

**COMPUESTOS  $\pi$  EXCESIVOS  
NO BÁSICOS  
FURANO, PIRROL Y TIOFENO  
INDOL Y BENZOFURANO**



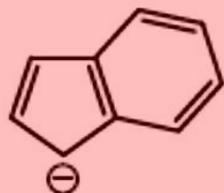
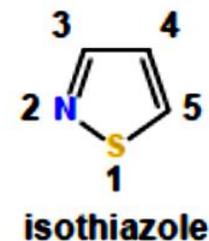
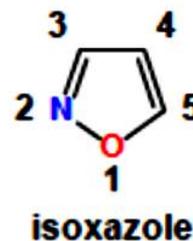
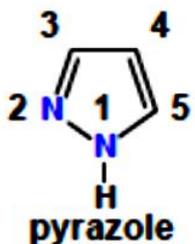
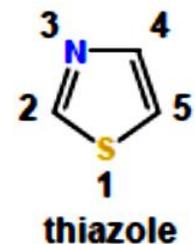
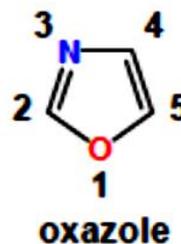
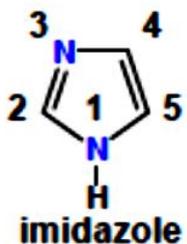
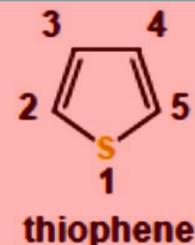
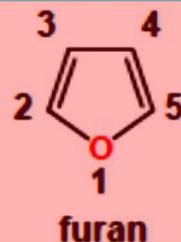
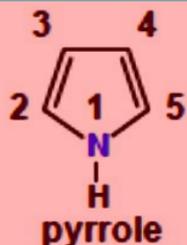
# Classification – Aromatic Five-Membered

Isoelectronic carbocycle

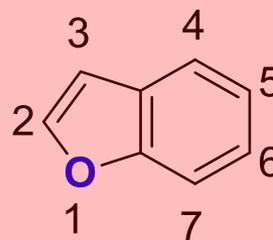
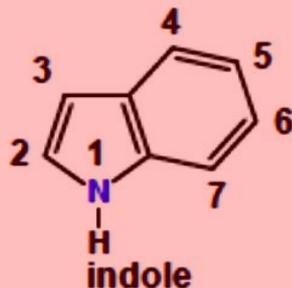
Heterocycles



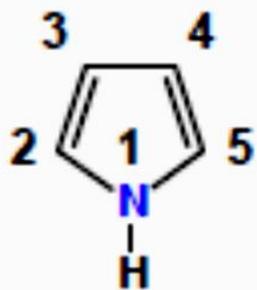
Anión ciclopentadienilo  
6 electrones  $\pi$   
5 átomos



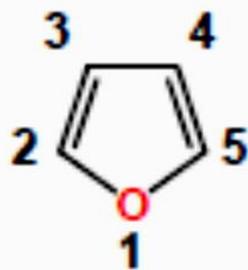
Anión del indeno



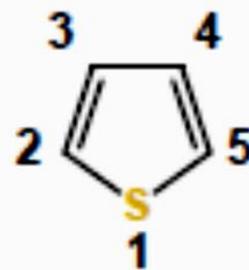
Anión del indeno  
Indol y benzofurano  
10 electrones  $\pi$   
9 átomos



Pirrol

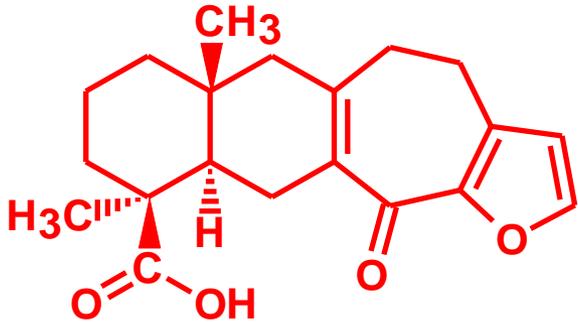


Furano



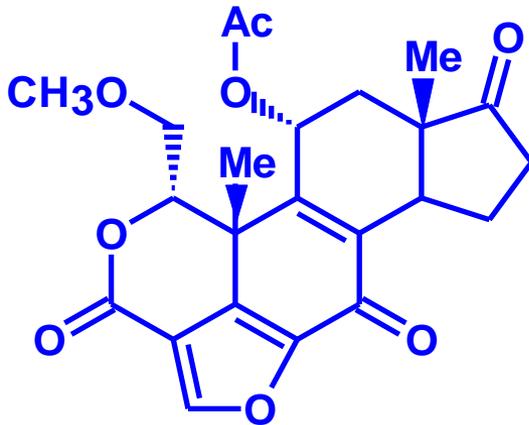
Tiofeno

## DERIVADOS DEL FURANO. PRODUCTOS NATURALES



### ÁCIDO HISPANOÍCO

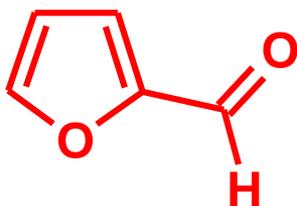
AISLADO DE LA *Ballota hispanica*, UNA PLANTA QUE CRECE EN ESPAÑA



### WORTMANINA

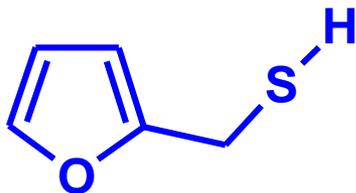
ANTIBIÓTICO, ANTIFUNGICIDA QUE SE OBTIENE DE LA *Penicillium wortmanni*

## DERIVADOS DEL FURANO. PRODUCTOS NATURALES



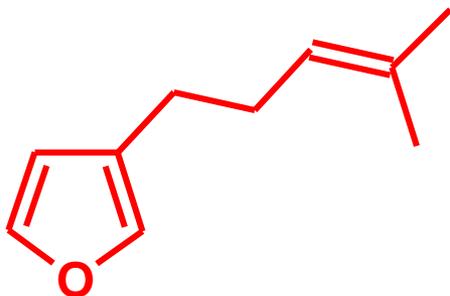
ALDEHÍDO DEL SALVADO (DEL LATÍN *FURFUR*, SALVADO)

**FURFURAL**



ES UNO DE LOS COMPUESTOS RESPONSABLES DEL AROMA DEL CAFÉ TOSTADO

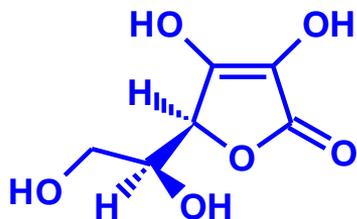
**FURILTIO**



ES UNO DE LOS TERPENOIDES, UN METABOLITO DE LAS PLANTAS

**PERILENO**

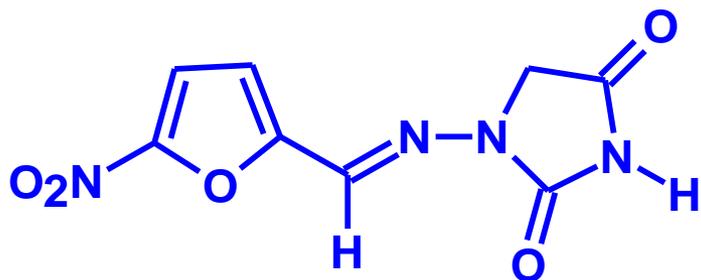
## DERIVADOS DEL FURANO. PRODUCTOS NATURALES



**ÁCIDO ASCÓRBICO  
(VITAMINA C)**

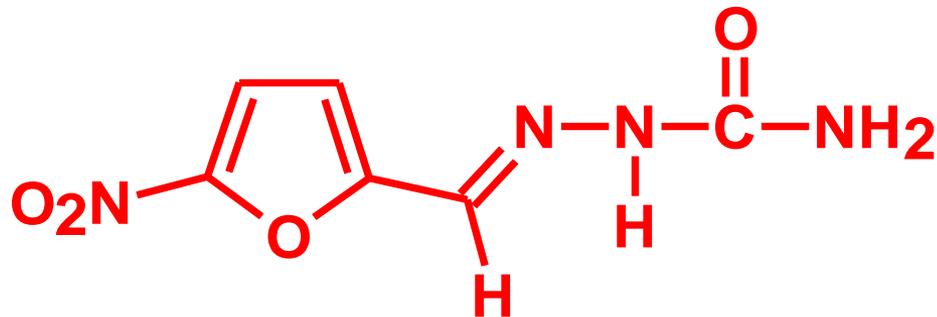
El enantiómero L (levógiro) de este ácido comúnmente se conoce como vitamina C. El nombre "ascórbico" proviene del prefijo *a-* ("sin") y del latín *scorbuticus* ("escorbuto"), procede de su propiedad de prevenir y curar el escorbuto.

## DERIVADOS DEL FURANO. AGENTES MEDICINALES



**NITROFURANTOÍNA**

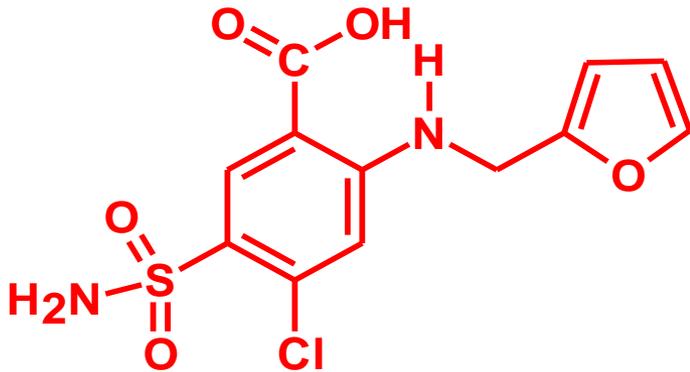
AGENTE  
ANTIBACTERIAL  
ESPECÍFICO PARA LAS  
INFECCIONES DEL  
TRACTO URINARIO



**NITROFUZONA**

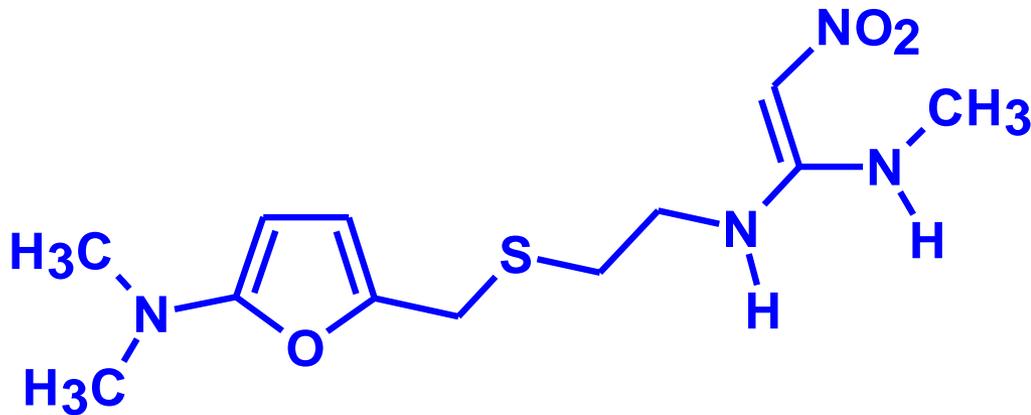
AGENTE  
ANTIBACTERIAL

## DERIVADOS DEL FURANO. AGENTES MEDICINALES



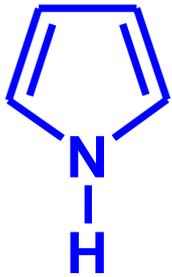
**FUROSEMIDA**

AGENTE DIURÉTICO  
USADO EN LA FALLA  
CONGESTIVA DEL  
CORAZÓN



**RANITIDINA**

SE USA EN EL  
TRATAMIENTO DE LA  
ÚLCERA ESTOMACAL



## PIRROL:

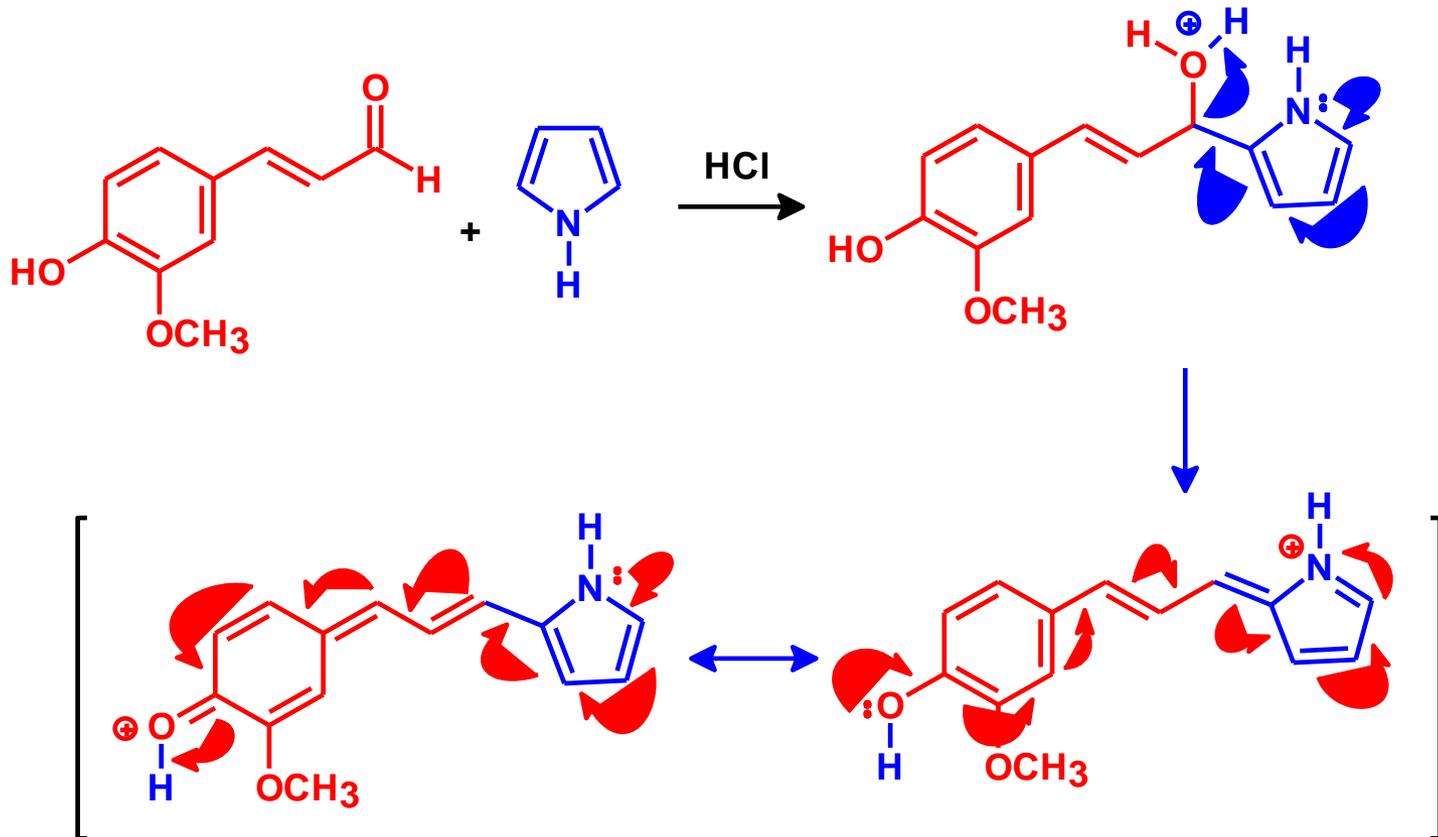
Se aisló por primera vez en 1857, de la pirólisis de huesos. La palabra deriva del griego *pûr*, πῦρ, 'fuego', 'fiebre' *pyrr-* πυρρός gr. (adj.), 'de color fuego'

Neologismos que usan el lexema

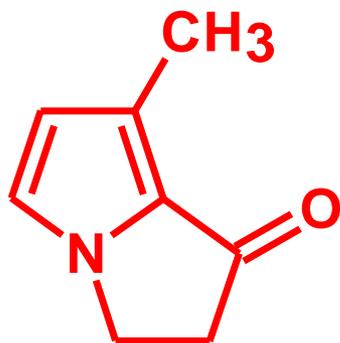
pirrol; pirrolina  
Lexemas que tienen la misma raíz *pyr(o)-* gr., 'fuego', 'fiebre'; *pyret(o)-* gr., 'fiebre'

## PYROS: ROJO

(ASTILLA DE PINO IMPREGNADA CON HCl)



## DERIVADOS DEL PIRROL. PRODUCTOS NATURALES



**DANAIDONA**

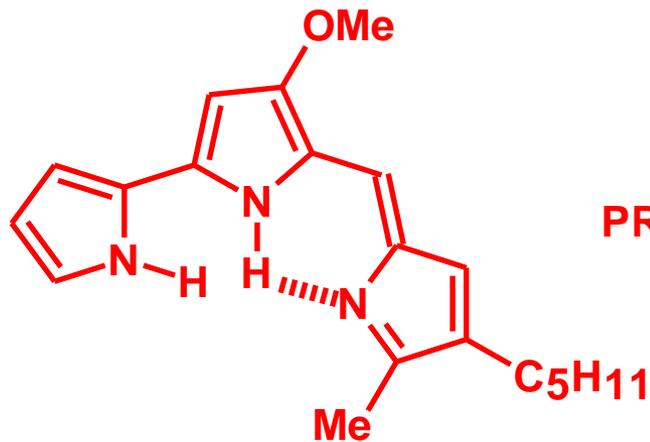
FEROMONA DE LA HEMBRA DE LA  
MARIPOSA MONARCA, *Lycorea*  
*ceres ceres*



