Integrated CO_2 conversion and energy storage in the aprotic Li battery
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The project proposal targets limitations in our basic understanding of the operation of electrochemical devices having dual functions such as **integrated CO_2 reduction** and **energy storage**. Lithium-ion battery is currently a key enabling technology for the transition of society from the use of fossil fuels towards increased use of renewable energy sources which is essential to meet ambitious emissions targets. The metal-oxygen and metal-carbon dioxide batteries are possible candidates for the next generation of the battery system comprising advantages of batteries and fuel cells. Li-O_2 and Li–CO_2 systems offer theoretical specific energies as high as 11400 and 1876 W.h.kg^{-1}, respectively. There is strong competition between different concepts of metal-gas batteries where the Li-CO_2 system has been a little explored concept so far.

Li-CO_2 battery has promising applications in the **space industry**, specifically in the **exploration of Mars**, where the atmospheric CO_2 content is as high as 95 % and high lithium abundance. Except space industry **CO_2 electrodes may also function effectively in oxygen-rich environments** with no loss in battery performance giving the potential to design flexible, multi-use battery systems for **Earth applications**.

One of the shortcomings for Li-CO_2 aprotic battery is the formation of nonconductive and insoluble discharge products that deposit in the pores of positive electrode and progressively block CO_2 conversion. The proper design of CO_2 electrode catalyst and fundamental understanding of CO_2 reduction (CRR) and CO_2 evolution reactions (CER) are key issues for the correct operation of CO_2 batteries. For a better understanding of processes occurring in the electrochemical cell we seek techniques such as *in-situ* observations of processes that influence the performance of new energy materials.

The project proposal assumes *in-situ* Raman studies of electrochemical reactions occurring on CO_2 electrode for a better fundamental understanding of sequential steps of CO_2 conversion and its impact on battery operation. The *in-situ* investigations will be supported by EXAFS studies at synchrotron SPRING8 in Hyogo, Japan, which will allow observations of catalyst structural changes. The structural modifications of the catalyst involve the study of double perovskites with the general structure of where the B-site cation is substituted to modify the kinetics of CRR/CER reactions. The classic powder type (3D material) and nanotubular catalyst (1D material) will be integrated into the battery system to give perspectives on the morphological aspects of the catalyst. It is expected that the scientific insight into the reactions will allow expanding **promising energy storage strategy and as an effective way to reduce greenhouse gas emissions by CO_2 reduction and the formation of discharge product Li_2CO_3 and carbon.**