review by Uwe Pischel contains a useful introduction to molecular logic, makes a clear albeit concise portrait of the current state of the art, and provides a critical discussion about the major challenges on the way to practical applications. Three original research articles (one communication paper by Szaciłowski et al. and two full papers by Tian et al. and by Remacle et al., respectively) show how complex logic functions can be obtained if molecular chromophores, nanostructured semiconductor electrodes, or electroactive self-assembled monolayers are interrogated with appropriate input signals.

Obviously, this Research Front cannot cover the topic in a comprehensive manner, and I apologize sincerely to those who might feel their work has been omitted. Nevertheless, I hope that this cluster of papers has been able to capture the excitement and challenges that pervade the study of molecular logic devices.

Enjoy!

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Alberto Credi was born in 1970. He received his 'Laurea' (1994) from the University of Bologna where, after a research period in the USA, he also earned his Ph.D. (1999). He is currently Associate Professor of chemistry at his Alma Mater. He received several scientific awards and co-authored more than 160 scientific papers in the fields of supramolecular chemistry, molecular devices, photochemistry, and electrochemistry. He is also the co-author of a monograph entitled Molecular Devices and Machines*, and of a handbook of photochemistry. Since January 2009 he has been an Associate Editor (commissioning) of the* Australian Journal of Chemistry.

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