Tetrahedron Letters,Vol.27,No.15,pp 1715-1718,1986
Printed in Great Britain

0040-4039/86 $3.00 + .00

A NEW AND VERSATILE METHOD FOR IODOFUNCTIONALIZATION OF 1,3-DIENES

José Barluenga,[a*] José M. González,[a] Pedro J. Campos,[a] and Gregorio Asensio[b]
Departamento de Química Orgánica, [a] Facultad de Química, Universidad de Oviedo,
33071-Oviedo, and [b] Facultad de Farmacia, Universidad de Valencia, 46010-Valencia,
Spain

Abstract: We wish to report the reactions of conjugated dienes with $I(py)_2BF_4$. This simple and general method allows the regiospecific 1,2-addition of iodine and a nucleophile to terminal dienes and the 1,4-addition to internal dienes.

The addition reactions to conjugated dienes have been widely reported processes,[1,2] but only some examples are synthetically valuable. The most common strategy employed for the last group of reactions are based on the use of transition metals derivatives as catalysts.[3] Other modern methods allow the monoaddition of sulphenyl chlorides,[4] the diacetoxylation,[5] the 1,2-diamination,[6] the 1,4-cycloamination,[7] the dialkoxylation,[8] and the nitroacetamidation[9] of these substrates.

Recently we have introduced the use of bis(pyridine)iodine(I) tetrafluoroborate **1** as a new reagent for the 1,2-difunctionalization of alkenes.[10] The versatility of the method prompted us to explore its utility in the field of the iodofunctionalization of 1,3-dienes, because while the chlorination and bromination of butadiene derivatives are extensively studied processes[1, 2, 11] very few reports have appeared devoted to the addition of iodine compounds to dienes.[12]

Now we have found that when terminal dienes (butadiene **2**, isoprene **3**, 2,3-dimethylbutadiene **4**) are allowed to react with **1** in the presence of a nucleophile 1,2-iodo functionalization takes place. Some reactions also required, as a first step, the addition of a stoichiometric amount of tetrafluoroboric acid to the reaction medium to form the corresponding pyridinium salt in order to avoid free pyridine acting as a nucleophile in a side reaction (Scheme 1, Table 1).

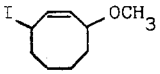
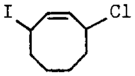
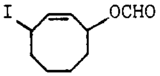
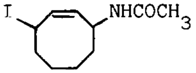
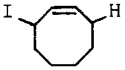
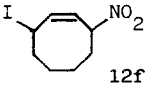
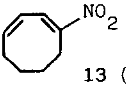
$$\mathbf{1} + CH_2{=}CR^1CR^2{=}CH_2 + 2\,HBF_4 + \underset{\mathbf{5}}{NuH(\text{or } Nu^-)} \xrightarrow[-2\,PyHBF_4]{} ICH_2(Nu)CR^1CR^2{=}CH_2$$

2; $R^1 = R^2 = H$
3; $R^1 = Me,\ R^2 = H$
4; $R^1 = R^2 = Me$

6; $R^1 = R^2 = H$
7; $R^1 = Me,\ R^2 = H$
8; $R^1 = R^2 = Me$

(Scheme 1)

TABLE 1. IODOFUNCTIONALIZATION OF CONJUGATED DIENES.

