Proceedings of the 7th World Congress on Recent Advances in Nanotechnology (RAN'21)
London, England – March 7 – 9, 2021
DOI: 10.11159/icnnfc21.02

Programmable 2D Materials

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Abstract

Although self-adaptive smart materials are widespread in nature, integration of such biological functions to artificial membranes has not yet been explored. Examples of the functions that can be targeted include, but are not limited to, self-reconstruction and self-recovery; regulated up-take and release of nutrients, water, and other chemicals; regulated permeation to specific classes of ions and molecules; regulation of ionic gradients across a membrane; the remote control of such functions by optical, electrical and magnetic stimuli. To this end, we are working on creating smart artificial membranes that are programmed to (at the moment of assembly) respond to external stimuli, and will be able to generate and store energy on demand. To achieve such complex functions, we base the technology on the combination of graphene-family, 2D, materials and macromolecules, polymers.

For example, recently we developed 2D membranes made of graphene-oxide and polyamine (which together form a network of ionic channels) that exhibit regulated permeability of water and monovalent ions, similar to biological membranes. Furthermore, we observed that permeation of some ions can be controlled by the presence of other ions, creating a "transistor effect" for selective ionic transport.

Artificial materials with intrinsic intelligence are critical not only to cellular functions, they are fundamental in many areas of science and technology and used widely in the food, pharmaceutical and energy industries. Such membranes are of great interest for modern technology such as extraction of Li+ for Li-ion batteries and Cs+ removal from radioactive waste. Such membranes can lead to further advances in the formation of super-nanocapacitors, membranes with selective release of ions for biofilm growth for food industry and pharmacy.

Keyword: 2D materials, graphene oxide, polyelectrolytes, membranes.