

**FIRST SYNTHESIS AND CYCLOADDITION REACTIONS OF 1-AZAAZULENE *N*-YLIDE**

Hiroyuki Fujii,\* Kaoru Iwafuji, Yoshiyuki Sawae, Noritaka Abe,\* and Akikazu Kakehi<sup>†</sup>

Department of Chemistry, Faculty of Science, Yamaguchi University, Yoshida, Yamaguchi 753-8512, Japan

<sup>†</sup>Department of Chemistry and Material Engineering, Faculty of Engineering, Shinshu University, Wakasato, Nagano 380-8553, Japan

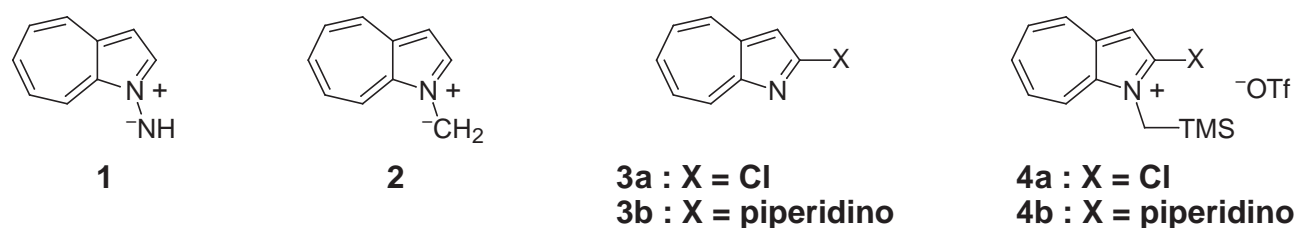
**Abstract** - 2-Substituted 1-azaazulene *N*-ylides were generated by the treatment of appropriate 1-trimethylsilylmethyl-1-azaazulenium triflates with CsF; the triflate salts were prepared from 1-azaazulenes and trimethylsilylmethyl triflate. The 1,3-dipolar cycloadditions of 2-chloro-1-azaazulene *N*-ylide, prepared *in situ*, with acetylenic esters gave 2a-azabenz[*cd*]azulene derivatives and 3a-azacyclopent[*a*]naphthalene derivatives. These structures were determined by X-Ray crystal structure analysis. A similar reaction of 2-piperidino-1-azaazulene *N*-ylide gave 3a-azacyclopent[*a*]azulene derivative as major product.

Heteroaromatic *N*-ylides,<sup>1,2</sup> a central figure of azomethine ylide,<sup>3</sup> have received attractive attentions for their synthetic versatility for the construction of fused heterocycles *via* 1,3-dipolar cycloaddition reaction.<sup>4,5</sup> Although a non-alternant heteroaromatic *N*-ylide has large potential for the construction of new heterocyclic nuclei, which have an interesting function such as bioactivity and dye, the investigation was rarely reported. Recently, we reported about the synthesis and reactions of 1-azaazulene *N*-imine (**1**) where interesting dipolar cycloadditions were observed.<sup>6</sup> For the development of azaazulene chemistry<sup>7</sup> and for an interest in the construction of new fused heterocycles, we advanced the investigation to the synthesis and reactions of 1-azaazulene *N*-ylides.

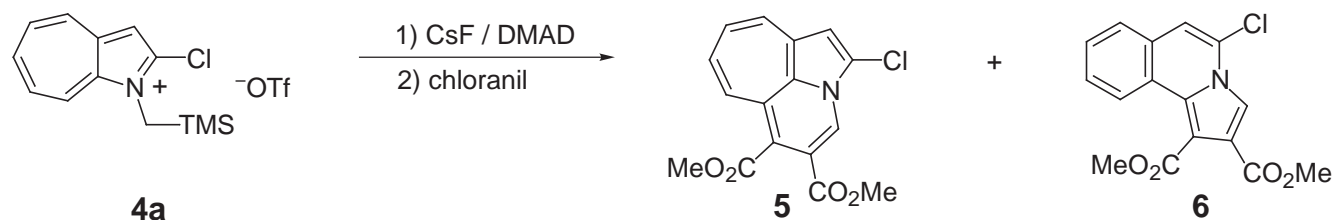
Because *N*-alkylations of 1-azaazulene are known,<sup>7,8</sup> we intend to make a 1-azaazulene *N*-ylide by *N*-trimethylsilylmethylation of 1-azaazulene followed by desilylation. Thus 2-chloro-1-azaazulene (**3a**) was treated with trimethylsilylmethyl triflate in dichloromethane for 48 h, and 2-chloro-1-trimethylsilylmethyl-1-azaazulenium triflate (**4a**) was obtained in 87% yield. Similar treatment of **3b** with trimethylsilylmethyl triflate in dichloromethane for 48 h gave **4b** in 81% yield.