DIENE	NUCLEOPHILE **5**	METHOD (a)	SOLVENT	PRODUCT	YIELD (%) (b)
2	CH_3OH	A	CH_3OH	$H_2C{=}CHCH(OCH_3)CH_2I$ **6a**	86
2	LiCl	B	Dioxane/H_2O	$H_2C{=}CHCH(Cl)CH_2I$ **6b**	40
2	HCl	C	CH_2Cl_2	**6b**	54
2	DMF	A	DMF/CH_2Cl_2 (1:1)	$H_2C{=}CHCH(OCHO)CH_2I$ **6c**	30 (c)
3	CH_3OH	A	CH_3OH	$H_2C{=}CHC(CH_3)(OCH_3)CH_2I$ $H_2C{=}C(CH_3)CH(OCH_3)CH_2I$ **7a** (d)	74
4	CH_3OH	A	CH_3OH	$H_2C{=}C(CH_3)C(CH_3)(OCH_3)CH_2I$ **8a**	78
9	CH_3OH	A	CH_3OH	$CH_3CH(OCH_3)CH{=}CHCHICH_3$ **11a** (e)	90
10	CH_3OH	A	CH_3OH/CH_2Cl_2 (1:15)	 **12a**	58
10	LiCl	B	Dioxane/H_2O	 **12b**	70
10	DMF	A	DMF/CH_2Cl_2 (1:1)	 **12c**	55 (c)
10	CH_3CN	A	CH_3CN	 **12d**	56
10	$HSi(C_2H_5)_3$	C	CH_2Cl_2	 **12e**	51
10	$NaNO_2$	B	Dioxane/H_2O	 **12f**  **13** (f)	60

(a) See note 14.

(b) Yields of isolated products, relative to starting $I(py)_2BF_4$ and not optimized.

(c) Compounds **6c** and **12c** partially decompose and its are mixtures. The yields are obtained by NMR.

(d) 6:1 mixture of regioisomers (by NMR). The mayoritary product is the adduct derived from methyl-subtituted double bond of isoprene **3**.

(e) Mixture of Z:E isomers (~1:1).

(f) Detected by NMR.

The specifity observed for the 1,2-addition in the case of terminal dienes regardless of the substitution C-2 and C-3 is noteworthy since the previously reported additions to methyl substituted butadienes[1] are preferentially 1,4-reactions.

By contrast, internal dienes (Z,E-2,4-hexadiene **9**, and 1,3-cyclooctadiene **10**) yield the 1,4-addition products in reaction with **1** (Scheme 2, Table 1) under similar reaction conditions.

$$1 + R^1CH{=}CHCH{=}CHR^2 + 2\,HBF_4 + \underset{5}{NuH(or\ Nu^-)} \xrightarrow[-2\,PyHBF_4]{} R^1CHICH{=}CHCH(Nu)R^2$$

9; $R^1 = R^2 = Me$
10; R^1, $R^2 = -(CH_2)_4-$

11; $R^1 = R^2 = Me$
12; R^1, $R^2 = -(CH_2)_4-$

(Scheme 2)

Products **12** derived from cyclic diene **10** are obtained as single stereoisomers.[13] When **10** reacts whith **1** and nitrite anion the 1-nitrodiene **13** is detected ($<15\%$ of the reaction crude) accompanying the 1,4-adduct **12f** even with short reaction times (10-12 minutes). Only the nitrodiene **13** is obtained after longer times (conditions: 12 h, room temperature, 58% yield of isolated **13**, purified by column chromatography).

The products **6**, **7**, **8**, **11**, **12**, and **13** showed elemental analyses and ^1H-NMR, ^{13}C-NMR and IR spectra in good agreement with the proposed structures.

Among the merits of this new method for the iodofunctionalization of dienes it should be noted its versatility by the nucleophile site which open up routes to otherwise unaccessible products and also the great regiospecificity observed in the sense that only 1,2- or 1,4-regioisomers are obtained, the orientation depending on the structures of the starting (terminal or internal) diene.

Acknowledgements: Financial support of this work by Comisión Asesora de Investigación Científica y Técnica (CAICYT), is gratefully acknowledged. One of us (J.M.G.) whishes to thank Ministerio de Educación y Ciencia for a predoctoral scholarship.

REFERENCES AND NOTES

1.- M. Cais in S. Patai: The Chemistry of Alkenes, Interscience Publ., London, 1964, cap. 12. G. Pattenden in D. Barton and W.D. Ollis: Comprehensive Organic Chemistry, Pergamon, Oxford, 1979, vol.1, p.171.

2.- H. von Brachel, V. Bahr: Houben-Weyl, Methoden der Organischen Chemie, Band 5/1c, G. Thieme, Stuttgart, 1970, p.1.