## DERIVADOS DEL PIRROL. PRODUCTOS NATURALES



CORAL  
INFECTADO CON  
LA BACTERIA

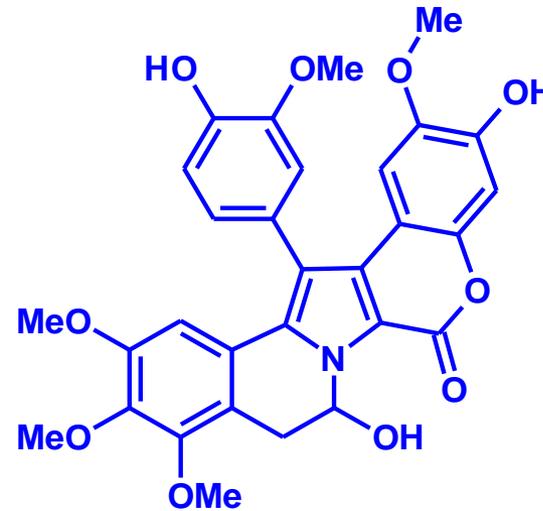


**PRODIGIOSINA**

PIGMENTO DE COLOR  
ROJO SANGRE DE LA  
BACTERIA *SERRATIA*  
*MARCESENS*

ACTIVIDAD ANTIBACTERIAL  
Y ANTIFUNGICIDA

## DERIVADOS DEL PIRROL. PRODUCTOS NATURALES

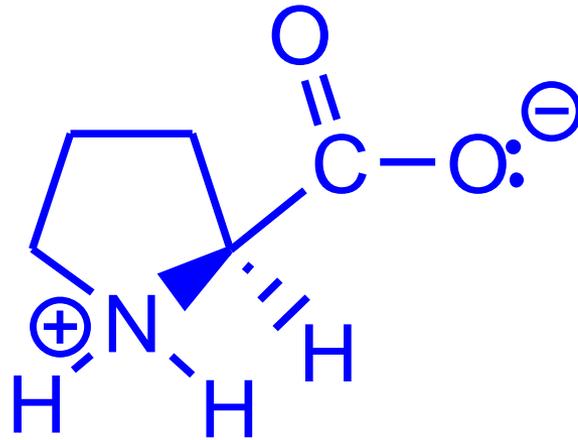


LAMELERINA A

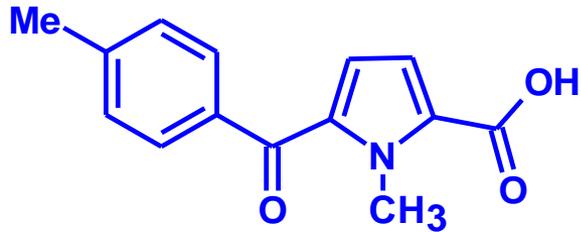
METABOLITO DE UN  
MOLUSCO DEL PACÍFICO,  
*LAMELLARIA*, *sp.*  
ANTIBIÓTICO.  
TRATAMIENTO CONTRA EL  
CÁNCER

# DERIVADOS DEL PIRROL. PRODUCTOS NATURALES

La prolina, es un aminoácido con un grupo amino secundario dentro de un anillo de cinco miembros, con el nitrógeno y el carbono  $\alpha$  formando parte de la estructura cíclica

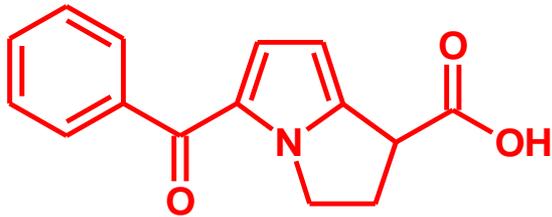


## DERIVADOS DEL PIRROL. AGENTES MEDICINALES



TOLMETÍN

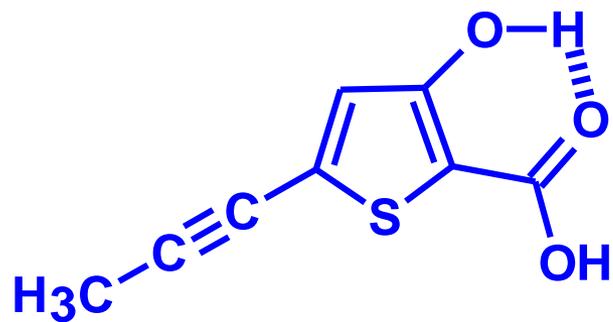
SE USA EN CLINICA COMO UN AGENTE ANTIINFLAMATORIO DE TIPO NO ESTEROIDAL MUY ÚTIL



CETOROLAC

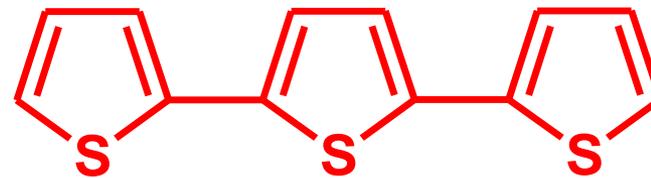
SE USA EN CLINICA COMO UN ANALGÉSICO NO ADICTIVO, MUY ÚTIL CON LA MISMA POTENCIA QUE LA MORFINA

## DERIVADOS DEL TIOFENO. PRODUCTOS NATURALES

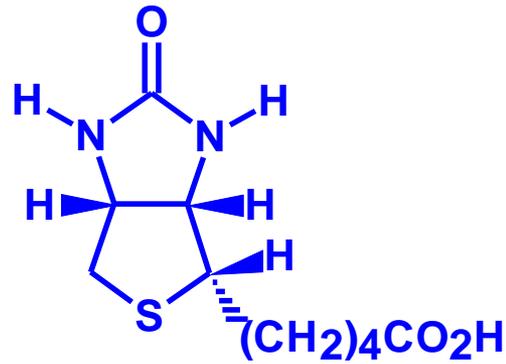


SE ENCUENTRA EN LA  
RAÍCES DE LA *Artemisa*  
*arborescens* L.

## DERIVADOS DEL TIOFENO. PRODUCTOS NATURALES



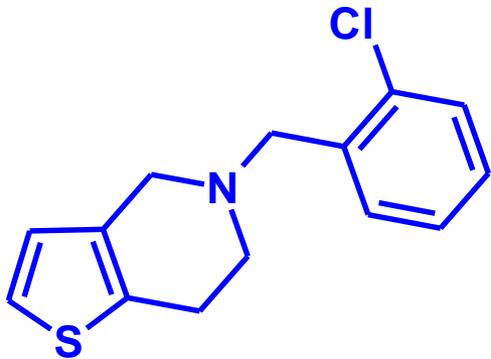
SE ENCUENTRA EN LA  
CALÉNDULA COMÚN,  
*Tagetes erecta* l.



**BIOTINA**  
**(VITAMINA H)**

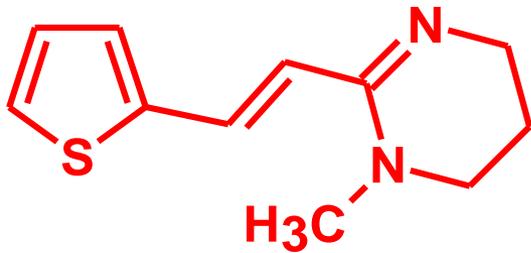
La **biotina**, **vitamina H**, **vitamina B7** y a veces también llamada **vitamina B8**; es una vitamina estable al calor, soluble en agua, alcohol y susceptible a la oxidación, interviene en el metabolismo de los hidratos de carbono, grasas, aminoácidos y purinas. La biotina es importante como un cofactor en la catálisis de reacciones metabólicas esenciales para sintetizar ácidos grasos, en la gluconeogénesis y en el metabolismo de la leucina.

## DERIVADOS DEL TIOFENO. AGENTES MEDICINALES



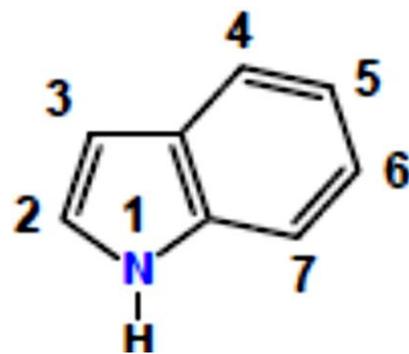
**TICLOPIDINA**

CLINICAMENTE ES UN IMPORTANTE INHIBIDOR DE LA AGREGACIÓN DE PLAQUETAS DE LA SANGRE Y ES UN AGENTE ANTITROMBÓTICO, ESPECIALMENTE EN PACIENTES SENSIBLES A LA ASPIRINA



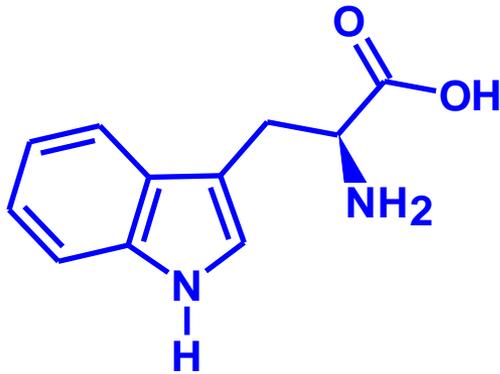
**PIRANTEL**

ANTIHELMINTICO, SE USA EN ESPECIAL CONTRA LOS NEMÁTODOS EN LOS ANIMALES



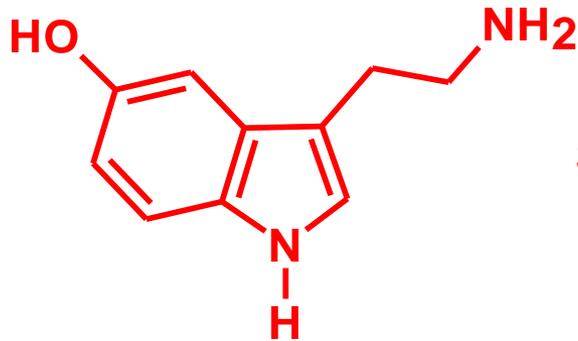
Indol

## DERIVADOS DEL INDOL. PRODUCTOS NATURALES



**TRIPTOFANO**

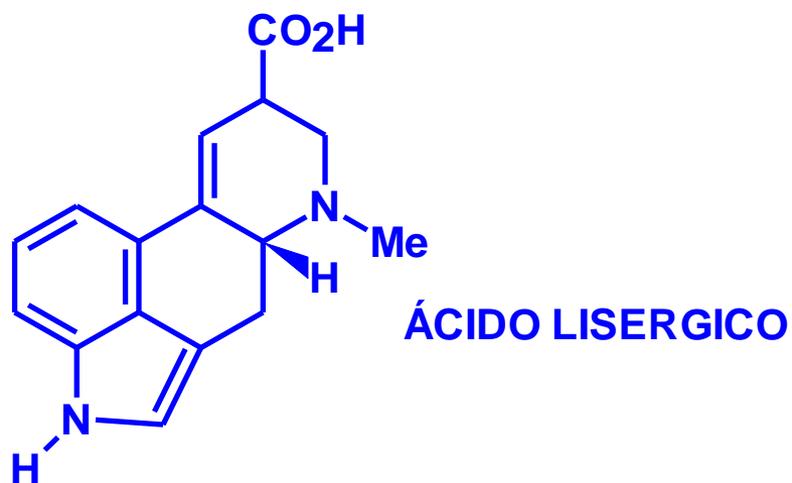
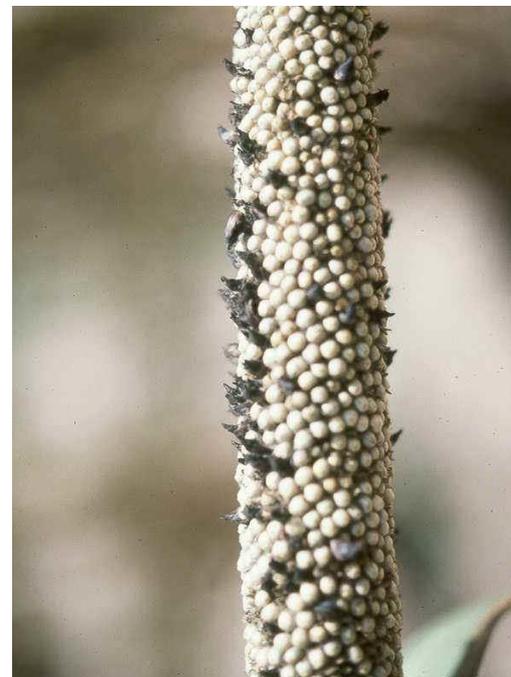
AMINOÁCIDO ESENCIAL,  
PRECURSOR DE LA  
SEROTONINA



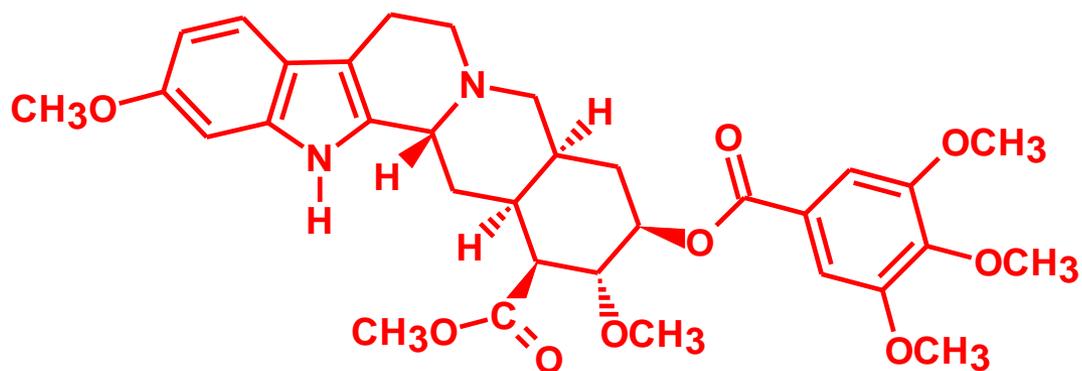
**SEROTONINA**

SE ENCUENTRA EN LOS  
TEJIDOS Y FLUÍDOS DE  
LOS VERTEBRADOS E  
INVERTEBRADOS. ESTA  
INVOLUCRADA EN  
PROCESOS FISIOLÓGICOS  
CENTRALES Y  
PERIFÉRICOS

# DERIVADOS DEL INDOL. PRODUCTOS NATURALES



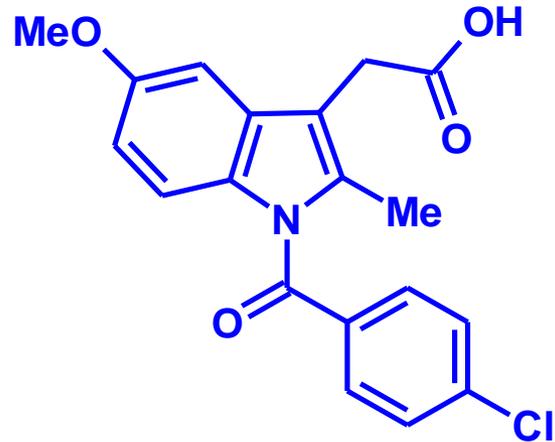
PRODUCTO DE LA  
RUPTURA ALCALINA DE  
LOS ALCALOIDES DEL *Ergot*



**RESERPINA**

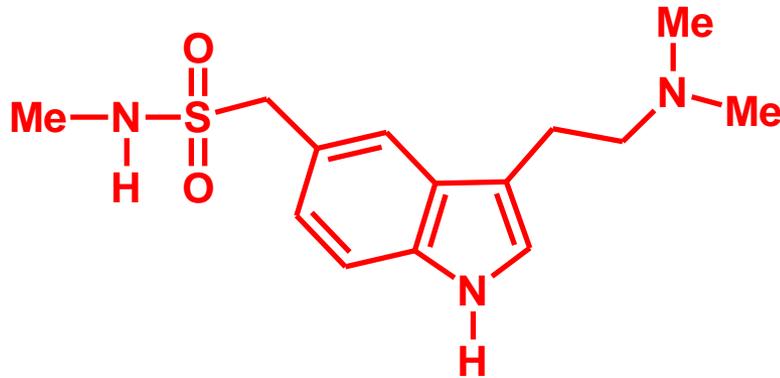
AISLADA DE LAS RAÍCES  
DE *Rauwolfia Serpentina* .  
TIENE ACTIVIDAD  
HIPOTENSIVA Y  
TRANQUILIZANTE

## DERIVADOS DEL INDOL. AGENTES MEDICINALES



UNA PODEROSO INHIBIDOR DE LA  
CICLOOXIGENASA. QUE SE USA COMO  
AGENTE ANTIINFLAMATORIO

**INDOMETACINA**



ANTAGONISTA DEL RECEPTOR

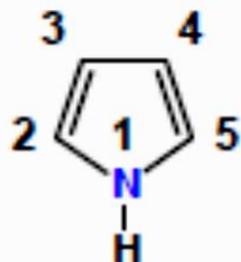
SELECTIVO DEL 5HT<sub>1</sub>, EL CUAL SE  
USA PARA TRATAR LOS DOLORES DE  
CABEZA OCASIONADOS POR LA  
MIGRAÑA

