FUNDACIÓN RAMÓN ARECES

Summer Course in Nanoscience and Nanotechnology

III "Julio Palacios" International Symposium

A Coruña, 21- 22 July 2022

ABSTRACT

Nanostructured systems for solid-state cooling

Socorro Castro García

Energy is one of the crucial challenges facing mankind, and solid-state chemists have the power of providing materials for a more sustainable world. Around 20% of the world's electricity consumption is devoted to refrigeration technologies, such as fridges, freezers, HVAC (heating, ventilation, and air conditioning) systems, etc. Moreover, demand on this sector is expected to markedly grow in the coming decades due to global warming. Actually, the current COVID-19 pandemic has put under the spotlight the great importance of refrigeration. For instance, one of the most pressing challenges is still the refrigeration of COVID-19 vaccines, a major barrier that limits worldwide distribution and access. Nowadays, most refrigeration technologies are still based on compression/expansion cycles of volatile gases, first exploited over 180 years ago. This technology, although mature and well-established, still operates well below its maximum theoretical thermodynamic efficiency. In turn, refrigeration systems account for 7% of the global greenhouse gas emissions, where 5% is due to indirect emissions from the inefficient energy consumption, and 2% is due to direct emissions of gas refrigerants, mainly fluorinated hydrocarbons (F-gases) with global warming potential (GWP) thousands of times larger than that of CO_2. Therefore, the Kigali Agreement and F-gas regulation (EU regulation no. 517/2014) urge phase-out of 80% of these F-gas refrigerants by 2030. In this pressing scenario, and looking for alternatives, solid-state materials that can present pressure-induced phase transitions are arising as a promising alternative to refrigerant gases. These solid materials, known as barocaloric compounds, can exhibit large thermal changes when undergoing a solid to solid phase transition induced by the application and removal of isostatic pressure, in a similar way to refrigerant gases.

In general, barocaloric materials can offer many advantages over gas refrigerants: they cannot escape to the atmosphere, they are easier to recover and reuse in case of system breakage, they can be transported in nonpressurized vessels, and they can lead toward more compact systems, among others. Nevertheless, it remains a major challenge finding materials that comply with all three main requirements for commercial refrigeration: (i) very large thermal changes, (ii) low operating pressures (similar to the current cooling systems), and (iii) wide operating temperature range near room temperature. In this context, a new world of solutions is opening up with hybrid nanostructured materials, constituted by organic and inorganic units. Such materials can undergo high-energy phase transitions, very suitable and interesting for use not only in solid-state cooling, but also in energy storage.

Javier García-Ben, Jorge López-Beceiro, Ramon Artiaga, Jorge Salgado-Beceiro, Ignacio Delgado-Ferreiro, Yury V. Kolen'ko, Socorro Castro-García, María Antonia Señarís-Rodríguez, Manuel Sánchez-Andújar, and Juan Manuel Bermúdez-García. "Discovery of Colossal Breathing-Caloric Effect under Low Applied Pressure in the Hybrid Organic−Inorganic MIL-53(Al)" , *Chem. Mater.* 2022, *34*, 3323−3332.