---

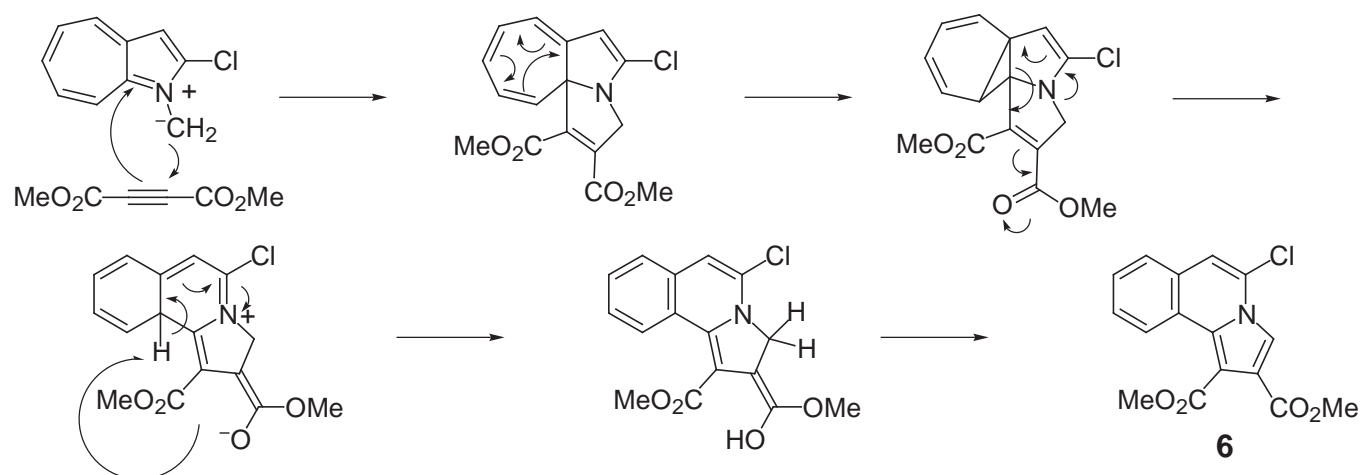
<sup>†</sup> Dedicated to Professor Yuichi Kanaoka on occasion of his 75th birthday.



Desilylation of the salt (**4a**) was attempted by the treatment with potassium carbonate or tetrabutylammonium fluoride, but no distinct product was obtained. Then the salt (**4a**) was treated with CsF, dried before use, in the presence of dimethyl acetylenedicarboxylate (DMAD) followed by the treatment of tetrachoro-*p*-benzoquinone (chloranil) in DMF. Two cycloadducts, dimethyl 2-chloro-2a-azabenz[*cd*]azulene-4,5-dicarboxylate (**5**) (8%) and dimethyl 4-chloro-3a-azacyclopenta[*a*]naphthalene-1,2-dicarboxylate (**6**) (27%), were isolated by silica gel chromatography. When KF was used as a desilylation reagent, in the presence of 18-crown-6-ether, the cycloadducts (**5** and **6**) were obtained in extremely low yields.



