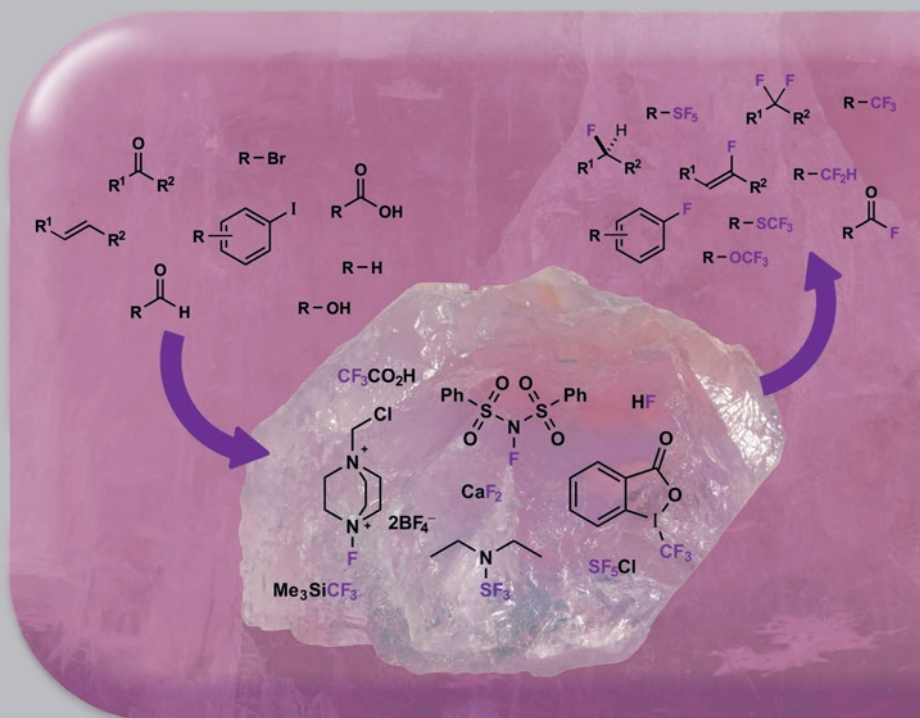




Science of Synthesis

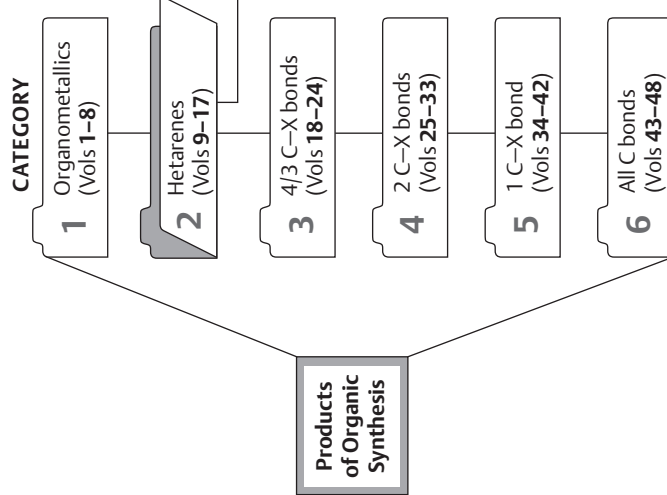
Modern Strategies in Organofluorine Chemistry 2

Volume Editor
J.-F. Paquin



Thieme

Organizational Structure of Science of Synthesis*



Classification is **based on the product**, with all products belonging to one of six broad-ranging categories. All products occupy a strict hierarchical position in Science of Synthesis, defined according to the classification principles*. Products in Categories 3-6 are organized according to oxidation state, with products containing the greatest number of carbon-heteroatom (C-X) or C-C π -bonds to a single carbon occupying the highest positions (e.g., carboxylates, enolates, and alcoholates are covered in Categories 3, 4, and 5, respectively).

Each category is subdivided into volumes (see opposing page), each of which is devoted to discrete groupings of compounds called **product classes** (e.g., "Thiophenes" is Product Class 10 of Volume 9). Product classes may be further subdivided into **product subclasses**, (e.g., "Thiophene 1,1-Dioxides" is Product Subclass 3 of Product Class 10 of Volume 9). Consequently, the relationship between heading name and heading number varies below product class level within individual volumes.

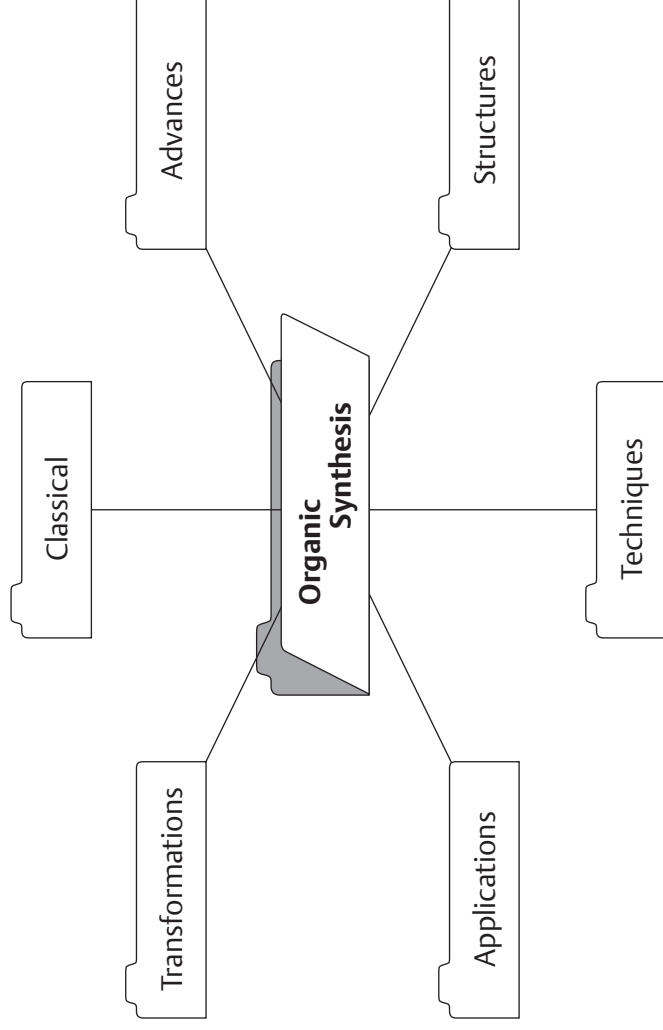
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For each product class or subclass, a number of methods are described for synthesizing the general product type. Often there are variations on a method given. Both methods and variations contain experimental procedures with relevant background information and literature references. **Selected products and reactions** display the scope and limitations of the methods.

