Synthesis of Cyclic and Linear Fluoroalkyl Aromatics by Photoinduced Reaction of Aromatics and 1,4-Diiodoperfluorobutane

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Introduction

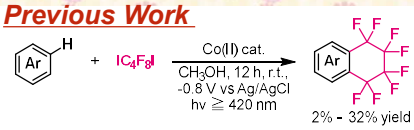
Unique properties of fluorine are…
- The biggest electro negativity
- The small Van der Waals radius
- The strongest C-F bond

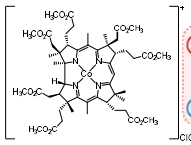
Organic Compounds

Fluorinated organic compounds are used as
Pharmaceuticals, Agrochemicals, Functional materials etc…

Anticancer Drug, Herbicide, Liquid Crystal

Previous Work

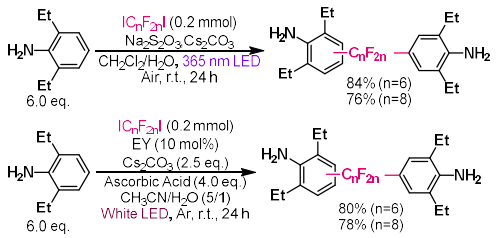




Cyclic fluoroalyla aromatics was synethesies woth Vitamin B_{12} as a catalyst
Limited substrate scope

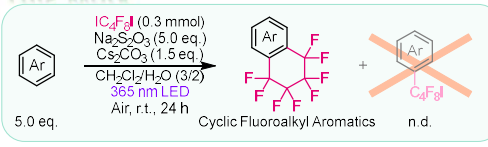
L. Cui, T. Ono, M. J. Hossain and Y. Hisaeda, RSC Adv., 2020, 10, 24862-24866

Our Previous Work



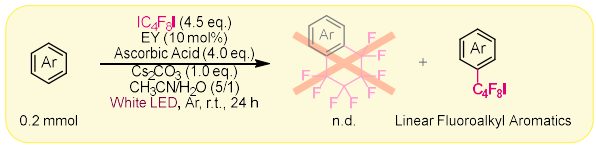
We have reported synthesis of fluorinated diamine compounds by photo-induced perfluoroalkylation

This Work



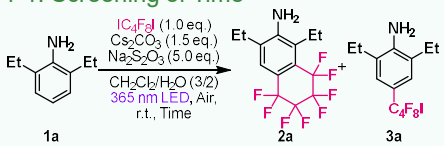
UV irradiation yielded a **cyclic compound** in which **two** iodine of fluorine source reacted with the same aromatic ring

Visible light irradiation in the presence of EY yielded a **cyclic compound** in which **two** iodine of fluorine source reacted with the aromatic ring



Results - Cyclic Fluoroalkyl Aromatics -

1-1. Screening of Time

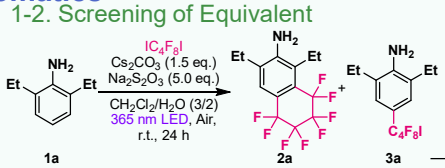


Entry	Time	Total	2a [a]	3a [a]
1	3 h	33%	12%	21%
2	6 h	46%	27%	19%
3	9 h	52%	36%	16%
4	17 h	54%	47%	7%
5	24 h	61%	56%	5%
6	48 h	61%	57%	4%

a) Determined by crude ^{19}F NMR using BTF as an internal standard.

The longer time
Increases the yield of 2a and **3a** is a precursor of **2a**
Decreases the yield of 3a

1-2. Screening of Equivalent



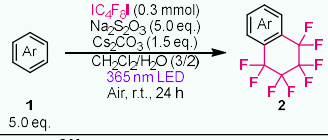
Entry	Sub (**1a**)	IC_4F_8I	2a [a]	3a [a]
1	0.3 mmol	1.0 eq.	56%	5%
2	0.3 mmol	6.0 eq.	55%	12%
3	2.0 eq.	0.3 mmol	65%	2%
4	3.0 eq.	0.3 mmol	73%	n.d.
5	4.0 eq.	0.3 mmol	77%	n.d.
6	5.0 eq.	0.3 mmol	80%	n.d.
7	6.0 eq.	0.3 mmol	73%	n.d.

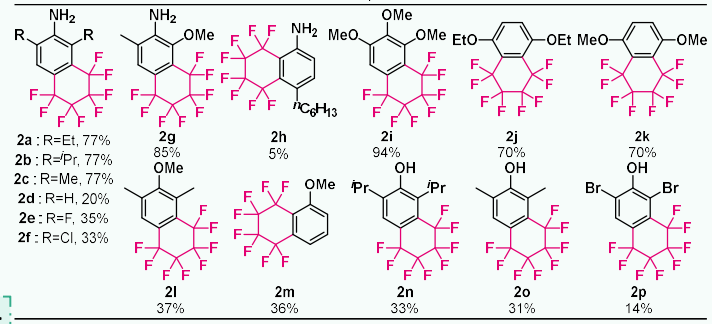
a) Determined by crude ^{19}F NMR using BTF as an internal standard.

The larger equivalent of substrate give high yields.