The structures of **5** and **6** were deduced on the basis of the spectroscopic data,<sup>9</sup> and confirmed by X-Ray crystallographic analysis.<sup>10</sup> The ORTEP drawings of these compounds were shown in Figure 1. In the <sup>1</sup>H NMR spectrum of **5**, rather high-field resonated signals of seven-membered ring protons appeared at  $\delta$  4.95 (H-7), 5.28 (H-8), 5.59 (H-9), and 5.72 (H-6), and a large divergence of the coupling constants was seen ( $J_{5-6} = 11.2$ ,  $J_{6-7} = 7.8$ , and  $J_{7-8} = 12.8$ ) in the seven-membered ring protons; these show the presence of the bond-alternation in the seven-membered ring.



In a similar treatment of **4a** with methyl propiolate in the presence of CsF, followed by treatment with chloranil, only the regioselective cycloadduct, methyl 4-chloro-3a-azacyclopenta[*a*]naphthalene-1-carboxylate (**7**), was obtained in 3% yield. These results show the generation of 2-chloro-1-azaazulene *N*-ylide (**8**). A plausible formation mechanism of **6** is shown in Scheme 1.

Interestingly, when 2-piperidino-1-(trimethylsilylmethyl)-1-azaazulene triflate (**4b**) was treated with CsF

and DMAD, compounds (**9** and **10**) were obtained in 10% and 1.5% yields, respectively, and the rearrangement product such as **6** was not obtained. This results indicate that the cycloaddition reaction was strongly affected by the functional group located at C-2 of the 1-azaazulene *N*-ylides.

In summary, 1-azaazulene *N*-ylides were trapped by acetylenic esters and the interesting cycloaddition-rearrangement reaction was observed. Further study and the MO consideration about the reactivity of the 1-azaazulene *N*-ylides are in progress.

