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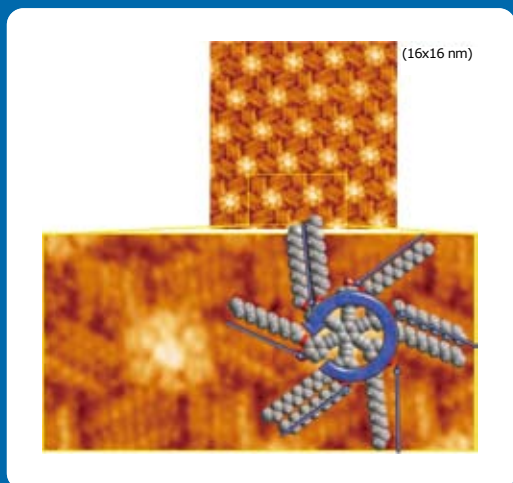
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Chemistry—A Structurally Based Science: My Journey from the Beauty in Fullerene Chemistry to Supramolecular Material Chemistry

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'Chemistry is an art.' As a college student, I could not really apprehend how chemistry is an art as told by a physical chemistry professor. As a research assistant at National Tsin-Hua University, fascinated by the colorful nature of organometallic compounds, I was involved in metal cluster organometallic chemistry and then I found that the beauty of the molecular structures of metal cluster compounds impressed me more. 'Chemistry is an art' has then seeded in my early career of research. As chemistry being recognized as a structurally based science, designs of molecular structures have always attracted me initially to get through the resulting beautiful science behind these beautiful molecules.

With the pleasant encounter of metal cluster chemistry, I then started my PhD journey to deeply appreciate metal cluster chemistry from Prof. John R. Shapley, one of the most well-known metal cluster chemists, at University of Illinois at Urbana-Champaign. John offered many projects to choose from and metal cluster fullerene chemistry stood out in my mind. To me the project was so attractive due to the following reasons. First of all, little was known then about fullerene organometallic chemistry, not to mention fullerene metal cluster chemistry. Exploring new scientific territory has always been an important attribute for scientists. Secondly, the project's high potential in catalysis applications is promising. Thirdly, the difficulty to

achieve the project is challenging since it was yet succeeded though some former group members and many other groups worldwide had tried. The last and most important reason behind the pick was the beauty of the molecular structures.¹ In sum, the great challenge and the beauty of the project caught my strong attention and drive me through all the bad and good times in my PhD career.

The reasons behind my pick had helped me going through the tough times for my first three PhD years, full of frustrations. It turned out the three years was not a waste but had improved my experimental skill and perseverance toward chemistry research. The key to the successful identification of the first triple dihapto bonding mode of a hexagon of C₆₀ to a Ru₃ cluster unit, Ru₃(CO)₉(μ₃-η², η², η²-C₆₀),² was later found to be the realization of the very low yield and difficulty of identification on thin layer chromatography of the product. Previous to this publication, C₆₀ was suggested to be aromatic and the suggestion led to many attempts trying to achieve the coordination of C₆₀ through a C₆ ring to a single metal center. However, later, C₆₀ was realized to react primarily as an electron-deficient alkene and sometimes as a diene. The C=C π bonds were recognized to be more localized than delocalized through the cage. However, the triple dihapto coordination mode of a hexagon in C₆₀ could not be achieved until my publication in 1996 (Figure 1). A

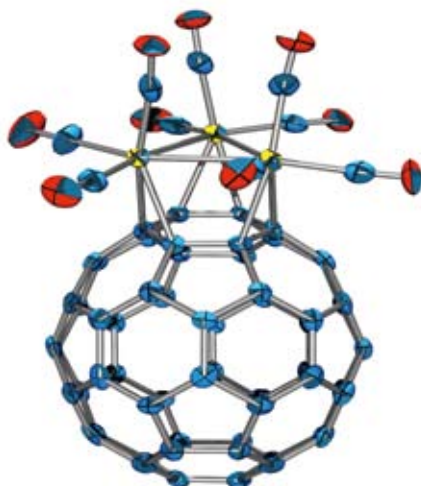


Figure 1. The first C₆ ring coordinated C₆₀ complex: the single crystal molecular structure of Ru₃(CO)₉C₆₀. Red, O; blue, C; yellow, Ru.

$\text{Ru}_3(\text{CO})_9$ unit was successfully face-capped onto the arene-like C_{60} cage. The significance of the new finding was highlighted by Chemical & Engineering News (C&EN) of American Chemical Society in the same year. A couple years later, the results were included in books including some major inorganic and organometallic chemistry textbooks. In 2010, Wikipedia presented the result under the topic of fullerene ligand.

With the success and understanding of the attributes of fullerene metal cluster compounds, other related compounds were synthesized and investigated. Phosphines were incorporated onto the ruthenium cluster in Ru_3C_{60} for improving the solubility and tuning the steric/electronic properties. The CO ligands were found to exhibit site exchange behaviors in the C_{60} and C_{70} derivatives.³ The Ru_3 unit was also used to cap the hexagon closest to the pole of C_{70} (Figure 2).⁴ Moreover, the structure of one of the isomers of two Ru_3 units capping two hexagons in one C_{70} cage was determined. Larger metal clusters were also successfully capped onto C_{60} with the help of phosphine incorporation to improve solubility for characterization.⁵ These results initiated the fullerene metal cluster chemistry and thereafter more than a hundred publications on this subject by other groups have been reported.

After my PhD journey cruising through fullerene chemistry, I then joined Prof. Timothy M. Swager's group at Massachusetts Institute of Technology to study liquid crystalline materials. For me, the beauty of the optical textures of liquid crystals (LCs) was irresistible. Moreover, the supramolecular correlations of LCs were beyond my imagination after focusing the molecular

structures. Tim is always full of energy on research and his research ideas then were just great to be highly appreciated by me. Against conventional wisdom on liquid crystalline compounds with rod-like or disc-like chemical structures, Tim's group discovered spherical tris-bidentate octahedral metal complexes exhibiting a propeller-like molecular geometry could pack into columns to lead to liquid crystallinity. The tris-bidentate nature provides two possible chiral senses (Δ and Λ). Excitingly, I was involved in the study of utilizing fluxionality of some octahedral coordination complexes to achieve cooperative chirality in liquid crystalline state induced by the incorporated peripheral chiral alkyl chains.⁶ The beauty of this project lies not only on the molecular structure but also the propeller columnar stacking and cooperative chiral induction.