* A complete description of the full classification principles can be found in the **Science of Synthesis Guidebook**.

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Science of Synthesis

Science of Synthesis is the authoritative and comprehensive reference work for the entire field of organic and organometallic synthesis.

Science of Synthesis presents the important synthetic methods for all classes of compounds and includes:

- Methods critically evaluated by leading scientists
- Background information and detailed experimental procedures
- Schemes and tables which illustrate the reaction scope



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Volume Editor

J.-F. Paquin

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Preface

As the pace and breadth of research intensifies, organic synthesis is playing an increasingly central role in the discovery process within all imaginable areas of science: from pharmaceuticals, agrochemicals, and materials science to areas of biology and physics, the most impactful investigations are becoming more and more molecular. As an enabling science, synthetic organic chemistry is uniquely poised to provide access to compounds with exciting and valuable new properties. Organic molecules of extreme complexity can, given expert knowledge, be prepared with exquisite efficiency and selectivity, allowing virtually any phenomenon to be probed at levels never before imagined. With ready access to materials of remarkable structural diversity, critical studies can be conducted that reveal the intimate workings of chemical, biological, or physical processes with stunning detail.

The sheer variety of chemical structural space required for these investigations and the design elements necessary to assemble molecular targets of increasing intricacy place extraordinary demands on the individual synthetic methods used. They must be robust and provide reliably high yields on both small and large scales, have broad applicability, and exhibit high selectivity. Increasingly, synthetic approaches to organic molecules must take into account environmental sustainability. Thus, atom economy and the overall environmental impact of the transformations are taking on increased importance.

The need to provide a dependable source of information on evaluated synthetic methods in organic chemistry embracing these characteristics was first acknowledged over 100 years ago, when the highly regarded reference source **Houben–Weyl Methoden der Organischen Chemie** was first introduced. Recognizing the necessity to provide a modernized, comprehensive, and critical assessment of synthetic organic chemistry, in 2000 Thieme launched **Science of Synthesis, Houben–Weyl Methods of Molecular Transformations**. This effort, assembled by almost 1000 leading experts from both industry and academia, provides a balanced and critical analysis of the entire literature from the early 1800s until the year of publication. The accompanying online version of **Science of Synthesis** provides text, structure, substructure, and reaction searching capabilities by a powerful, yet easy-to-use, intuitive interface.

From 2010 onward, **Science of Synthesis** is being updated quarterly with high-quality content via **Science of Synthesis Knowledge Updates**. The goal of the **Science of Synthesis Knowledge Updates** is to provide a continuous review of the field of synthetic organic chemistry, with an eye toward evaluating and analyzing significant new developments in synthetic methods. A list of stringent criteria for inclusion of each synthetic transformation ensures that only the best and most reliable synthetic methods are incorporated. These efforts guarantee that **Science of Synthesis** will continue to be the most up-to-date electronic database available for the documentation of validated synthetic methods.

Also from 2010, **Science of Synthesis** includes the **Science of Synthesis Reference Library**, comprising volumes covering special topics of organic chemistry in a modular fashion, with six main classifications: (1) Classical, (2) Advances, (3) Transformations, (4) Applications, (5) Structures, and (6) Techniques. Titles will include *Stereoselective Synthesis*, *Water in Organic Synthesis*, and *Asymmetric Organocatalysis*, among others. With expert-evaluated content focusing on subjects of particular current interest, the **Science of Synthesis Reference Library** complements the **Science of Synthesis Knowledge Updates**, to make **Science of Synthesis** the complete information source for the modern synthetic chemist.

The overarching goal of the **Science of Synthesis** Editorial Board is to make the suite of **Science of Synthesis** resources the first and foremost focal point for critically evaluated information on chemical transformations for those individuals involved in the design and construction of organic molecules.

Throughout the years, the chemical community has benefited tremendously from the outstanding contribution of hundreds of highly dedicated expert authors who have devoted their energies and intellectual capital to these projects. We thank all of these individuals for the heroic efforts they have made throughout the entire publication process to make **Science of Synthesis** a reference work of the highest integrity and quality.

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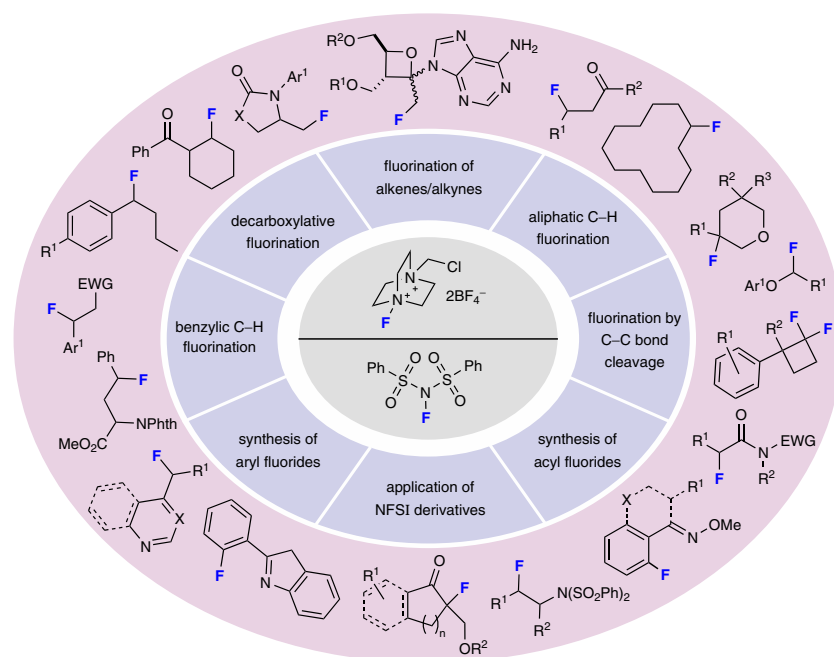
Abstracts