3.- Selected examples: B. Akermark, J.E. Bäckvall, A. Löwenberg, K. Zetterberg, J. Organometal. Chem., **166**, C33 (1979). J.E. Bäckvall, R.E. Nordberg, J. Am. Chem. Soc., **103**, 4959 (1981). J.E. Bäckvall, R.E. Nordberg, J.E. Nyström, Tetrahedron Lett., **23**, 1617 (1982). M. Green, S. Greenfield, M. Kersting, J. Chem. Soc. Chem. Commun., 18 (1985). T. Hayashi, K. Kabeta, Tetrahedron Lett., **26**, 3023 (1985).

4.- W.H. Mueller, P.E. Butler, J. Chem. Soc. Chem. Commun., 646 (1966).

5.- S. Uemura, H. Miyashi, A. Tabata, M. Okano, Tetrahedron, **37**, 291 (1981). S. Uemura, S.I. Fukuzawa, M. Okano, Tetrahedron Lett., **22**, 5331 (1981).

6.- K.B. Sharpless, S.P. Singer, J. Org. Chem., **41**, 2504 (1976).

7.- J. Barluenga, J. Pérez-Prieto, G. Asensio, J. Chem. Soc. Chem. Commun., 1181 (1982).

8.- J. Barluenga, J. Pérez-Prieto, G. Asensio, J. Chem. Soc. Perkin Trans. I, 629 (1984).

9.- A.J. Bloom, M. Fleischmann, J.M. Mellor, Tetrahedron Lett., **25**, 4971 (1984).

10.- J. Barluenga, J.M. González, P.J. Campos, G. Asensio, Angew. Chem., **97**, 341 (1985); Angew. Chem. Int. Ed. Engl., **24**, 319 (1985).

11.- G.E. Heasley, V.L. Heasley, S.L. Manatt, H.A. Day, R.V. Hodges, P.A. Kroon, D.A. Redfield, T.L. Rold, D.E. Willianson, J. Org. Chem., **38**, 4109 (1973). G.E. Heasley, D.C. Hayse, G.R. McClug, D.K. Strickland, V.L. Heasley, P.D. Davis, D.M. Ingle, K.D. Rold, T.S. Ungermann, J. Org. Chem., **41**, 334 (1976).

12.- See ref. **2** , p.894.

13.- The study of the stereochemistry of compounds **12** is presently in progress.

14.- The following represents the typical experimental procedures for iodofunctionalization of 1,3-dienes.

Method A: A mixture of the corresponding diene (5 mmol), HBF_4 (10 mmol, 1.40 ml of 54% ethereal solution), and an anhydrous solvent (15 ml) was cooled at -40°C and **1** (5 mmol, 1.86 g) was added. After 10 minutes of stirring the red solution was allowed to arise to 0°C and then it was hydrolized, extracted with CH_2Cl_2 , dried with anh. Na_2SO_4 and evaporated in vacuo. The resulting crude was the esentially pure (by NMR) regioisomer indicated in Table 1. The reaction was carried out under argon atmosphere.

Method B: In a mixture of dioxane (20 ml) and water (10 ml) the inorganic salt (20 mmol) and the corresponding diene (5 mmol) were dissolved, then **1** (5 mmol, 1.86 g) was added. After 15 minutes of stirring at room temperature, the solution was extracted with CH_2Cl_2 and it treated by the procedure above described in A.

Method C: To a solution of **1** (5 mmol, 1.86 g) in anhydrous CH_2Cl_2 (15 ml) at room temperature 10 mmol of acid (HBF_4 in ether for **12e** or HCl in ether for **6b**) were added. After two minutes of stirring, the corresponding diene (5 mmol) dissolved in CH_2Cl_2 (5 ml) was introduced into the reaction flask. Additionally triethylsilane (5 mmol, 0.64 ml) was required for the preparation of product **12e**. After two hours the reaction was treated by the procedure described in method A (including the inert atmosphere).

(Received in UK 24 February 1986)