Research at the University of Houston's Department of Chemistry

Chemistry is central among the natural sciences. Chemists seek fundamental insights into the nature of matter and its organization, while advancing chemical industry and medical, environmental, and energy technologies. The faculty at the University of Houston's Department of Chemistry pursue a great diversity of research projects aimed at mitigating climate change, developing new medical treatments and imaging techniques, finding ways to produce plastics with lower environmental impact, and developing unprecedented materials for use in lighting and energy industries. Research endeavors within our department are organized in three broad divisions: organic, inorganic, and physical.

In the *Organic Division*, **Brookhart** (a member of the National Academy of Sciences) performs synthetic and mechanistic organometallic chemistry aimed at developing new homogeneous catalysts for olefin polymerizations. **Cai** and his students work on anti-infection coatings, bacterial interference, and biofilms. **Carrow** creates transition metal catalysts that address challenges in sustainability and materials chemistry, with a particular focus on sustainable plastics. **Comito's** group develops new main group organometallic catalysts for polymer and organic synthesis to address the longstanding limitations of the currently used transition metal catalysts. **Daugulis** has research interests in the development of new chemical reactions by applying organometallic chemistry to organic chemistry problems and olefin polymerization. **Do's** group specializes in the design, synthesis, and studies of catalysts for both materials and biological applications, such as the preparation of new polymerization catalysts and catalysts that can operate within living cells. **Gilbertson** creates synthetic methods for the preparation of small molecules for therapeutic uses in the treatment of cancers, infectious diseases, and addiction. **Harth**'s group is invested in the development of polymerization methodologies to combine non-polar polyolefins with other polymer classes to capitalize on their properties and develop advanced materials. **Lee** and coworkers are developing interfacial and nanoparticle chemistry, including creating advanced coatings to mitigate corrosion in various environments. The **May** group is creating methods to rapidly and efficiently synthesize complex organic molecules that exhibit challenging architectures and intriguing biological properties. **Miljanic** designs materials for the capture of greenhouse gases such as carbon dioxide and fluorinated refrigerants, as well as for the recycling of fluorinated anesthetics. **Wu** and coworkers use the tools of theoretical chemistry to develop a detailed understanding of materials, molecules, and chemical processes that enable better catalysis, gas capture, battery materials, and medicinal applications.

The *Inorganic Division* is where cutting-edge research and innovation converge. Led by a distinguished faculty, students are immersed in the intricacies of molecular inorganic and organometallic synthesis, honing their skills in precise air-free handling, biologically mediated synthesis, molecular biology, crystal growth, and ceramic synthesis. One of its faculty members, **Bocarsly**, is developing in situ electrochemical methods to gain a new understanding of the structure and magnetism of high-performance battery cathodes. He also focuses on magnetic phase transitions and magnetocalorics for the development of more energy-efficient refrigeration. **Brgoch** combines machine learning, experiments, and computation to investigate complex chemical and physical phenomena in materials chemistry. His group's research aims to develop next-generation materials for energy-efficient LED lighting, new structural materials for mining and manufacturing, and a better understanding of the chemistry of anionic transition metals as potential heterogeneous catalysts. **Guloy** is a leader in synthesizing and characterizing crystalline organic-inorganic hybrid materials. His group's work involves designing crystalline solids with tunable properties based on the structural and electronic flexibility of the inorganic and organic moieties. These materials serve as functional model systems for understanding the chemistry and physics of low-dimensional materials for electronic, optical, and superconducting applications. **Halasyamani** grows large single crystals to investigate structure-property relationships in second-order non-linear optical behavior. His group studies phenomena such as second-harmonic generation, piezoelectricity, ferroelectricity, pyroelectricity, and multiferroic behavior to gain a better understanding of these materials. **Jacobson** synthesizes and characterizes transition metal oxide systems with layered or framework structures. His group focuses on asymmetric layer structures and open framework structures that absorb molecules and the development of new synthetic techniques, including hydrothermal electro-crystallization and reactions in ionic liquids. **Teets** is developing synthetic strategies to control and optimize the photophysical and photochemical properties of organometallic compounds. His research targets compounds with enhanced or unique features, such as efficient phosphorescence in the visible spectrum for next-generation OLEDs and powerful photoreductants for photoredox catalysis. **Zastrow** aims to understand how metals in gut microbes affect host health, disease, and immune response. Her work employs biological and chemical approaches, including bioinorganic chemistry and chemical biology, to uncover and examine the roles of essential metals in the gut microbiota. Her research involves protein biochemistry and design, molecular biology, synthesis, cell imaging, and absorption and fluorescence spectroscopy.

Research in the *Physical Division* aims to reveal the fundamental interactions, mechanisms, and processes of wide-ranging chemical and biochemical systems, from surface-attached small molecules to energy and quantum materials to DNA transcription and neuroactive proteins in live cells. To reach a molecular-level understanding, unique advanced techniques with appropriate spatial, temporal, and energy resolutions are used, offering insights that cannot be obtained by conventional analytical tools. In the biological area, **Chen** employs single-molecule spectroscopy and imaging to study how cells manage copper and antioxidants at a molecular level, aiming to discover regulatory rules to devise health-enhancing therapeutic strategies for neurodegenerative diseases such as ALS and Alzheimer's. The **Xu** group invented super-resolution force spectroscopy and is using the new quantum sensing technique to reveal protein synthesis mechanisms and facilitate drug development. To study how light and materials interact, **Chiang** uses scanning probe microscopic and spectroscopic methods to probe fundamental light-induced physiochemical phenomena relevant to next-generation quantum materials, electrocatalysis, and intracellular delivery for immunotherapy. For next-generation energy solutions, **Yang** uses time-resolved electron imaging and optical methods to investigate the elementary steps in energy materials' responses to the absorption of light and the mechanisms of energy flow across materials' interfaces. The surface-specific spectroscopy and imaging methods in the **Baldelli** group are employed to reveal fundamental electrochemical processes to gain insights on catalysis and corrosion. In addition to the aforementioned thrusts at experimental frontiers, **Bittner** uses theoretical chemical physics methods to investigate quantum phenomena and emergent properties of optical-electronic materials. The **Lubchenko** group seeks to understand how large collections of particles exhibit behaviors different from those of individual particles in metals, inorganic materials, molecules, and proteins.