Purpose

To understand the mechanisms of chemical reactions with unprecedented resolution

Sponsor

U.S. Department of Energy
Office of Basic Energy Sciences
Chemical Sciences Division

Features

- *located in the Center for Radiation Chemistry Research (CRCR) in Brookhaven's Chemistry Department*
- *measures chemical reactions with 7-picosecond (7×10^{-12} seconds) resolution*
- *studies photochemistry of radical species with 50-femtosecond (50×10^{-15} seconds) resolution*

Collaborating institutions

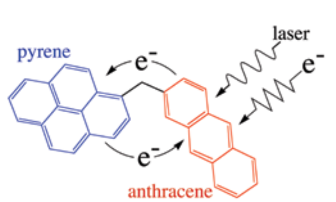
- *U.S.: Bowling Green State University, Fordham University, Massachusetts Institute of Technology, National Institute of Standards & Technology, North Carolina State University, Princeton University, Rutgers University, Stanford University, University of Colorado, University of Florida, University of North Carolina at Wilmington*
- *international: Memorial University of Newfoundland, Canada; University of Paris-Sud, France; University of Erlangen, Germany; Kanagawa Institute of Technology, Japan; Technical University of Lodz, Poland*

Complementary facilities

- *2-MeV electron Van de Graaff accelerator for 40-nanosecond (40×10^{-9} seconds) pulse radiolysis*
- *Cobalt-60 gamma source for continuous irradiation*

Web address

www.chm.bnl.gov/SciandTech/PRC/wishart/crcrintr.html

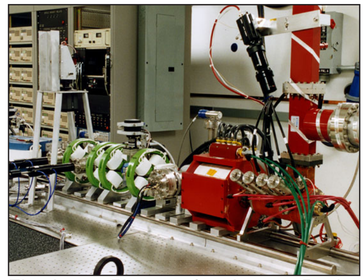


LEAF is used to study extremely fast electron transport reactions, such as the one shown here between pyrene and anthracene, which has applications in solar energy conversion.

Laser Electron Accelerator Facility (LEAF)

Studying Fast Reactions Using Electrons and Lasers

Radiation is widely used for medical therapy, sterilization, food preservation, manufacturing, and the study of chemical reactions. Despite the benefits of radiation, there is still much to learn about its effects on chemistry.



The Laser Electron Accelerator Facility at Brookhaven National Laboratory

To reveal the inner workings of radiation chemistry on ever-shorter time scales, scientists are devising new tools. One such tool is the Laser Electron Accelerator Facility (LEAF) developed within Brookhaven National Laboratory's Chemistry Department.

LEAF: Leading a new generation

Within LEAF, a short-pulsed laser is aimed at an electron gun with a light-sensitive cathode. When struck by ultraviolet laser light, the photocathode emits electrons from its surface in 7-picosecond pulses. The pulsed electron beam is then boosted to higher energy within LEAF's microwave-driven, linear accelerator, which is only one foot long.

The beam is then directed down one of two beam lines, at the end of which is a sample, which is usually a solution. LEAF's electron beam induces the ionization of molecules within the sample, in a process called pulse radiolysis.

LEAF is the fastest system to study pulse radiolysis in the country and one of the three fastest in the world. LEAF is also the first such device based on a new photocathode electron gun that was developed at Brookhaven and elsewhere, and that has enabled a new generation of faster, cheaper, smaller, and more capable accelerators to be built for pulse radiolysis.

High-energy electrons

When the high-energy electrons produced by LEAF strike a sample, their energy is transferred through collisions with the sample's molecules.

If enough energy is transferred to a molecule, then one or more of its electrons are ejected, creating a positive ion. If less energy is transferred, then the molecule is "excited," that is, its grip on electrons is weakened but not broken.

LEAF relies upon ionization and excitation to break chemical bonds and form highly reactive "radical" species, which are then used to study how chemical reactions occur.

Using light to detect reactions

The LEAF detection system uses light to measure the speed of reactions. The same laser system used to generate the electron pulse also provides another laser that is synchronized with the electron beam to strike the sample at different time intervals.

While the electrons induce radiolysis within the sample, this laser pulse takes a spectroscopic "snapshot" of the reaction. The timing of each snapshot is controlled by changing the distance that the laser beam travels before hitting the sample. The resulting sequence of snapshots creates a profile of the reaction with a 7-picosecond resolution.

Applications of LEAF

LEAF is very useful for the study of electron transport. Electron transport is the simplest chemical reaction, involving the movement of electrons within and between molecules.

A familiar example of an electron-transport reaction is photosynthesis, which is the conversion of light into chemical energy by plants.

Understanding how electron-transport reactions occur is necessary to design systems that store solar energy. Using LEAF, research into solar energy storage is part of an ongoing effort at Brookhaven to develop ways to produce environmentally friendly fuels such as hydrogen.

Brookhaven National Laboratory is managed for the U.S. Department of Energy by Brookhaven Science Associates, a company founded by Stony Brook University and Battelle.

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