Petasis-Ferrier Rearrangement

Name Reaction Presentation

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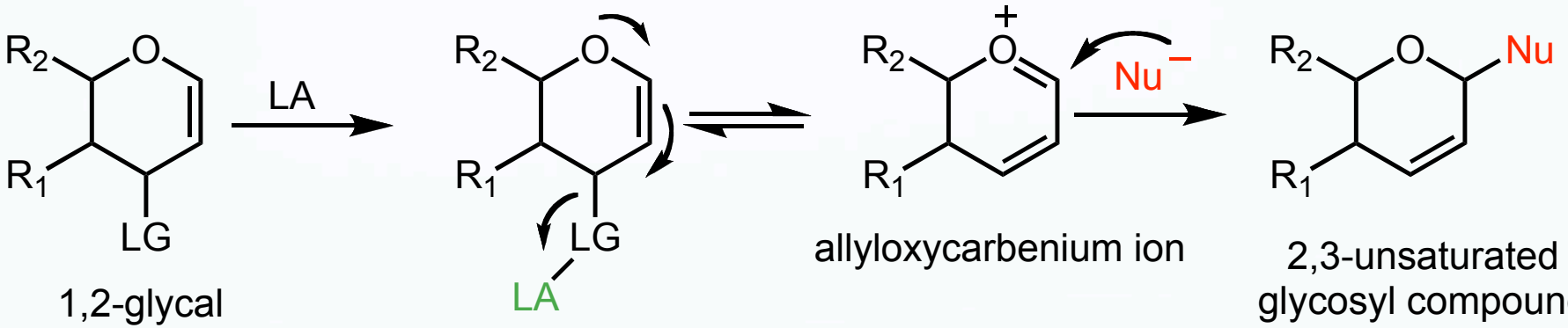
Ferrier Reaction

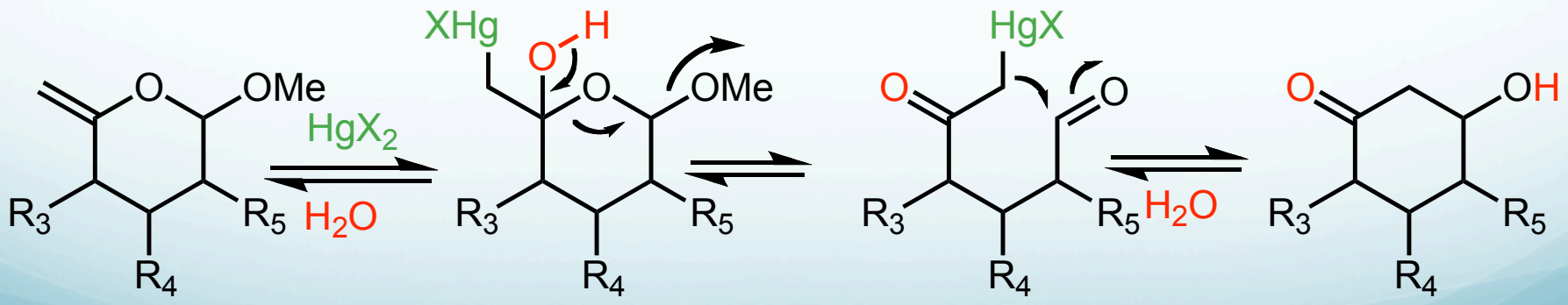
LA = $BF_3.OEt_2$, $SnCl_4$,I_2 Nuc = OR,SR_2, NR_2
R_1= *O*-acyl, R_2 = CH_2-*O*-acyl, LG = *O*-acyl, OTs

Type I Ferrier Reaction (1962)



Ferrier, R. J.; Overend, W. G.; Ryan, M. E. *J. Chem. Soc.* **1962**, 3667–3670.

Type II Ferrier Rearrangement (1979)



R_3, R_4, R_5 = *O*-acyl, *O*-alkyl

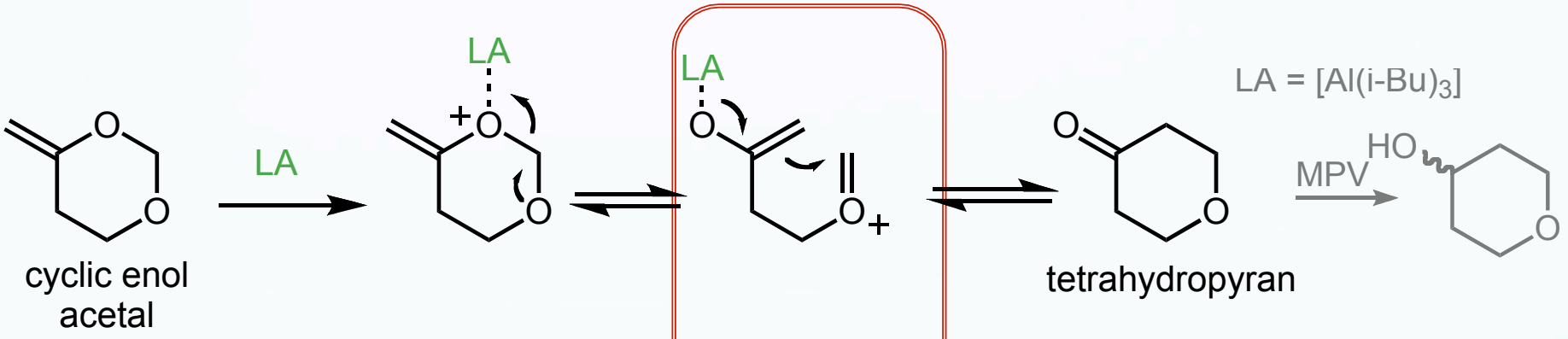
Ferrier, R. J. *J. Chem. Soc., Perkin Trans. 1* **1979**, 1455–1458.

Dr. Robin J. Ferrier

- PhD, University of Edinburgh, UK, 1957, " Synthetic and mechanistic studies of monosaccharide compounds "
- Professor, London University, UK
- Post-doctoral, Berkeley, Professor Melvin Calvin
- Chair of Organic Chemistry, Victoria University of Wellington, New Zealand,1970
- Consultant, GlycoSyn, Industrial Research Limited (IRL), New Zealand

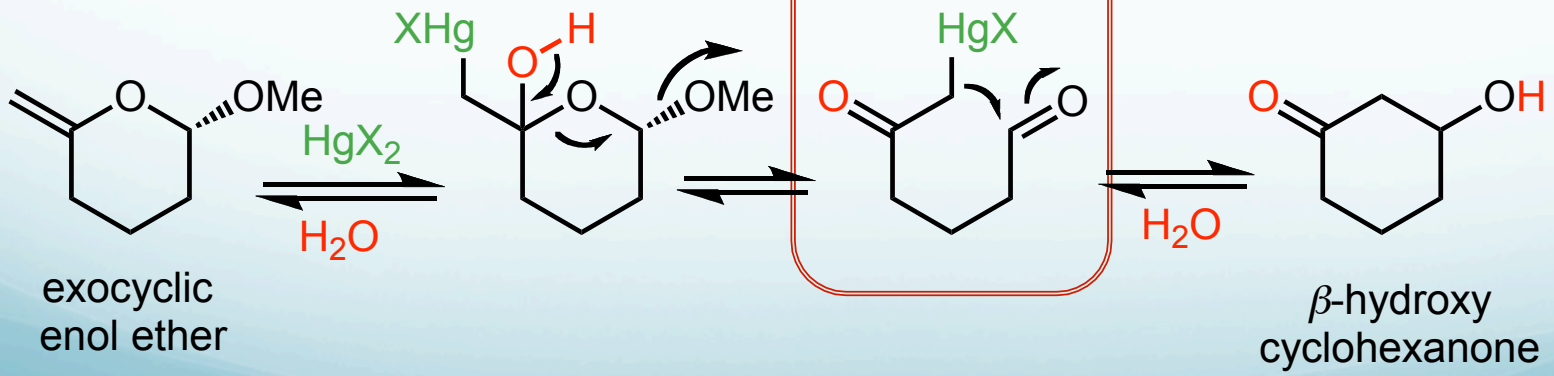
Petasis Rearrangement

Petasis Rearrangement (1996)



Petasis, N. A.; Lu, S.-P. *Tetrahedron Lett.* **1996**, *37*, 141–144.

Ferrier Rearrangement Type II (1979)

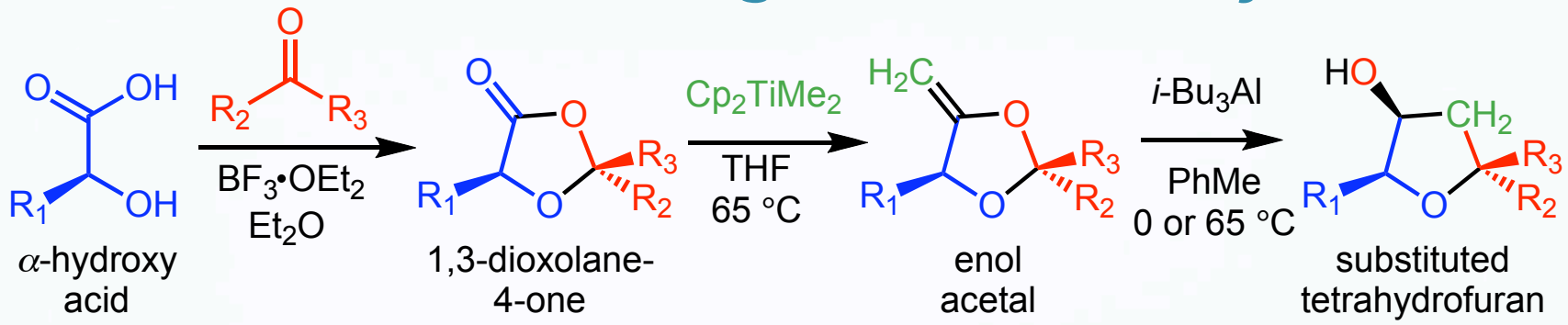


Ferrier, R. J. *J. Chem. Soc., Perkin Trans. 1* **1979**, 1455–1458.

Dr. Nicos A. Petasis

- B.S. Chemistry, Aristotle University of Thessaloniki, Greece, 1978
- Ph.D. Organic Chemistry, University of Pennsylvania, 1983
- Research Associate and Adjunct Lecturer, University of Pennsylvania, 1984-1987
- Harold and Lillian Moulton Chair and Professor in Chemistry, 2001- present University of Southern California
- New Synthetic Methods and Strategies, organotitanium, organoboron, combinatorial chemistry and catalysis

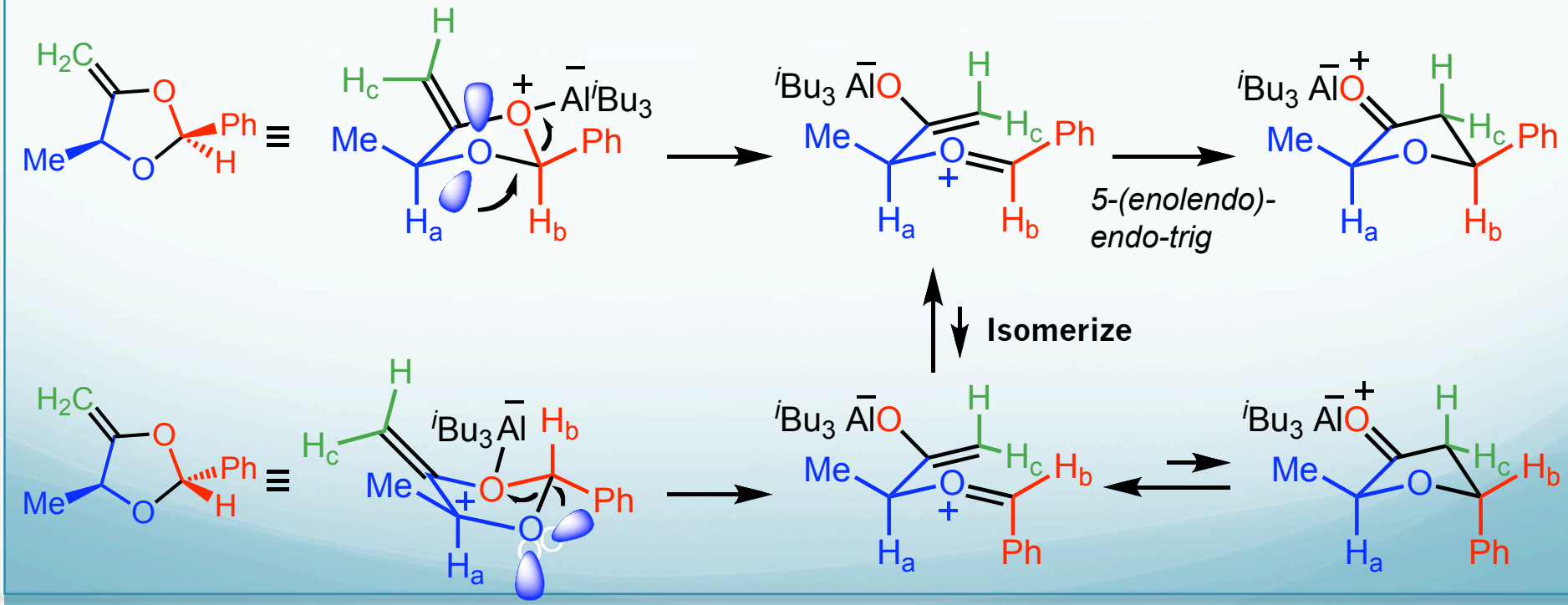
Petasis-Ferrier Rearrangement : Tetrahydrofuran



R_3 = Ph, R_2 = H
R_2 = Ph, R_3 = H

90 % yield
>99 % syn

R_3 = Ph, R_2 = H in the product

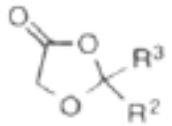
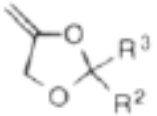
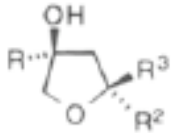


*** Chiral Starting Material**

Petasis, N. A.; Lu, S-P. *J. Am. Chem. Soc.* **1995**, *117*, 6394–6395.