p 3

2.1 Electrophilic Fluorinating Agents

D. Saha, T. Aggarwal, Y. Sumii, A. K. Yadav, and N. Shibata 

Fluorine is a uniquely reactive element, and its incorporation via electrophilic fluorination has driven significant advances in synthetic organic chemistry. The development of stable, selective, and user-friendly fluorinating reagents has revolutionized methods for the controlled introduction of fluorine atoms. In this review, we highlight the pivotal roles of Selectfluor and NFSI in enabling the synthesis of a broad range of organofluorine compounds through C(sp³)–H and C(sp²)–H bond functionalization over the past two decades. Although both reagents were originally developed for electrophilic fluorination, their utility has since expanded to include radical and oxidative fluorination processes, particularly under transition-metal catalysis and photocatalytic conditions.

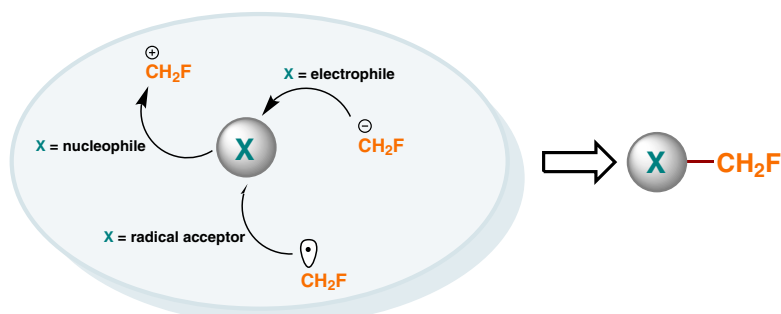


Keywords: fluorine · fluorination · radical reactions · transition metals · photocatalysis · Selectfluor · *N*-fluorobenzenesulfonamide

2.2 Synthesis of Monofluoromethylated Compounds

A. Das^{ID}, N. Ramkumar^{ID}, and J. Veliks^{ID}

The incorporation of monofluoromethyl groups into organic scaffolds has emerged as a prominent area of interest since the mid-20th century, driven by the unique biological properties these groups impart. This substituent functions as a versatile bioisostere for methyl and hydroxymethyl groups, with the capacity to form subtle hydrogen bonds that significantly impact molecular recognition and pharmacological behavior. In contrast to the well-established di- and trifluoromethylation reactions, monofluoromethylation remains synthetically challenging due to the inherent instability and high reactivity of monofluoromethyl reagents. Since the early 1980s, substantial efforts have been dedicated to developing reliable, cost-effective, and practical methodologies for monofluoromethyl group introduction. This review summarizes recent advances in reagent design and synthetic strategies for achieving selective and efficient monofluoromethylation, underscoring its growing importance in drug discovery and functional materials.

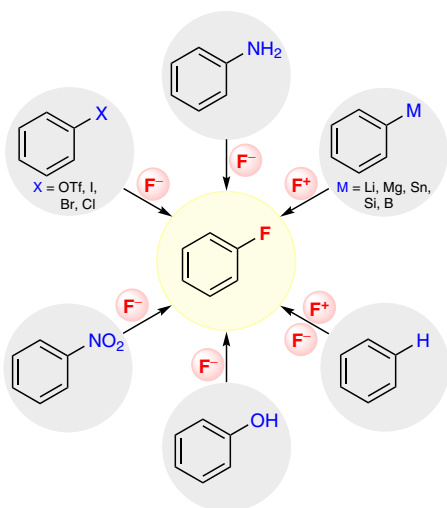


Keywords: organofluorine chemistry · C–F bond formation · monofluoromethylation · fluoro-methyl reagents · intramolecular fluorination · transition-metal catalysis · photochemistry · electrochemistry · mechanochemistry

2.3 Synthesis of Aryl and Hetaryl Fluorides

X. Wang^{id} and J. Hu^{id}

Aryl and hetaryl fluorides, as important structural motifs, are widely applied in pharmaceuticals, agrochemicals, positron emission tomography (PET) imaging agents, and organic materials. Profound changes in properties such as solubility, lipophilicity, bioavailability, and/or metabolic stability of the target molecules have been imparted via the introduction of fluorine atoms. Thus, much effort has been contributed to the synthesis of (het)aryl fluorides. In this review, we discuss the key developments in the synthesis of (het)aryl fluorides based on nucleophilic substitution of diazo, (pseudo)halo, nitro, and phenolic hydroxy groups, as well as electrophilic substitution of hydrogen and organometallic groups, both with and without the assistance of transition-metal catalysis.

