Hydrogen plays an important role in many processes in the chemical industry. Many different products are made through the hydrogenation of various compounds. Perhaps most important of all is the hydrogenation of nitrogen to form ammonia, as this reaction helps feed much of the world’s population. Additionally, hydrogen is expected to play an important role in the energy transition as a renewable fuel. However, there are still challenges that must be addressed before hydrogen can be more widely used. One of these challenges is that there are few materials that can selectively transport ionic hydrogen (H+, H-) at temperatures above 200 °C, which leaves a gap in fuel cell operating temperatures[1, 2] and hinders the development of solid-state electrochemical ammonia synthesis and other reactions.

To address this, new proton conductors and hydride-ion conductors must be developed. In this project, we aim to find such materials and learn more about the mechanisms of the ion transport within them. Primarily, we investigate two classes of materials: metal hydrides as mixed hydride-electronic conductors and metal hydroxides as proton conductors. The ion transport mechanisms are analyzed with electrochemical impedance spectroscopy, which must always be combined with other techniques to get a complete picture of the ions’ motion. Examples of other techniques are computational methods and solid-state nuclear magnetic resonance. We collaborate with other researchers for these. Additionally, we use in-house powder X-ray diffraction, thermogravimetric analysis, temperature-programmed desorption, differential scanning calorimetry, and infrared spectroscopy for further characterization.