Substrate Scope

R_1 = H, 65 °C

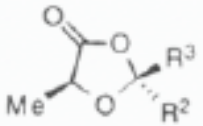
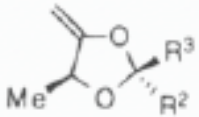
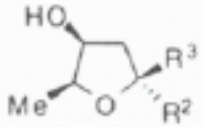
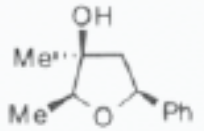
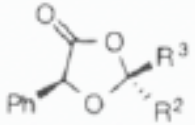
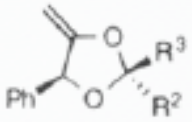
Entry	1,3-Dioxolan-4-one[a,b]	Vinyl acetal / ketal[b,c]	Conditions[d]	Tetrahydrofuran[b]
				
1	**3a**, R^2, R^3= $(CH_2)_5$	**5a**, 88%	$^iBu_3Al$, 65 °C	**6a**, 65% (R = H)
2			Me_3Al, 65 °C	**7a**, 50% (R = Me)
3			Et_3Al, 65 °C	**8a**, 55% (R = Et)
4	**3b**, R^2 = H, R^3 = ^{t}Bu	**5b**, 83%	$^iBu_3Al$, 65 °C	**6b**, 78% (80% syn)
5	**3c**, R^2 = H, R^3 = CH_2Ph	**5c**, 89%	$^iBu_3Al$, 65 °C	**6c**, 75% (61% syn)
6	**3d**, R^2 = H, R^3 = $(CH_2)_9Me$	**5d**, 88%	$^iBu_3Al$, 65 °C	**6d**, 83% (62% syn)

[a]Prepared according to literature procedures. Compound 3h was prepared via the TMSOTf-catalyzed reaction between tBuCHO and the bis-TMS derivative of glycolic acid.'" while compounds 3e.d were prepared from the aldehyde and glycolic acid in the presence of BF_3OEt_2 [b]Yields were determined following isolation by distillaition or chromatography and were not optimized.[c] Prepared by the reaction of **3** with dimethyltitanocenc at 65 °C in THF, [d] All reactions were carried out with 2 equiv of the aluminum reagent in toluene at the indicated temperature.

Petasis, N. A.; Lu, S-P. *J. Am. Chem. Soc.* **1995**, *117*, 6394–6395.

Substrate Scope

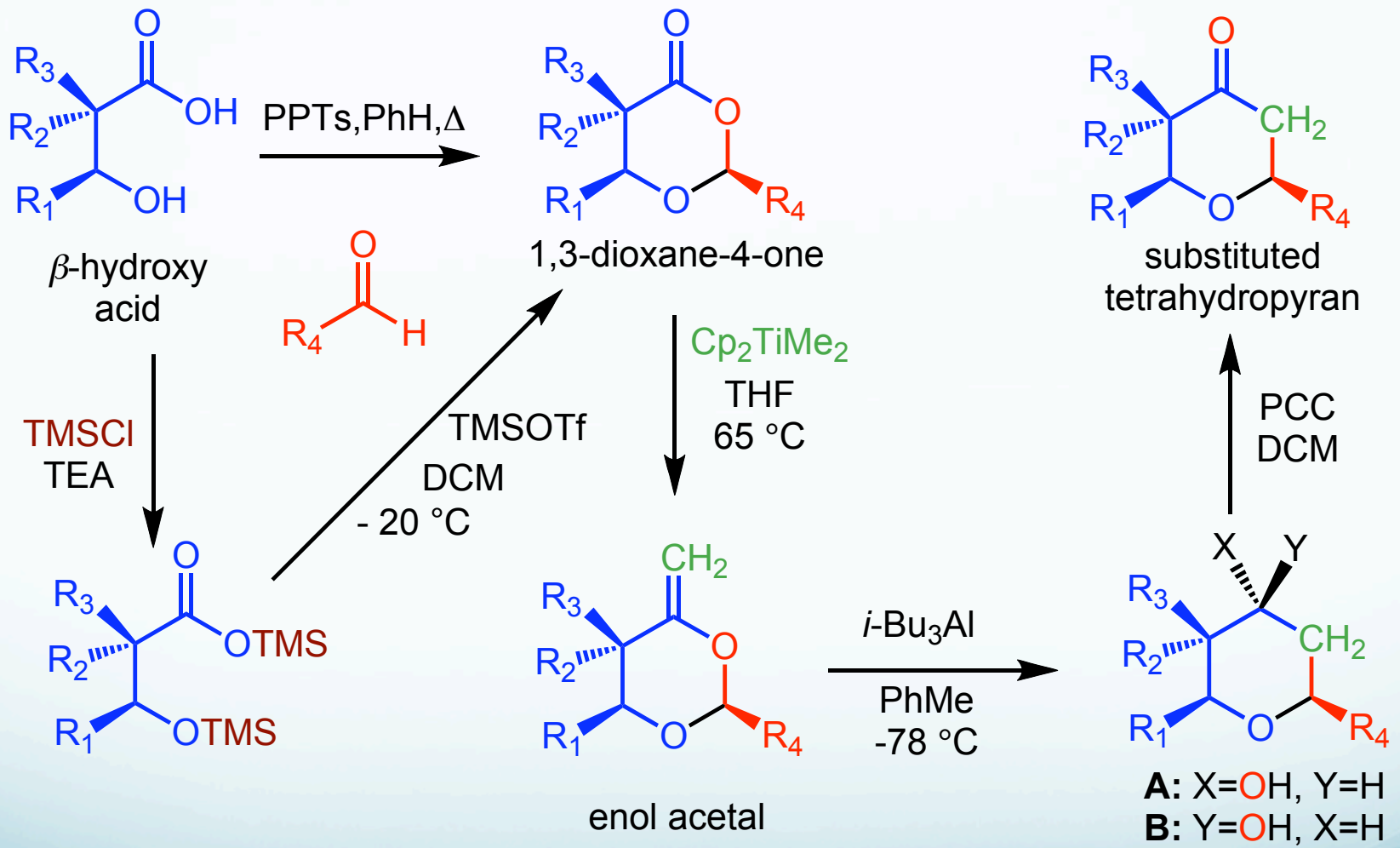
R_1 = Me, 0 °C or Ph, -78 °C

Entry	1,3-Dioxolan-4-one[a,b]	Vinyl acetal / ketal[b,c]	Conditions[d]	Tetrahydrofuran[b]
				
7	**3e**, $R^2, R^3 = (CH_2)_5$	**5e**, 90%	$^iBu_3Al$, 0 °C	**6e**, 91% (91% syn)
8	**3f**, R^2 = Me, R^3 = ^{t}Bu	**5f**, 86%	$^iBu_3Al$, 0 °C	**6f**, 90% (71% syn)
9	**3g**, R^2 = Ph, R^3 = H	**5g**, 55%	$^iBu_3Al$, 0 °C	**6h**, 90% (> 99% syn)
10	**3h**, R^2 = H, R^3 = Ph	**5h**, 55%	$^iBu_3Al$, 0 °C	**6h**, 90% (> 99% syn)
				
11			Me_3Al, 0 °C	**7h**, 77% (> 99% syn)
				
12	**3i**, R^2 = H, R^3 = ^{t}Bu	**5i**, 91%	$^iBu_3Al$, -78 °C	dec.
13	**3j**, R^2 = H, R^3 = Ph	**5j**, 74%	$^iBu_3Al$, -78 °C	dec.
14	**3k**, $R^2 = R^3$ = Me	**5k**, 76%	$^iBu_3Al$, -78 °C	dec.

Dec. = Decomposed

Petasis, N. A.; Lu, S-P. *J. Am. Chem. Soc.* **1995**, *117*, 6394–6395.

Petasis-Ferrier Rearrangement : Tetrahydropyran



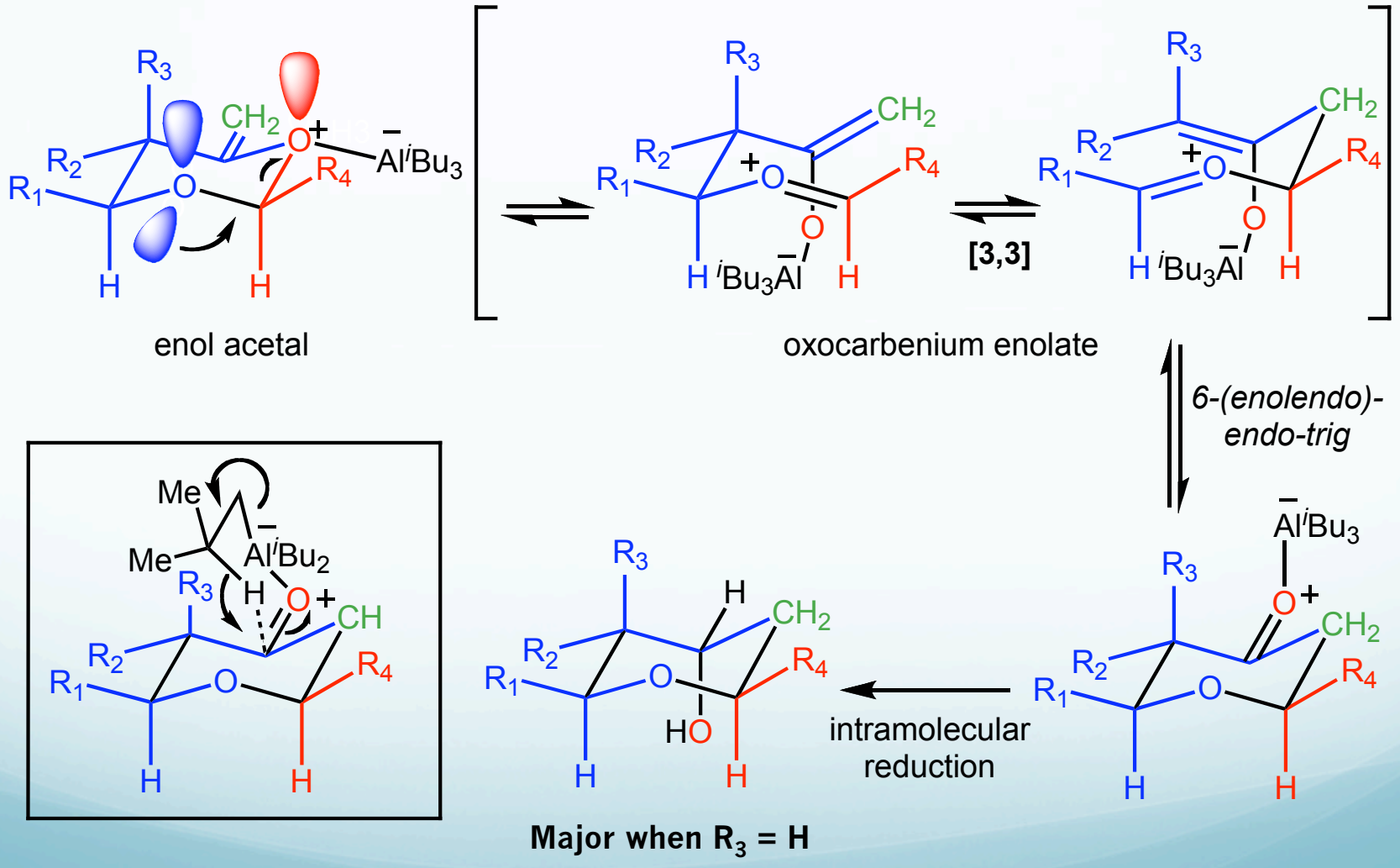
*** Chiral Starting Material**

Major product depends upon substitution pattern

Petasis, N. A.; Lu, S.-P. *Tetrahedron Lett.* **1996,** *37,* 141–144.

Petasis-Ferrier Rearrangement : Tetrahydropyran

Mechanism:



Petasis, N. A.; Lu, S.-P. *Tetrahedron Lett.* **1996,** *37,* 141–144.

Substrate Scope

Table 1. Synthesis of tetrahydropyrans from 1,3-dioxan-4-ones (**4**).