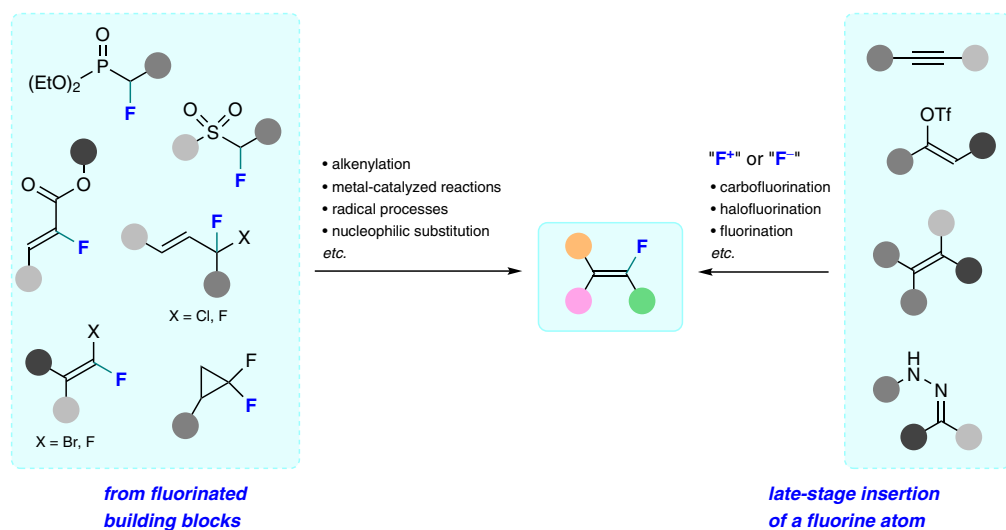


Keywords: fluorine · aryl fluorides · hetaryl fluorides · nucleophilic substitution · diazo compounds · nitro compounds · phenols · electrophilic substitution

2.4 Monofluoroalkenes

S. Couve-Bonnaire^{ID}, T. Castanheiro^{ID}, and J.-P. Bouillon^{ID}

Monofluorinated alkenes have emerged as an important class of versatile molecules; this structural unit is notably found in various bioactive compounds and also serves as an organic synthesis platform toward more-complex fine molecules. The fluoroalkene moiety is also known as a stable isosteric and isoelectronic mimic of the amide bond. Thus, this motif can also be used as a bioisostere in structure–activity relationship studies in pharmaceutical and agrochemical domains to circumvent problems associated with peptides, such as poor membrane permeability and poor in vivo stability. This review focuses on synthetic strategies for the preparation of monofluoroalkenes derived from a selection of protocols published in the period 2013–2023. Given the large diversity of methods for preparing monofluoroalkenes, the focus herein is on monofluoroalkenes that have carbon or hydrogen atoms on the alkene (in addition to fluorine). The review is divided into two parts according to the two main strategies to access monofluoroalkenes: the use of fluorinated building blocks or by using fluorination agents.

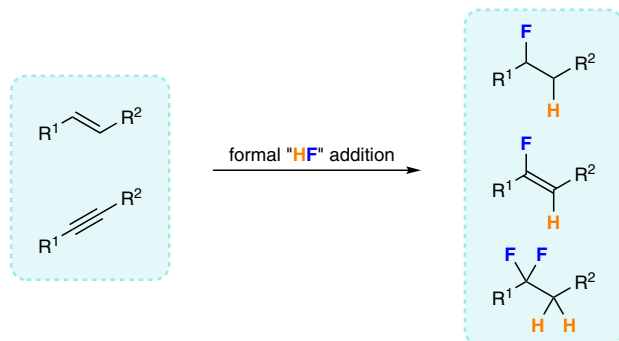


Keywords: organofluorine chemistry · fluorine · fluoroalkenes · alkenylation · metal catalysis · fluorinated building blocks · allyl difluorides · difluorocyclopropanes · bromofluoroalkenes · difluoroalkenes · radical reactions · nucleophilic substitution · nucleophilic fluorination · electrophilic fluorination

2.5 Hydrofluorination of Alkenes and Alkynes

X. Bertrand^{id} and J.-F. Paquin^{id}

This is a comprehensive review on the synthesis of fluoroalkanes, monofluoroalkenes, and *gem*-difluoroalkanes by hydrofluorination of alkenes and alkynes. Various strategies have been reported for such transformations, including those based on the use of HF complexes, transition-metal catalysis, photochemistry, and electrochemistry. The substituents and the substitution pattern are shown to have a drastic impact on the reactivity. Therefore, particular conditions have been developed for the specific classes of substrate (such as styrenes, ynamides, and haloalkynes) that are presented in this chapter. Finally, radiofluorination using this type of approach is also discussed.

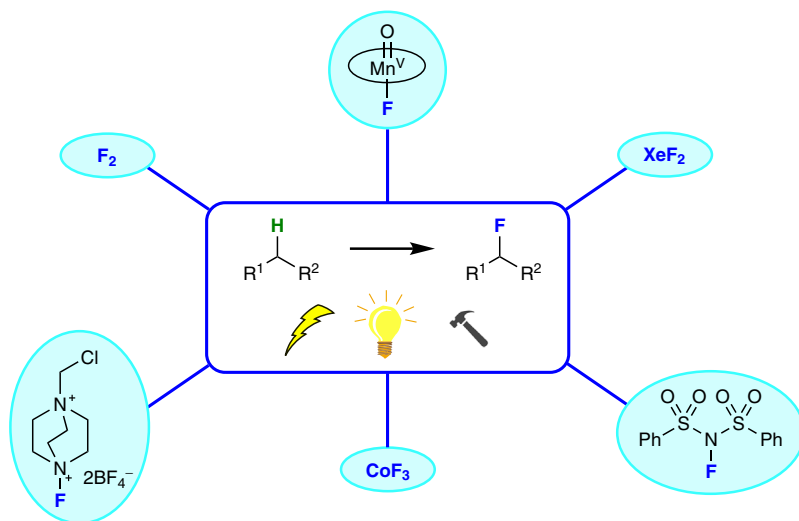


Keywords: organofluorine · hydrofluorination · alkenes · alkynes · addition reactions · monofluoroalkenes · monofluorination · difluorination · transition-metal catalysis · photochemistry · electrochemistry · radiofluorination

2.6 Direct Fluorination of C(sp³)—H Bonds

J. Ruskin^{id} and T. Lectka^{id}

Ever since the legendary era of Henri Moissan and his isolation of fluorine gas, chemists have sought to harness new reagent technology for achieving fluorination at C—H positions. The development of new reagents, from *N*-fluorobenzenesulfonimide (NFSI) to Selectfluor, has aided in the quest. In this review, we explore methods for the fluorination of otherwise unactivated C—H bonds, with a particular focus on aliphatic substrates through predominately radical-based approaches.