1-3. Screening of Substrates

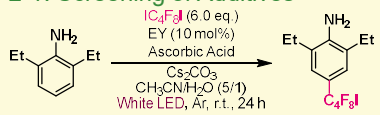
Applicable to a wide range of aromatic compounds





Results - Liner Fluoroalkyl Aromatics -

2-1. Screening of Additives

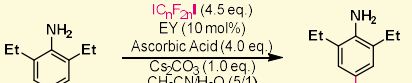


Entry	Ascorbic Acid	Cs_2CO_3	Yield [a]
1	4.0 eq.	1.5 eq.	64%
2	4.0 eq.	1.0 eq.	81%
3	4.0 eq.	0.5 eq.	68%
4	4.0 eq.	-	51%
5	6.0 eq.	1.5 eq.	79%
6	3.0 eq.	0.5 eq.	66%

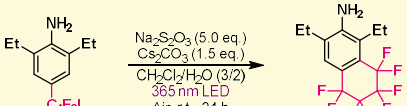
a) Determined by crude ^{19}F NMR using BTF as an internal standard.

Improved yields due to **suppression of acid-base reactions!**

2-2. Screening of Fluorine Sources



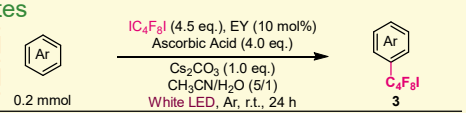
2-3. Reaction of Iodine Compound

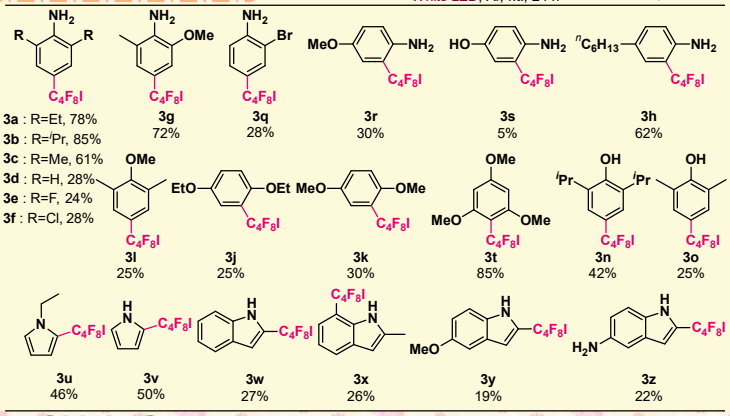


Transformation from 3a to 2s was confirmed

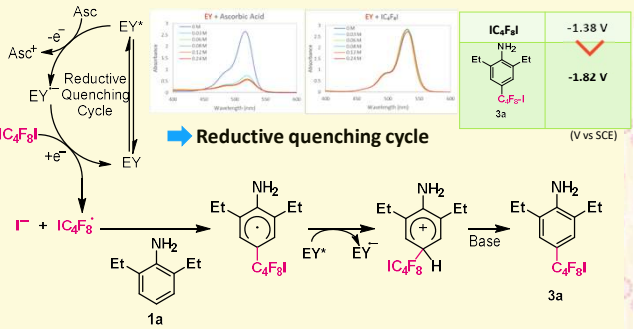
2-4. Screening of Substrates

Applicable to a wide range of aromatic compounds, including **heteroaromatics.**

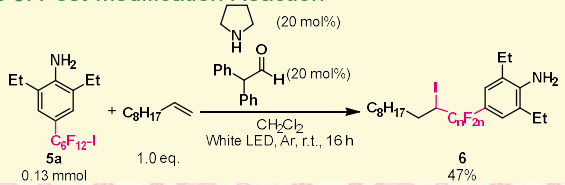




2-5. Proposed Mechanism

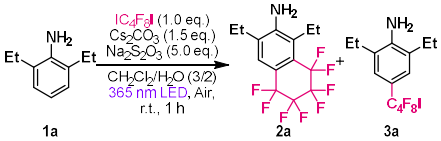


2-6. Post-Modification Reaction



Development of Light Sources

3-1. 365 nm UV Light LED

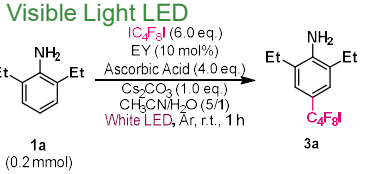


Entry	Light Source	2a [a]	3a [a]
1	Our light source	8%	45%
2	Spot Irradiation from CCS Inc.	trace	n.d.
3	EvoluChem™ LED Lights from HepatoChem	n.d.	24%

a) Determined by crude ^{19}F NMR using BTF as an internal standard.

Efficient
Cheap
Good Reproducibility

3-2. Visible Light LED



Entry	Light Source	Yield [a]
1	Our light source (Green)	72%
2	Our light source (Blue)	80%
3	Our light source (White)	76%
4	Spot Irradiation from CCS Inc. (Green)	trace
5	Spot Irradiation from CCS Inc. (Blue)	5%
6	Spot Irradiation from CCS Inc. (White)	8%
7	EvoluChem™ LED Lights from HepatoChem (425 nm)	78%
8	EvoluChem™ LED Lights from HepatoChem (450 nm)	73%
9	TUNA BLUE from Kessil (427 nm)	72%
10	White LED from HAYASHI-REPIC CO., LTD.	28%

a) Determined by crude ^{19}F NMR using BTF as an internal standard.

Conclusion

Lead **two different products** depending on the reaction conditions! **Various substrates** bare this reactions☆ Successful **Post-Modification Reaction**