Compd	R^1	R^2	R^3	R^4	Vinyl acetal (**6**)[d,e]	Alcohol[e,f] (**7**:**8**) B:A	Ketone (**9**)[e,g,h]
4a[a]	H	Me	Me	Ph	72%	91% (1:1)	96%
4b[a]	Me	H	H	^{t}Bu	88%	81% (1:1.5)	
4c[b]	Me	H	H	$(CH_2)_2Ph$	86%	96%	98% (86%cis)
4d[b]	Me	H	H	$(CH_2)_9Me$	80%	93%	95% (88%cis)
4e[a]	Me	H	H	Ph	70%	90%	93% (93%cis)
4f[b]	H	Ph	H	^{i}Pr	67%	88% (1:8)	92% (>99%cis)
4g[b]	H	H	Ph	^{i}Pr	65%	90% (1:0)	
4h[c]	Me	$PhCH_2$	H	^{t}Bu	75%	92% (1:8)	

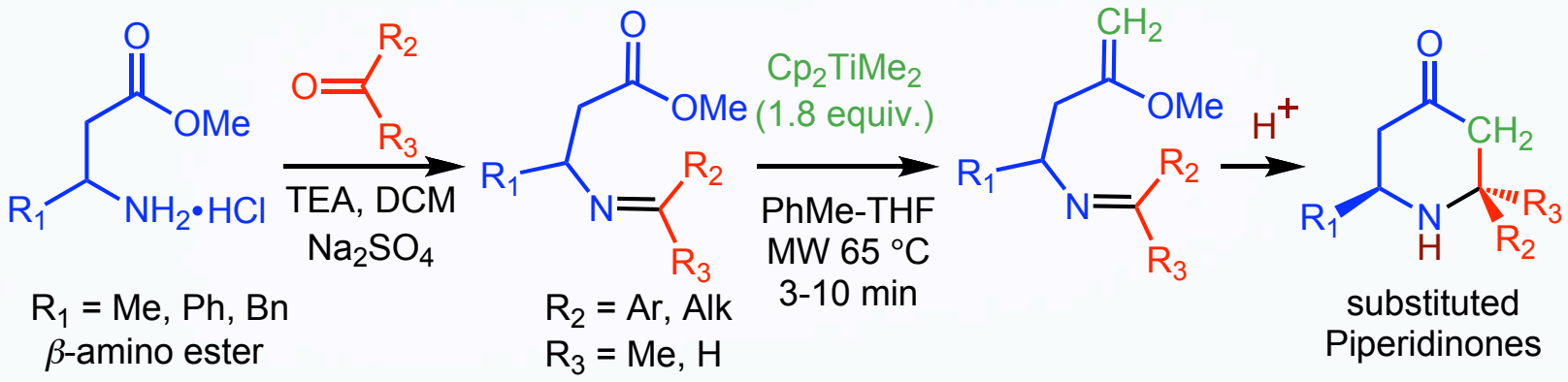
[a]Prepared from **2** and **3**.[4c] [b]Prepared from **1** and **3**.[4b] [c]Prepared by the alkylation of **4b** with LDA at -78 °C and benzyl bromide.[6] [d]Vinyl acetals were prepared by the reaction of **4** with dimethyltitanocene at 65 °C in THF.[5] [e]Yields were determined followed isolation by distillation or chromatography and were not optimized. [f]Obtained by the reaction of the vinyl acetal with 2 equiv. of $^iBu_3Al$ in toluene at -78 °C. [g]Obtained by oxidation of the alcohol with PCC in CH_2Cl_2. [h]Ratios of the relative stereochemistry at C_2 and C_6 were determined with NMR and are indicated in parentheses.

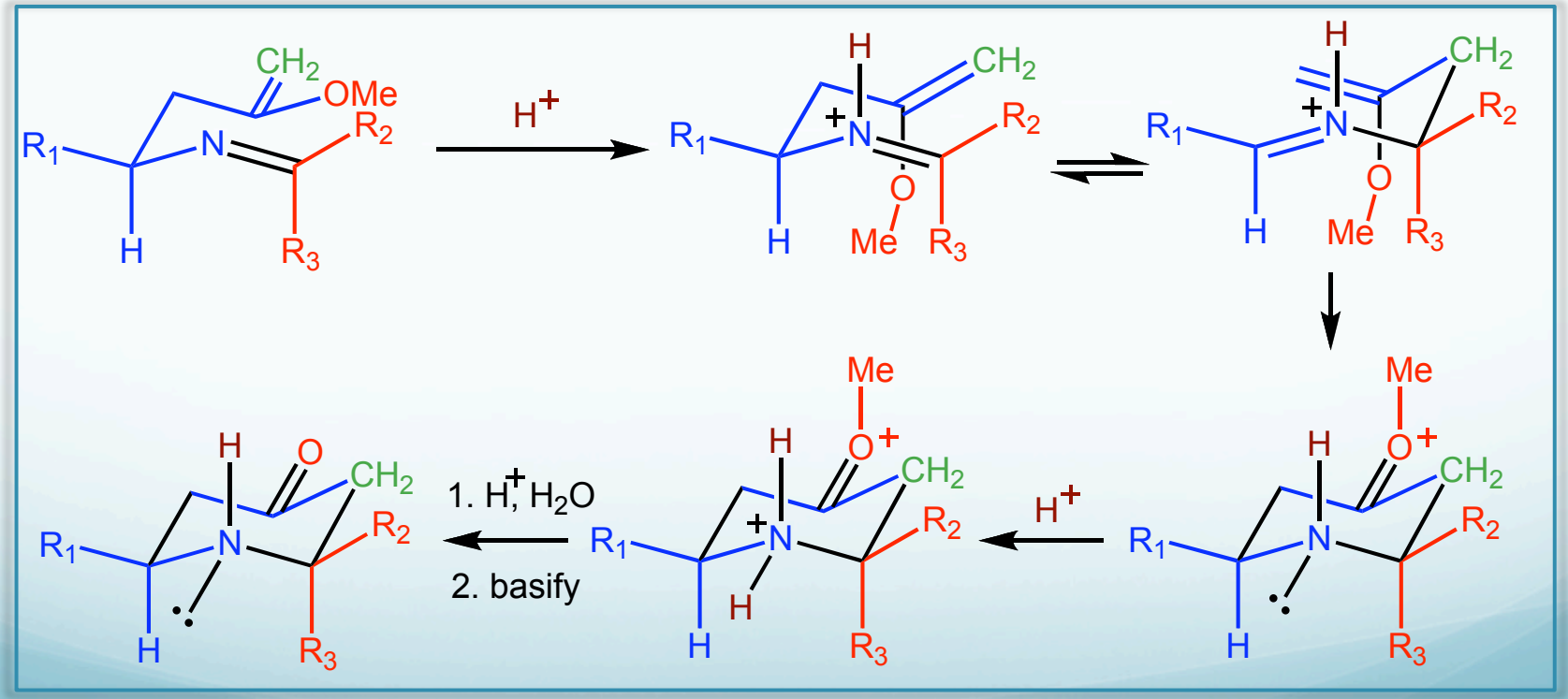
Petasis, N. A.; Lu, S.-P. *Tetrahedron Lett*. **1996,** *37,* 141–144.

Petasis-Ferrier Rearrangement : Main Features

- The straightforward construction of the substrate enol acetals allows the stereocontrolled assembly of complex fragments.
- The configuration of the acetal carbon is retained or enhanced during the rearrangement.
- The rearrangement of 5-membered enol acetals takes place at a much higher temperature than for 6-membered substrates.(may be due more facile *6-(enolendo)-endo-trig* cyclization)
- Trialkylaluminum were found to be the most effective reagents (*i*-Bu_3Al, Me_3Al and Me_2AlCl)
- The stereoselective reduction (last step) depends on the substitution pattern and occur when *i*-Bu_3Al used (not occurs if Me_2AlCl used)
- Drawback: Olefination step can lead to olefin stereoisomers when applied titanocene is other than Dimethyl titanocene.

Nitrogen Analogue to Petasis-Ferrier Rearrangement





Adriaenssens, L. V.; Hartley, R. C. *J. Org. Chem.* **2007**, *72*, 10287-10290.

Substrate Scope

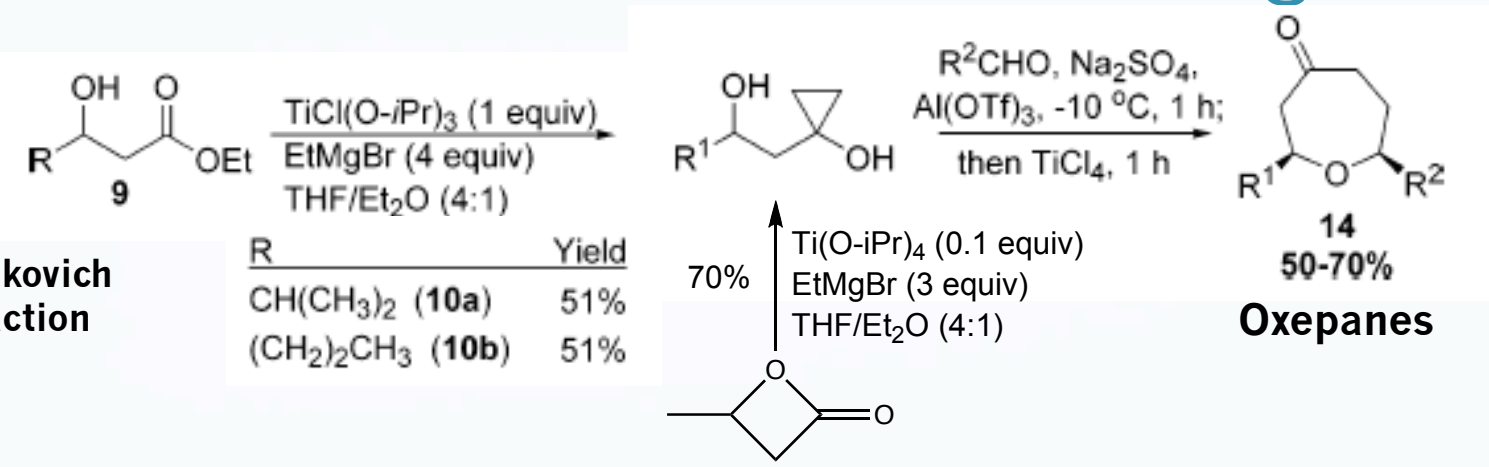
TABLE 1. Summary of Reaction Conditions and Yields for the Synthesis of Piperidinones