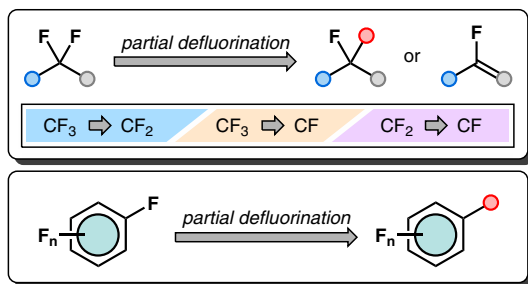


Keywords: fluorine · organofluorine chemistry · radical fluorination · C—H bond activation · late-stage functionalization · photochemistry · aliphatic fluorination · mechanochemistry · electrosynthesis · N—F reagents

2.7 Exploiting C—F Bond Activation for the Synthesis of Organofluorine Compounds

T. Semeniuk^{1b} and J.-D. Hamel^{1b}

The partial defluorination of polyfluorinated organic compounds is an alternative route to construct lightly fluorinated organic molecules that relies on C—F bond activation. Attaining selectivity for partial defluorination can be highly challenging, as C—F bond strength typically decreases after each defluorinative event. This review highlights effective methods to achieve carbon–element bond formation or perform elimination reactions that result in a broad range of (het)aryl, vinyl, allenyl, (hetero)benzyl, and allyl fluorides, as well as α -fluorinated carbonyl derivatives.

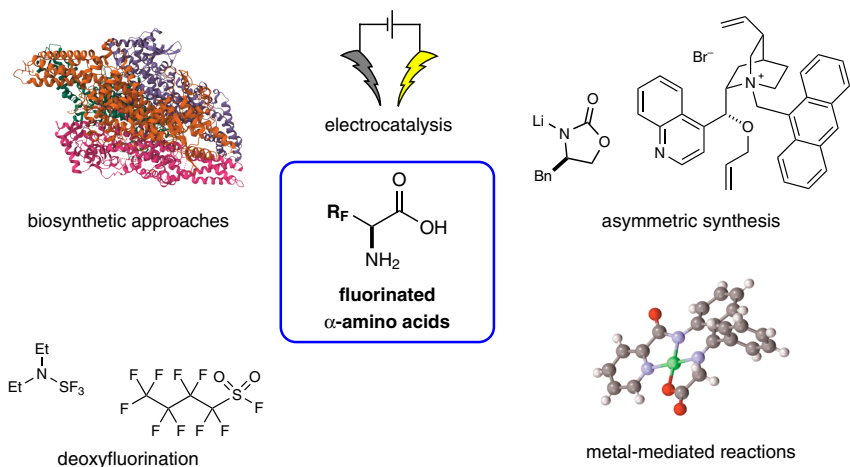


Keywords: fluorine · organofluorine chemistry · organic fluorides · C—F activation · C—F functionalization · partial defluorination · enantioselective synthesis · diastereoselective synthesis · nucleophilic aromatic substitution · cross coupling · photocatalysis · transition-metal catalysis · electrochemistry

2.8 Synthetic Approaches to Fluorinated α -Amino Acids

C. M. Lloyd^{1b}, K. F. Dowell^{1b}, and W. D. G. Brittain^{1b}

Fluorine incorporation into peptides and biomolecules is an area that has seen rapid growth over the last few decades. The installation of fluorine atoms into peptides can improve their stability, potency, and membrane permeability, offering substantial benefits in pharmaceutical applications. Being able to introduce fluorine into these classes of molecules often relies on the ability to access the prerequisite fluorinated amino acid building blocks. This review will summarize the advancements made by synthetic chemists to access proteinogenic fluorinated α -amino acids including biosynthetic, electrochemical, and enantioselective approaches.

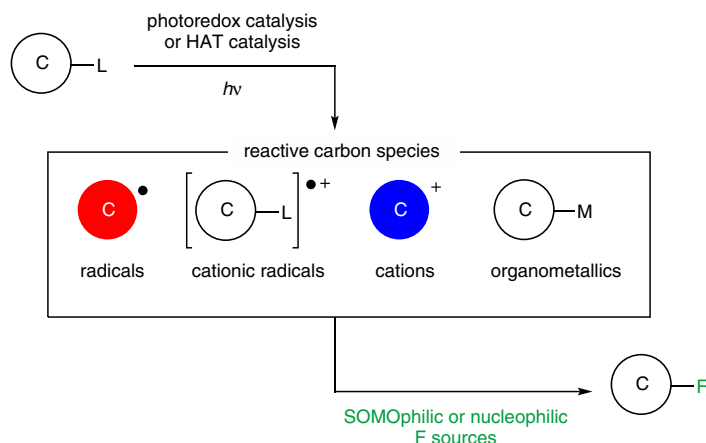


Keywords: fluorine · organofluorine chemistry · amino acids · peptide synthesis · fluorination · asymmetric synthesis · trifluoromethylation · electrochemistry · biosynthesis

2.9 Fluorination Enabled by Photoredox Reactions

T. Koike 

In recent years, photoredox catalysis has become a useful strategy in the field of synthetic chemistry because generation of reactive radicals, ionic species, and organometallics under mild reaction conditions can be realized. This review mainly discusses fluorination reactions of carbon skeletons using photoredox catalysis. In addition, seminal works on photochemical hydrogen-atom transfer (HAT) and photocatalyst-free photoinduced electron-transfer systems are also handled. These systems can be applied to fluorination reactions of C–H bonds, C–C bonds, C=C bonds, and appropriate functional groups.