**SUMATRIPTANO  
(IMITREX)**

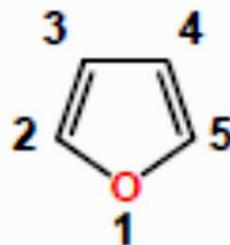


# MÉTODOS DE SÍNTESIS

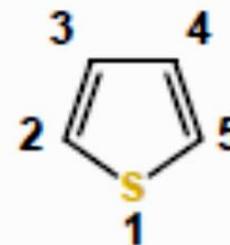
## ANILLOS HETEROCÍCLICOS DE 5 MIEMBROS CON UN HETEROÁTOMO



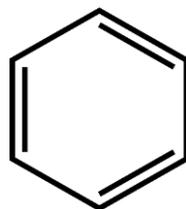
Pirrol



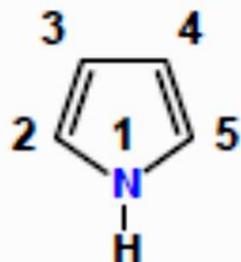
Furano



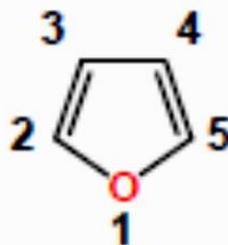
Tiofeno



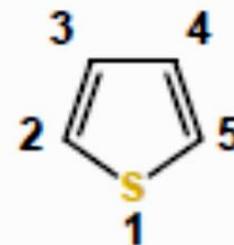
Benceno  
ER = 36 kcal/Mol



Pirrol  
ER = 21 kcal/Mol

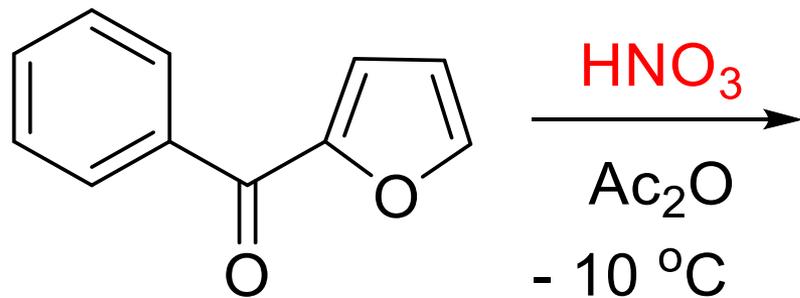


Furano  
ER = 16 kcal/Mol

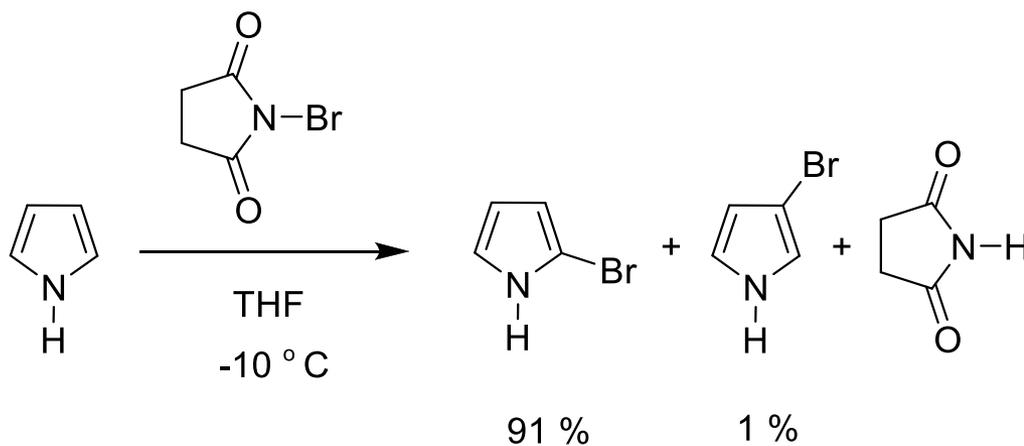
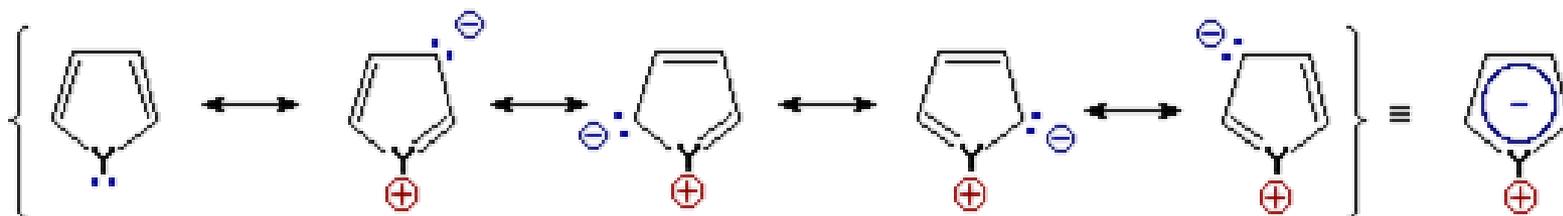


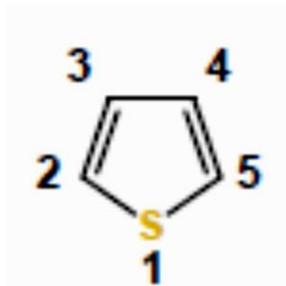
Tiofeno  
ER = 28 kcal/Mol



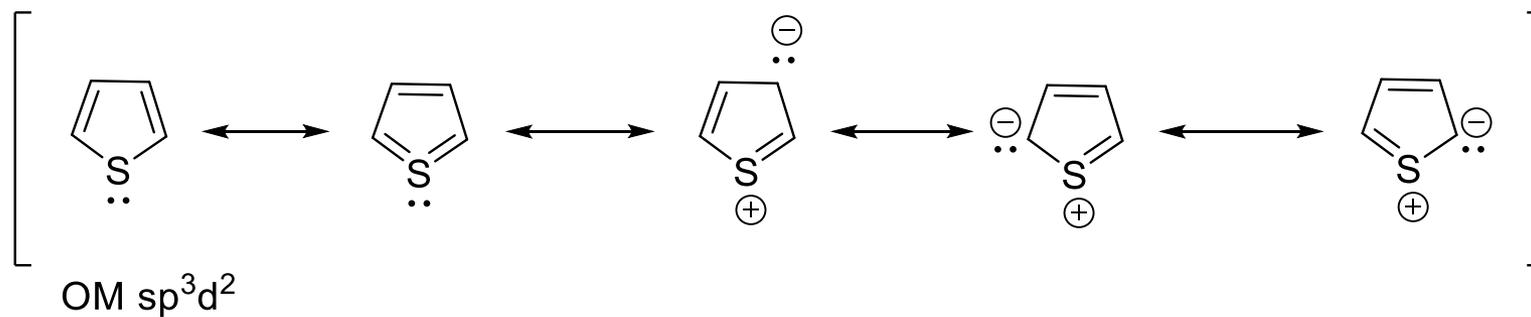
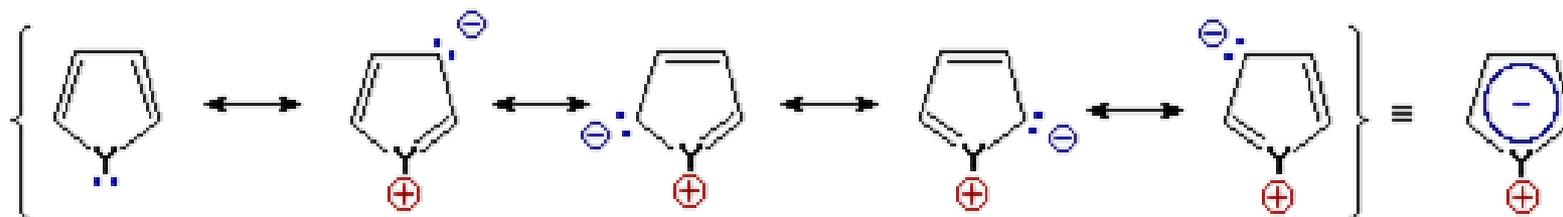


# COMPUESTOS $\pi$ -EXCESIVOS: FORMAS RESONANTES CON CARGA

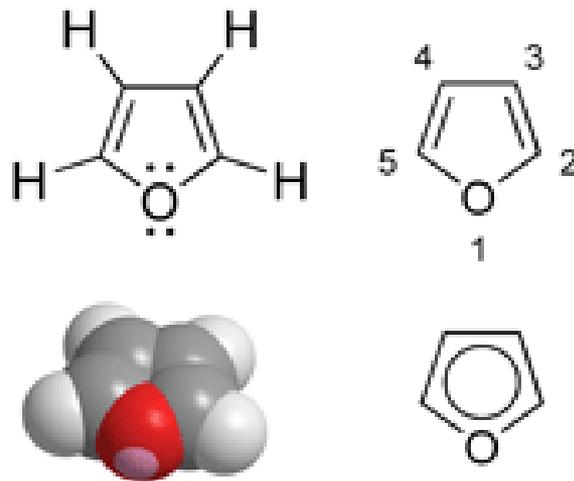




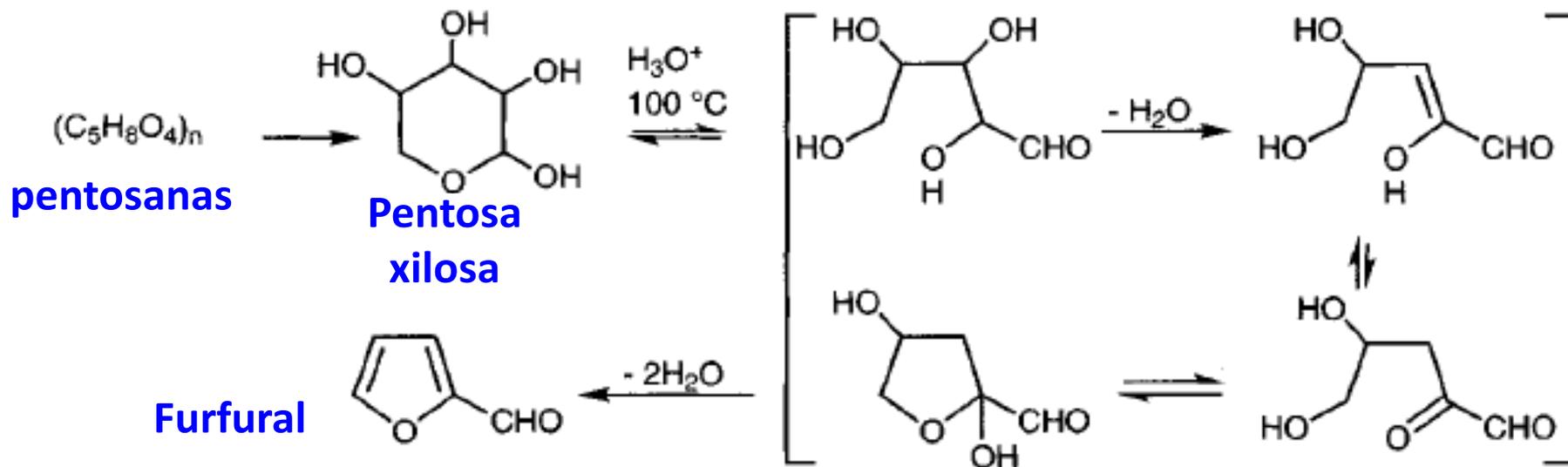
Tiofeno  
ER = 28 kcal/Mol



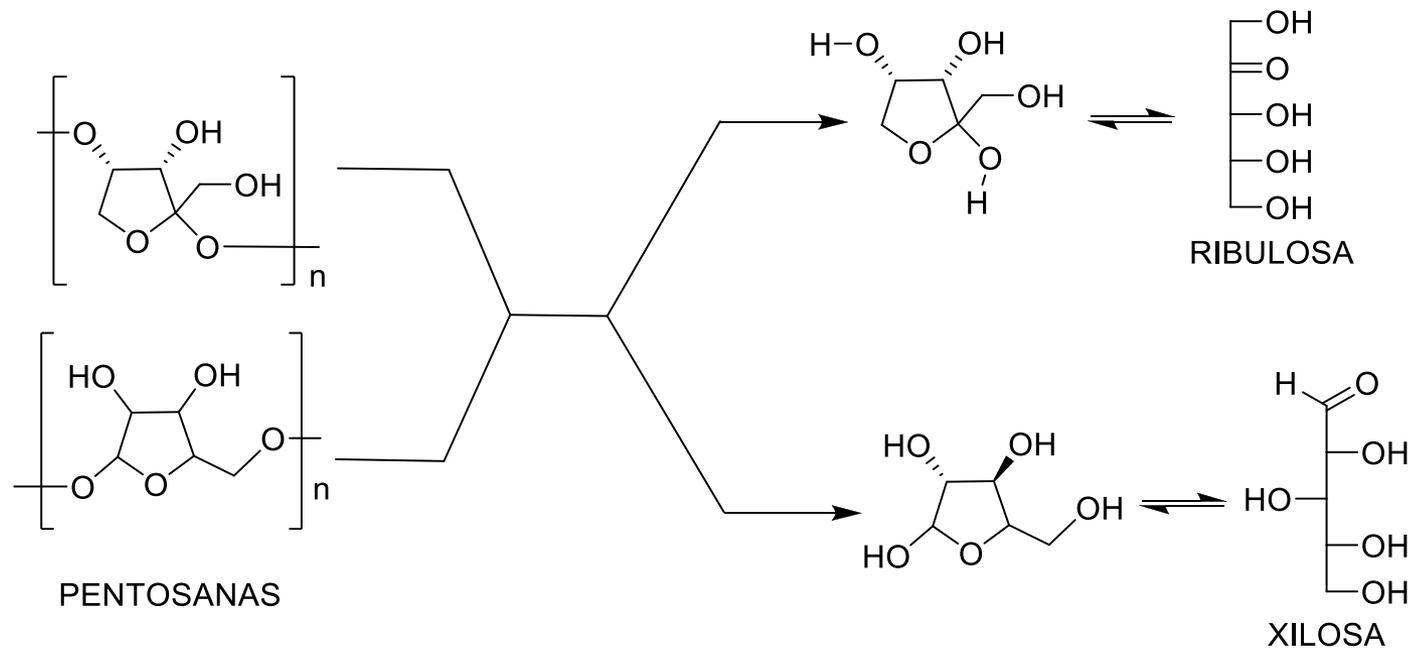
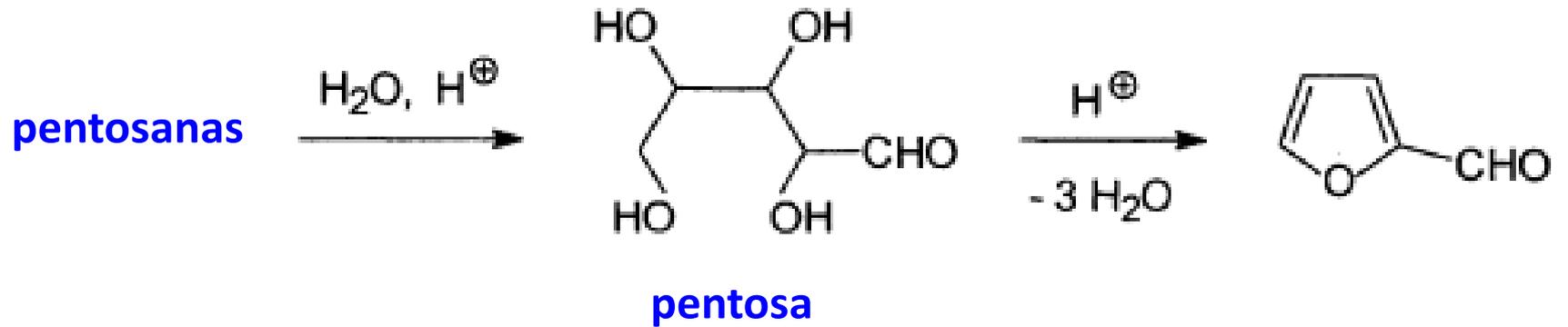
# FURANO