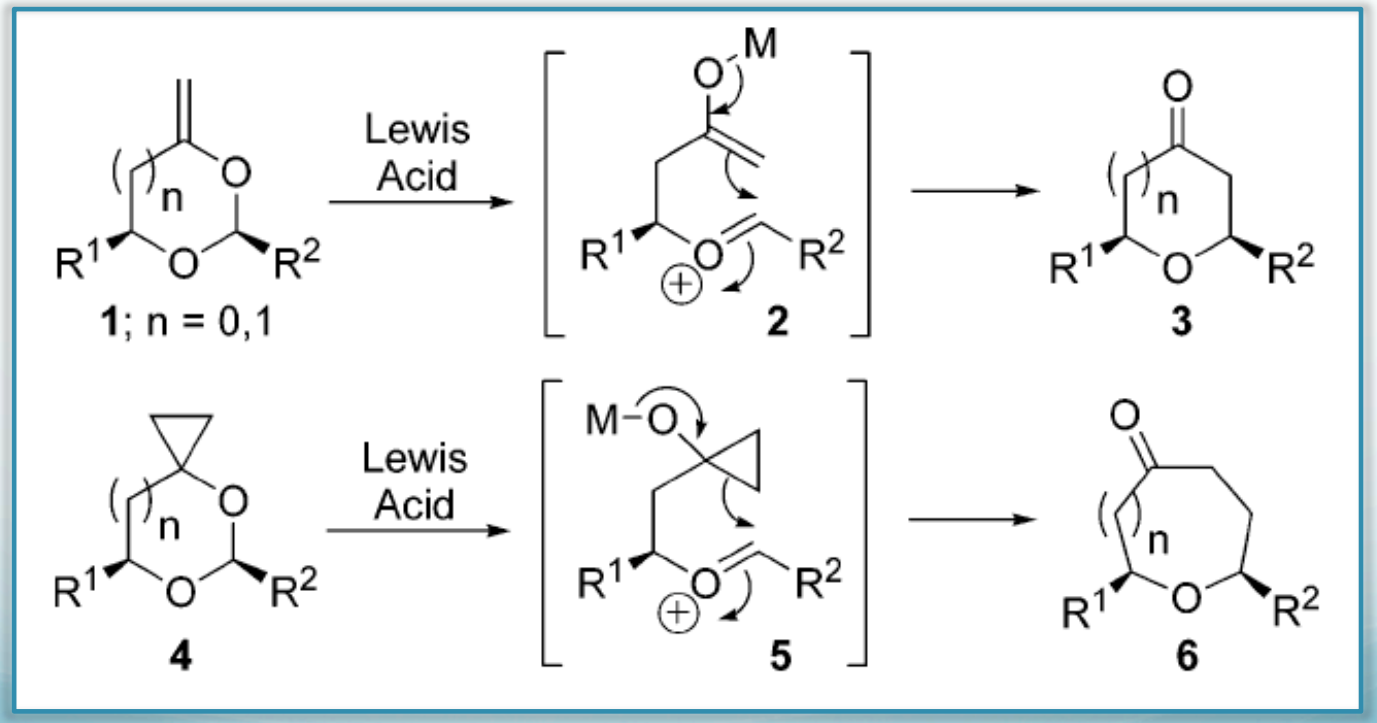
entry	compd	yield[a] of imine **19**, %	piperidinones **21** R^1	R^2	R^3	cyclization conditions acid	solvent	temp, °C	time, h	hydrolysis	yield[b] from **19**, %
1	**A**	75[c]	Me	Ph	H	7 M HCl	H_2O	20	0.5		61[d]
2	**B**	89	Ph	Ph	H	7 M HCl	H_2O	20	0.5		62[d]
3	**C**	94	Ph	2,4-$MeOC_6H_3$	H	7 M HCl	H_2O	20	17		12[d]
4	**D**	74[e]	Me	Ph	Me	7 M HCl	H_2O	20	17		trace
5	**A**	75[c]	Me	Ph	H	2 equiv of TsOH	CH_2Cl_2	20	17	1 M HCl (0.5 h)	61
6	**E**	83	$PhCH_2$	Ph	H	2 equiv of TsOH	CH_2Cl_2	40	17	1 M HCl (0.5 h)	61
7	**C**	94	Ph	2,4-$MeOC_6H_3$	H	2 equiv of TsOH	CH_2Cl_2	20	17	1 M HCl (0.5 h)	40
8	**F**	87[c]	Me	(*E*)-4-$MeOC_6H_4CH{=}CH$	H	2 equiv of TsOH	$CHCl_3$	60	17	1 M HCl (0.5 h)	37
9	**C**	94	Ph	2,4-$MeOC_6H_3$	H	2 eq.uiv of TsOH	DME	20	17	1 M HCl (0.5 h)	51
10	**G**	61	Me	2,4-$MeOC_6H_3$	H	2 equiv of TsOH	DME	20	17	1 M HCl (0.5 h)	58
11	**H**	58	Me	3-Br C_6H_4	H	2 equiv of TsOH	DME	20	17	1 M HCl (0.5 h)	48
12	**I**	90	Ph	^{t}Bu	H	2 equiv of TsOH	DME	20	17	1 M HCl (0.5 h)	58
13	**J**	91[f]	Ph	Et	H	2 equiv of TsOH	DME	20	17	1 M HCl (0.5 h)	34
14	**B**	72	Ph	Ph	H	2 equiv of TsOH	DMSO	28	17	1 M HCl (0.5 h)	61
15	**A**	75[c]	Me	Ph	H	2 equiv of Al(^{i}Bu)$_3$	DMSO	28	17	1 M HCl (0.5 h)	68
16	**B**	72	Ph	Ph	H	2 equiv of Al(^{i}Bu)$_3$	DMSO	28	17	1 M HCl (0.5 h)	70
17	**C**	94	Ph	2,4-$MeOC_6H_3$	H	2 equiv of Al(^{i}Bu)$_3$	DMSO	28	17	1 M HCl (0.5 h)	66
18	**K**	55	Me	2-F C_6H_4	H	2 equiv of Al(^{i}Bu)$_3$	DMSO	28	17	1 M HCl (0.5 h)	64
19	**F**	87[c]	Me	(*E*)-4-$MeOC_6H_4CH{=}CH$	H	2 equiv of Al(^{i}Bu)$_3$	DMSO	28	17	1 M HCl (0.5 h)	51
20	**D**	74[e]	Me	Ph	Me	2 equiv of Al(^{i}Bu)$_3$	DMSO	28	17	1 M HCl (0.5 h)	69[g]
21	**L**	73	Ph	$-(CH_2)_5-$		2 equiv of Al(^{i}Bu)$_3$	DMSO	28	17	1 M HCl (0.5 h)	52

[a] Isolated yield from amines **18** after purification. [b] Isolated yield after purification; except where otherwise indicated, only the 2,6-*syn* isomer was detected by NMR of the crude mixture and only this isomer was isolated; relative stereochemistry was assigned by NOE, except for **21B**, which was assigned by comparison with the literature. [c] Yield based on aldehyde. [d] Isolated as HCl salt. [e] *E*:*Z* ratio was 93:7. [f] **19**:**18**:propionaldehyde 80:13:7. [g] dr (2,6-*syn*:2,6-*anti*) = 89:11 in both crude mixture and isolated material.

Adriaenssens, L. V.; Hartley, R. C. *J. Org. Chem.* **2007**, *72*, 10287-10290.

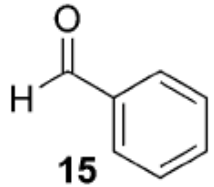
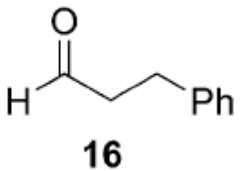
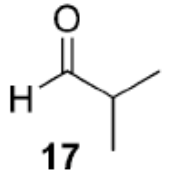
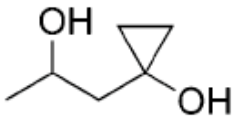
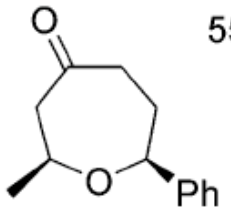
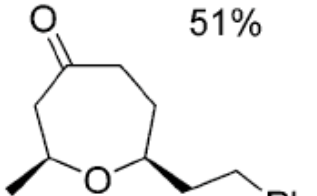
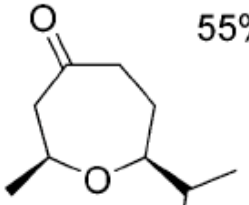
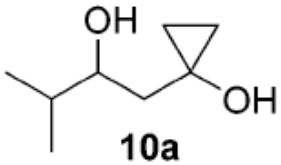
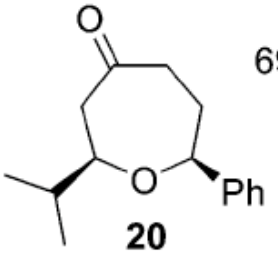
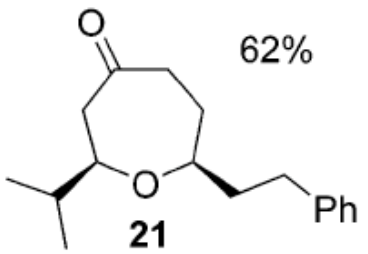
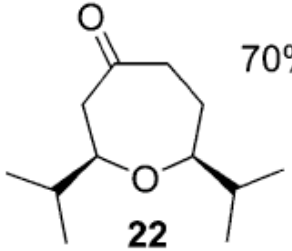
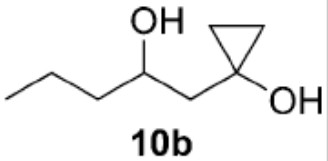
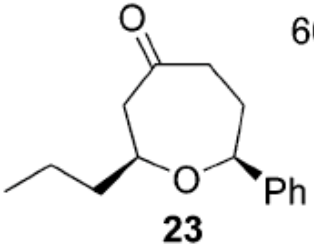
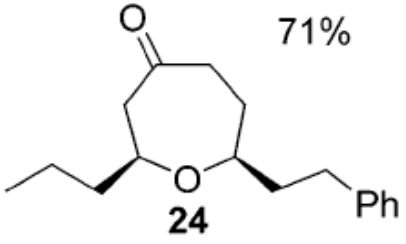
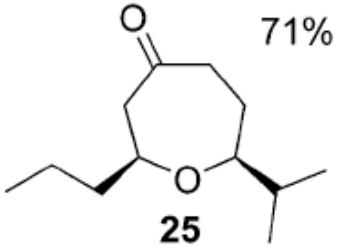
Variant of Petasis-Ferrier Rearrangement





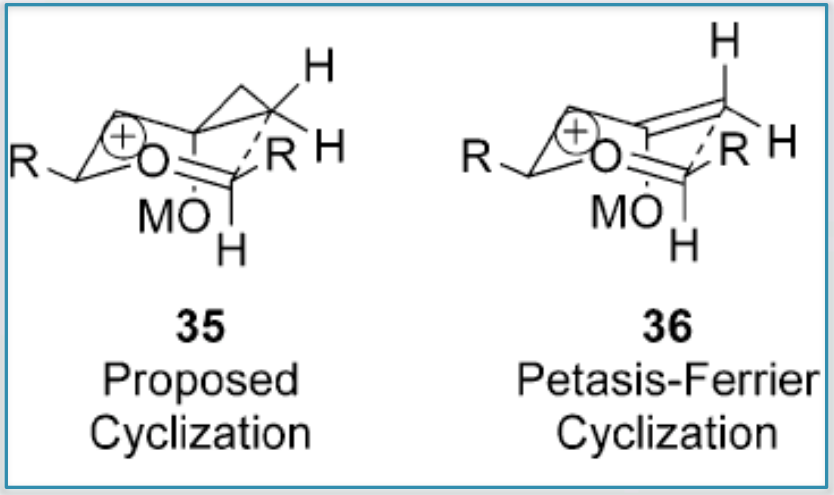
O'Neil, E.; Kingree, S. V.; Minbiole, K. P. C. *Org. Lett.* **2005**, *7*, 515-517.

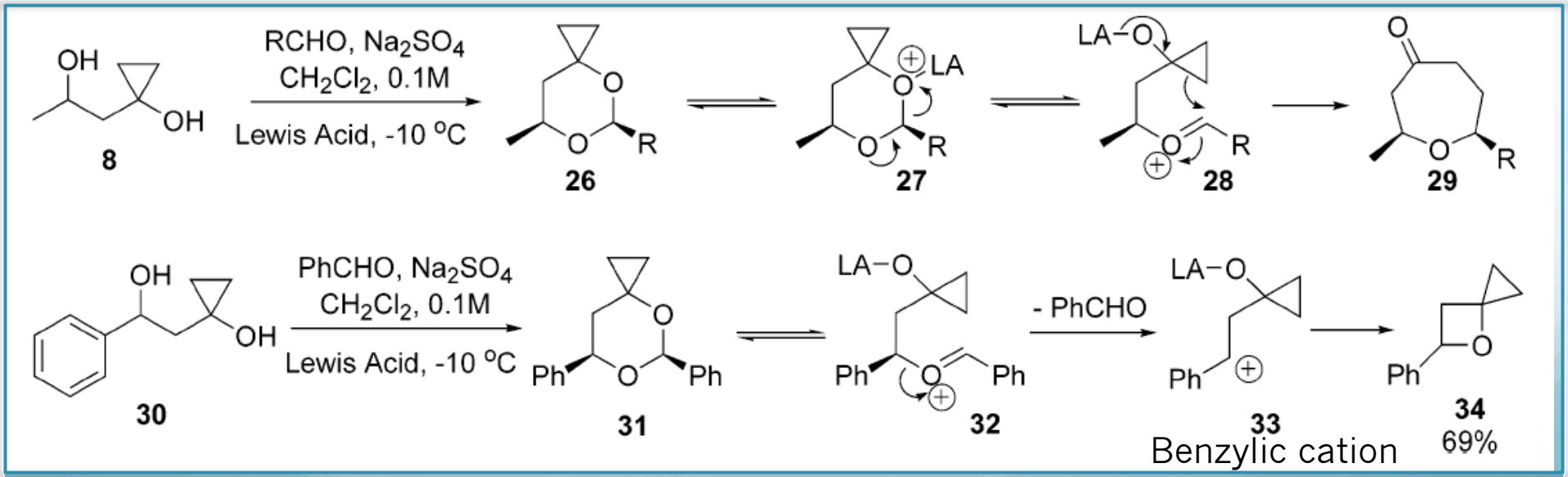
Substrate Scope

diol \ RCHO	 **15**	 **16**	 **17**
 **8**	 55% **12**	 51% **18**	 55% **19**
 **10a**	 69% **20**	 62% **21**	 70% **22**
 **10b**	 66% **23**	 71% **24**	 71% **25**

O'Neil, E.; Kingree, S. V.; Minbiole, K. P. C. *Org. Lett.* **2005**, *7*, 515-517.

Mechanism



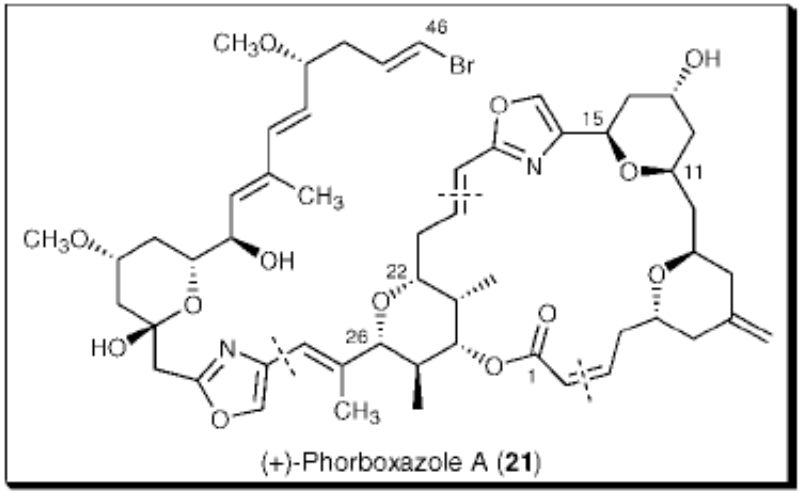


O'Neil, E.; Kingree, S. V.; Minbiole, K. P. C. *Org. Lett.* **2005**, *7*, 515-517.

