Title: Stitching Molecules Together from Renewable Building Blocks with Electricity

Abstract: Chemical manufacturing relies on the use of fossil carbon feedstock as both energy and starting materials in the synthesis of useful molecules. One approach to greener manufacturing is the carbon capture and utilization strategy (CCU), where carbon dioxide is taken from industrial point sources and used as raw material for chemical production. Alternatively, longer carbon chains can be obtained from renewable sources such as biomass and upgraded to valuable chemical products. To add an extra degree of sustainability, these technologies can take advantage of electrochemistry – the direct application of electricity to a reaction as a source of energy – rather than relying on energy from burning fossil fuels. With an increasing percentage of electricity coming from renewable sources such as solar and wind, electrochemistry is becoming a viable option for chemical processes with a lower dependence on oil and gas.

This seminar will describe past and future efforts in using electrochemical methods for sustainable chemical production by making use of renewable materials such as carbon dioxide or alcohols derived from biomass. The products of these reactions find use in various industries such as pharmaceuticals, agrochemicals, fuels, materials, and more. Emphasis is placed on using kinetic and mechanistic studies to assist in process design and optimization. Future efforts involve the addition of a third element of sustainability, wherein sacrificial half-reactions are avoided, thus decreasing waste and increasing system efficiency. Ultimately, the methods described herein will reduce the carbon footprint of the chemical industry while maintaining production of valuable chemical goods.

Bio: Dr. Rachel Baker joined Queen's University as an Assistant Professor in the Department of Chemical Engineering in July 2023, and currently holds the inaugural Robins Family Professorship of Engineering Chemistry. Her research program involves the development of carbon-neutral and carbon-negative chemical processes, using renewable electricity as an energy source and sustainable materials as building blocks. The program will focus on pairing together electrochemical reactions, and understanding their mechanistic pathways, to decrease waste and better prepare these processes for industrial implementation. Before joining Queen's, Rachel completed a Postdoctoral Fellowship in the Department of Chemistry and Chemical Engineering at the California Institute of Technology under Dr. Karthish Manthiram (2022 – 2023). Rachel completed her PhD in Chemistry from the University of Toronto, under the supervision of Dr. Mark Lautens (2017 – 2022), and earned her Bachelor's in Engineering Chemistry at Queen's University (2013 – 2017). Outside of the lab, she is passionate about youth outreach, and enjoys an adventure, whether it's travelling somewhere new or through a classic mystery novel.