

## Spotlights on Recent JACS Publications

### ■ SODIUM AND CHLORIDE COMPLEXES EXHIBIT REMARKABLE STRENGTH

The list of molecular species with the highest ion-binding capabilities in the gas phase is topped by crown ethers and a few of the most basic amino acids. Now, researchers led by Terry McMahon and David O'Hagan demonstrate that a new class of compounds, all-*cis*-1,2,3,4,5,6-hexafluorocyclohexane with a dipole moment on the order of 7 D, tops the list of anion-binding organic molecules and gives rise to molecular complexes of sodium and chloride ions that are among the most strongly bound ever observed (DOI: [10.1021/jacs.6b02856](https://doi.org/10.1021/jacs.6b02856)).

The team uses electrospray ionization to generate the ionic complexes, which are subsequently isolated on the basis of their mass with the help of a quadrupole ion trap mass spectrometer. The compounds are then irradiated with wavelength tunable infrared light, which allows the researchers to obtain their vibrational signatures. In parallel, they carry out computational work that reveals that the ionic complexes are extremely tightly bound. The ion–molecule interactions highlighted in this study are unique because of their binding strength and the relatively small size of the cyclohexane-based organic fluorine molecules.

**Christine Herman**, Ph.D.

### ■ CRITICAL MIDDLE STEPS IN PENICILLIN BIOSYNTHESIS

In 1928, Alexander Fleming at St. Mary's Hospital in London discovered an antimicrobial compound produced by a mold. That compound, penicillin, ushered in the antibiotic era of medicine. Today, many pathogens are resistant to penicillin-type drugs. To help them come up with new antibiotics, researchers want to better understand how bacteria and fungi biosynthesize these drugs.

Isopenicillin N synthase, or IPNS, is an essential enzyme in the pathway to penicillin. It installs the  $\beta$ -lactam ring, a chemical structure ubiquitous to penicillin antibiotics, and another structure called a thiazolidine ring. The group of Sir Jack Baldwin at the University of Oxford demonstrated in the 1980s that the  $\beta$ -lactam ring is generated first, followed by the thiazolidine ring. IPNS uses an iron cofactor and oxygen to cleave two aliphatic carbon–hydrogen bonds for these two steps.

Reactive intermediates in this pathway have been proposed, but experimental evidence for their existence was lacking. Now Carsten Krebs, J. Martin Bollinger, Shengfa Ye, and colleagues provide that evidence, showing that IPNS forms two distinct intermediates: a Fe(III)-superoxo complex that initiates closure of the  $\beta$ -lactam ring and a Fe(IV)-oxo intermediate, which enables formation of the thiazolidine ring. (DOI: [10.1021/jacs.6b04065](https://doi.org/10.1021/jacs.6b04065)).

The authors conclude, "The results show that the intermediates are high-spin Fe(III)-superoxo and high-spin Fe(IV)-oxo complexes, respectively, in agreement with published mechanistic proposals derived from Baldwin's founding work."

**Rajendrani Mukhopadhyay**, Ph.D.

### ■ REVEALING EXCITED-STATE DYNAMICS IN CYCLIC DNA MINIDUPLEXES

The photoexcitation of DNA by UV radiation can lead to DNA damage and mutation. Models of DNA excited states formed via UV excitation have focused on the effects of either base pairing or base stacking, but researchers have struggled to disentangle these two noncovalent interactions. Hence, the mechanism behind the slow energy relaxation in double-stranded DNA remains intensely debated.

Bern Kohler, Cynthia Burrows, and colleagues use time-resolved infrared spectroscopy to investigate the excited-state dynamics of two cyclic DNA miniduplexes—these model molecules are the shortest possible DNA duplexes that exhibit both base stacking and pairing (DOI: [10.1021/jacs.6b03216](https://doi.org/10.1021/jacs.6b03216)). The researchers obtain results similar to those from longer DNA strands, which support earlier evidence of a proton-coupled electron-transfer deactivation mechanism and suggest that excited states in longer double helices rapidly localize over two adjacent base pairs. Moreover, a miniduplex in which nucleobase modification disrupts base stacking lacks long-lived excited states.

This work in DNA miniduplexes reveals how base-stacking and base-pairing mediates electronic energy relaxation in UV-excited DNA. Moreover, the small size of these molecules makes possible future detailed theoretical study using high-level quantum chemical calculations.