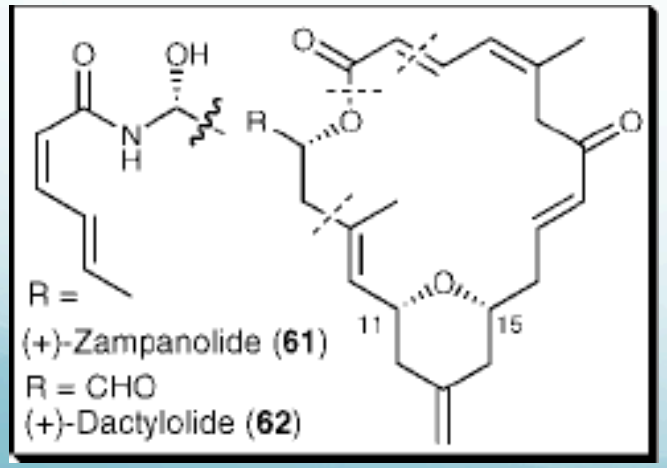
Application to Total Synthesis

(+)-Phorboxazole A

Smith, A. B., III; Verhoest, P. R.; Minbiole, Kevin P.; Lim, J. J. *Org Lett* **1999**, *1*, 909-912. (b) Smith, A. B., III; Minbiole, K. P.; Verhoest, P. R.; Beauchamp, T. J. *Org Lett* **1999**, *1*, 913-916. (c) Smith, A. B., III; Verhoest, P. R.; Minbiole, K. P.; Schelhaas, M. *J. Am. Chem. Soc.* **2001**, *123,* 4834–4836. (d)Smith, A. B., III; Minbiole, K. P.; Verhoest, P. R.; Schelhaas, M. *J. Am. Chem. Soc.* **2001**, *123,* 10942–10953. (e) Smith, A. B., III; Razler, T. M.; Ciavarri, J. P.; Hirose, T.; Ishikawa, T. *Org. Lett.* **2005**, *7*, 4399–4402. (f) Smith, A. B.; Razler, T. M.; Ciavarri, J. P.; Hirose, T.; Ishikawa, T.; Meis, R. *J. Org. Chem.* **2008**, *73,* 1192–1200. (g) Smith, A. B., III; Razler, T. M.; Meis, R.; Pettit, G. R. *J. Org. Chem.* **2008**, *73,* 1201–1208.



(+)-Phorboxazole A (**21**)



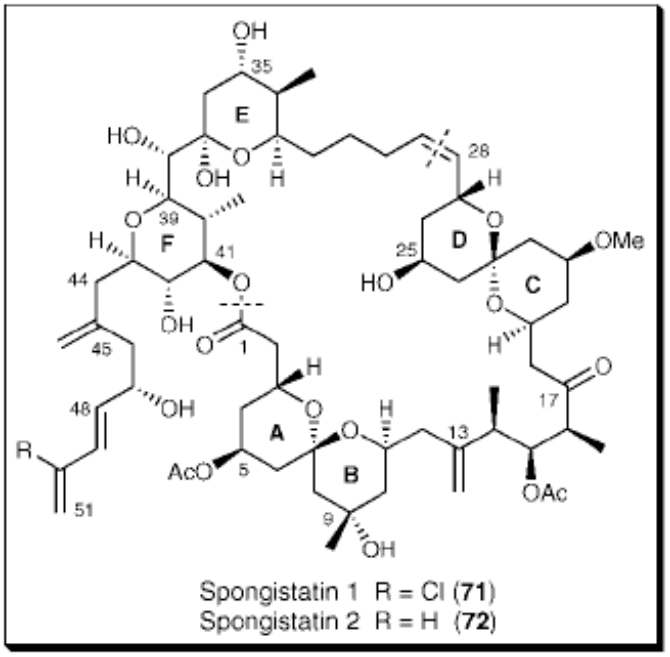
(+)-Zampanolide and (+)-Dactylolide

(a) Smith, A. B., III; Safonov, I. G.; Corbett, R. M. *J. Am. Chem. Soc.* **2001**, *123,* 12426–12427. (b) Smith, A. B., III; Safonov, I. G. *Org. Lett.* **2002**, *4,* 635–637. (c) Smith, A. B., III; Safonov, I. G.; Corbett, R. M. *J. Am. Chem. Soc.* **2002**, *124,*11102–11113.

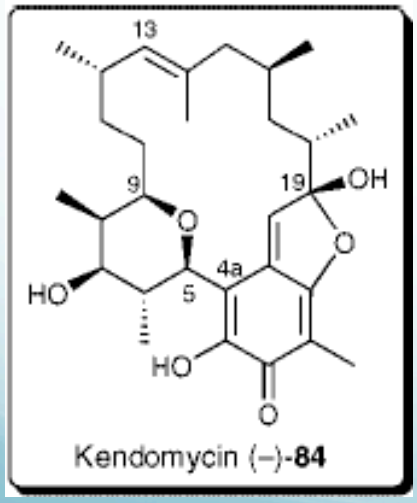
Application to Total Synthesis

(+)-Spongistatin 1

(a) Smith, A. B., III; Zhu, W.; Shirakami, S.; Sfouggatakis, C.; Doughty, V. A.; Bennett, C. S.; Sakamoto, Y. *Org. Lett.* **2003**, *5,* 761–764. (b) Smith, A. B., III; Sfouggatakis, C.; Gotchev, D. B.; Shirakami, S.; Bauer, D.; Zhu, W.; Doughty, V. A. *Org. Lett* **2004, *6***, 3637-3640.



Spongistatin 1 R = Cl (**71**)
Spongistatin 2 R = H (**72**)



Kendomycin (–)-**84**

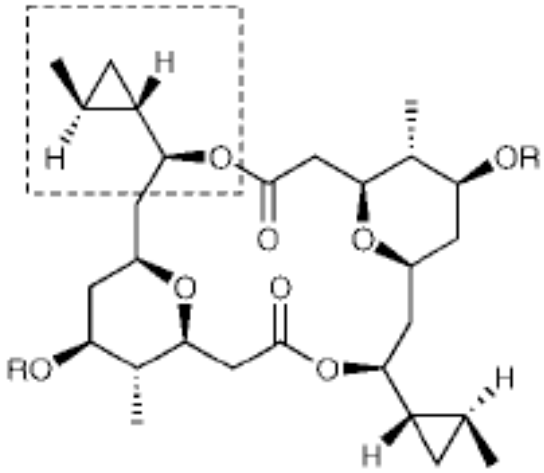
(-)-Kendomycin

(a) Smith, A. B., III; Mesaros, E. F.; Meyer, E. A. *J. Am. Chem. Soc.* **2005**, *127,* 6948–6949. (b) Smith, A. B., III; Mesaros, E. F.; Meyer, E. A. *J. Am. Chem. Soc*. **2006**, *128,* 5292–5299.

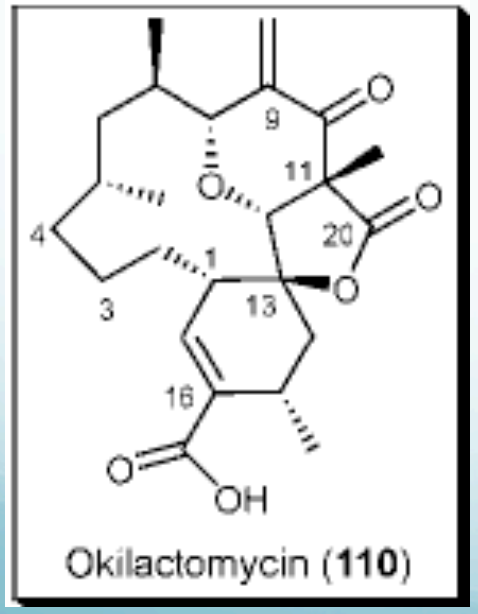
Application to Total Synthesis

(-)-Clavosolide A

Smith, A. B., III; Simov, V. *Org. Lett***. 2006***, 8,* 3315–3318.



(–)-Clavosolide A (**101**) (Proposed)



Okilactomycin (**110**)

(-)-Okilactomycin

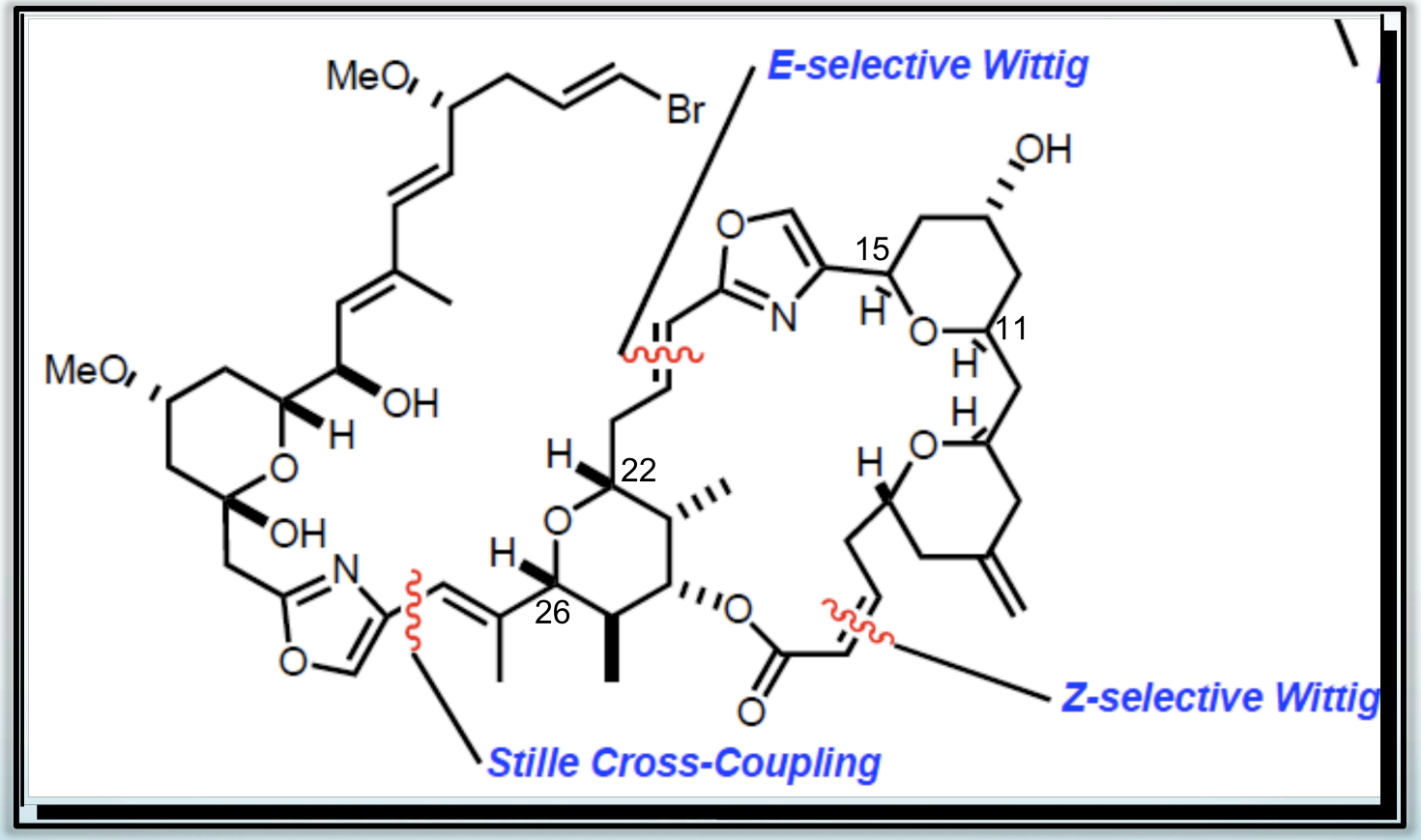
(a) Smith, A. B., III; Basu, K.; Bosanac, T. *J. Am. Chem. Soc.* **2007***, 129,* 14872–14874.*(b)* Smith, A. B., III; Bosanac, T.; Basu, K . *J. Am. Chem. Soc.* **2009,** *131,* 2348-2358.