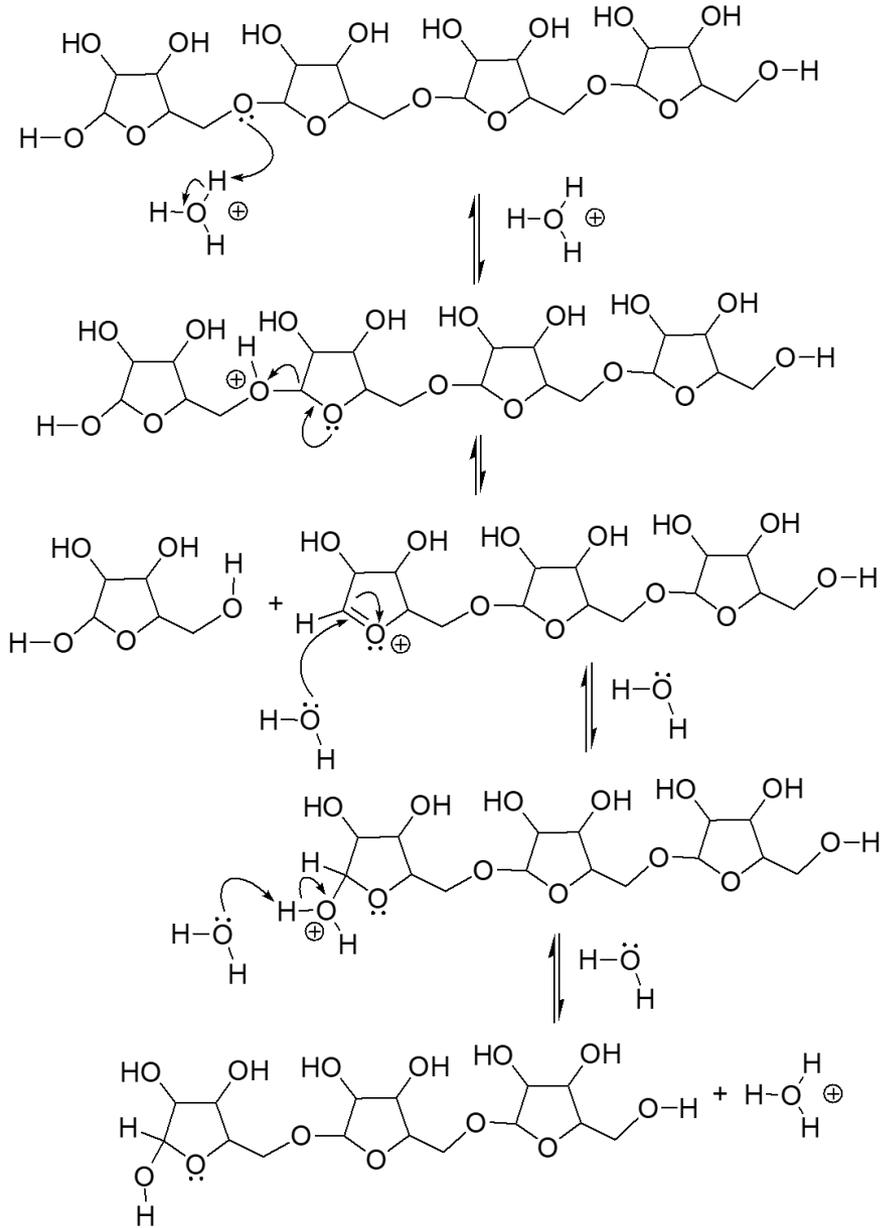
# MÉTODOS DE OBTENCIÓN DE FURANO

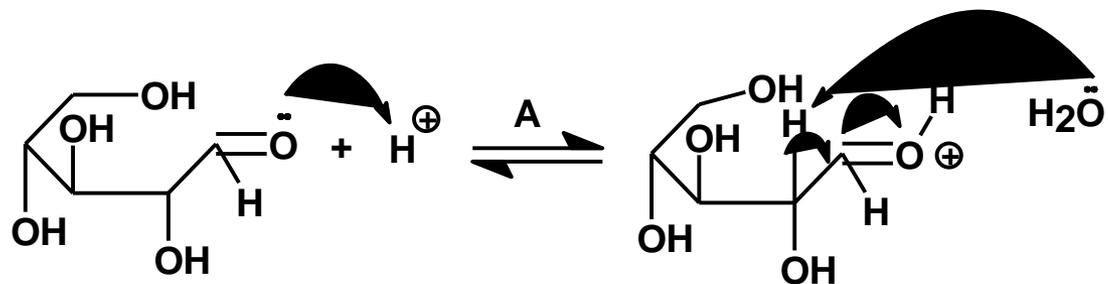


# DESHIDRATACIÓN DE AZÚCARES



HIDRÓLISIS DE UNA  
CADENA DE  
PENTOSANA DE  
n = 4

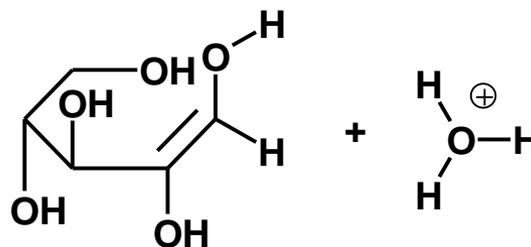
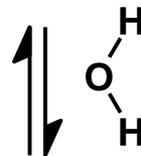




TAUTOMERO CETO

TAUTOMERO CETO  
PROTONADO

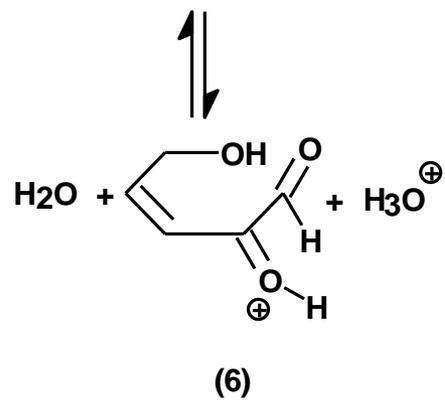
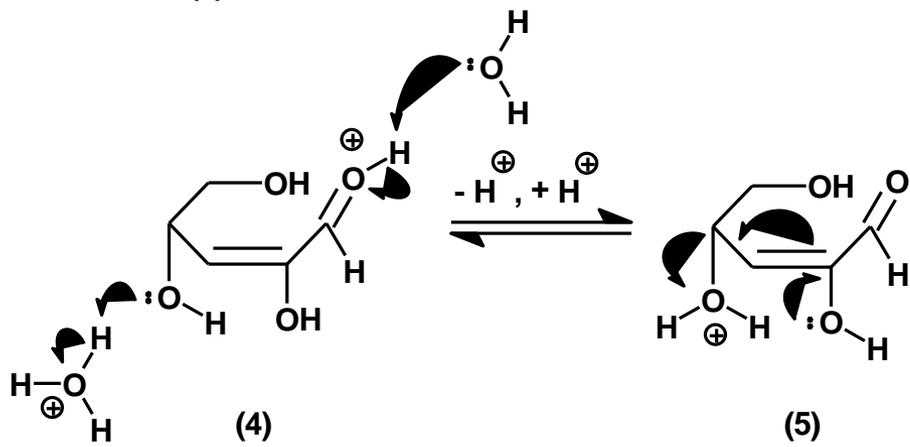
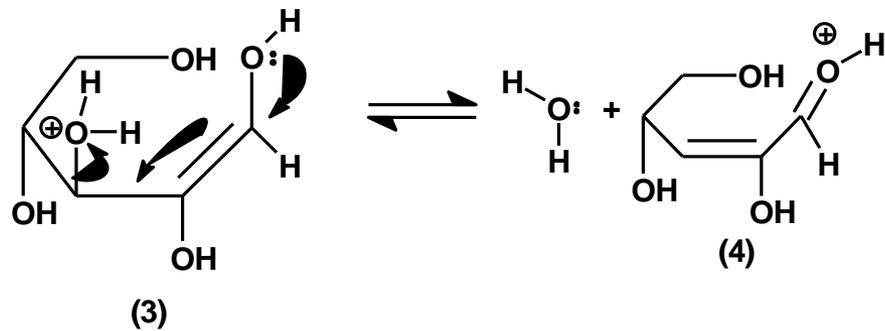
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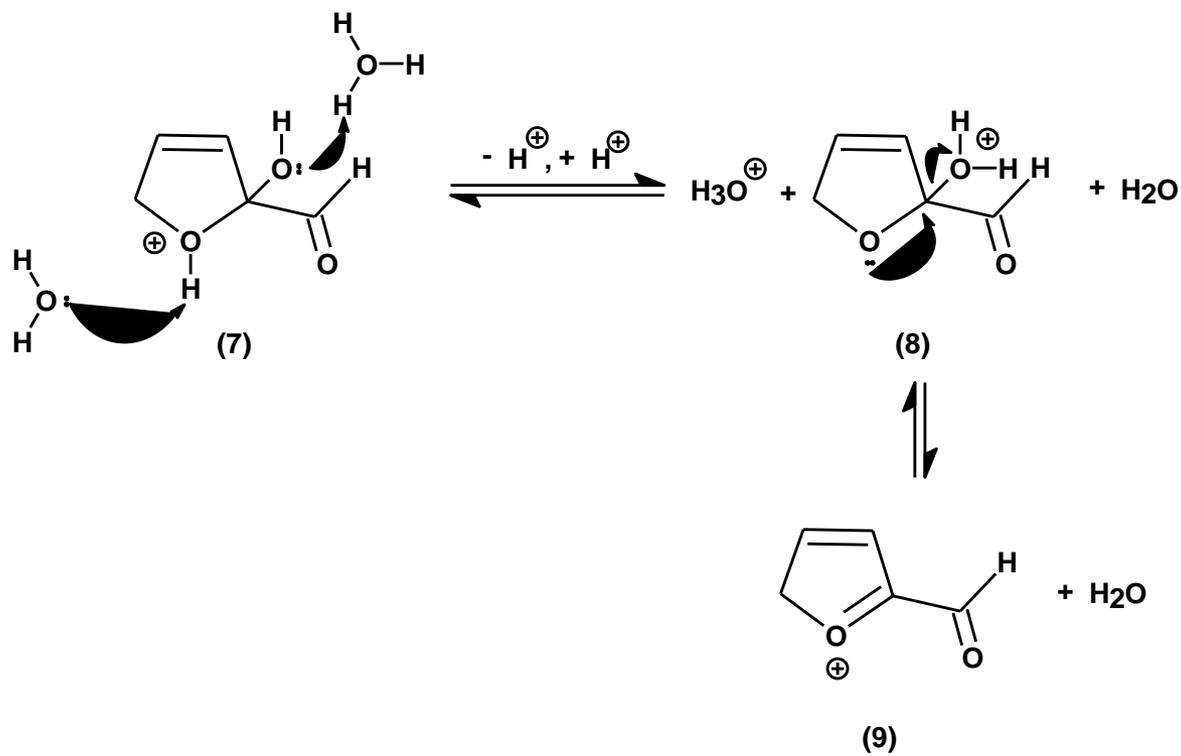
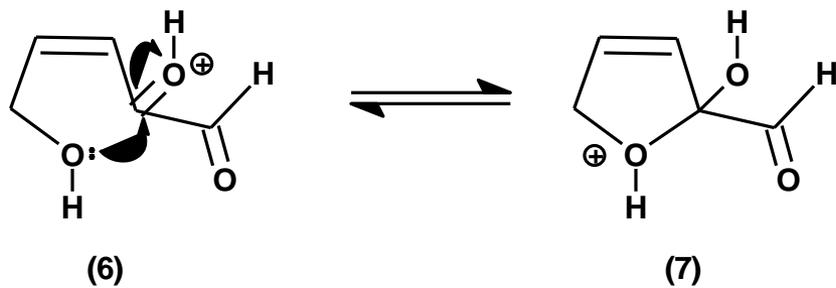


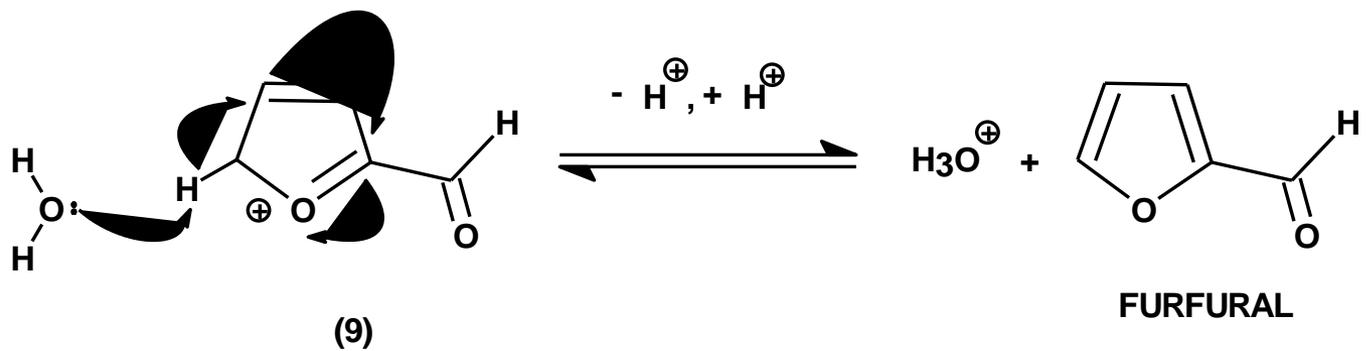
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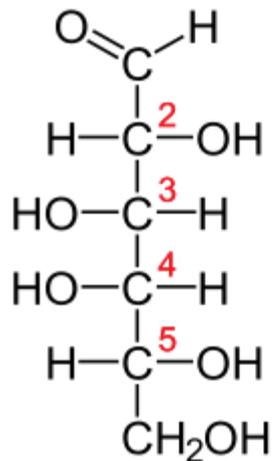
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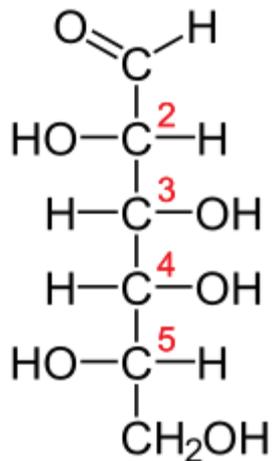