**Hui Jin**, Ph.D.

### ■ THE SECRET OF TRIETHYLBORANE/OXYGEN IN CHAIN INITIATION

Triethylborane ( $\text{Et}_3\text{B}$ ) and oxygen ( $\text{O}_2$ ) are a common initiator pair used in preparative radical chain reactions. Although  $\text{Et}_3\text{B}/\text{O}_2$ , capable of initiating many types of radical transformations, has become a standard reagent in organic synthesis, the detailed mechanism remains unclear, especially the dependence of initiation efficiency on oxygen supply.

Now, Dennis Curran and Timothy McFadden have developed a complete kinetic theory for the reactions between  $\text{Et}_3\text{B}$  and  $\text{O}_2$  and conducted a thorough experimental analysis on radical chain processes initiated by  $\text{Et}_3\text{B}/\text{O}_2$  (DOI: [10.1021/jacs.6b04014](https://doi.org/10.1021/jacs.6b04014)). The researchers are able to clarify the mechanistic difference between  $\text{Et}_3\text{B}/\text{O}_2$  and azobis(isobutyronitrile), another typical chain initiator, and identify two distinct reaction regimes for  $\text{Et}_3\text{B}/\text{O}_2$  based on the oxygen level in the environment.

These results are used to successfully rationalize recently reported hydrostannation of alkynes and alkylborane/water reduction, demonstrating the wide scope of this study in analyzing and understanding radical chain reactions. The discussions on the effectiveness of initiators provide practical guidelines in terms of initiator selection and condition optimization for synthetic chemists.

**Xin Su**, Ph.D.

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## ■ HETEROCHIRAL SELF-SORTING AND ASSEMBLY GET THE GOLDEN TOUCH

Smaller molecules that self-assemble sequentially into larger ones and chiral molecules that join with their complementary opposites—so-called heterochiral self-sorting—are both common in nature, and creating artificial systems that display these characteristics could be helpful for better understanding them. However, few examples of heterochiral self-sorting exist in synthetic metal–organic assemblies, and even fewer artificial systems exist with both heterochiral self-sorting and sequential self-assembly.

Vivian Yam and co-workers report a system that uses chiral chlorogold precursors to produce a variety of gold clusters (DOI: [10.1021/jacs.6b03844](https://doi.org/10.1021/jacs.6b03844)). When the researchers react enantiomerically uniform precursors with hydrogen sulfide, they form enantiomeric products through sequential self-assembly. Conversely, when they react a racemic mixture of these same precursors, the resulting product is achiral with higher symmetry, demonstrating that the chiral precursors self-sort to form a material that incorporates both enantiomers to the same extent.

The chiral products and the achiral one display very different photophysical behaviors. For example, the chiral assemblies only absorb UV light, but the achiral one also absorbs light in the visible spectrum. Similarly, the chiral products are photoluminescent in solution, but the achiral one is only emissive in the solid state. The authors suggest that this unusual collection of gold clusters could give insight into heterochiral self-sorting and sequential self-assembly in nature.

**Christen Brownlee**

## ■ CARBAZOLE MACROCYCLES ARE THE FIRST SINGLET POLYRADICALS SYNTHESIZED

Juan Casado, Jun Ding, David Casanova, Jishan Wu, and their colleagues have synthesized the first singlet  $\pi$ -conjugated systems with polyradical character (DOI: [10.1021/jacs.6b04539](https://doi.org/10.1021/jacs.6b04539)).

$\pi$ -Conjugated systems that are stable singlet diradicals in the ground state, like graphene nanoribbons and some polyaromatic hydrocarbons, have interesting optical and electronic properties that make them useful for nonlinear optics, field-effect transistors, and organic spintronics. But molecules with more than two radicals that are also singlets in the ground state are unstable and difficult to synthesize. They are also hard to model because the molecules must overcome a large energy gap to transition from a closed shell to an open shell molecule with unpaired electrons in separate orbitals.

The authors have built two macrocycles using units that become aromatic when they are radicals, designed with the thought that the stability arising from the aromatic transition would drive the molecules to become polyradicals. One macrocycle has four alternating quinoidal and aromatic carbazole units, and the other has six such units. Both molecules exhibit polyradical character, shown via modeling and room temperature spectroscopic characterization. They are also weakly magnetic at room temperature. The authors suggest that when synthesized, larger polyradical organic frameworks might become magnetic at higher temperatures.

**Melissae Fellet, Ph.D.**