After being an independent researcher at Tamkang University, most of my research work has been focusing on designing new liquid crystalline materials, investigating their supramolecular structure, and their potential applications. As aforementioned, compounds exhibiting liquid crystalline properties were with mainly rod-like or disc-like molecular structures. To start my own research, rod-like and disc-like molecules were designed for investigations on tuning their liquid crystalline properties for practical applications in display technologies. For rod-like compounds, symmetry breaking and rotational bulk of rigid core were utilized to enhance liquid crystallinity. The rotational bulk was realized by the rotational freedom of C-C single bonds in rigid molecular rods with naphthalene unit.

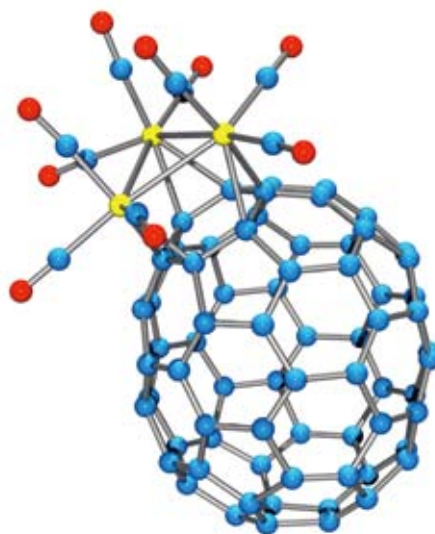


Figure 2. The first C_6 -face-capped C_{70} complex: the single crystal molecular structure of $\text{Ru}_3(\text{CO})_9\text{C}_{70}$. Red, O; blue, C; yellow, Ru.

Disc-like compounds were also investigated towards applications of optical compensating films in liquid crystal displays (LCDs) and one dimensional optoelectronic conduction.⁷ Materials showing the discotic nematic phase, the least ordered discotic phase to show a bit more ordered intermolecular packing than that of randomly packed liquids, were designed and working temperatures were tuned for practical applications through molecular design. Extrusion from disc periphery⁸ (Figure 3) and laterally-attached chain configuration⁹ (Figure 4) were employed to manipulate inter-disc interactions for resulting low melting LC materials to be used in fabrication of optical compensating films in LCDs. With the same molecular

core, materials showing molecular swirl geometry (Figure 5) were designed and the molecular swirl packing along molecular plane (Figure 6) was studied by scanning tunneling microscopy (STM).¹⁰ In liquid crystalline state, the molecular swirls exhibit highly correlated supra-structures along the molecular plane by swirl gearing interactions (Figure 7), and hence neighboring swirls are packed with the same swirl orientation sense. At the same time, the molecular swirls pack cooperatively with the same sense of swirl orientation along disc normal to lead to column formation by the strong inter-planar attractions. The two inter-disc correlations, along and perpendicular to the molecular plane, lead to highly correlated supra-structures over a large domain.

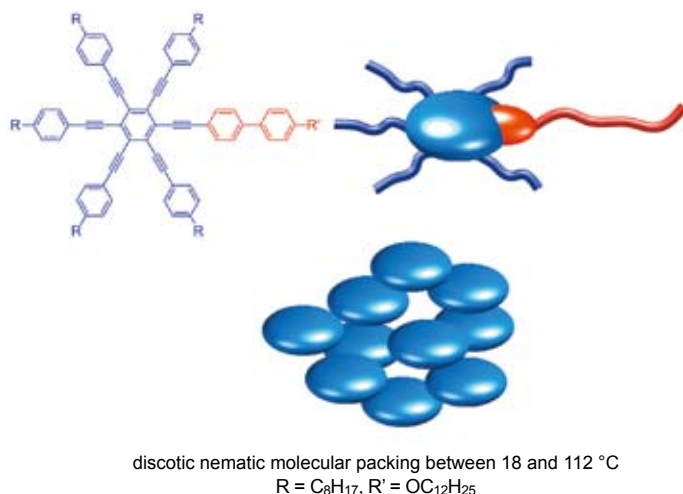


Figure 3. Room-temperature discotic nematic liquid crystals by extrusion from the disc of hexaynylbenzene. The chemical structure, schematic representations showing the extrusion of the unique sidearm, and schematic representation showing disc packing in the nematic phase.