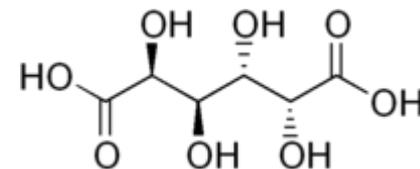




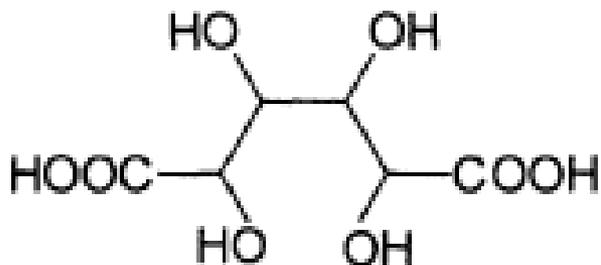
**D-GALACTOSA**



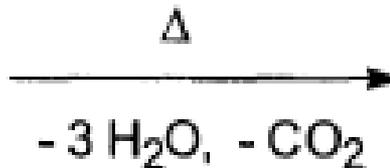
**L-GALACTOSA**



**Ácido mucico**  
**Ácido galactárico**



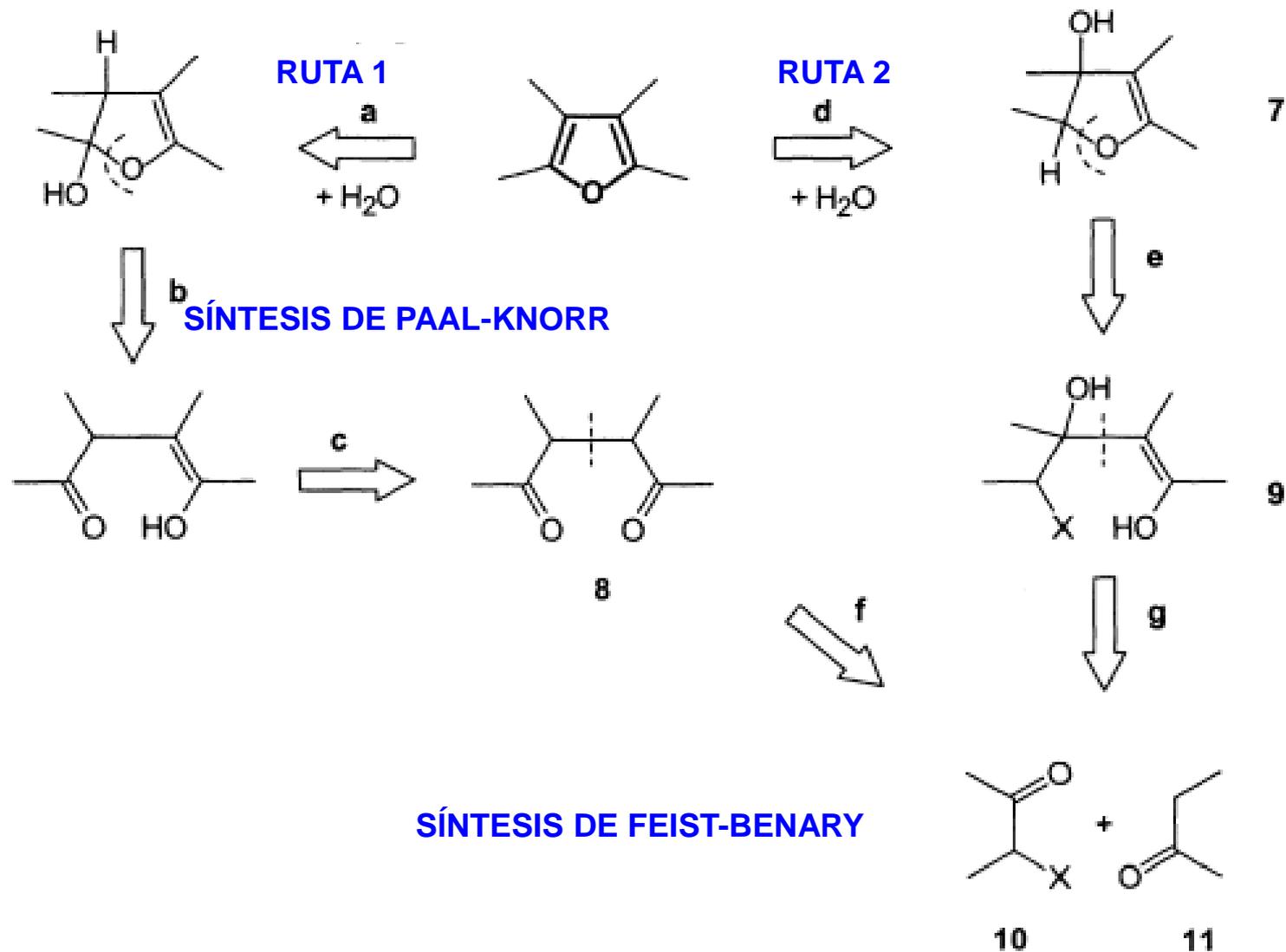
**Ácido mucico**



**Ácido piromúxico**  
**Ácido furoico**

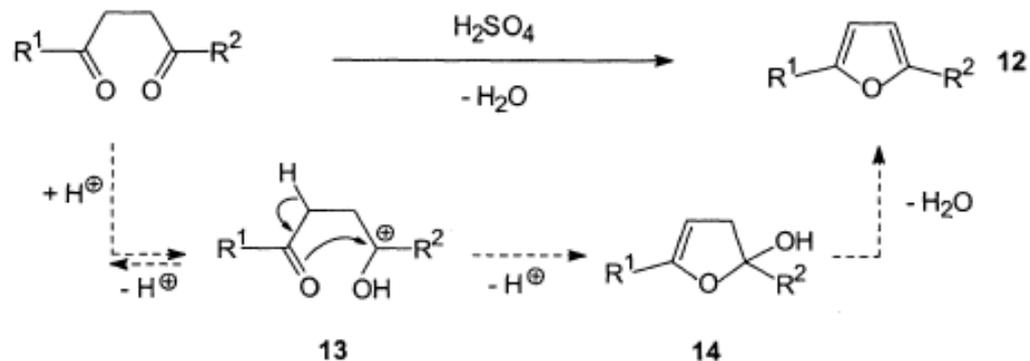


# MÉTODOS DE OBTENCIÓN DE FURANO

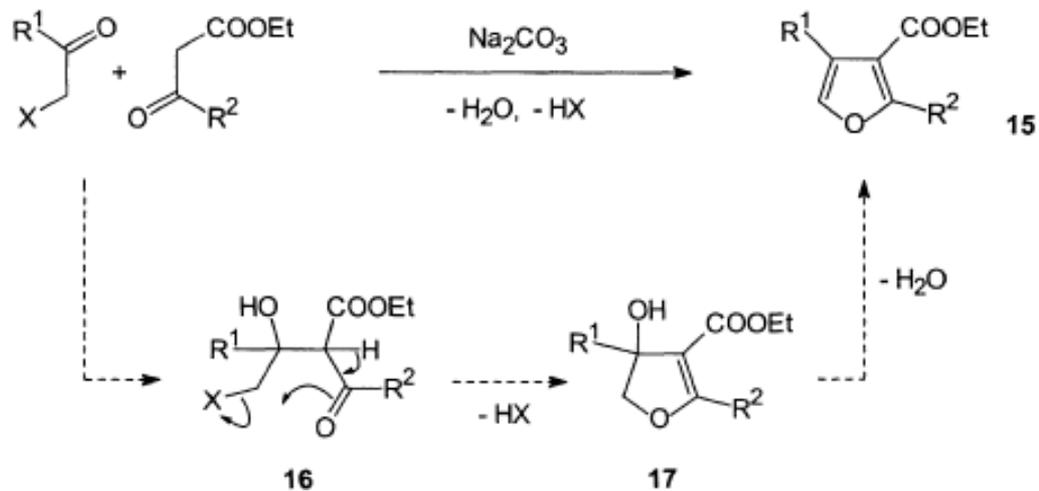


# MÉTODOS DE OBTENCIÓN DE FURANO

## SÍNTESIS DE PAAL-KNORR

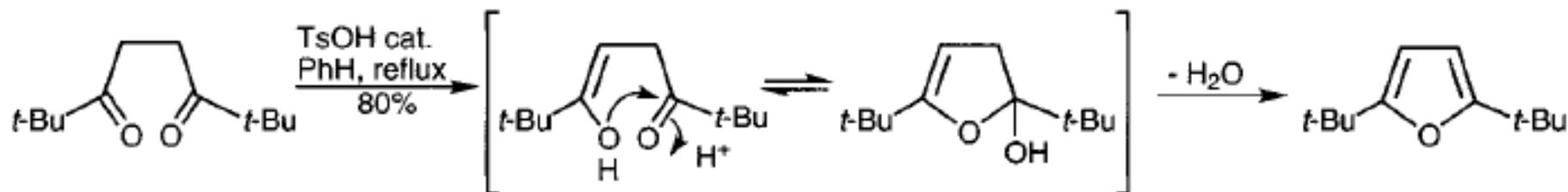


## SÍNTESIS DE FEIST-BENARY

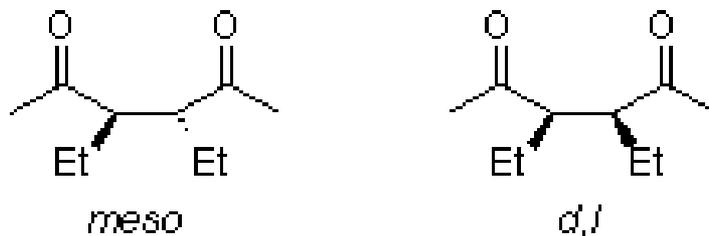


# MÉTODOS DE OBTENCIÓN DE FURANO

## SÍNTESIS DE PAAL-KNORR



### Mecanismo de la reacción

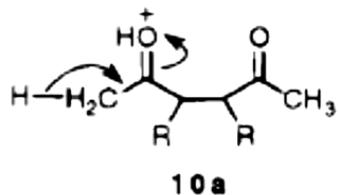


Intermediates in the Paal-Knorr Synthesis of Furans  
Venkataraman Amarnath, and Kalyani Amarnath  
*J. Org. Chem.*, **1995**, 60 (2),301–307

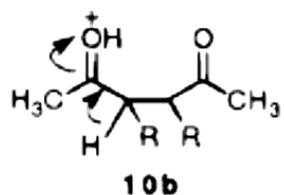




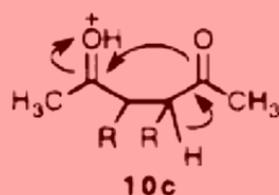
*pathway a*



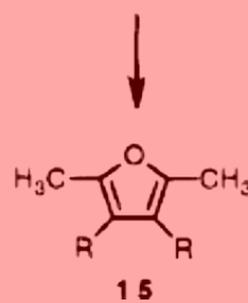
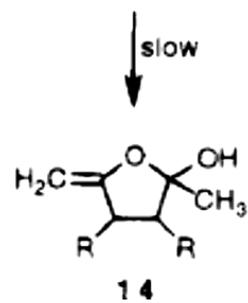
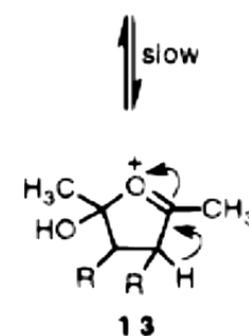
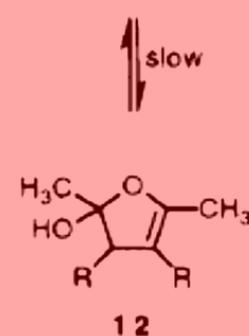
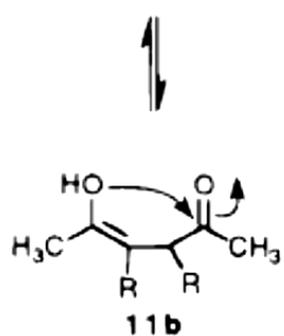
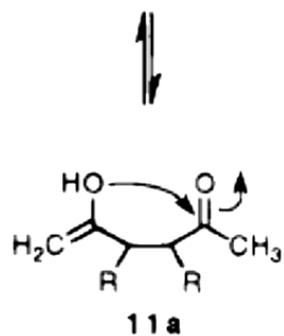
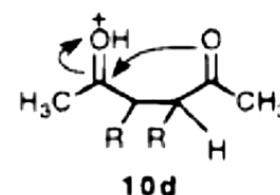
*pathway b*



*pathway c*



*pathway d*

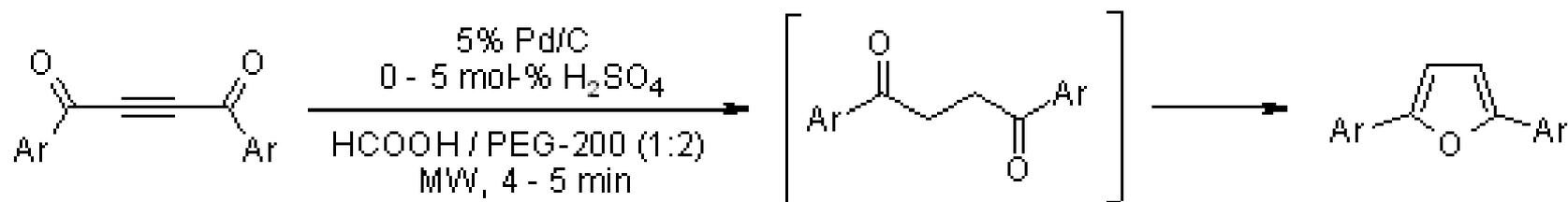
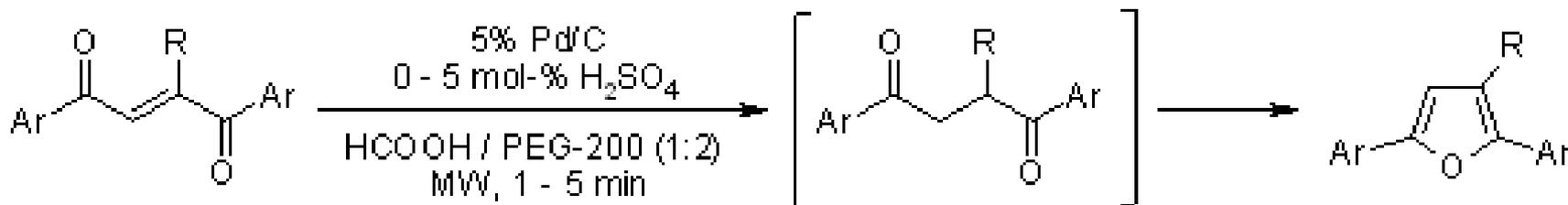


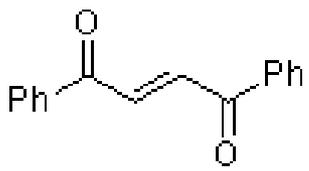
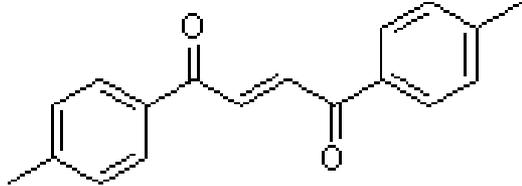
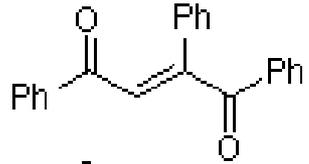
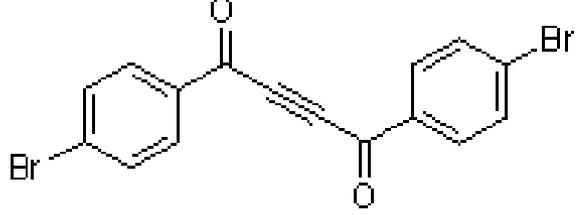
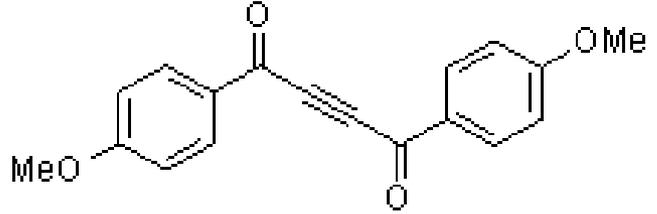
- a. R = CH<sub>3</sub>
- b. R = C<sub>2</sub>H<sub>5</sub>
- c. R = CH(CH<sub>3</sub>)<sub>2</sub>



## Facile Microwave-Mediated Transformations of 2-Butene-1,4-diones and 2-Butyne-1,4-diones to Furan Derivatives

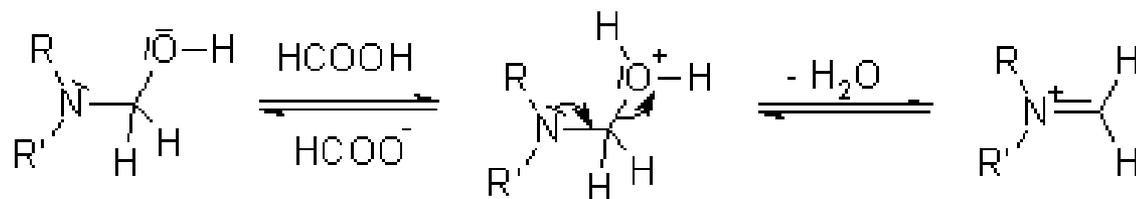
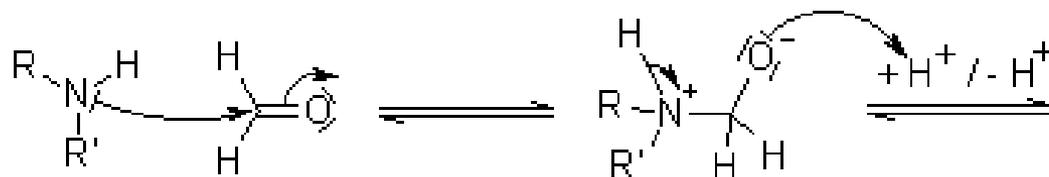
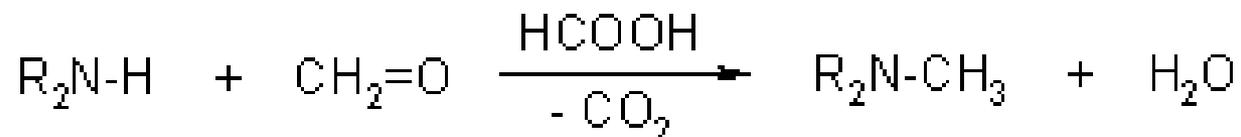
H. S. P. Rao, S. Jothilingam, *J. Org. Chem.*, **2003**, *68*, 5392-5394.

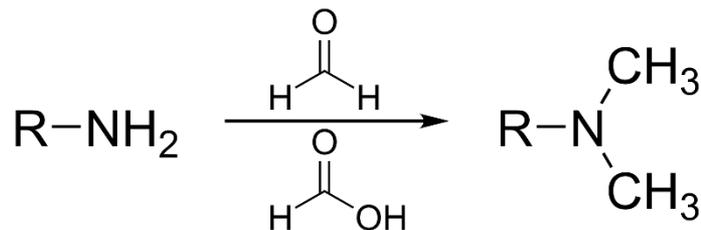


substrate	H <sub>2</sub> SO <sub>4</sub> (mol-%)	Power (W)	t (min)	yield (%; isol.)
	0	400	1.0	95
	5	200	5.0	96
	5	200	5.0	84
	0	155	4.0	93
	5	200	5.0	88



## Reacción Eschweiler-Clarke

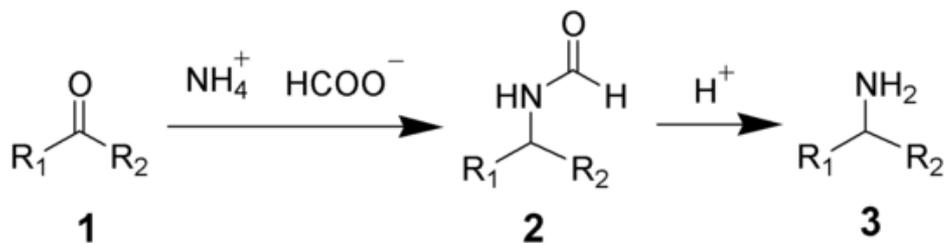




[https://en.wikipedia.org/wiki/Formic\\_acid#/media/File:Eschweiler-Clarke\\_Reaction.svg](https://en.wikipedia.org/wiki/Formic_acid#/media/File:Eschweiler-Clarke_Reaction.svg)

## Reacción de Leuckart

Es la reacción química que convierte aldehídos o cetonas en aminas por aminación reductiva en presencia de calor. La reacción, que lleva el nombre de Rudolf Leuckart, utiliza formiato de amonio o formamida como donador de nitrógeno y agente reductor. Requiere altas temperaturas, generalmente entre 120 y 130 ° C; para la variante de formamida, la temperatura puede ser superior a 165 ° C

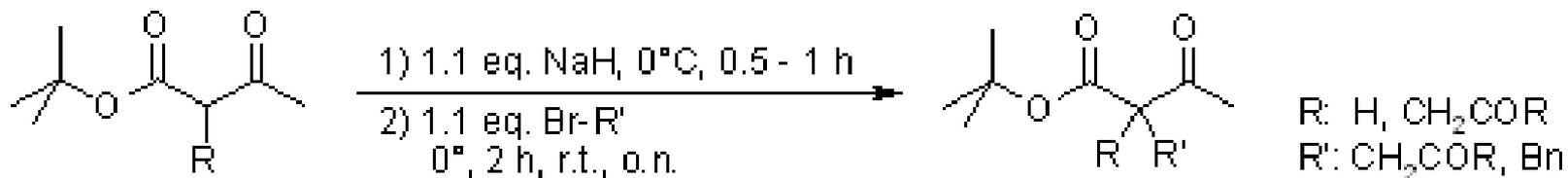


[https://en.wikipedia.org/wiki/Leuckart\\_reaction#/media/File:Leuckart\\_Reaction\\_Scheme.png](https://en.wikipedia.org/wiki/Leuckart_reaction#/media/File:Leuckart_Reaction_Scheme.png)