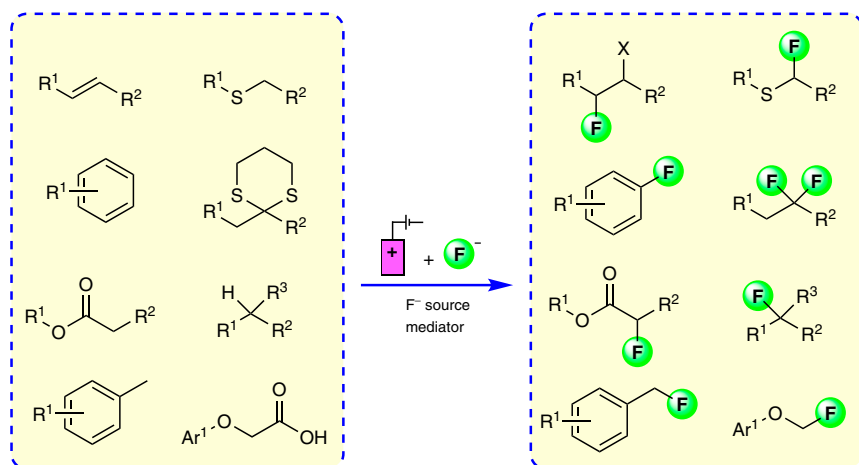


Keywords: photoredox catalysis · metallaphotoredox catalysis · hydrogen-atom transfer (HAT) · photoinduced electron transfer · single-electron transfer (SET) · redox reactions · radicals · ionic radicals · carbocationic species · organometallics · SOMOphilic fluorination · nucleophilic fluorination · C–H functionalization

2.10 Fluorination Enabled by Electrochemistry

S. Inagi^{1b}, K. Taniguchi^{1b}, and K. Lam^{1b}

Organic electrosynthesis, which involves the electrochemical activation of organic molecules for subsequent reactions, offers a more environmentally friendly alternative to traditional synthetic methods by enabling oxidation and reduction processes without relying on hazardous or toxic reagents. Electrochemical fluorination, in particular, represents a safer and cleaner approach compared to conventional chemical fluorination methods. This review highlights the advancements in fluorination enabled by electrochemistry, providing an overview of methodologies employing nucleophilic and electrophilic fluorine sources, with a focus on recent trends and innovations in the field.

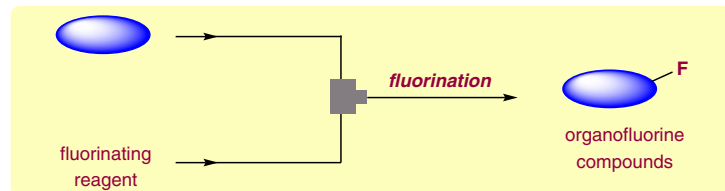


Keywords: fluorine · fluorination · electrosynthesis · electrochemistry · anodic fluorination · hydrogen fluoride · mediators · Selectfluor · radical fluorination

2.11 Fluorination Reactions under Flow Conditions

H. Amii^{1b}

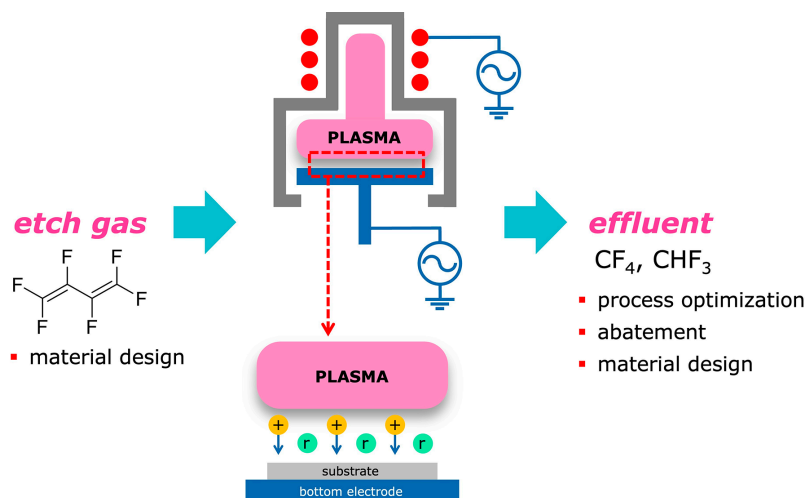
Fluorine-containing organic compounds are useful substances across diverse fields of science and technology owing to their unique physical and chemical properties. Due to the demands of human life, the development of new synthetic methods for preparing organofluorine compounds continues to attract significant attention. Flow synthesis has been explored as a technique for the production of such chemicals with high efficiency and selectivity. In this review, recent advances in the fluorination of organic molecules using flow microreactor systems are discussed.



Keywords: fluorine · flow microreactors · fluorination · nucleophilic fluorination · electrophilic fluorination · radical fluorination · photoredox reactions · electrochemical synthesis

2.12 Industrial Applications of Fluorine Chemistry in Plasma Etch GasesP. Kirsch 

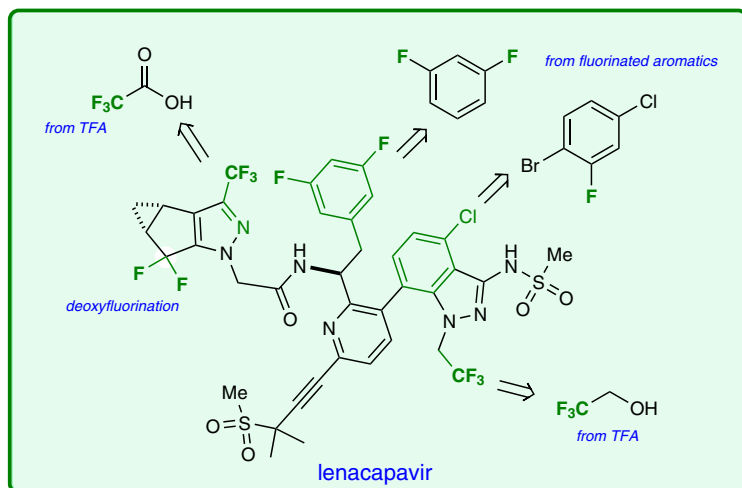
Reactive ion etching is a key technology in the production of advanced semiconductor devices with a resolution of down to sub-10-nm scales. Depending on the exact application, NF_3 , SF_6 as well as complex fluoro(hydro)carbons are used to generate a plasma consisting of ions and other reactive species which converts silicon and its derivatives into volatile compounds. Recently, the development objectives of new etch gases have moved from pure performance to a more complex set of properties including low global warming potential (GWP) and compliance with regulation on fluoroorganic compounds (PFAS). The structure of fluorinated etch gases with low GWP incorporates chemically "weak spots" facilitating atmospheric degradation. The fragmentation in the energetic plasma environment can be predicted by computational methods, enabling the optimization of the ion composition for high etch rate or selectivity between different materials.



