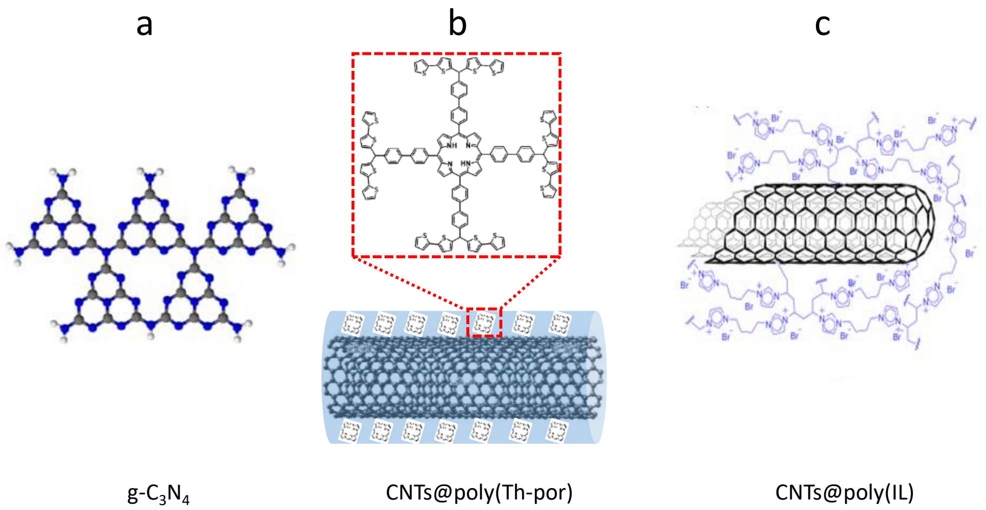
With the rapid development of intelligent electronic devices and electric vehicles, the need for new energy sources to power them is constantly increasing. These include batteries and fuel cells. In particular, lithium-sulfur (Li-S) batteries are considered one of the most promising next-generation energy storage devices due to their very high theoretical energy density of 2600 Wh kg^{-1} and inexpensive sulfur raw material. As a result, it is believed that Li-S battery technology may displace conventional lithium-ion (Li ion) batteries.

Li-S batteries use sulfur as the cathode material and metallic lithium as the anode. During the operation of such a battery, sulfur and lithium undergo gradual redox reactions to soluble lithium polysulfides (LiPSs) and then to insoluble solid lithium sulfide (Li_2S). However, there are fundamental challenges associated with the sulfur cathode, such as poor sulfur and lithium sulfide conductivity, dissolution and diffusion of cathodic reaction intermediates (polysulfides) from the cathode area, and high volume variability of the sulfur cathode material. This results in a rapid decline in battery parameters such as capacity, efficiency, and energy density, which is a significant barrier to not allowing this technology to be commercially marketed. One of the leading research efforts aimed at solving these problems is searching for catalytic cathode materials that, on the one hand, allow trapping LiPSs in the cathode material space and, on the other hand, accelerate the further transformation of these intermediates to the final Li2S product.

The present project proposes the use of new nanostructured catalytic materials, the structure of which is shown below. They have catalytic properties tailored to the sulfur redox reactions occurring in Li-S batteries. The research proposed in this project will lead to the development of Li-S batteries with excellent specific capacity, high power and energy density, and long life.



Schematic showing the structure of (a) a carbon nitride, g-C_3N_4, (b) a carbon nanotube with a thin polymeric film of catalytic porphyrin centers deposited inside the polymer, and (c) a carbon nanotube with a thin film of ionic liquid-based polymer deposited on its surface.