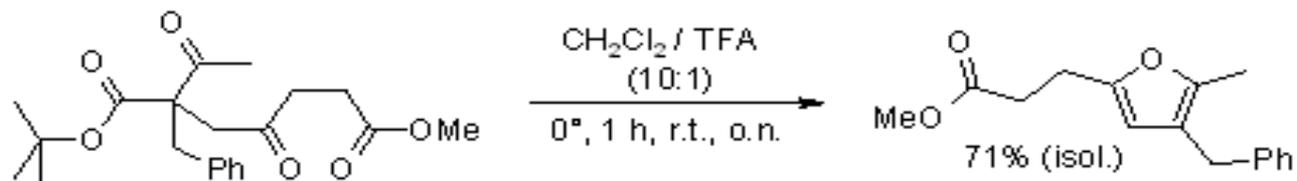
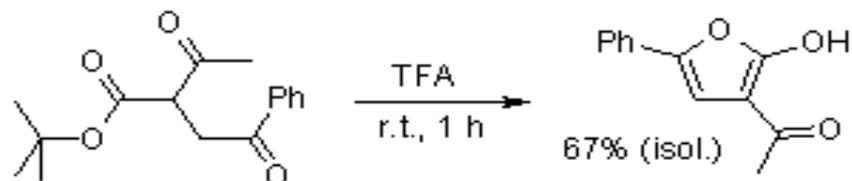
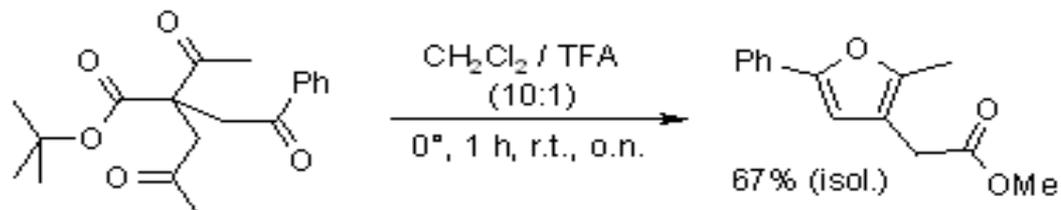
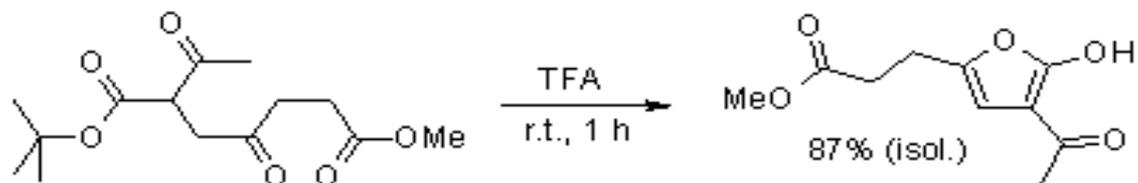
# Synthesis of Tri- and Tetrasubstituted Furans Catalyzed by Trifluoroacetic Acid

F. Stauffer, R. Neier, *Org. Lett.*, **2000**, *2*, 3535-3537.



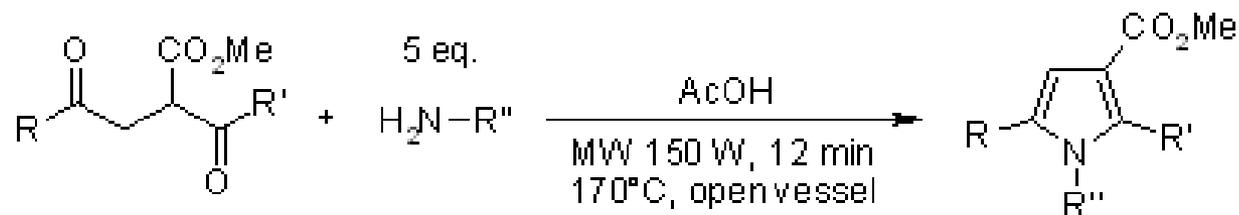
substrate	product	yield (% , isol.)	substrate	product	yield (% , isol.)
		92			56
		95			89





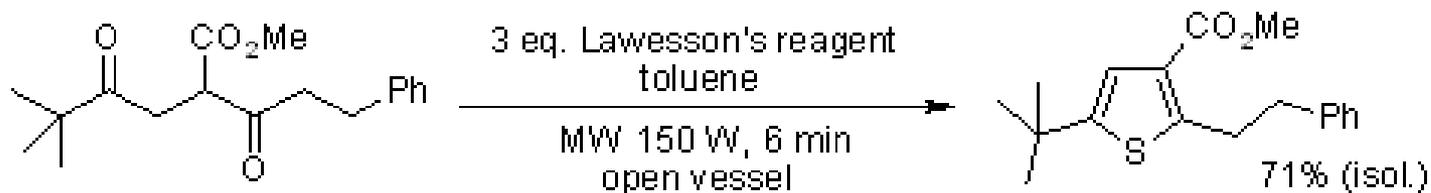
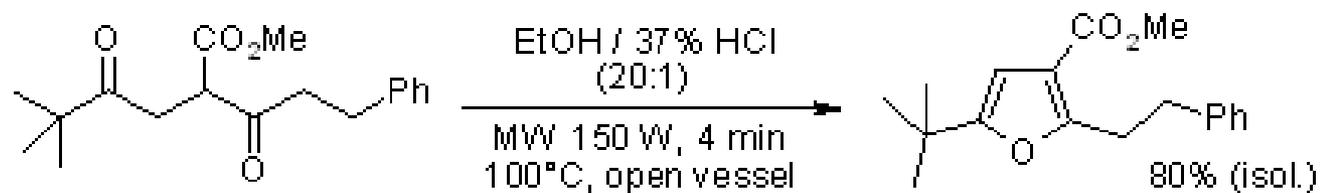
# Microwave-Assisted Paal-Knorr Reaction - Three-Step Regiocontrolled Synthesis of Polysubstituted Furans, Pyrroles and Thiophenes

G. Minetto, L. F. Raveglia, A. Segá, M. Taddei, *Eur. J. Org. Chem.*, **2005**, 5277-5288.



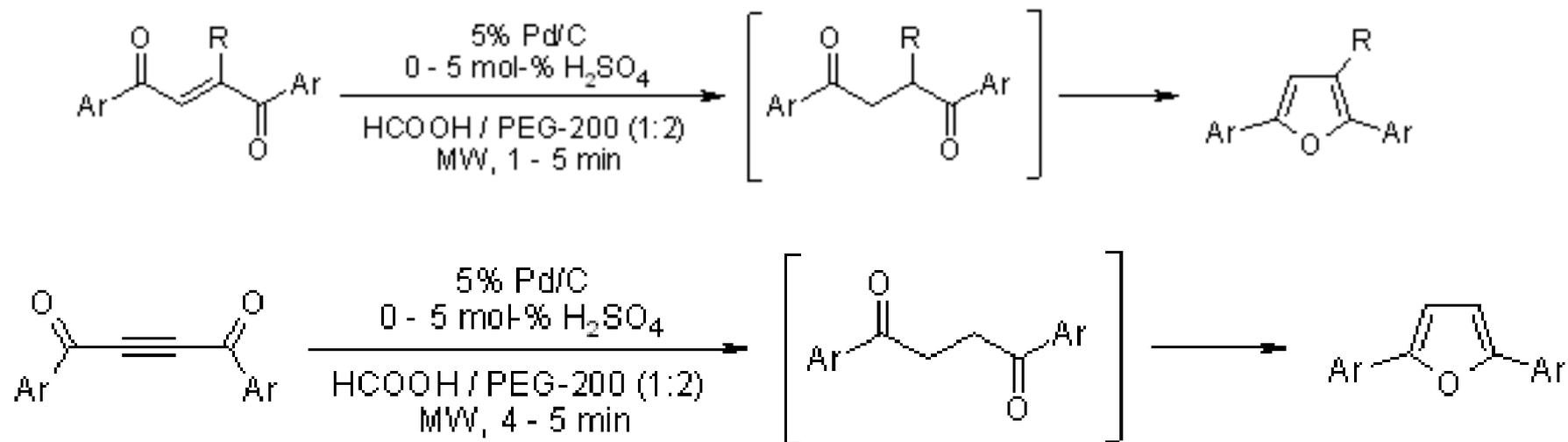
Product	Yield (% isol.)	Product	Yield (% isol.)	Product	Yield (% isol.)
	88		77		79
	82		88		79

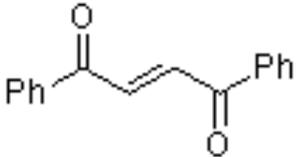
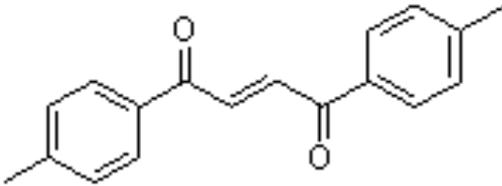
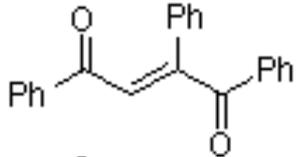
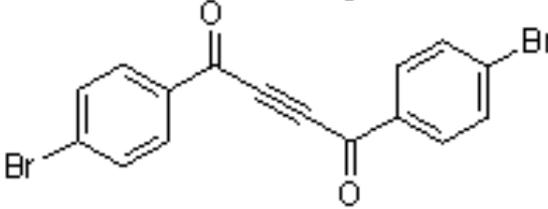
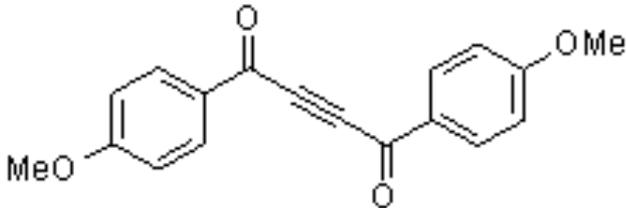




## Facile Microwave-Mediated Transformations of 2-Butene-1,4-diones and 2-Butyne-1,4-diones to Furan Derivatives

H. S. P. Rao, S. Jothilingam, *J. Org. Chem.*, **2003**, *68*, 5392-5394.

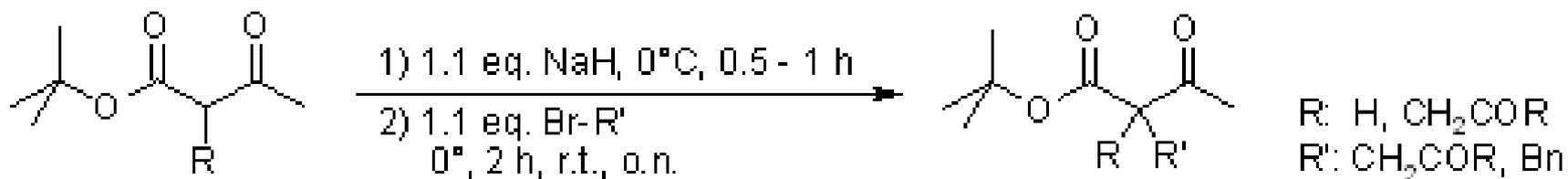


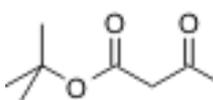
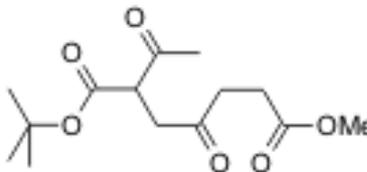
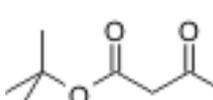
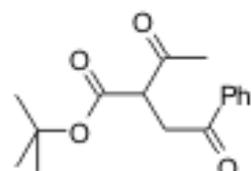
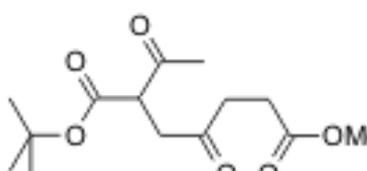
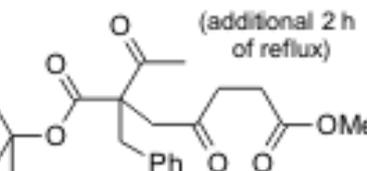
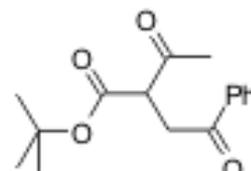
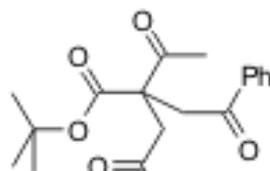
substrate	H <sub>2</sub> SO <sub>4</sub> (mol-%)	Power (W)	t (min)	yield (% , isol.)
	0	400	1.0	95
	5	200	5.0	96
	5	200	5.0	84
	0	155	4.0	93
	5	200	5.0	88



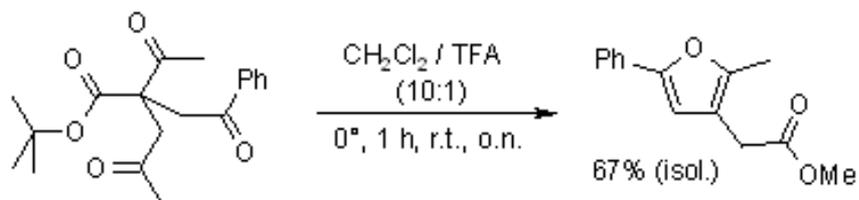
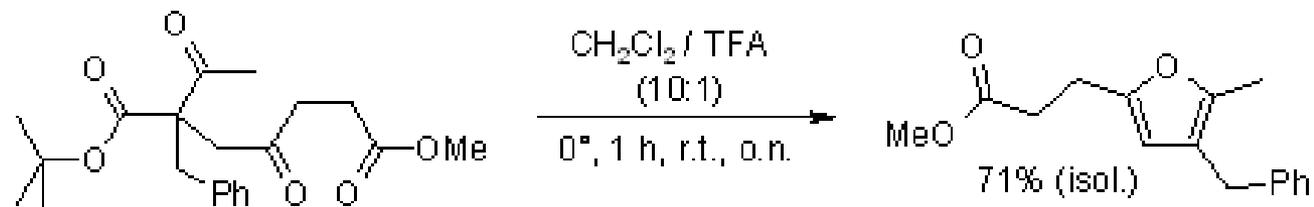
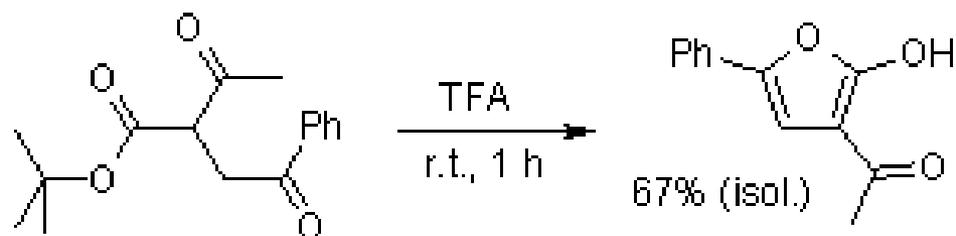
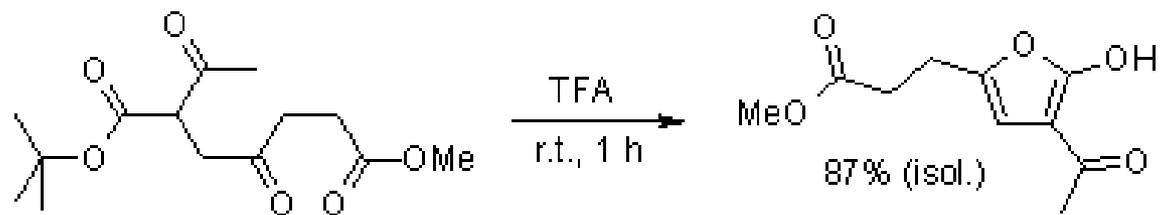
# Synthesis of Tri- and Tetrasubstituted Furans Catalyzed by Trifluoroacetic Acid

F. Stauffer, R. Neier, *Org. Lett.*, **2000**, *2*, 3535-3537.



substrate	product	yield (% isol.)
		92
		95
	 (additional 2 h of reflux)	56
		89





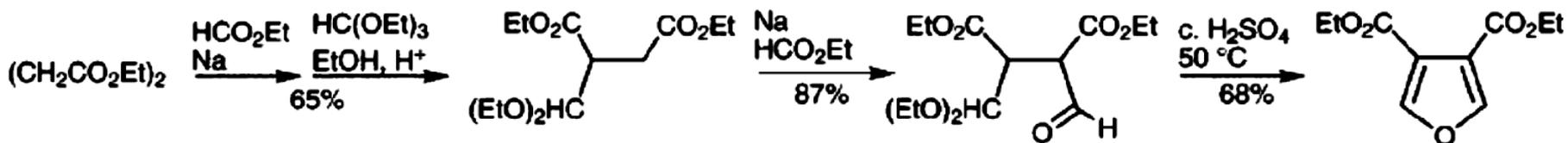
La aproximación sintética para obtener un sustrato 1,4-dicarbonílico, se ha establecido de varias maneras. Los ejemplos incluyen

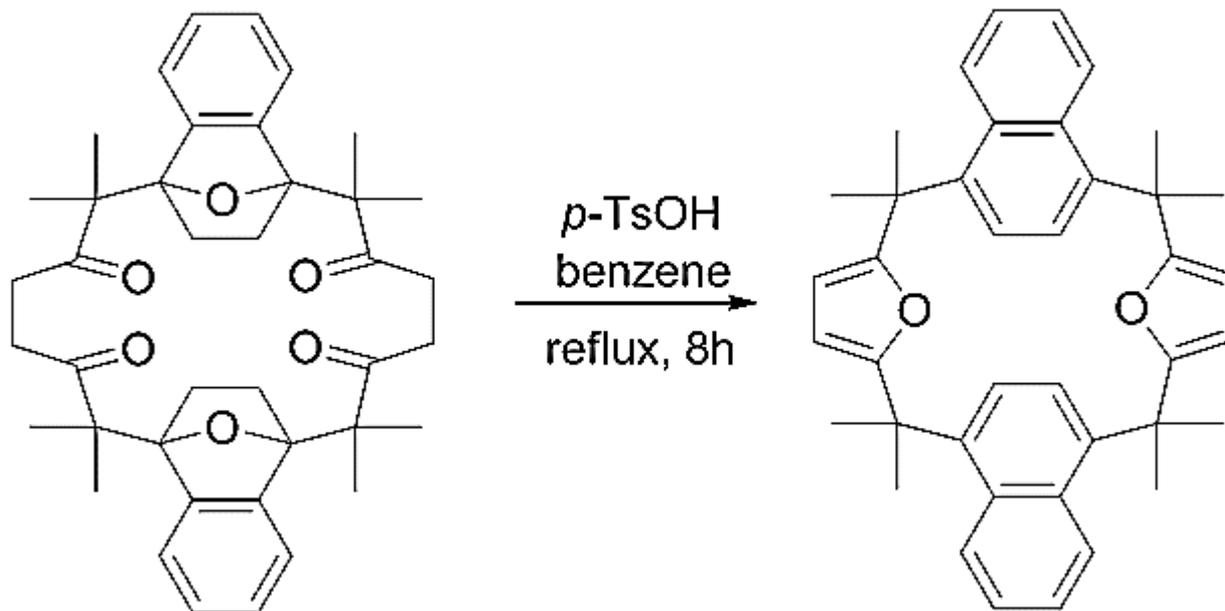
- 1) La alquilación de iminas con haluros de 2-alcoxialilo (equivalentes de 2-halocetonas), (Jacobson, R. M., Raths, R. A. and McDonald, J. H., / . Org. Chem., 1977, 42, 2545; Jacobson, R. M., Abbaspour, A., and Lahm, G. P., ibid. 1978, 43, 4650).
- 2) La adición de aniones  $\beta$ -cetoéster a nitroalquenos, seguida de la reacción Nef (Boberg, F. and Kieso, A., Justus Liebigs Ann. Chem., 1959, 626, 71).
- 3) La carbonilación catalizada por rodio de acetales de acroleína 2-sustituidos. Botteghi, C, Lardicci, L., and Menicagli, R., / . Org. Chem., 1973, 38, 2361.