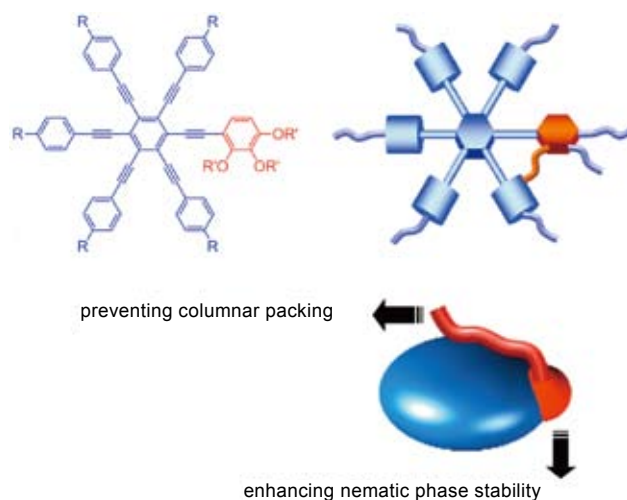
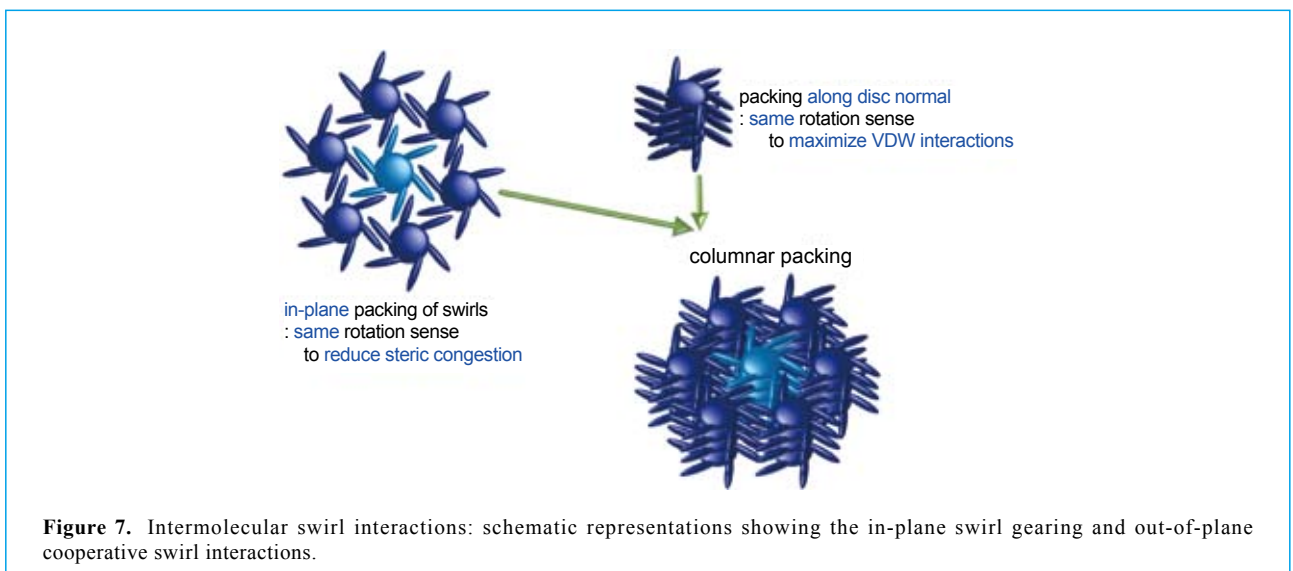
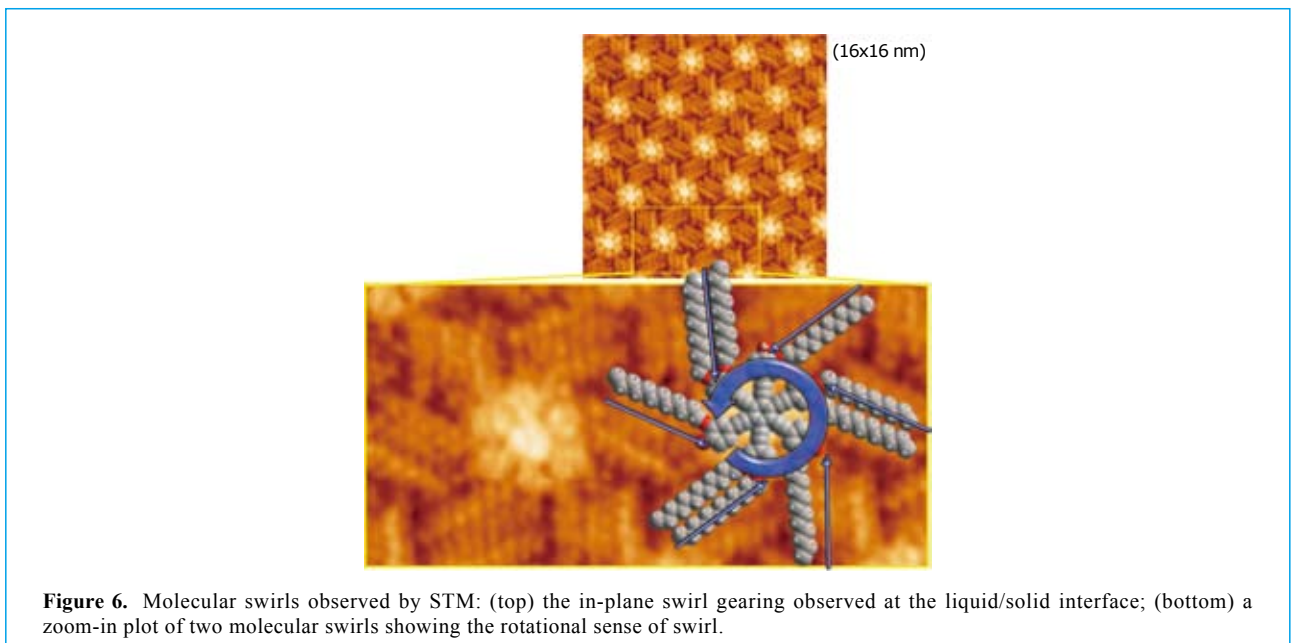
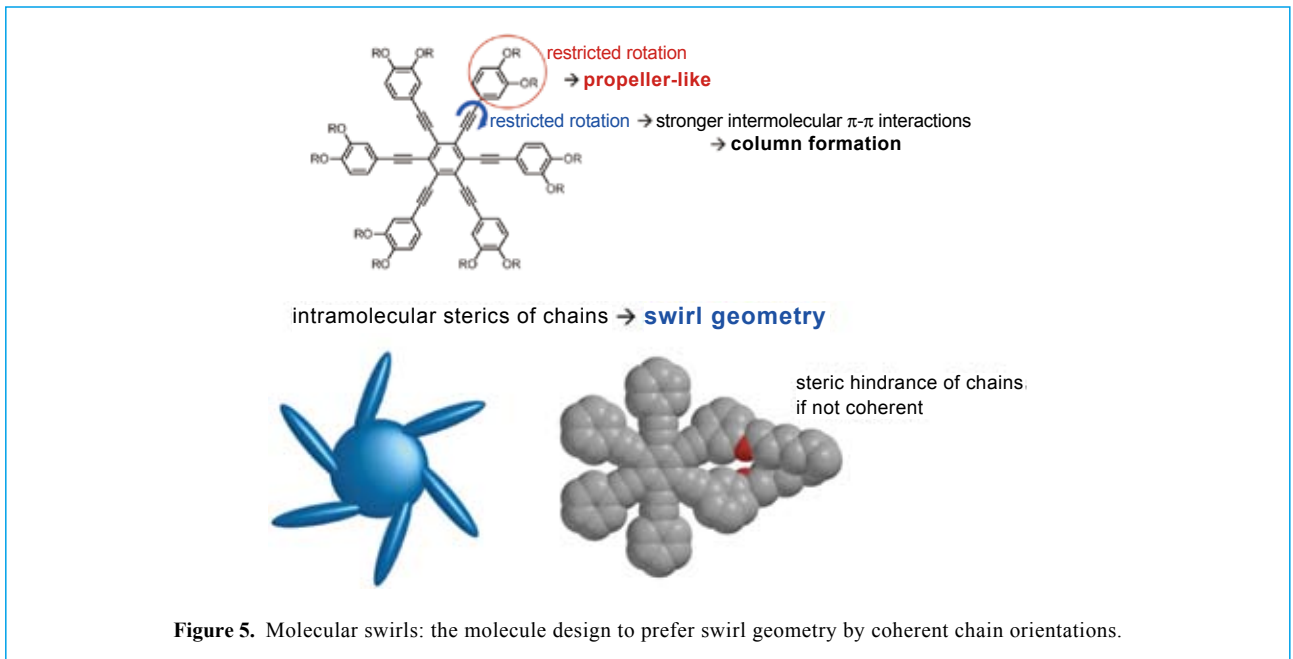


Figure 4. Lowering melting temperature and enhancing nematic liquid crystallinity by laterally attached chains to one sidearm of hexaynylbenzenes. The chemical structure, schematic representations showing the hindered rotation of the unique sidearm, and schematic representation showing the functions of the unique sidearm in the nematic phase.