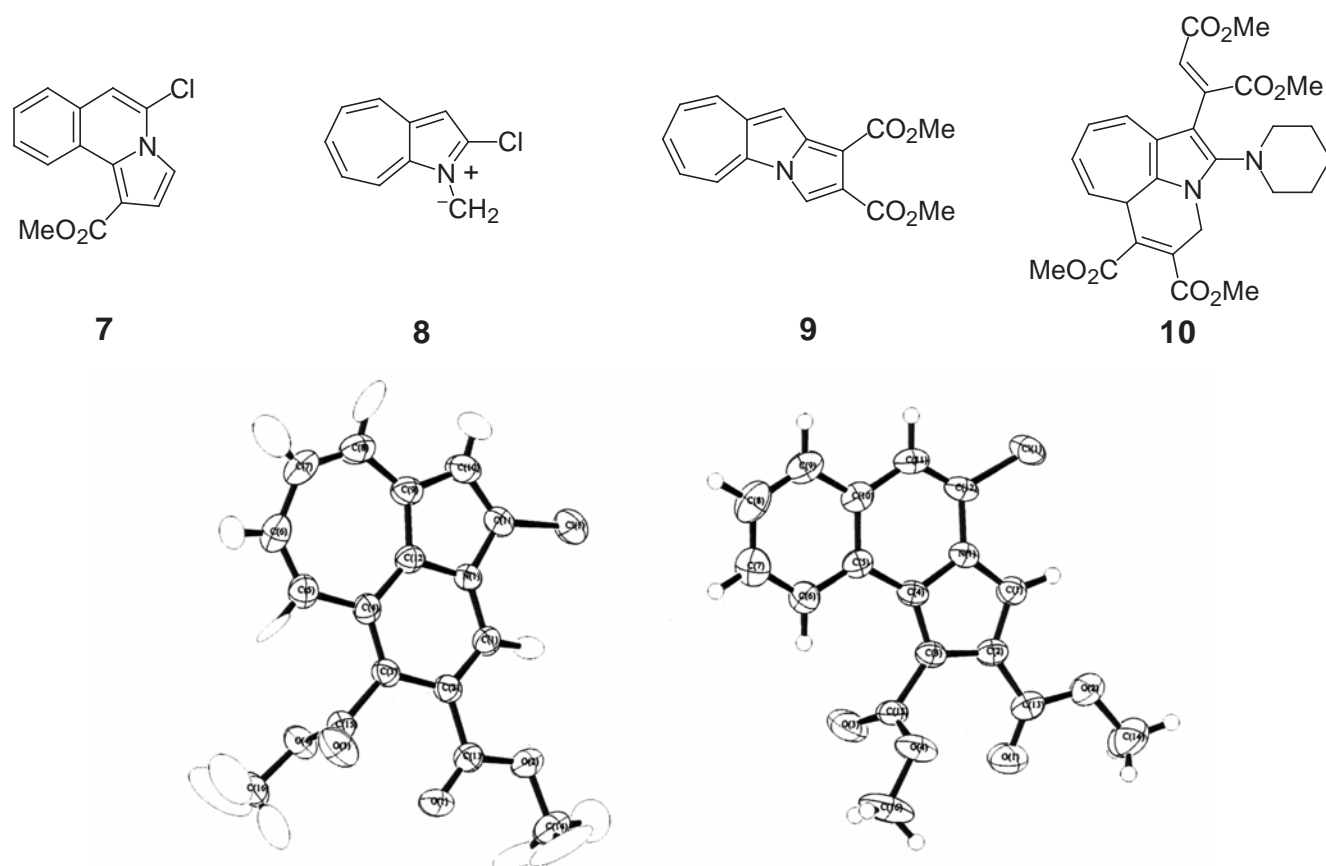


Figure 1. ORTEP drawings of **5** (left) and **6** (right) with thermal ellipsoids (50% probability).

## ACKNOWLEDGMENTS

This work was partially supported by a Grand-in Aid for Scientific Research on Priority Areas (A) of Exploitation of Multi-Element Cyclic Molecules (Nos. 13029083 and 14044074) from the Ministry of Education, Culture, Sports, Science and Technology, Japan.

## REFERENCES

1. A. W. Johnson, 'Ylid Chemistry,' Academic Press, New York, 1966, chapter 7.
2. I. Zugravescu and M. Petrovanu, 'N-Ylid Chemistry,' McGraw-Hill, New York, 1976.
3. O. Tsuge and S. Kanemasa, *Adv. Heterocycl. Chem.*, 1989, **45**, 231.
4. A. Padwa, '1,3-Dipolar Cycloaddition Chemistry, Vols. 1 and 2,' Wiley, New York, 1984.
5. R. Huisgen, *Angew. Chem., Int. Ed. Engl.*, 1963, **2**, 565.