El dialdehído (como monoacetal) necesario para la síntesis de furan-3,4-dicarboxilato de dietilo se obtuvo mediante dos condensaciones de Claisen sucesivas entre succinato de dietilo y succinato de etilo. formatear, como se muestra en la secuencia siguiente (Kornfeld, E. C. and Jones, R. G., / . Org. Chem., 1954, 19, 1671)



El dialdehído (como monoacetal) necesario para la síntesis de furan-3,4-dicarboxilato de dietilo se obtuvo mediante dos condensaciones de Claisen sucesivas entre succinato de dietilo y succinato de etilo. Formatear, como se muestra en la secuencia siguiente (Kornfeld, E. C. and Jones, R. G., *Org. Chem.*, 1954, 19, 1671)



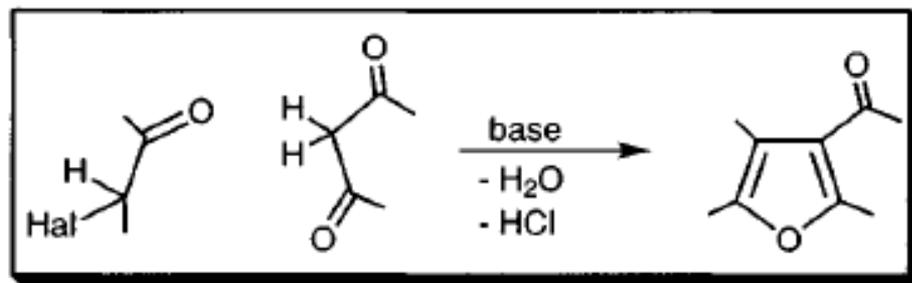


Hart, H.; Takehira, Y, *The Journal of Organic Chemistry*, **1982**,*47*, 4370,

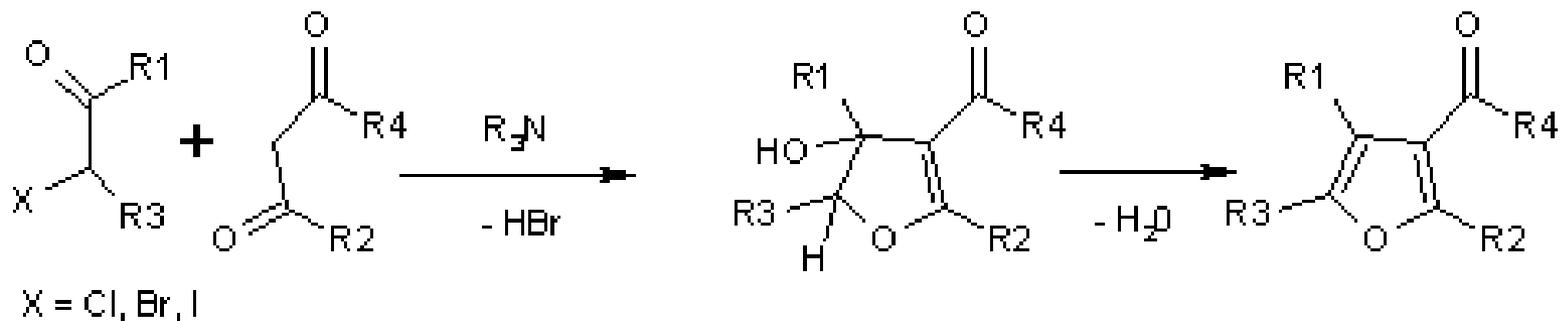


# MÉTODOS DE OBTENCIÓN DE FURANO

## Síntesis de Feist-Benary



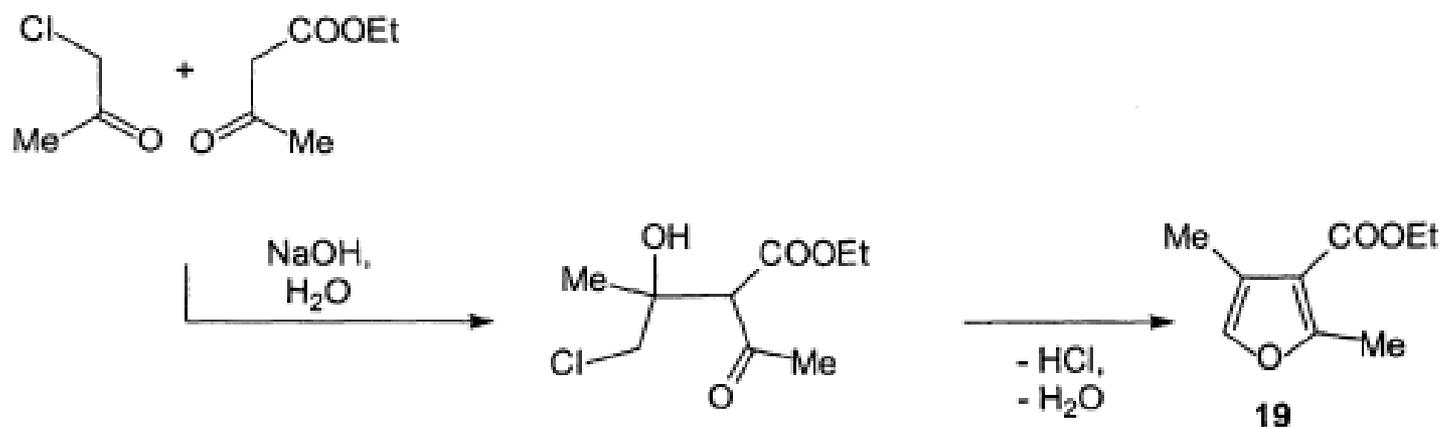
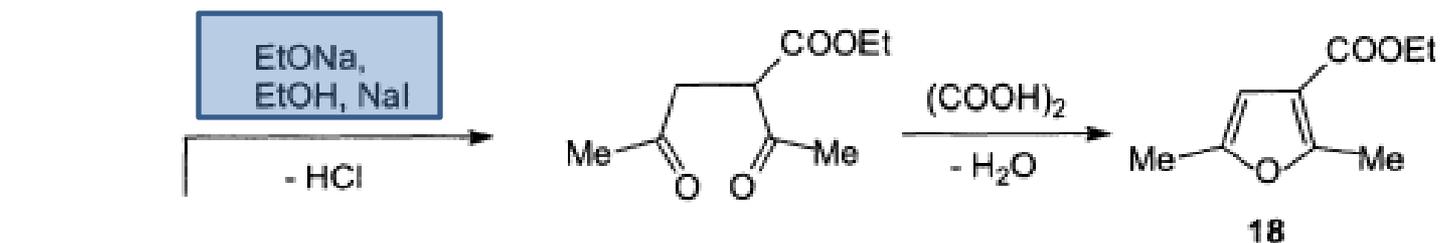
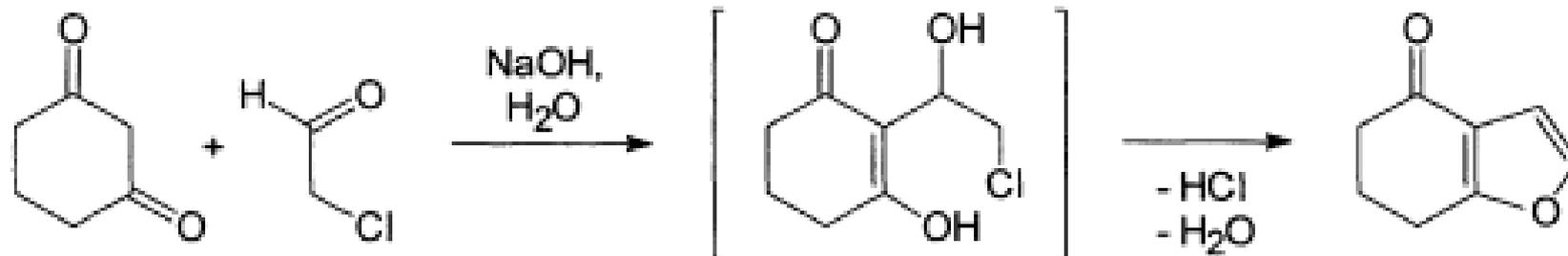
Franz Feist (1902), Erich Benary (1911)



Feist F., *Ber.*, **1902**, 35, 1539, 1547.  
Benary E., *Ber.*, **1911**, 44, 489, 493.



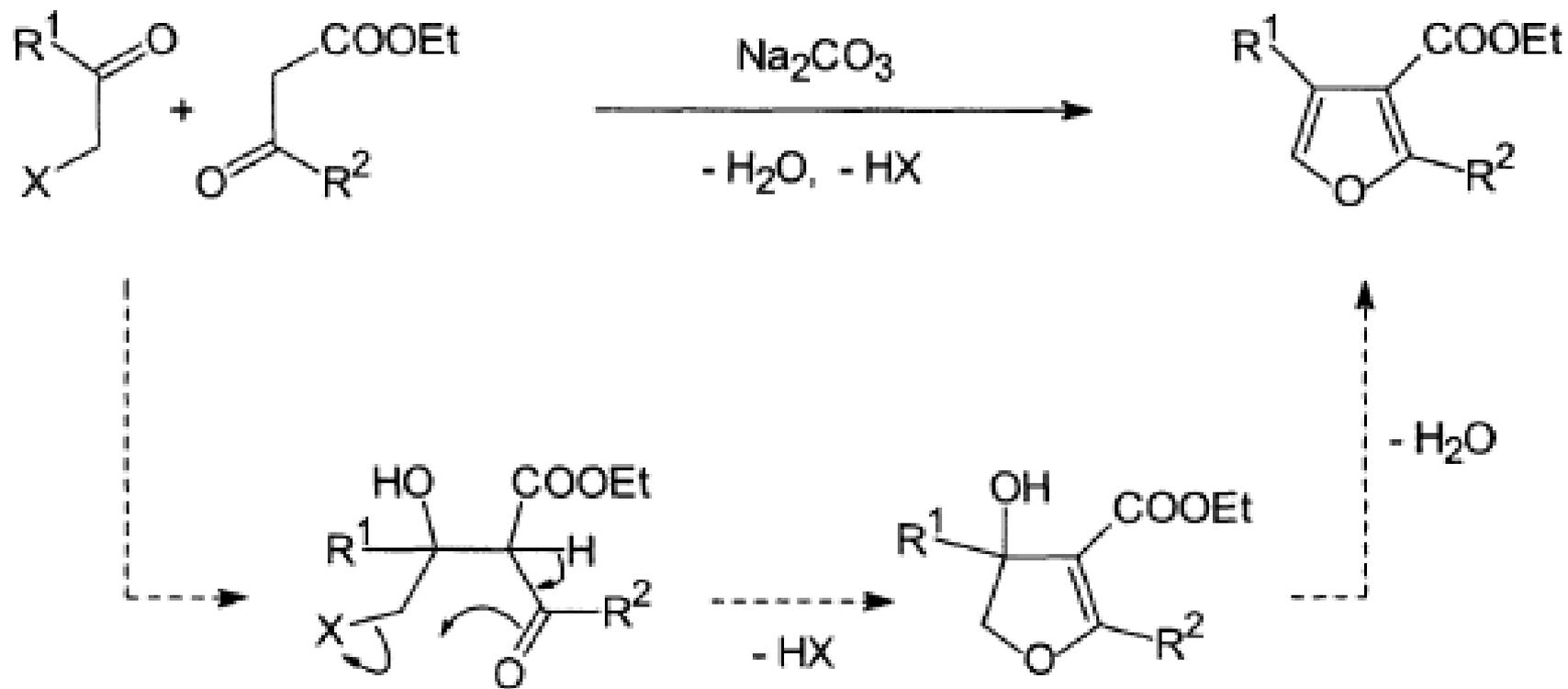
# MÉTODOS DE OBTENCIÓN DE FURANO



Feist F., *Ber.*, **1902**, 35, 1539, 1547  
 Benary E., *Ber.*, **1911**, 44, 489, 493

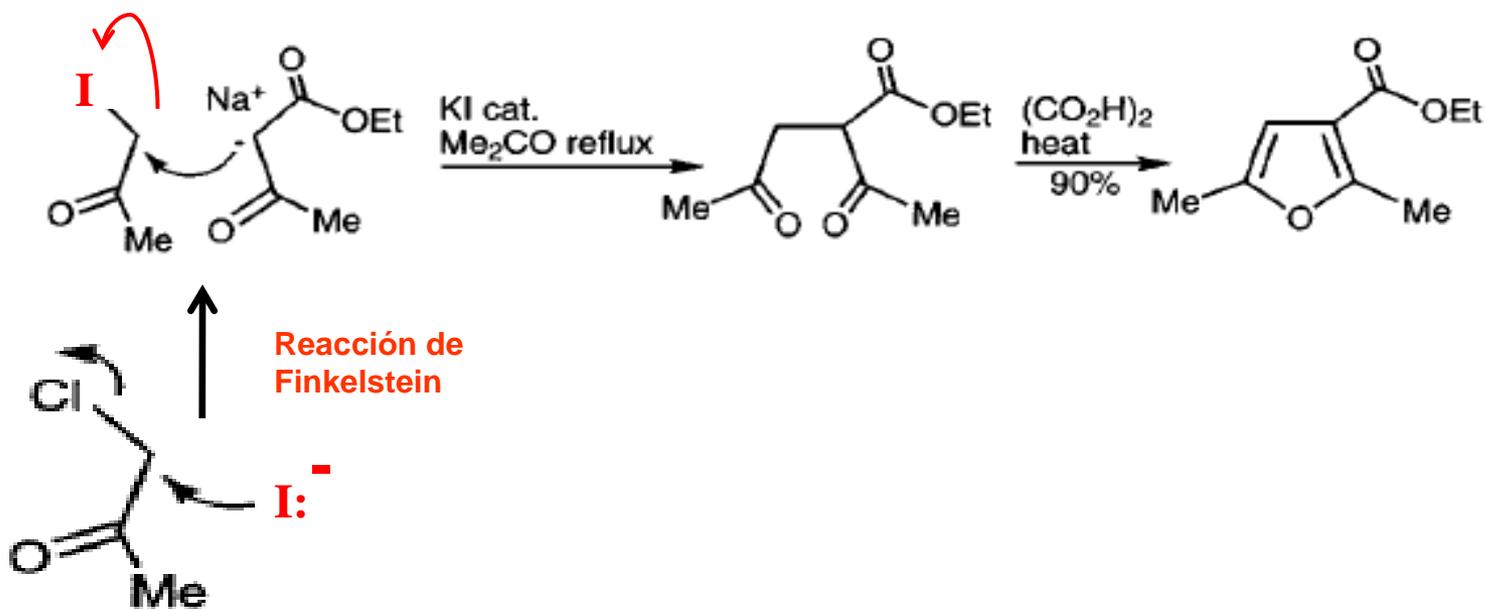
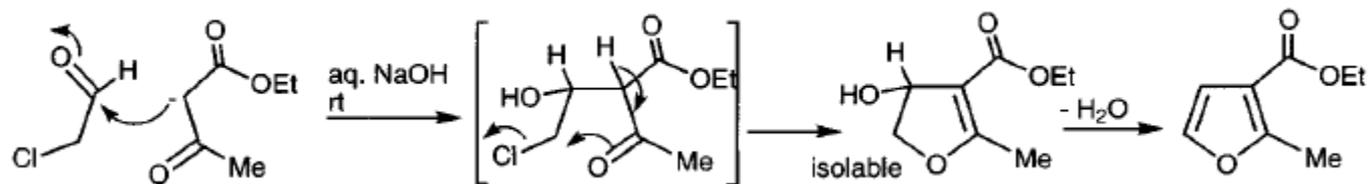