Apart from rod-like and disc-like molecular shapes, molecular geometries in-between the two^{11,12} (Figure 8) have always intrigued scientists in the LC field. Moreover, due to the anisotropy along three coordinate axis of the molecular geometry, the molecular packing of such systems may lead to the formation of the biaxial nematic phase, the long been sought holy grail of LC research, if molecular packing along the three axis can be controlled individually. It should be noted that molecules in liquid crystalline states are with sufficient energy to tumble or rotate along some axis. The ordered molecular packing is in a dynamic equilibrium rather than being static in crystals. However, intermolecular packing is a result of multiple intermolecular interactions. Usually, only the major interactions comprehended and the

interplay of various interactions is difficult to predict and controlled. Generally, the more complicated the structure, the more complexed the intermolecular interactions. The key lies on the molecular design to bias intermolecular interactions along the three axis. Fine tuning the molecular structure to give nondegenerate molecular packing along the three axis was found to be the key for obtaining the biaxial nematic phase. Cross-like compounds were then synthesized. In single crystals, the molecular packing along the three axis are found to be nondegenerate (Figure 9). Similar molecular packing is also found in its nematic phase, identified by powder X-ray diffraction, resulting a biaxial nematic phase which has been confirmed by polarizing optical textures (Figure 10) and conoscopies.^{13,14}

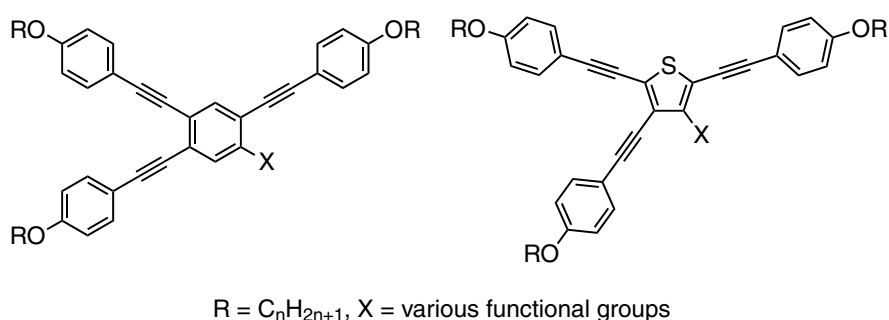


Figure 8. An unconventional molecular geometry showing liquid crystallinity: the rigid y-shaped molecules exhibiting nematic liquid crystalline phases at low melting temperatures.

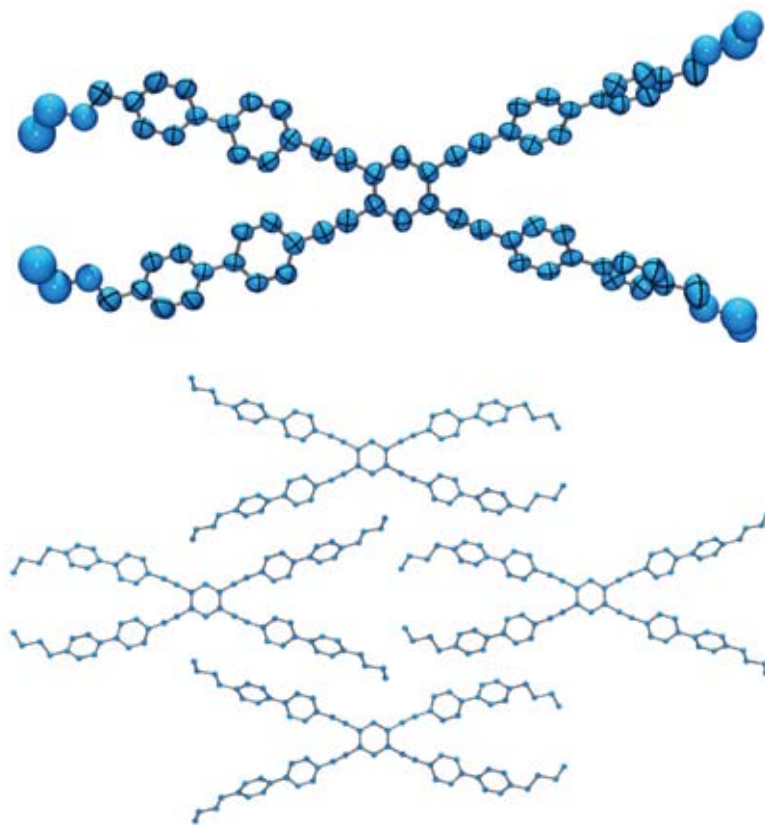


Figure 9. Cross-like molecule for optically biaxial nematic liquid crystallinity: the single crystal molecular structure (top) and the anisotropic molecular packing along the molecular plane (bottom).