Keywords: Bosch process · computational chemistry · fluorocarbons · fluoroorganic synthesis · global warming potential (GWP) · mass spectrometry · perfluoroalkyl substances (PFAS) · plasma chemistry · reactive ion etching

2.13 Industrial Applications of Fluorine Chemistry in PharmaceuticalsS. Caron^{1b}, J. Lee^{1b}, Y. Liu^{1b}, T. N. Nguyen^{1b}, J. L. Piper^{1b}, and A. C. Vicini^{1b}

The development of approaches for the preparation of active pharmaceutical ingredients (APIs) containing fluorine continues to be a topic of significant importance, due to the ability of fluorine to enhance the metabolic stability, bioavailability, and overall efficacy of biologically active compounds. This review provides an overview of common methods and strategies within the industry to deliver these molecular targets on an industrial scale to support clinical development and eventual commercialization. Three general approaches are discussed in detail: (i) sourcing fluorinated commodities that are available across all industries, (ii) custom synthesis of starting materials or building blocks, and (iii) incorporation of fluorine within the regulatory process description. Key advances in modern synthetic methods, limitations, and the increasingly important topic of sustainability are also discussed.



Keywords: fluorine · organofluorine chemistry · fluorinated active pharmaceutical ingredients (APIs) · drug discovery · per- and polyfluorinated organic compounds · C–F activation · hydrofluoroolefins (HFOs) · fluorinated commodities · electrophilic fluorination · $\text{S}_\text{N}\text{Ar}$ fluorination · α -fluorination · deoxyfluorination · late-stage fluorination · Halex reactions · Balz–Schiemann reactions · Sandmeyer reactions

Modern Strategies in Organofluorine Chemistry 2

	Preface	V
	Abstracts	IX
	Table of Contents	XXIII
2	Introduction J.-F. Paquin 	1
2.1	Electrophilic Fluorinating Agents D. Saha, T. Aggarwal, Y. Sumii, A. K. Yadav, and N. Shibata 	3
2.2	Synthesis of Monofluoromethylated Compounds A. Das  , N. Ramkumar  , and J. Veliks 	139
2.3	Synthesis of Aryl and Hetaryl Fluorides X. Wang  and J. Hu 	199
2.4	Monofluoroalkenes S. Couve-Bonnaire  , T. Castanheiro  , and J.-P. Bouillon 	233
2.5	Hydrofluorination of Alkenes and Alkynes X. Bertrand  and J.-F. Paquin 	347
2.6	Direct Fluorination of C(sp³)—H Bonds J. Ruskin  and T. Lectka 	403
2.7	Exploiting C—F Bond Activation for the Synthesis of Organofluorine Compounds T. Semeniuk  and J.-D. Hamel 	449
2.8	Synthetic Approaches to Fluorinated α-Amino Acids C. M. Lloyd  , K. F. Dowell  , and W. D. G. Brittain 	501
2.9	Fluorination Enabled by Photoredox Reactions T. Koike 	555
2.10	Fluorination Enabled by Electrochemistry S. Inagi  , K. Taniguchi  , and K. Lam 	581
2.11	Fluorination Reactions under Flow Conditions H. Amii 	613
2.12	Industrial Applications of Fluorine Chemistry in Plasma Etch Gases P. Kirsch 	643

2.13

Industrial Applications of Fluorine Chemistry in PharmaceuticalsS. Caron^{}, J. Lee^{}, Y. Liu^{}, T. N. Nguyen^{}, J. L. Piper^{}, and A. C. Vicini^{} ... 657**Author Index** 687**Abbreviations** 711

Chemical (cont.)

Name Used in Text	Abbreviation Used in Tables and on Arrow in Schemes	Abbreviation Used in Experimental Procedures
1,2-dimethoxyethane	DME	DME
dimethylacetamide	DMA	DMA
dimethyl acetylenedicarboxylate	DMAD	DMAD
2-(dimethylamino)ethanol	Me ₂ N(CH ₂) ₂ OH	2-(dimethylamino)ethanol
4-(dimethylamino)pyridine	DMAP	DMAP
dimethylformamide	DMF	DMF
dimethyl sulfide	DMS	DMS
dimethyl sulfoxide	DMSO	DMSO
1,3-dimethyl-3,4,5,6-tetrahydro- pyrimidin-2(1 <i>H</i>)-one	DMPU	DMPU
ethyl diazoacetate	EDA	EDA
ethylenediaminetetraacetic acid	edta	edta
hexamethylphosphoric triamide	HMPA	HMPA
hexamethylphosphorous triamide	HMPT	HMPT
iodomethane	MeI	MeI
<i>N</i> -iodosuccinimide	NIS	NIS
lithium diisopropylamide	LDA	LDA
lithium hexamethyldisilazane	LiHMDS	LiHMDS
lithium isopropylcyclohexylamide	LICA	LICA
lithium 2,2,6,6-tetramethylpiperidine	LTMP	LTMP
lutidine	lut	lut
methylaluminum bis(2,6-di- <i>tert</i> -butyl-4-methyl- phenoxide)	MAD	MAD
methyl ethyl ketone	MEK	methyl ethyl ketone
methylmaleimide	NMM	NMM
4-methylmorpholine <i>N</i> -oxide	NMO	NMO
1-methylpyrrolidin-2-one	NMP	NMP
methyl vinyl ketone	MVK	methyl vinyl ketone
petroleum ether	PE ^a	petroleum ether
<i>N</i> -phenylmaleimide	NPM	NPM
polyphosphoric acid	PPA	PPA
polyphosphate ester	PPE	polyphosphate ester
potassium hexamethyldisilazane	KHMDS	KHMDS
pyridine	pyridine ^b	pyridine
pyridinium chlorochromate	PCC	PCC
pyridinium dichromate	PDC	PDC
pyridinium 4-toluenesulfonate	PPTS	PPTS
sodium bis(2-methoxyethoxy)aluminum hydride	Red-Al	Red-Al
tetrabutylammonium bromide	TBAB	TBAB

^a Used to save space; abbreviation must be defined in a footnote.^b py used on arrow in schemes.