6. N. Abe, K. Odagiri, and A. Kahehi, *J. Chem. Soc., Perkin Trans. 1*, 1997, 2189.
7. Recent reviews see, N. Abe, *Recent Res. Devel. Org. & Bioorg. Chem.*, 2001, **4**, 17; N. Abe, *Trends in Heterocycl. Chem.*, 2001, **7**, 25.
8. N. Abe, Y. Fukumoto, H. Fujii, and A. Kakehi, *Heterocycles*, 2002, **56**, 171.
9. Selected data for some compounds. **5**:  $^1\text{H}$  NMR ( $\text{CDCl}_3$ , 400 MHz): 3.74 (3H, s), 3.77 (3H, s), 4.95 (1H, dd,  $J$  11.2, 7.8 Hz), 5.28 (1H, dd,  $J$  12.7, 7.8 Hz), 5.59 (1H, d,  $J$  12.7 Hz), 5.72 (1H, d,  $J$  11.2 Hz), 6.07 (1H, s), 7.36 (1H, s);  $^{13}\text{C}$  NMR ( $\text{CDCl}_3$ , 100.6 MHz): 52.2, 52.3, 111.2, 111.3, 119.1, 121.5, 123.7, 124.3, 128.5, 133.2, 134.0, 137.3, 139.1, 164.8, 167.6;  $m/z$  (rel. intensity) 317 ( $\text{M}^+$ , 75), 286(100), 256(21), 164(34); **6**:  $^1\text{H}$  NMR ( $\text{CDCl}_3$ , 400 MHz): 3.91 (3H, s), 4.06 (3H, s), 7.06 (1H, s), 7.14-7.57 (3H, m), 8.12 (1H, s), 8.19 (1H, d,  $J$  8.0 Hz);  $^{13}\text{C}$  NMR ( $\text{CDCl}_3$ , 100.6 MHz): 52.0, 52.9, 111.4, 113.4, 117.4, 117.5, 123.3, 123.8, 124.4, 126.8, 127.8, 128.0, 128.5, 129.5, 163.8, 167.5;  $m/z$  (rel. intensity) 317 ( $\text{M}^+$ , 100), 286 (39), 271 (30), 200 (30).
10. **Crystal data of 5**: black prism,  $\text{C}_{16}\text{H}_{12}\text{NO}_4\text{Cl}$ ,  $M = 317.73$ , triclinic, space group P-1,  $a = 9.745(2)\text{\AA}$ ,  $b = 10.227(3)\text{\AA}$ ,  $c = 7.378(2)\text{\AA}$ ,  $\alpha = 94.53(2)^\circ$ ,  $\beta = 98.28(2)^\circ$ ,  $\gamma = 75.24(2)^\circ$ ,  $V = 702.9(3)$ ,  $Z = 2$ ,  $D_{\text{calc}} = 1.274\text{g/cm}^3$ , crystal dimension 0.38 x 0.62 x 0.68 mm. Data were measured on a Rigaku AFC 5S radiation diffractometer with graphite-monochromated Mo-K $\alpha$  radiation. Total 3431 reflections (3240 unique) were collected using  $\omega$ - $2\theta$  scan technique with in a  $2\theta$  range of  $55.0^\circ$ . The structure was solved by direct methods (SIR92), and refined a full-matrix least squares methods using 308 variables refined with 2022 reflections [ $I > 2\sigma(I)$ ]. The final refinement converged to  $R = 0.049$  and  $R_w = 0.047$ ; selective bond lengths ( $\text{\AA}$ ): N(1)—C(1) 1.370(4), C(1)—C(2) 1.350(4), C(2)—C(3) 1.438(4), C(3)—C(4) 1.377(4), C(4)—C(5) 1.463(5), C(5)—C(6) 1.349(5), C(6)—C(7) 1.449(6), C(7)—C(8) 1.332(6), C(8)—C(9) 1.450(5), C(9)—C(10) 1.405(5), C(10)—C(11) 1.363(5), C(11)—N(1) 1.378(4); **Crystal data of 6**: yellow prism,  $\text{C}_{16}\text{H}_{12}\text{NO}_4\text{Cl}$ ,  $M = 317.73$ , monoclinic, space group  $\text{P}2_1/\text{c}$ ,  $a = 11.383(6)\text{\AA}$ ,  $b = 9.137(8)\text{\AA}$ ,  $c = 14.896(7)\text{\AA}$ ,  $\beta = 110.95(3)^\circ$ ,  $V = 1447(2)$ ,  $Z = 4$ ,  $D_{\text{calc}} = 1.458\text{g/cm}^3$ , crystal dimension 0.12 x 0.56 x 0.68 mm. Data were measured on a Rigaku AFC 5S radiation diffractometer with graphite-monochromated Mo-K $\alpha$  radiation. Total 3659 reflections (3530 unique) were collected using  $\omega$ - $2\theta$  scan technique with in a  $2\theta$  range of  $55.0^\circ$ . The structure was solved by direct methods (SIR88), and refined a full-matrix least squares methods using 199 variables refined with 1658 reflections [ $I > 2\sigma(I)$ ]. The final refinement converged to  $R = 0.060$  and  $R_w = 0.063$ ; selective bond lengths ( $\text{\AA}$ ): N(1)—C(1) 1.367(6), C(1)—C(2) 1.371(6), C(2)—C(3) 1.407(7), C(3)—C(4) 1.381(6), C(4)—C(5) 1.449(7), C(5)—C(6) 1.398(7), C(6)—C(7) 1.372(8), C(7)—C(8) 1.390(9), C(8)—C(9) 1.375(9), C(9)—C(10) 1.395(8), C(10)—C(11) 1.441(7), C(11)—C(12) 1.314(7), C(12)—N(1) 1.408(6).