*Smith, A. B., III; Fox, R. J.; Razler, T. M. *Acc. Chem. Res.* **2008**, *41,* 675-687

Dr. Amos B. Smith

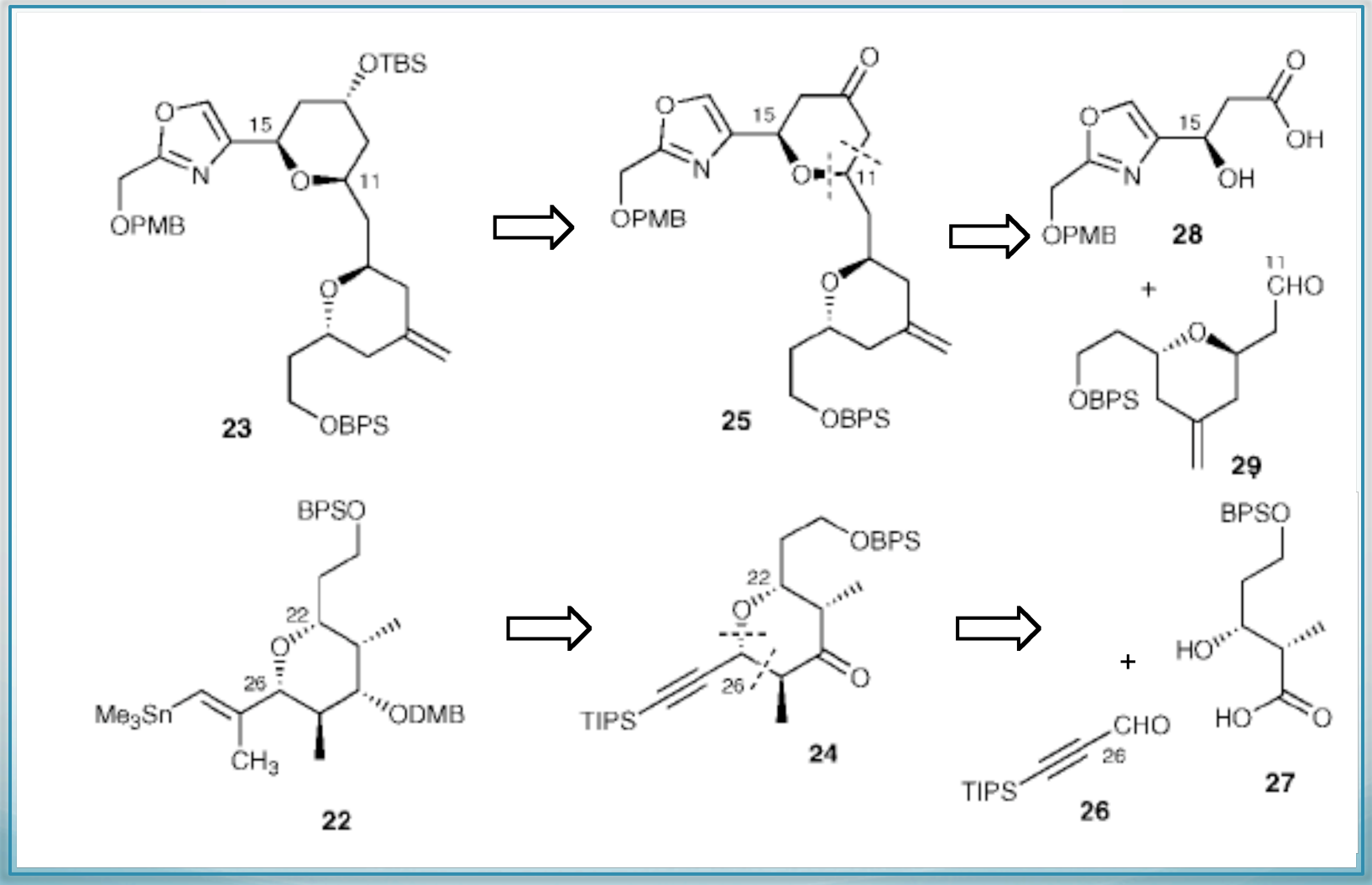
- Bucknell University's first combined four-year B.S.- M.S. degree in Chemistry, 1966
- PhD,1972 & Research Associate at Rockefeller University.
- Professor, Department of Chemistry at the University of Pennsylvania, 1973
- Currently, Rhodes-Thompson Professor of Chemistry, a Member of the Monell Chemical Senses Center, the Associate Director of the Penn Center for Molecular Discovery (PCMD),
- First Editor-in-Chief of the new American Chemical Society journal, Organic Letters, 1998

Phorboxazole A



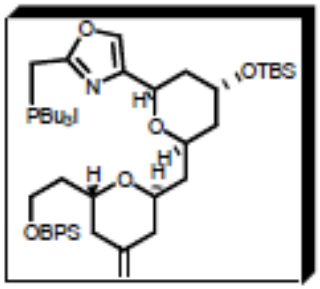
Smith, A. B., III; Minbiole, K. P.; Verhoest, P. R.; Schelhaas, M. *J. Am. Chem. Soc.* **2001**, *123,* 10942–10953.

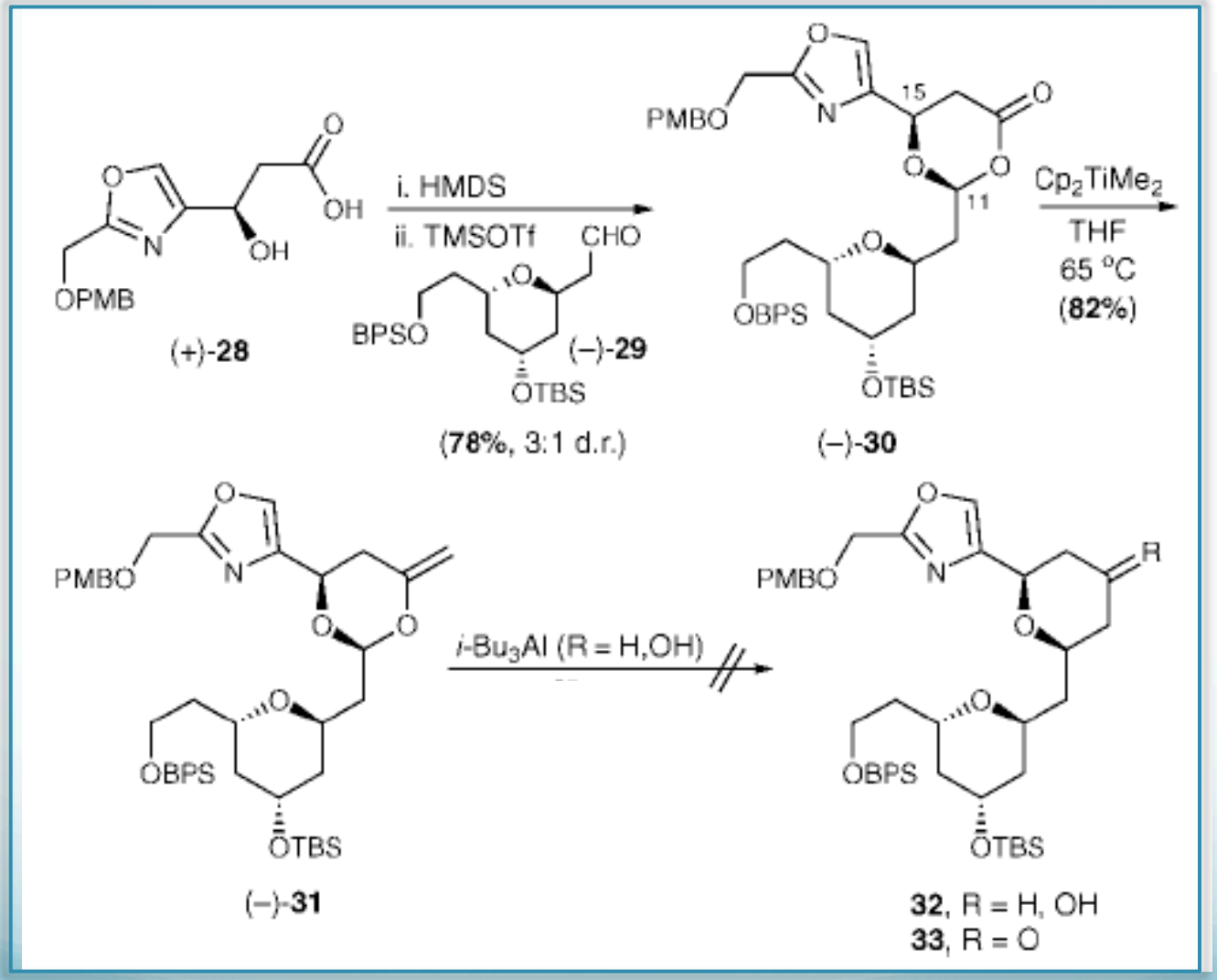
Retrosynthetic Analysis



Smith, A. B., III; Minbiole, K. P.; Verhoest, P. R.; Schelhaas, M. *J. Am. Chem. Soc.* **2001**, *123,* 10942–10953.

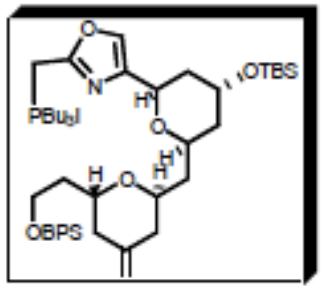
Initial Attempts towards P-F Reaction

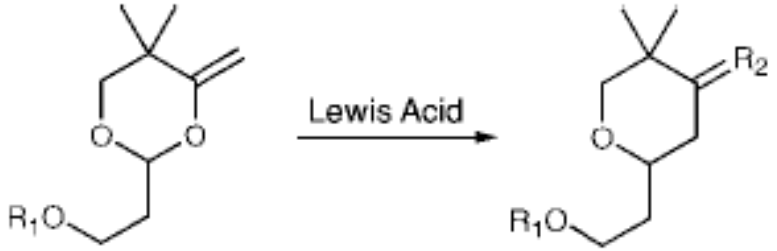




Smith, A. B., III; Minbiole, K. P.; Verhoest, P. R.; Schelhaas, M. *J. Am. Chem. Soc.* **2001**, *123,* 10942–10953.

Optimization of P-F Reaction





34a, R_1=Ph
34b, R_1=BPS

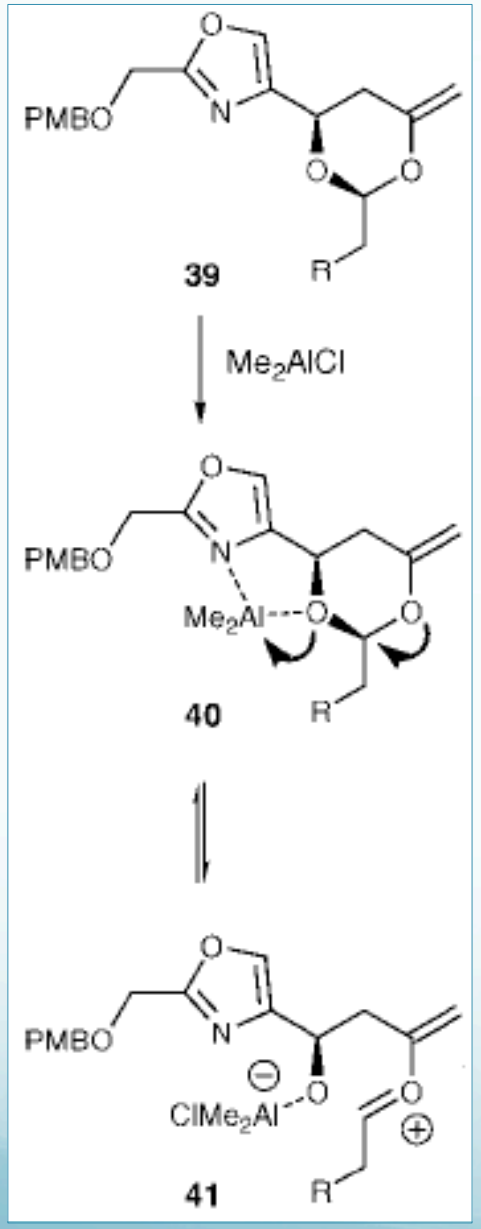
35, R_1=Ph, R_2=(H, OH)
36, R_1=Ph, R_2=O
37, R_1=BPS, R_2=(H, OH)
38, R_1=BPS, R_2=O

Lewis Acid	R_1=Ph	R_1=BPS
i-Bu_3Al	87% (**35**)	85% (**37**)
$ZnCl_2$	25% (**36**)	0%
Me_2AlCl	**95% (36)**	**92% (38)**
$MeAlCl_2$	60% (**36**)	--
BF_3•OEt_2	0%	--
$TiCl_4$	0%	--
$TiCl_2$(O*i*-Pr)$_2$	0%	--
$SnCl_4$	0%	--

But failed

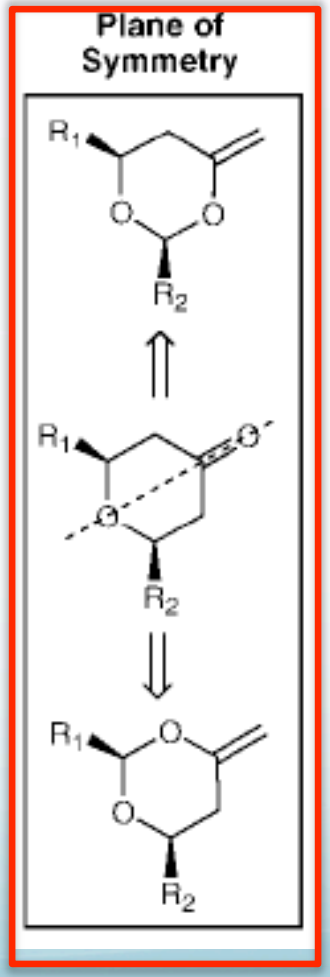
Smith, A. B., III; Minbiole, K. P.; Verhoest, P. R.; Schelhaas, M. *J. Am. Chem. Soc.* **2001**, *123,* 10942–10953.