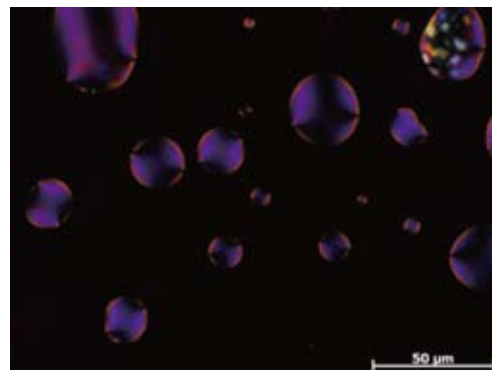
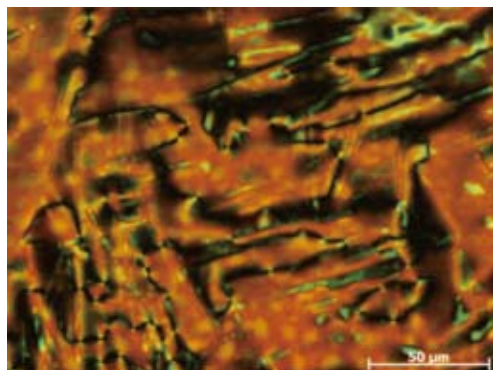
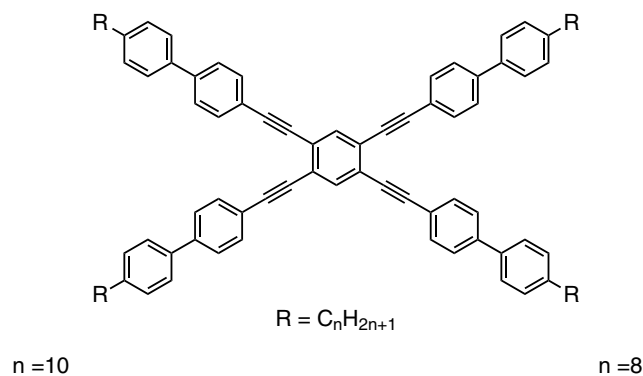


Figure 10. Polarizing optical micrographs of cross-like liquid crystalline compounds showing exclusively the two-brush characteristics suggest the phase to be biaxial nematic which was confirmed by powder X-ray diffraction and conoscopy.

Recently, my group has accidentally discovered an aggregation-induced-emission (AIE) molecular skeleton. On the way of making hexaphenylbenzene by trimerization of bisphenylalkyne, water was not excluded in the $Co_2(CO)_8$ catalyzed reaction (Figure 11). Months after taking nuclear magnetic resonance (NMR) spectra, though the molecular structure was then yet determined from the spectra, single crystals of the major product crystalized out of the solution in the NMR tube, the second accident. Moreover, the crystals are fluorescent as compared to the non-fluorescent solution. Single crystal structural determination uncovered the compound to be tetraphenyl-1,3-butadiene instead of hexaphenylbenzene.¹⁵ The beauty of this project is the switch of fluorescence of the same compound in solution and in solid.

In addition to the research work solely from my group, interesting cooperation works with other groups, domestic and international, have blossomed in recent years. Through cooperation, young students from both parties have gained a bigger scope on research. My cooperation with domestic researchers spans a wide research fields including organic chemistry, analytical chemistry, physical chemistry, supramolecular chemistry,^{16,17} polymer chemistry,¹⁸ electrical engineering,^{19,20} bioinorganic chemistry, and forestry. With long time cooperation with Prof. Long-Li Lai at National Chi-Nan University, LCs from a variety of dendrimers have been disclosed and the LC formation mechanisms of these dendrimers have been studied.²¹⁻²³ With the great assistance from Prof. Chun-hsien Chen of National Taiwan University, many high resolution STM micrographs of the dynamic molecular

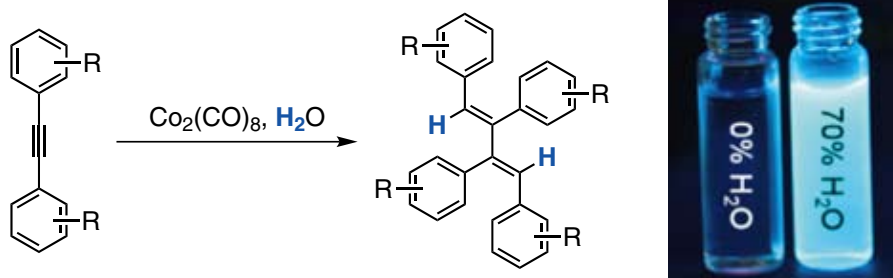


Figure 11. A new molecular skeleton showing AIE: tetraphenyl-1,3-butadienes, the synthesis and a photograph demonstrating AIE.

packing of our LC molecules at liquid/solid interface (Figure 6) have been obtained to correlate dynamic intermolecular correlations in liquid crystalline states.^{10,24,25} With Prof. Sheng-Hsien Chou, a molecular switch by an organogel was achieved.¹⁶ Phosphorescence behaviors of metallomesosens were investigated through cooperation with Prof. Yun Chi of National Tsing-Hua University and Prof. Pi-Tai Chou of National Taiwan University.²⁶ Organic nanomaterials with dynamic shape changes was investigated with Prof. Chien-Chung Cheng of National Chia-Yi University.²⁷ Recently, as the chair, I have called together a group of several scientists for an energy project. After being away from fullerene chemistry for more than fifteen years, the fullerene metal cluster chemistry comes back for this energy project.

Internationally, my group has long been involved in research cooperation with groups in Japan and France. Prof. Tohru Yamada of Keio University and I started research cooperation by student exchange first. Later, by incorporating expertise from both parties, chiral groups have been generated onto our LC systems. More importantly, the cooperation has nourished many young scientists from Japan and Taiwan. They are now involved in academic or industrial jobs in their countries. With Prof. Hsiao-Hua Yu, then at RIKEN, conjugated polymers of dioxothiophenes by direct C–H arylation has been

developed. With Prof. Michito Yoshizawa of Tokyo Institute of Technology, facile catch/release of fullerene compounds by a photo-responsive molecular tube has been disclosed.²⁸ The concept and the supra-molecular structure are again a beauty unable to resist. With Prof. Remi Chauvin of University of Toulouse, new projects are under way.

I deeply appreciate all collaborators for their kindness to let me enjoy their sciences and the beauty of their research. My group members, past and current, are acknowledged for their hard working style and their appreciation on research projects of the group. The young prospects start their young research careers from the beauty of molecules, then suffer from the originally looked easy but eventually found nontrivial chemical synthesis and property investigations, and finally comprehend the beauty of the sciences behind their projects. As some chemical providers offer various building blocks in recent years, molecular designs and chemical synthesis have been expedited, and young students can avoid some frustrations on synthesis and enjoy more of the beauty of science. I have enjoyed a lot in the journey by working with the most talented scientists by cooperation and the most promising students from my group and other interacted groups. The beauty of molecules and science behind these scientific projects lasts, and the journey towards the beauty of chemistry goes on.

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Introduction of the author:



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[Specialties] Organometallic Chemistry, Liquid Crystal Chemistry, Organic Synthesis, Material Chemistry

Compounds Composed of Two Elements (4)

Kentaro Sato

We have covered compounds consisting of carbon and one other element so far. Let us continue covering bielemental compounds and take a look at the family of nitrogen oxides this time. Nitrogen oxides are collectively called NO_x and infamously known as the cause of air pollution. Nevertheless, their structures are diverse and there are many important examples.