Chemical (cont.)

Name Used in Text	Abbreviation Used in Tables and on Arrow in Schemes	Abbreviation Used in Experimental Procedures
tetrabutylammonium chloride	TBACl	TBACl
tetrabutylammonium fluoride	TBAF	TBAF
tetrabutylammonium iodide	TBAI	TBAI
tetracyanoethene	TCNE	tetracyanoethene
tetrahydrofuran	THF	THF
tetrahydropyran	THP	THP
2,2,6,6-tetramethylpiperidine	TMP	TMP
trimethylamine <i>N</i> -oxide	TMANO	trimethylamine <i>N</i> -oxide
<i>N,N,N',N'</i> -tetramethylethylenediamine	TMEDA	TMEDA
tosylmethyl isocyanide	TosMIC	TosMIC
trifluoroacetic acid	TFA	TFA
trifluoroacetic anhydride	TFAA	TFAA
trimethylsilyl cyanide	TMSCN	TMSCN

Ligands

acetylacetonato	acac
2,2'-bipyridyl	bipy
1,2-bis(dimethylphosphino)ethane	DMPE
2,3-bis(diphenylphosphino)bicyclo[2.2.1]hept-5-ene	NORPHOS
2,2'-bis(diphenylphosphino)-1,1'-binaphthyl	BINAP
1,2-bis(diphenylphosphino)ethane	dppe (not diphos)
1,1'-bis(diphenylphosphino)ferrocene	dppf
bis(diphenylphosphino)methane	dppm
1,3-bis(diphenylphosphino)propane	dppp
1,4-bis(diphenylphosphino)butane	dppb
2,3-bis(diphenylphosphino)butane	Chiraphos
bis(salicylidene)ethylenediamine	salen
cyclooctadiene	cod
cyclooctatetraene	cot
cyclooctatriene	cte
η^5 -cyclopentadienyl	Cp
dibenzylideneacetone	dba
6,6-dimethylcyclohexadienyl	dmch
2,4-dimethylpentadienyl	dmpd
ethylenediaminetetraacetic acid	edta
isopinocampheyl	lpc
2,3- <i>O</i> -isopropylidene-2,3-dihydroxy-1,4-bis(diphenylphosphino)butane	Diop
norbornadiene (bicyclo[2.2.1]hepta-2,5-diene)	nbd
η^5 -pentamethylcyclopentadienyl	Cp*

Radicals

acetyl	Ac
aryl	Ar
benzotriazol-1-yl	Bt
benzoyl	Bz
benzyl	Bn
benzyloxycarbonyl	Cbz
benzyloxymethyl	BOM
9-borabicyclo[3.3.1]nonyl	9-BBN
<i>tert</i> -butoxycarbonyl	Boc
butyl	Bu
<i>sec</i> -butyl	<i>s</i> -Bu
<i>tert</i> -butyl	<i>t</i> -Bu
<i>tert</i> -butyldimethylsilyl	TBDMS
<i>tert</i> -butyldiphenylsilyl	TBDPS
cyclohexyl	Cy
3,4-dimethoxybenzyl	DMB
ethyl	Et
ferrocenyl	Fc
9-fluorenylmethoxycarbonyl	Fmoc
isobutyl	iBu
mesityl	Mes
mesyl	Ms
4-methoxybenzyl	PMB
(2-methoxyethoxy)methyl	MEM
methoxymethyl	MOM
methyl	Me
4-nitrobenzyl	PNB
phenyl	Ph
phthaloyl	Phth
phthalimido	NPhth
propyl	Pr
isopropyl	iPr
tetrahydropyranyl	THP
tolyl	Tol
tosyl	Ts
triethylsilyl	TES
triflyl, trifluoromethanesulfonyl	Tf
triisopropylsilyl	TIPS
trimethylsilyl	TMS
2-(trimethylsilyl)ethoxymethyl	SEM
trityl [triphenylmethyl]	Tr

General

absolute	abs
anhydrous	anhyd
aqueous	aq
boiling point	bp
catalyst	no abbreviation
catalytic	cat.
chemical shift	δ
circular dichroism	CD
column chromatography	no abbreviation
concentrated	concd
configuration (in tables)	Config
coupling constant	J
day	d
density	d
decomposed	dec
degrees Celsius	$^{\circ}\text{C}$
diastereomeric ratio	dr
dilute	dil
electron-donating group	EDG
electron-withdrawing group	EWG
electrophile	E^+
enantiomeric excess	ee
enantiomeric ratio	er
equation	eq
equivalent(s)	equiv
flash-vacuum pyrolysis	FVP
gas chromatography	GC
gas chromatography-mass spectrometry	GC/MS
gas-liquid chromatography	GLC
gram	g
highest occupied molecular orbital	HOMO
high-performance liquid chromatography	HPLC
hour(s)	h
infrared	IR
in situ	in situ
in vacuo	in vacuo
lethal dosage, e.g. to 50% of animals tested	LD_{50}
liquid	liq
liter	L
lowest unoccupied molecular orbital	LUMO
mass spectrometry	MS
medium-pressure liquid chromatography	MPLC
melting point	mp
milliliter	mL
millimole(s)	mmol
millimoles per liter	mM
minute(s)	min
mole(s)	mol
nuclear magnetic resonance	NMR
nucleophile	Nu^-
optical purity	op
phase-transfer catalysis	PTC
proton NMR	^1H NMR