Chemical Communication Principles and Applications

Ramón Martínez-Máñez[1,2,3,4],

[1] Instituto Interuniversitario de Investigación de Reconocimiento Molecular y Desarrollo Tecnológico (IDM), Universitat Politècnica de València, Universitat de València. Camino de Vera, s/n. 46022, Valencia, Spain.
[2] CIBER de Bioingeniería, Biomateriales y Nanomedicina (CIBER-BBN)
[3] Unidad Mixta UPV-CIPF de Investigación en Mecanismos de Enfermedades y Nanomedicina, Universitat Politècnica de València, Centro de Investigación Príncipe Felipe. Valencia, Spain.
[4] Unidad Mixta de Investigación en Nanomedicina y Sensores. Universitat Politècnica de València, IIS La Fe, Valencia, Spain. email: rmaez@qim.upv.es

rmaez@qim.upv.es

Engineering chemical communication (communication through the exchange of chemical messengers) between micro/nanosystems is receiving increasing attention from scientists. Although a number of micro and nanodevices (e.g., drug carriers, sensors, motile systems, nanoreactors) have been developed in the last decades, engineering communication at the micro/nanoscale is a recent emergent topic. In fact, most of the studies in this research area have been published within the last 5 years. The importance of the topic relies not only on its novelty and interdisciplinarity, but it is also expected to provide breakthroughs in many areas including nanotechnology, biomedicine, biotechnology and ICT.

In communication theory terms, communication occurs upon the exchange of information between two entities. Thus, there is a sender that receives a stimulus and converts the information into a code. The message is transmitted from the sender to the receiver through a certain medium. The receiver finally decodes the message and produces a certain action. In this context, chemical communication offers certain advantages over traditional telecommunications, such as the small dimensions of molecular components, low energy requirements and the possibility to actuate in aqueous environments and biological contexts.

Inspired by nature – where information is exchanged by means of molecules – the development of chemical communication strategies holds wide implications from different points of views. Published examples rely on nanotechnology and synthetic biology for the creation of micro and nanodevices that can communicate. Communication enables to construct new complex systems, capable of performing advanced coordinated tasks that go beyond those carried out by individuals, which is useful in many different fields already employing synthetic micro/nanodevices. In addition, the possibility to communicate synthetic and living systems can further advance in our understanding of biochemical processes, provide completely new tailored therapeutic and diagnostic strategies, ways to tune cellular behavior and develop new biotechnological tools.

This presentation, we will summarize advances by our laboratory in the design of modes of chemical communication. These models embrace from simple linear communication (transmission of information between two points) to more complex pathways such as interactive communication (feedback) and multicomponent communication (involving several entities). Using illustrative experimental designs, we will demonstrate the realization of these models which involve not only communication between engineered particles, but also between particles and living systems. [1-5]

References

[1] C. Gimenez, E. Climent, E. Aznar, R. Martínez-Máñez, S. Sancenón, M.D. Marcos, P Amorós, K Rurack, Angewandte Chemie International Edition 53, (2014) 12629-12633.
[2] A. Llopis-Lorente, P Díez, A Sánchez, M.D. Marcos, F. Sancenón, P-. Martínez-Ruiz, R. Villalonga, R. Martínez-Máñez, Nature Communications 8 (2017) 15511.
[3] B. de Luis, A. Llopis-Lorente, P. Rincón, J. Gadea, F. Sancenón, E. Aznar, R. Villalonga, R. Martínez-Máñez, Angewandte Chemie International Edition 58 (2019) 14986-14990.
[4] B. de Luis, A. Morellá-Aucejo, A. Llopis-Lorente, T.M. Godoy-Reyes, R. Villalonga, E. Aznar, F. Sancenón, R. Martínez-Máñez, Chemical Science 12 (2021) 1551-1559.
[5] B. de Luis, A. Morellá-Aucejo, A. Llopis-Lorente, J. Martínez-Latorre, F. Sancenón, C. López, J.R. Murguía, R. Martinez-Manez, Nano Letters 22 (2022) 1836-1844.

Figures

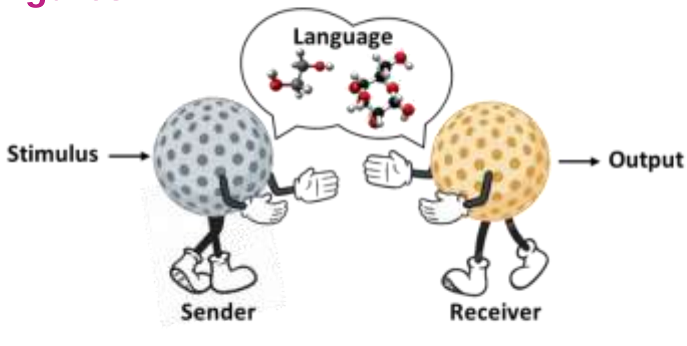

Figure 1. Schematic illustration of the concept of chemical communication between micro/nanoparticles.