Dinitrogen Monoxide (N₂O)

Dinitrogen monoxide (N₂O), which is also known as nitrous oxide, is a colorless gas. It has resonance structures as shown below.

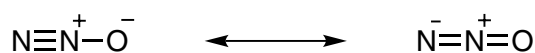
Nitrous oxide was discovered in 1772 by Joseph Priestley in England. Because the inhalation of the gas causes drunk feeling and cramping of facial muscles (which causes smiley expression), it is called “laughing gas.” Back then, N₂O was a popular recreational gas and there were said to be shows featuring the euphoric effects of inhaling it. The participants of the show laughed out loud on the stage, walked around randomly while bowing repeatedly, stepped into the audience and tried to walk over them, so these shows must have been quite chaotic.

However, people began to learn to use the biochemical effects of N₂O for more productive purposes, such as for anesthesia during dental treatment. For thousands of years, the patients of surgical operations had had to endure the pain, so the advent of anesthesia by laughing gas was a historic discovery. Many other analgesic substances were introduced later, but nitrous oxide is still used today for its potent pain-relieving effect.

On the other hand, nitrous oxide is known as the strongest ozone-destroying substance and also has about 300 times stronger greenhouse effect than carbon dioxide. Considering the impact it has on the environment, it is one of the gases we should avoid as much as possible.

Nitrogen Monoxide (NO)

Nitrogen monoxide (NO) is also a colorless gas, which is produced by reacting nitrogen and oxygen under high temperature conditions. Another way of generating it is from the reaction between copper and dilute nitric acid, which is an experiment some people might remember from middle school chemistry class.



The first person who synthesized nitrogen monoxide is considered to be the sixteenth-seventeenth century Belgian scientist Jan Baptist van Helmont, who is also known to have coined the word *gas* from *chaos*. However, the aforementioned Joseph Priestley is generally credited as the one who analyzed it carefully and left a systematic record.

Nitrogen monoxide is toxic and inhaling it causes symptoms of the central nervous system and the loss of consciousness in just a few minutes. It is oxidized in the body to produce nitric acid and nitrous acid, both of which can damage the respiratory organs. It is a rather scary substance, though it may not be as serious as nitrogen dioxide.

Nitrogen monoxide, however, has important biological functions too. For example, it helps increase the blood flow by relaxing the smooth muscle of blood vessels. The reason that nitroglycerin and amyl nitrite are used as the medications of coronary heart disease is because these prodrugs decompose to produce nitrogen monoxide in the body. Interestingly, this mechanism of action is associated with how other drugs work too, including Viagra.

The role of nitrogen monoxide, which is naturally a toxic gas, as a biological signaling agent in the cardiovascular system was discovered by Louis Ignarro, Rober Furchgott, and Ferid Murad. The three scientists were awarded the Nobel Prize in Physiology or Medicine in 1998, which was undisputable considering the significance of the discovery.

Nitrogen monoxide is also involved in the activation of the immune system. Macrophages, which are one of the immune cells, produce a large amount of nitrogen monoxide to kill pathogens. However, for septic patients, generation of too much NO can lead to excessive vasodilation and dangerous levels of hypotension. Despite being consisting of only two atoms, the biological role of nitrogen monoxide is surprisingly profound.

Nitrogen Dioxide (NO₂)

Just like nitrogen monoxide, nitrogen dioxide is a stable free radical species. It is a rare gas noticeably colored brown, and the color originates from its structure in which the unpaired electron is delocalized throughout the molecule. The unpaired electron is also the reason why the molecule is V-shaped at the central nitrogen atom, unlike the linear molecule of carbon dioxide.

Besides having a high inflammatory effect on the respiratory system, NO₂ has a property to hinder the transport of oxygen by competitively binding to hemoglobin. It also reacts with oxygen in the air promoted by ultraviolet irradiation to produce toxic ozone, which is the main cause of so-called photochemical smog. When it is dissolved in water, NO₂ becomes nitric acid and nitrous acid, thus is responsible for acid rain. In addition, it is a strong oxidant that can form explosive substances upon contact with flammable compounds such as hydrocarbons. All in all, this is one of the least environmentally friendly substances.

In a laboratory, it can be generated by adding concentrated nitric acid to copper. In nature, it is formed by processes such as lightning-induced reactions and carried to the ground dissolved in rainwater. The resulting nitrate salts are absorbed by plants as nutrients and become a part of biological constituents such as proteins. This is an important nitrogen fixation process occurring in the natural world.

Dinitrogen Tetroxide (N₂O₄)

There is an equilibrium between nitrogen dioxide and dinitrogen tetroxide, which shifts towards the latter at low temperatures. Dinitrogen tetroxide is no longer a free radical species and has no color, but it still tends to be slightly colored due to the small amount of nitrogen dioxide present in the mixture.

One of the important applications of N₂O₄ is its use as a rocket propellant. As a strong oxidizer, N₂O₄ reacts with hydrazine compounds, the fuel, to form a “hypergolic” propellant. It was used for sending rockets such as the American Titan and the Chinese Chang Zheng out of the stratosphere, making contributions to the outer space development. However, it is highly toxic and there has been a concern about its impact on the environment.

Dinitrogen Trioxide (N₂O₃)

Although not as well-known as the ones we have seen so far, dinitrogen trioxide (N₂O₃) also exists. It is formed when nitrogen monoxide and nitrogen dioxide are combined at low temperatures. In gas phase, it dissociates back to NO and NO₂, so it can only exist as either liquid or solid.

As shown below, the structure of N_2O_3 is the one that contains an N–N bond, and the other plausible structure corresponding to nitrous acid anhydride ($O=N-O-N=O$) is not known. The latter is probably too unstable to exist long enough to be detected.