Inherent Pseudo symmetry of P-F Reaction

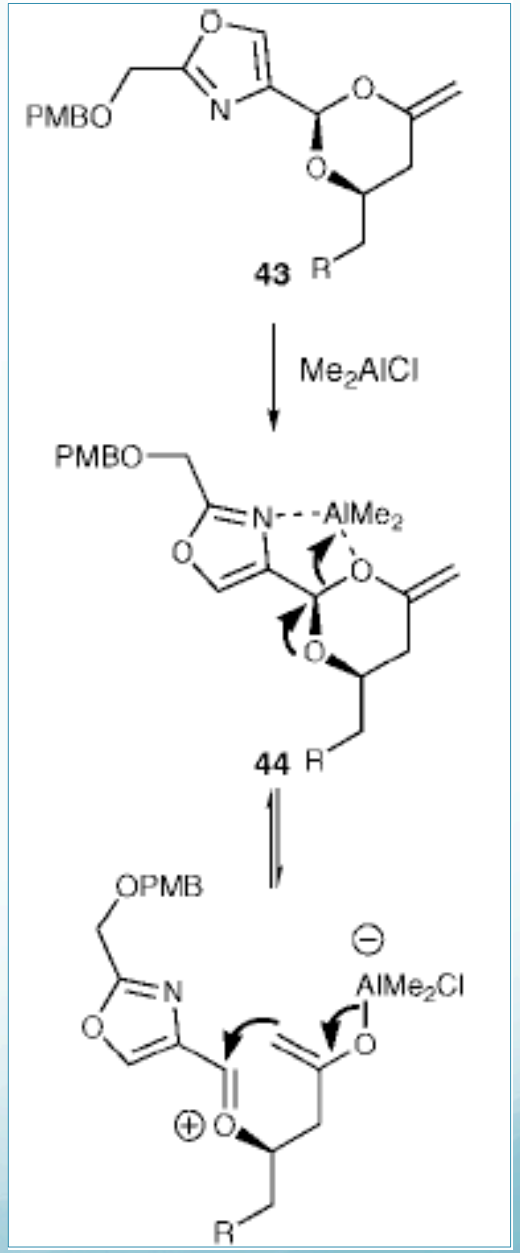


Unproductive Al coordination

Switch Coupling Partners

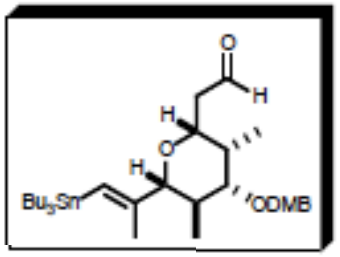


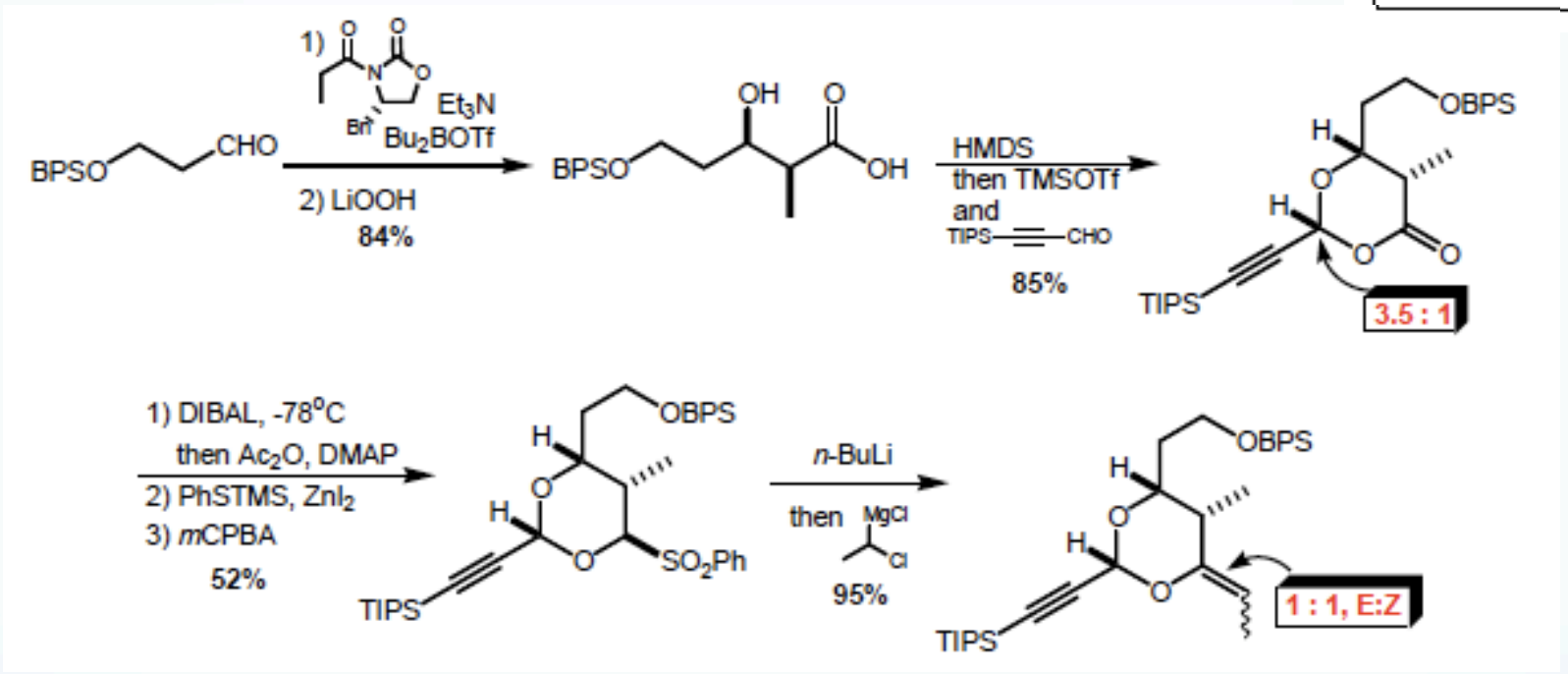
Yield = 89 %

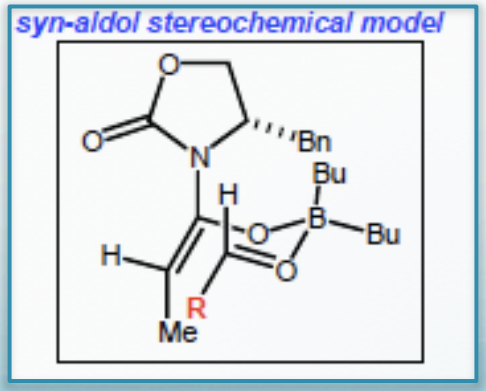


Productive Al coordination

P-F Reaction for other fragment

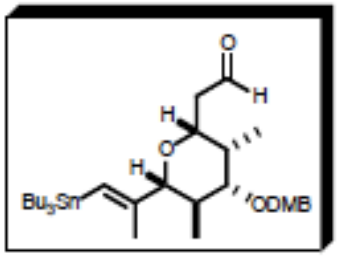


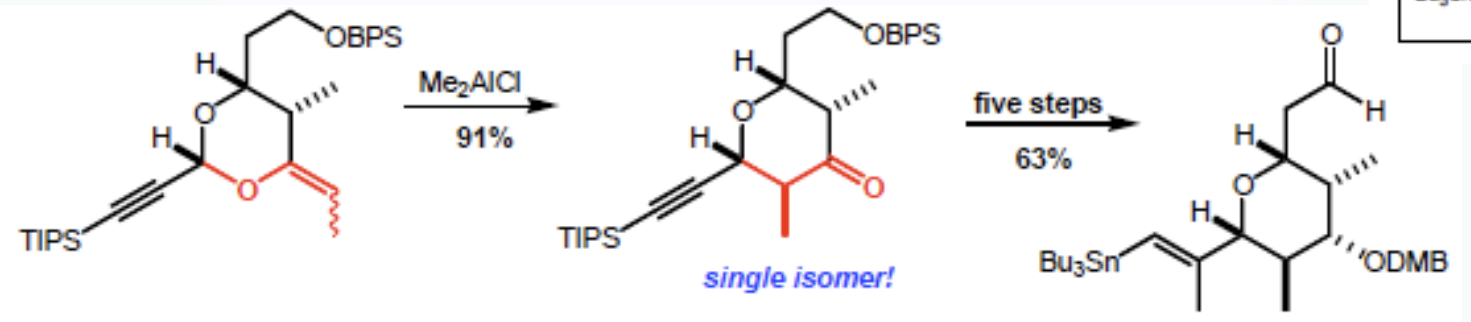


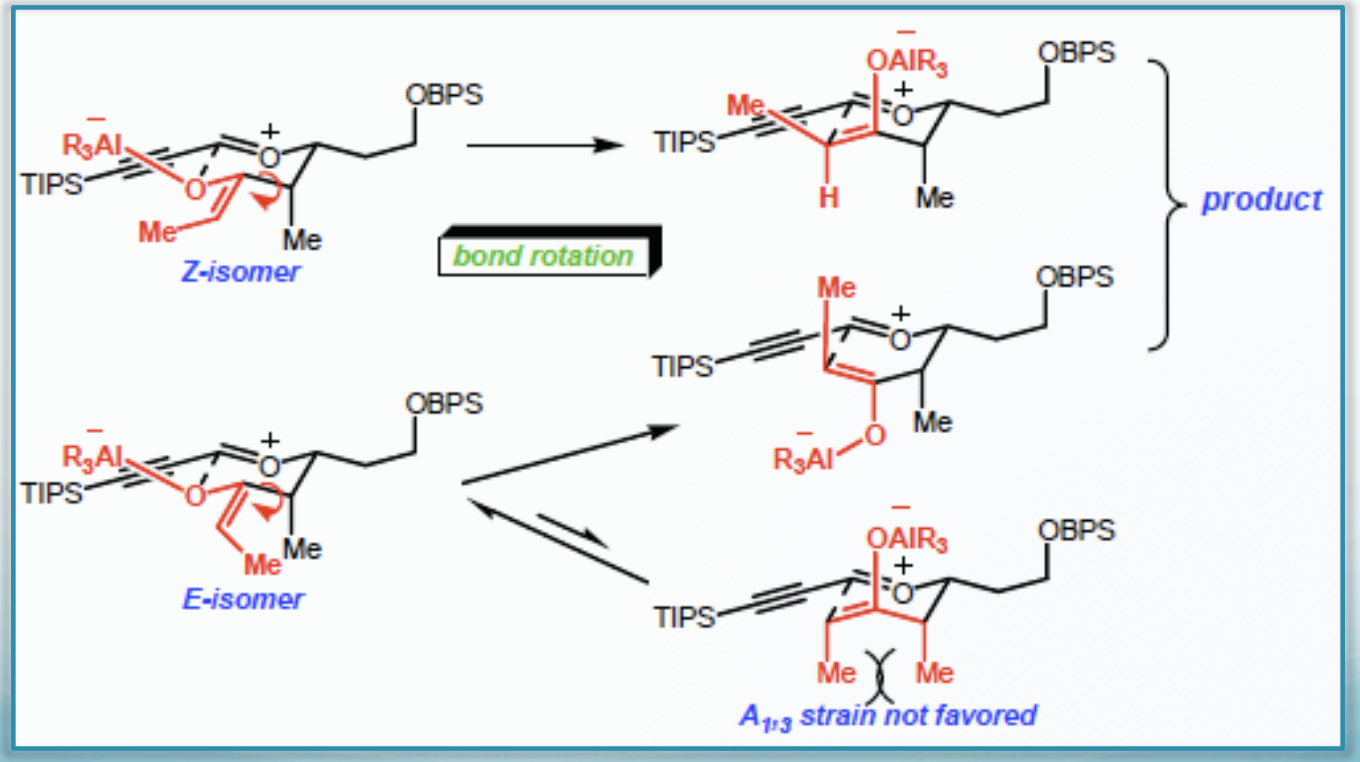


Smith, A. B., III; Minbiole, K. P.; Verhoest, P. R.; Schelhaas, M. *J. Am. Chem. Soc.* **2001**, *123,* 10942–10953.

Mechanistic Rationale







Smith, A. B., III; Minbiole, K. P.; Verhoest, P. R.; Schelhaas, M. *J. Am. Chem. Soc.* **2001**, *123,* 10942–10953.

Thanks

Application to Total Synthesis

- **(+)-Phorboxazole A [4]**

  (a) Smith, A. B., III; Verhoest, P. R.; Minbiole, Kevin P.; Lim, J. J. *Org Lett* **1999**, *1*, 909-912. (b) Smith, A. B., III; Minbiole, K. P.; Verhoest, P. R.; Beauchamp, T. J. *Org Lett* **1999**, *1*, 913-916. (c) Smith, A. B., III; Verhoest, P. R.; Minbiole, K. P.; Schelhaas, M. *J. Am. Chem. Soc.* **2001**, *123,* 4834–4836.(d)Smith, A. B., III; Minbiole, K. P.; Verhoest, P. R.; Schelhaas, M. *J. Am. Chem. Soc.* **2001**, *123,* 10942–10953.