Dinitrogen Pentoxide (N_2O_5)

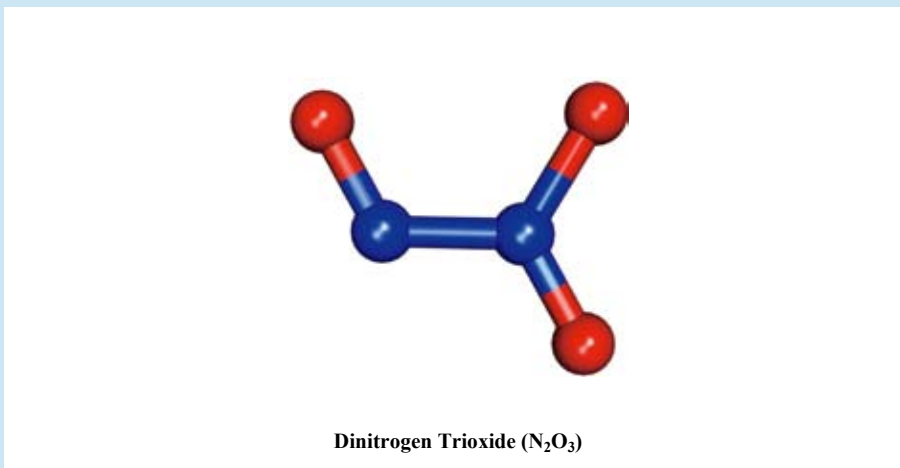
Unlike the other NO_x compounds, dinitrogen pentoxide is a solid at room temperature because it is actually an ionic species consisting of NO_3^- and NO_2^+ ions. In gas phase, it exists as a neutral molecule with the structural formula of $O_2N-O-NO_2$. Its handling requires care, however, since it spontaneously decomposes to nitrogen dioxide and oxygen even at room temperature.

This molecule corresponds to the anhydride of nitric acid, and it can be obtained by dehydration of nitric acid by phosphorus pentoxide. It gradually reverts back to nitric acid when it reacts with the moisture in the air.

Trinitramide (Tetranitrogen Hexoxide, N_4O_6)

The latest addition to the nitrogen oxide family is trinitramide having the molecular formula of N_4O_6 . It was the first member in 170 years, with the last one preceding it being dinitrogen pentoxide discovered in 1840. As you can see in the picture below, it can be called the triamide form of nitric acid. It was synthesized by the reaction of potassium dinitramide ($KN(NO_2)_2$) with nitronium tetrafluoroborate (NO_2BF_4) at a low temperature. In contrast to dinitrogen tetroxide, which has a completely planar structure, trinitramide has a propeller-like twisted shape.

It is obviously an extremely high-energy compound and it is too unstable to exist at room temperature. As a rocket propellant oxidizer, it is thought to be 20 to 30% more efficient than its conventional counterparts, and its chlorine-free nature makes it environmentally friendlier. It is possible that rockets in near future will fly to the outer space using this compound as a fuel component.



The structural possibility of nitrogen oxide compounds is wide open on paper, but actual synthesis of them is probably among the most challenging. Let us wait for the next member to join in, though it may take a long time.

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[Brief career history] He was born in Ibaraki, Japan, in 1970. 1995 M. Sc. Graduate School of Science and Engineering, Tokyo Institute of Technology. 1995-2007 Researcher in a pharmaceutical company. 2008-Present Freelance science writer. 2009-2012 Project assistant professor of the graduate school of Science, the University of Tokyo. 2014-present Publicist for π -system figuration, scientific research on innovative areas.

[Specialty] Organic chemistry

[Website] The Museum of Organic Chemistry <<http://www.org-chem.org/yuuki/MOC.html>>

Reagents for Perovskite Solar Cells: Highly Pure Lead(II) Halides

L0279	Lead(II) Iodide (99.99%, trace metals basis) (1)	1g	5g	25g
L0288	Lead(II) Bromide (2)	1g	5g	25g
L0292	Lead(II) Chloride (3)	1g	5g	25g
L0291	Lead(II) Chloride (purified by sublimation) (4)	1g	5g	

Recently, intensive research on the perovskite solar cell was developed to provide 20% power conversion efficiency (PCE) that is comparable with PCE of the CIGS solar cell.¹⁾ The perovskite solar cell is solution-processible for manufacturing at low cost. Normally, use of pure materials can provide a high PCE with reproducibility.

Lead(II) halides (1–4) are highly pure materials manufactured by our purification technology. For instance, lead(II) iodide (1) has extremely low water content and we can assure 99.99% purity on a trace metal basis. 1 is soluble in DMF and other organic solvents to give very clear solutions, thus it is excellent for solution-processible device fabrications (eg. one-step solution, two-step solution, etc).^{2,3)} A mixing of lead(II) bromide (2) and other halogenated materials in a one-step solution process can provide solar cell devices with various absorption wavelengths. In addition, a lead(II) bromide-based perovskite fabricated a light-emitting diode.⁴⁾ We also provide lead(II) chloride (3) for solar cell use as well as the other lead(II) chloride (4) having a sublimed grade. Lead(II) chloride is useful for vapor deposition with methylammonium iodide (MAI) for fabricating a solar cell device, and for one-solution processible devices by mixing with MAI (1:3 ratio).⁵⁾

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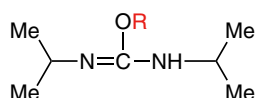
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Organic onium salts with low water content:

M2556	Methylamine Hydroiodide (Water <100 ppm)	1g	5g	25g
M2589	Methylamine Hydrobromide (Water <100 ppm)	1g	5g	
F0974	Formamidine Hydroiodide (Water <100 ppm)	1g	5g	
F0973	Formamidine Hydrobromide (Water <100 ppm)	1g	5g	
I0970	Imidazole Hydroiodide (Water <100 ppm)	1g	5g	
A2902	Acetamidine Hydroiodide (Water <100 ppm)	1g	5g	

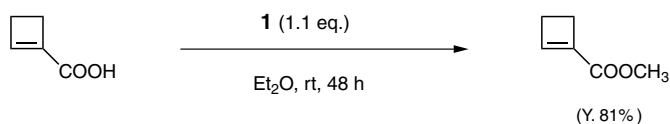
Alkylation Reagents for Ester Synthesis

D4587	<i>N,N'</i> -Diisopropyl- <i>O</i> -methylisourea (1)	5mL
E1058	<i>O</i> -Ethyl- <i>N,N'</i> -diisopropylisourea (2)	5mL 25mL
T3123	<i>O,N,N'</i> -Triisopropylisourea (3)	5mL 25mL
B4178	<i>O-tert</i> -Butyl- <i>N,N'</i> -diisopropylisourea (4)	1g 5g
B4480	<i>O</i> -Benzyl- <i>N,N'</i> -diisopropylisourea (5)	1mL 5mL

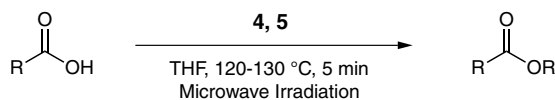


- 1: R = Me
- 2: R = Et
- 3: R = *i*-Pr
- 4: R = *t*-Bu
- 5: R = Bn

O-Alkylisoureas (1) to (5) are convenient and useful esterification reagents for the direct alkylation of carboxylic acids. For example, Golding *et al.* have reported the esterification of 1-cyclobutenecarboxylic acid using 1, affording the corresponding methyl ester.¹⁾



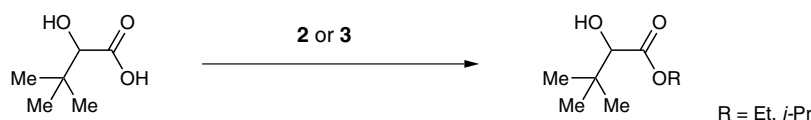
Moreover, Linclau *et al.* have reported the microwave-accelerated esterification of carboxylic acids using 4 and 5, affording the corresponding esters in excellent yields within several minutes.²⁾



Entry	Isourea (eq.)	Carboxylic acid	Yield (%) of ester ^{a)}
1	5 (1.3)		83
2	4 (4.5)		87

a) Isolated yield after column chromatography.

For another example, the esterification reaction using 2 and 3 also has been reported as below.³⁾



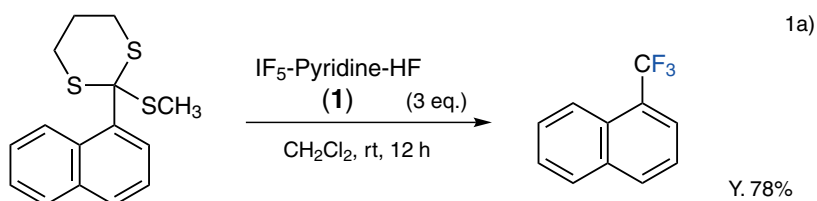
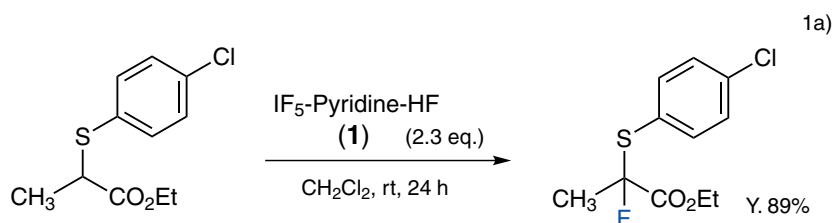
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A New Stable Fluorinating Reagent with Ease of Handling (Hara Reagent)

P2140 IF₅-Pyridine-HF (1)

1g 5g 25g



IF₅-Pyridine-HF (**1**), which was first reported by Hara *et al.*, is a novel fluorinating reagent. **1** is a crystalline solid reagent with air stability and non-hygroscopicity which makes it easier to handle. **1** can be applied to various fluorination reactions of sulfides.¹⁾ In addition, **1** iodofluorinates alkenes with stereo- and regioselectivity.²⁾

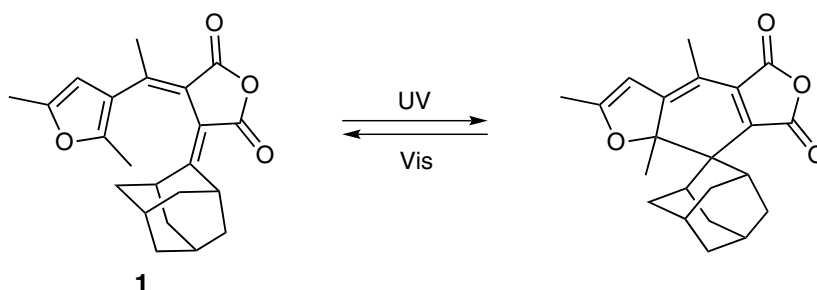
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Fulgide-Type Photochromic Material: Aberchrome 670

A2869 Aberchrome 670 (1)

200mg 1g

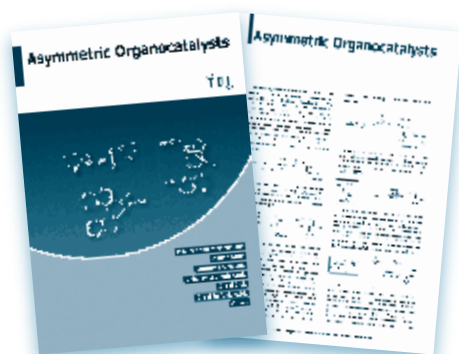


Diarylethenes¹⁾ and fulgides²⁾ are P-type photochromic materials in which these ring-closed forms are thermally stable but open to provide the original compounds by irradiation with visible light. Aberchrome 670 (1) that is a fulgide-type photochromic material has been entered into our product-line.

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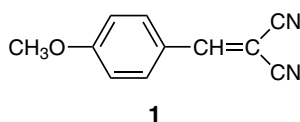


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Kinase Inhibitor

T3074 Tyrphostin A1 (1)

200mg 1g



Tyrphostins are small molecules which are designed to bind to the substrate subsite of the protein tyrosine kinase (PTK) domain.¹⁾ Tyrphostin A1 (**1**) inhibits STAT4 phosphorylation.²⁾ STAT3 phosphorylation is also down-regulated by **1**.²⁾ On the other hand, because of acting epidermal growth factor receptor kinase (EGFRK) with a high IC₅₀ (>1,250 μM),¹⁾ **1** is sometimes used as a negative control.^{3,4)}

1 has been used for enhancement of rAAV (recombinant adeno-associated virus) mediated transgene expression.⁵⁾ The research article shows that, when the cells were treated at 500 μM of **1**, a 1,000-fold enhancement was achieved up to 100 virus articles per cell level.⁵⁾

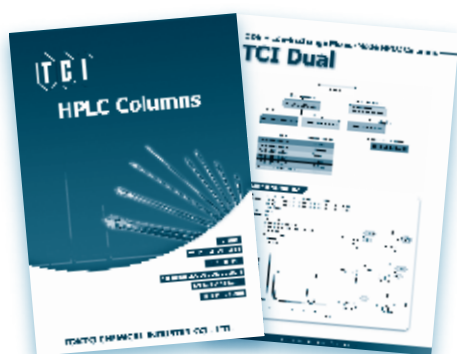
STAT: signal transducer and activator of transcription

This product is for research purpose only.

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