- **(+)-Zampanolide and (+)-Dactylolide [3]**

  (a) Smith, A. B., III; Safonov, I. G.; Corbett, R. M. *J. Am. Chem. Soc.* **2001**, *123,* 12426–12427. (b) Smith, A. B., III; Safonov, I. G. *Org. Lett.* **2002**, *4,* 635–637. (c) Smith, A. B., III; Safonov, I. G.; Corbett, R. M. *J. Am. Chem. Soc.* **2002**, *124,*11102–11113.

- **(+)-Spongistatin 1 [2]**

  (a) Smith, A. B., III; Zhu, W.; Shirakami, S.; Sfouggatakis, C.; Doughty, V. A.; Bennett, C. S.; Sakamoto, Y. *Org. Lett.* **2003**, *5,* 761–764. (b) Smith, A. B., III; Sfouggatakis, C.; Gotchev, D. B.; Shirakami, S.; Bauer, D.; Zhu, W.; Doughty, V. A. *Org. Lett* **2004**, ***6***, 3637-3640.

- **(-)-Kendomycin [2]**

  (a) Smith, A. B., III; Mesaros, E. F.; Meyer, E. A. *J. Am. Chem. Soc*. **2005**, *127,* 6948–6949. (b) Smith, A. B., III; Mesaros, E. F.; Meyer, E. A. *J. Am. Chem. Soc*. **2006**, *128,* 5292–5299.

- **(-)-Clavosolide A [1]**

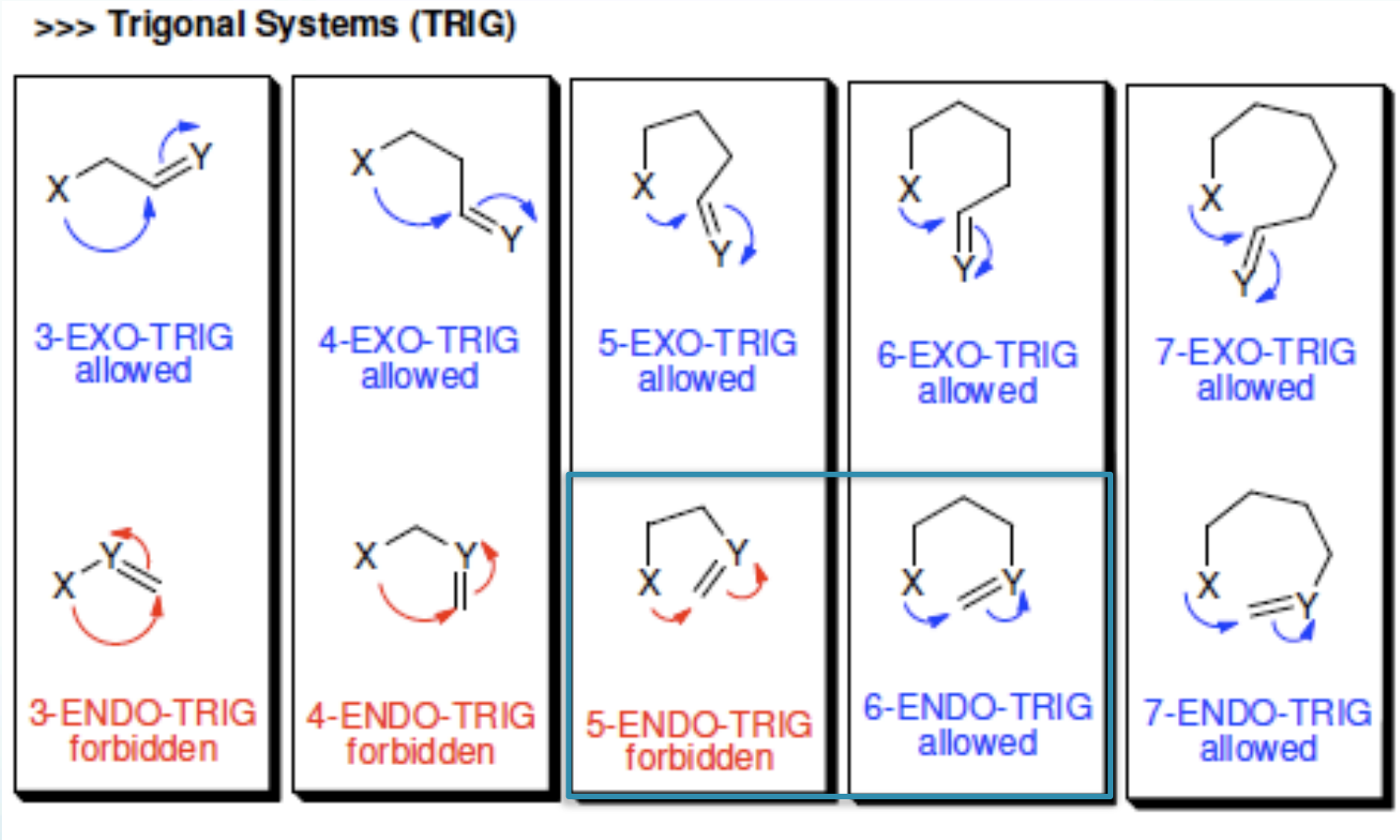
  Smith, A. B., III; Simov, V. *Org. Lett*. **2006**, *8,* 3315–3318.

- **(-)-Okilactomycin [2]**

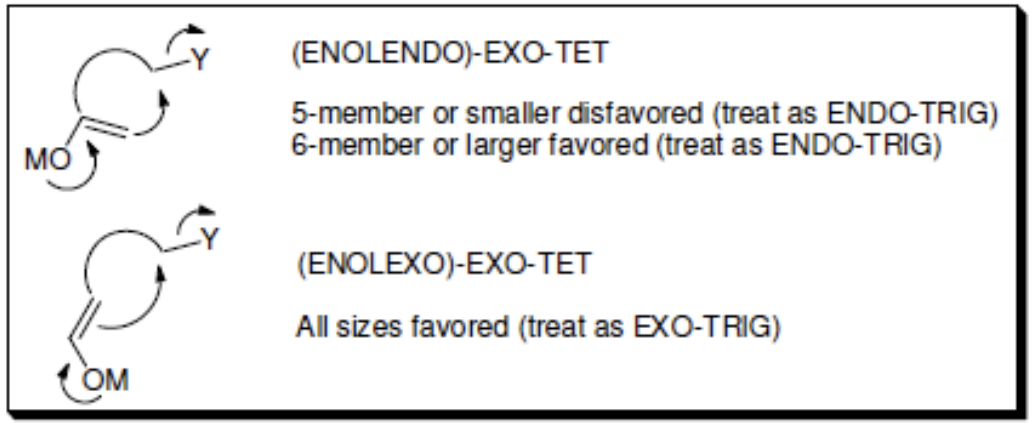
  (a) Smith, A. B., III; Basu, K.; Bosanac, T. *J. Am. Chem. Soc.* **2007**, *129,* 14872–14874.*(b)* Smith, A. B., III; Bosanac, T.; Basu, K . *J. Am. Chem. Soc.* **2009,** *131,* 2348-2358.

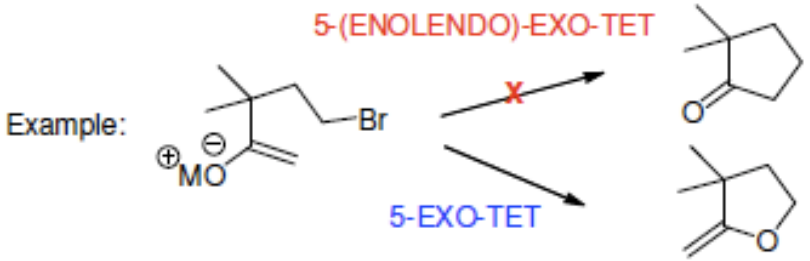
- *Smith, A. B., III; Fox, R. J.; Razler, T. M. *Acc. Chem. Res.* **2008**, *41,* 675-687

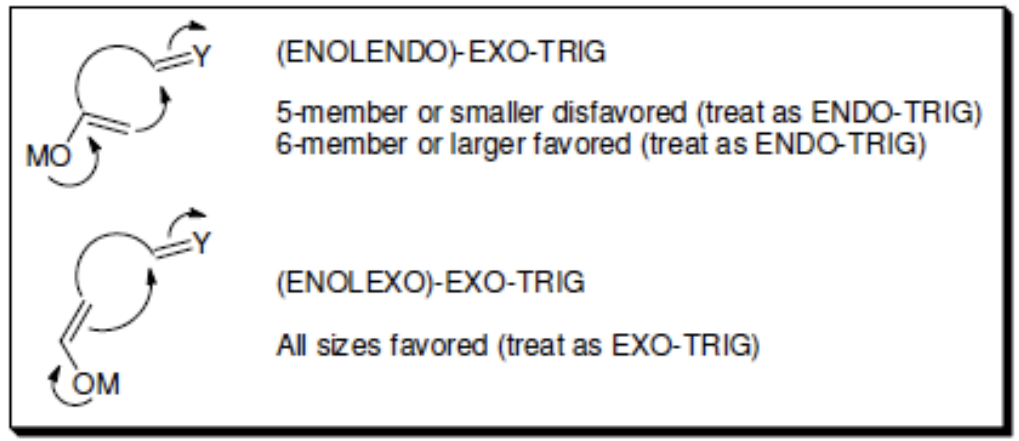
Baldwin Rules



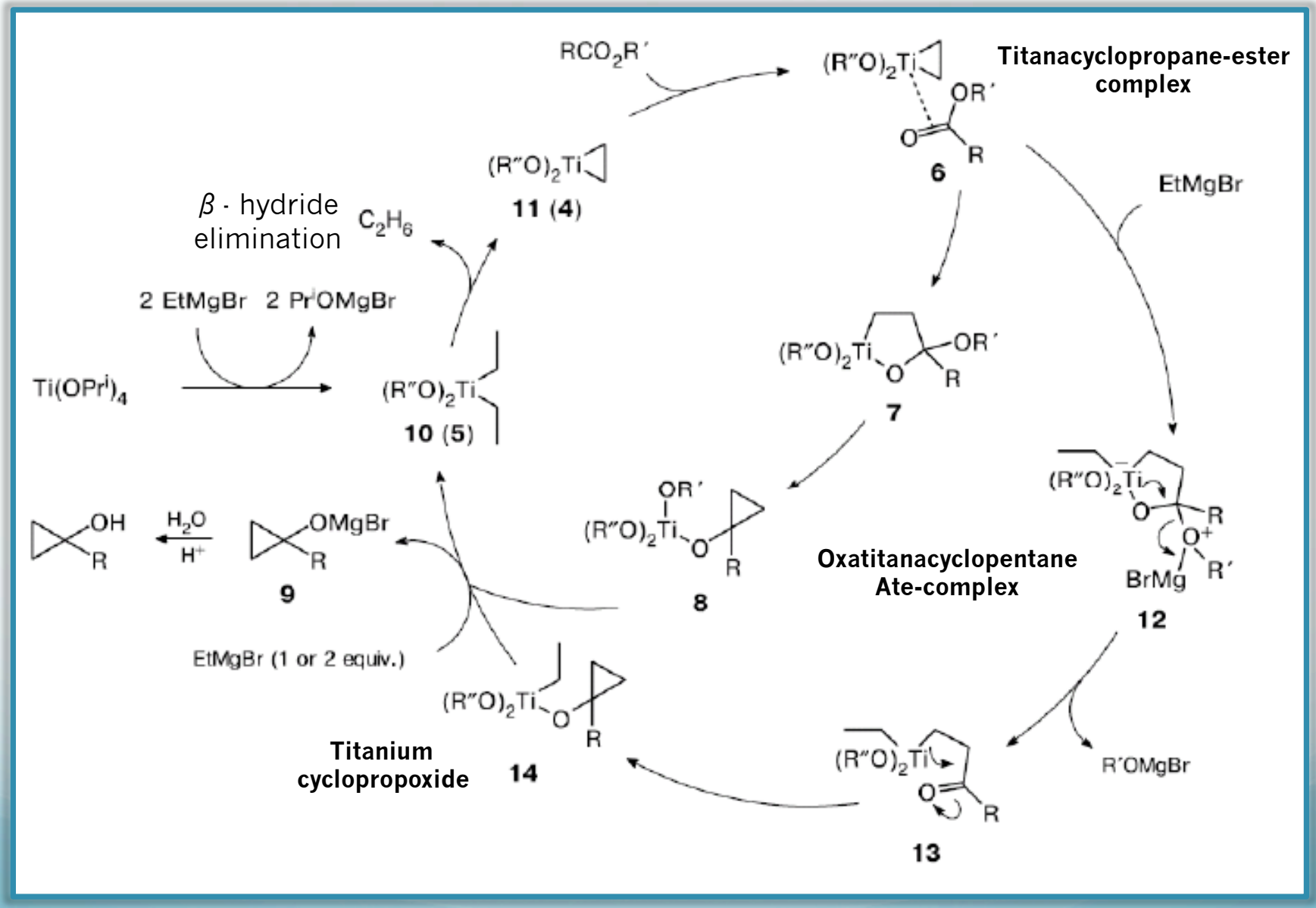
Ring closures involving enolates







Kulinkovich Reaction: Mechanism



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