## SÍNTESIS DE FEIST-BENARY

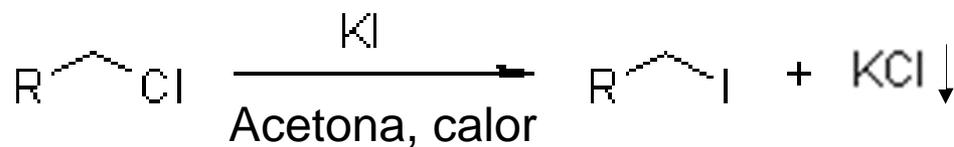
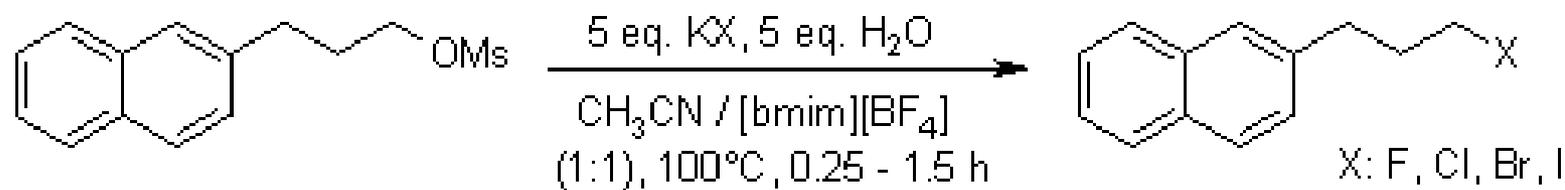
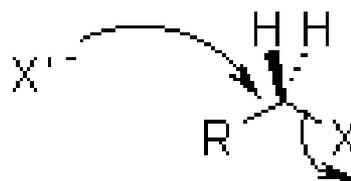


# MÉTODOS DE OBTENCIÓN DE FURANO

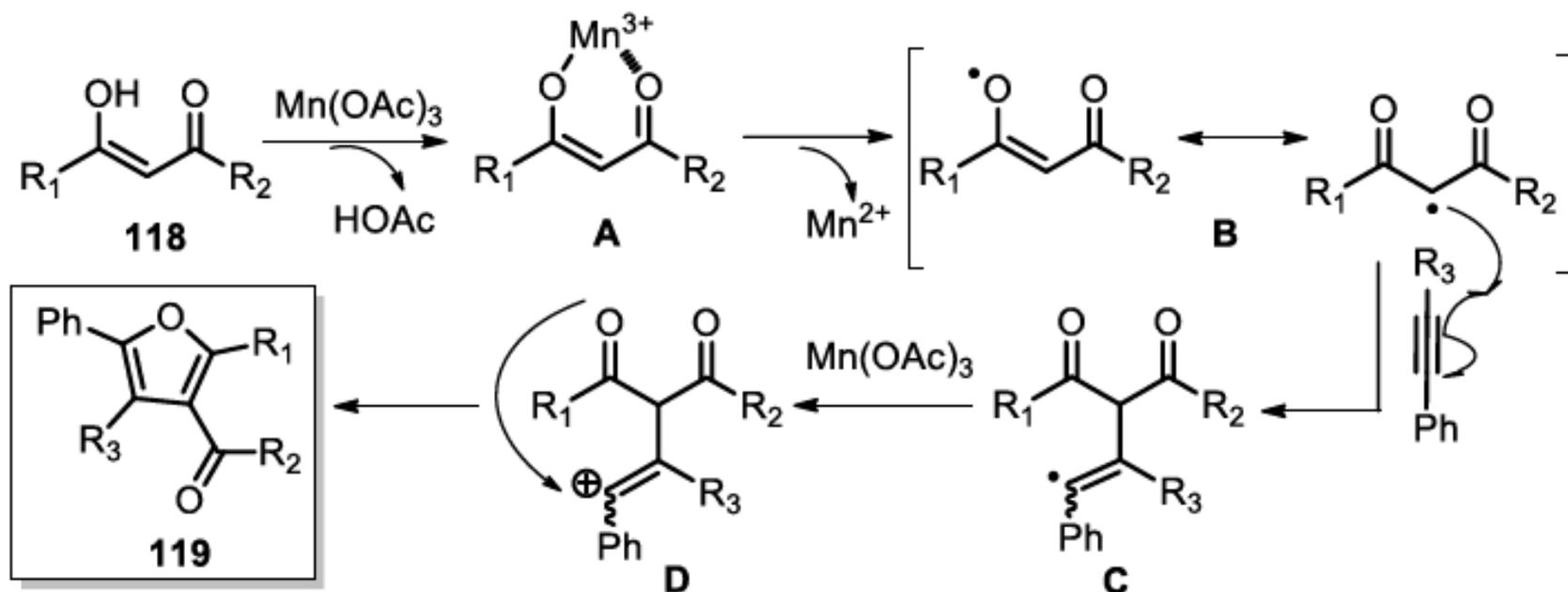
## SÍNTESIS DE FEIST-BENARY



## Reacción de Finkelstein



A) Mondal, 2013 **Mecanismo**



El  $Mn(OAc)_3$  reacciona con la forma enólica del sistema 1,3-dicarbonílico **118** formando un complejo Mn(III)-enolato **A**. En esta estructura el Mn(III) es reducido a Mn(II) para formar el radical centrado en oxígeno **B**, el cual se encuentra en resonancia para generar el radical  $\alpha$ -carbonilo más estable. Dicho radical se puede adicionar de forma intra o intermolecular a diversos aceptores. Por ejemplo, puede adicionarse a un alquino interno para formar el intermediario **C**, el cual puede ser oxidado al carbocatión **D** con otra molécula de  $Mn(OAc)_3$  y finalmente formar el núcleo de furano **E** luego de una ciclación intramolecular **A**

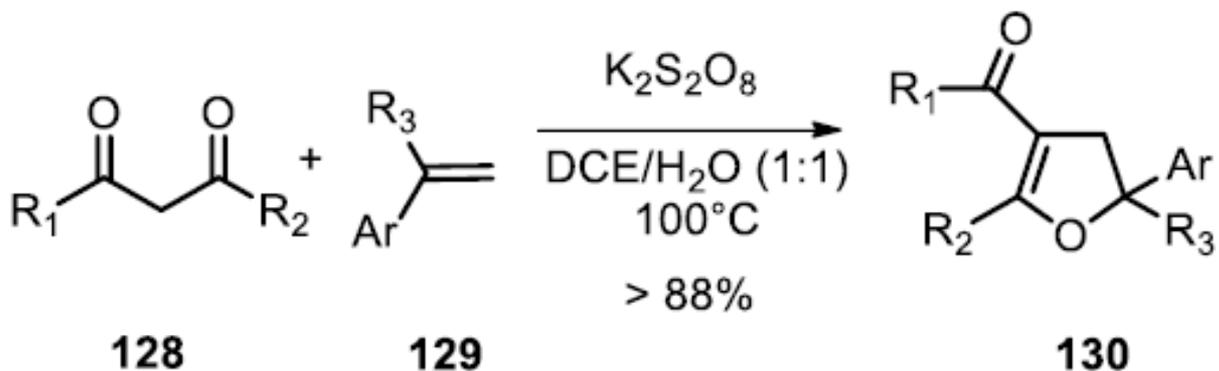
Snider, B., B. *Tetrahedron*. **2009**, 65, 10738-10744.

Heiba, E. I.; Dessau, R. M. *J. Am. Chem. Soc.* **1972**, 94, 2888–2889.

Alagoz, O.; Yilmaz, M.; Pekel, A. T. *Synth. Commun.* **2006**, 36, 1005-1013



A) Guo, 2015



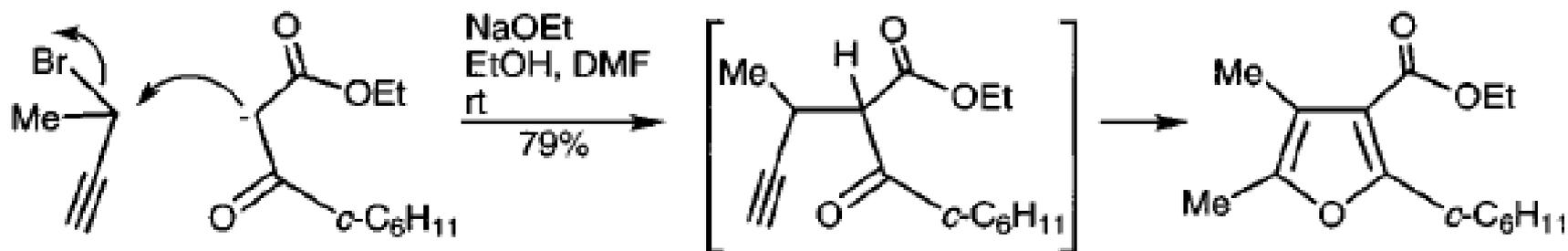
De otra parte, Guo y colaboradores reportaron en 2015 una metodología libre de metales para la síntesis de dihidrofuranos **130** mediante una adición/ciclación tándem entre un sistema 1,3-dicarbonílico **128** y estireno **129** promovido por  $K_2S_2O_8$  (A).

Wang, S.; He, L.; Guo, L. *Synthesis* **2015**, *47*, 3191-3197.

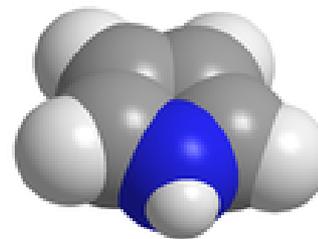
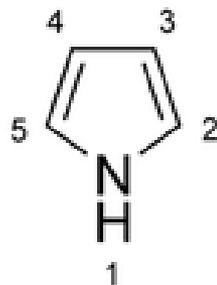
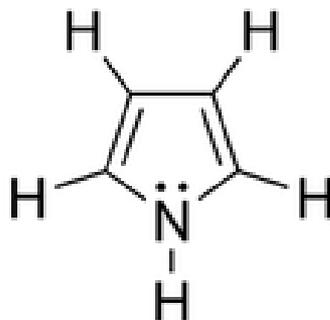


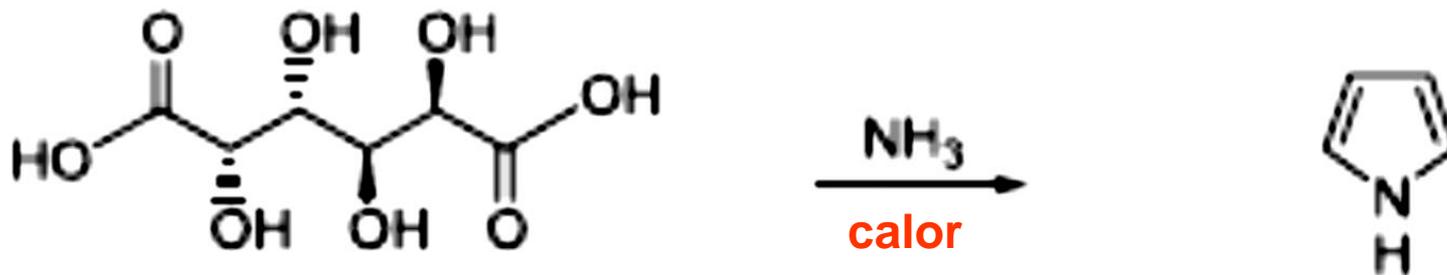
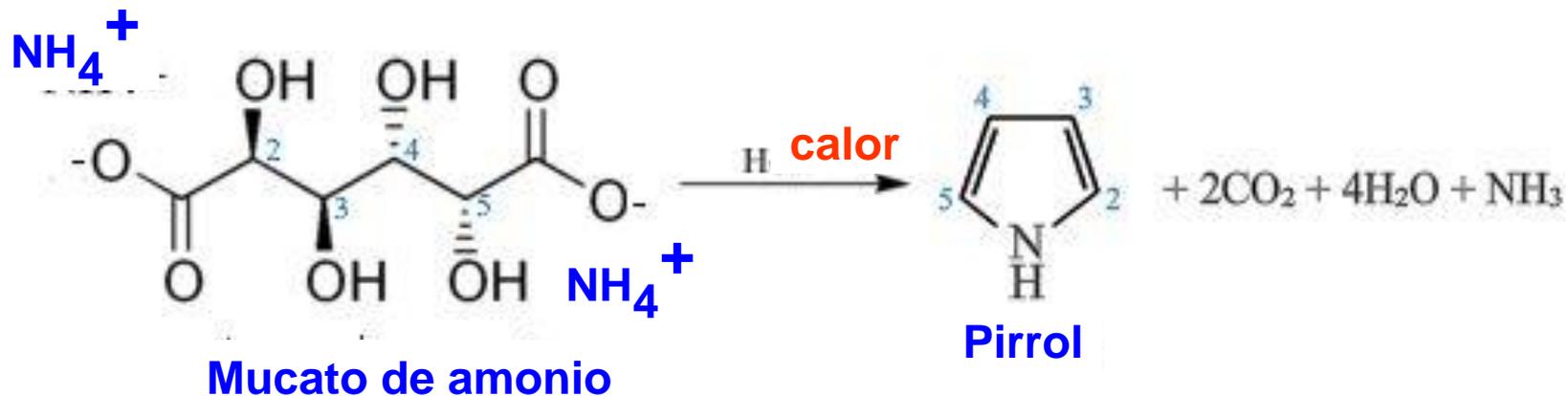
Las 4-pentinonas pueden cerrarse a furanos usando  $\wedge$ -butóxido de potasio (Arcadi, A. and Rossi, E., *Tetrahedron*, **1998**, 54, 15253) o bencilo. metóxido de trimetilamonio. (MaGee, D. I. and Leach, J. D., *Tetrahedron Lett.*, **1997**, 38, 8129).

La 2-alkilación catalizada por bases de compuestos 1,3-dicarbonílicos con haluros de propargilo, es seguida, *in situ*, por el cierre del anillo 5-exo-dig



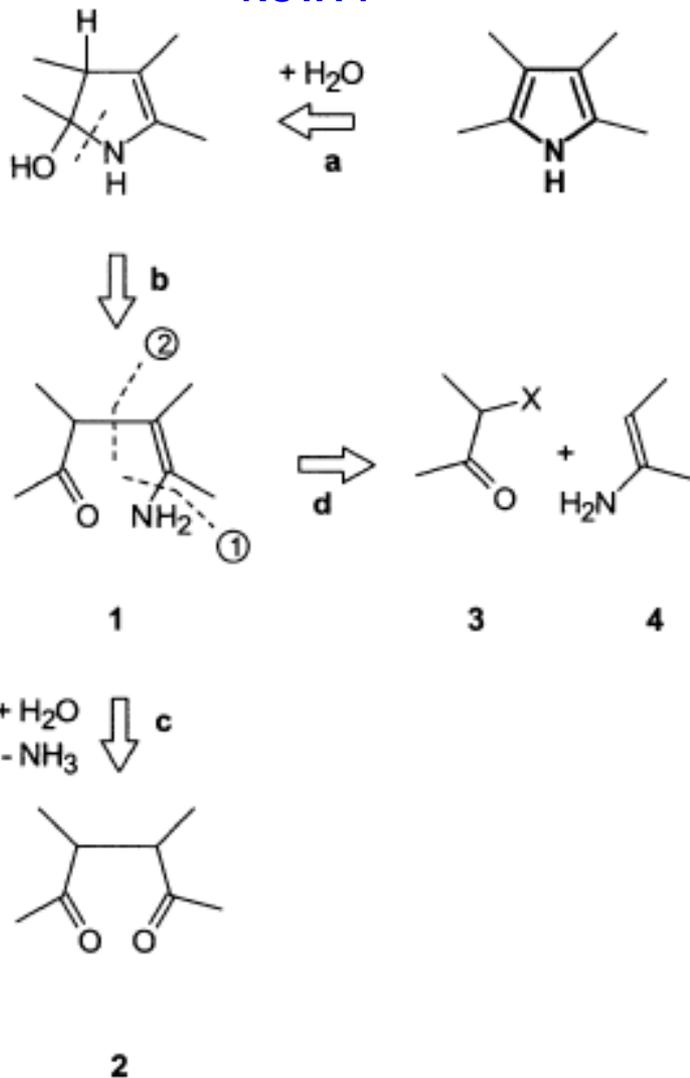
# PIRROL



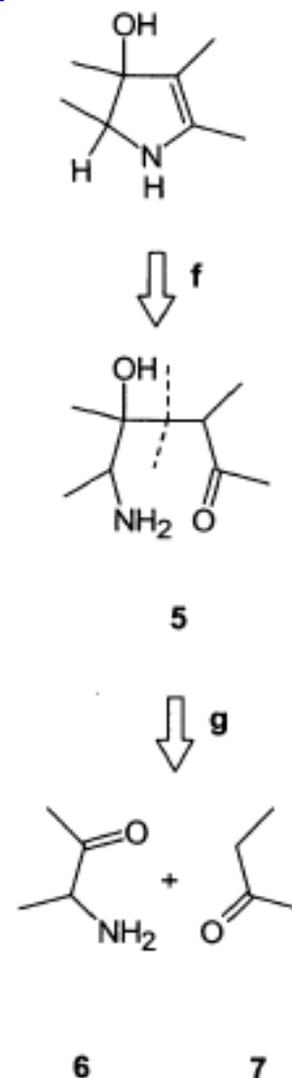


# MÉTODOS DE OBTENCIÓN DE PIRROL

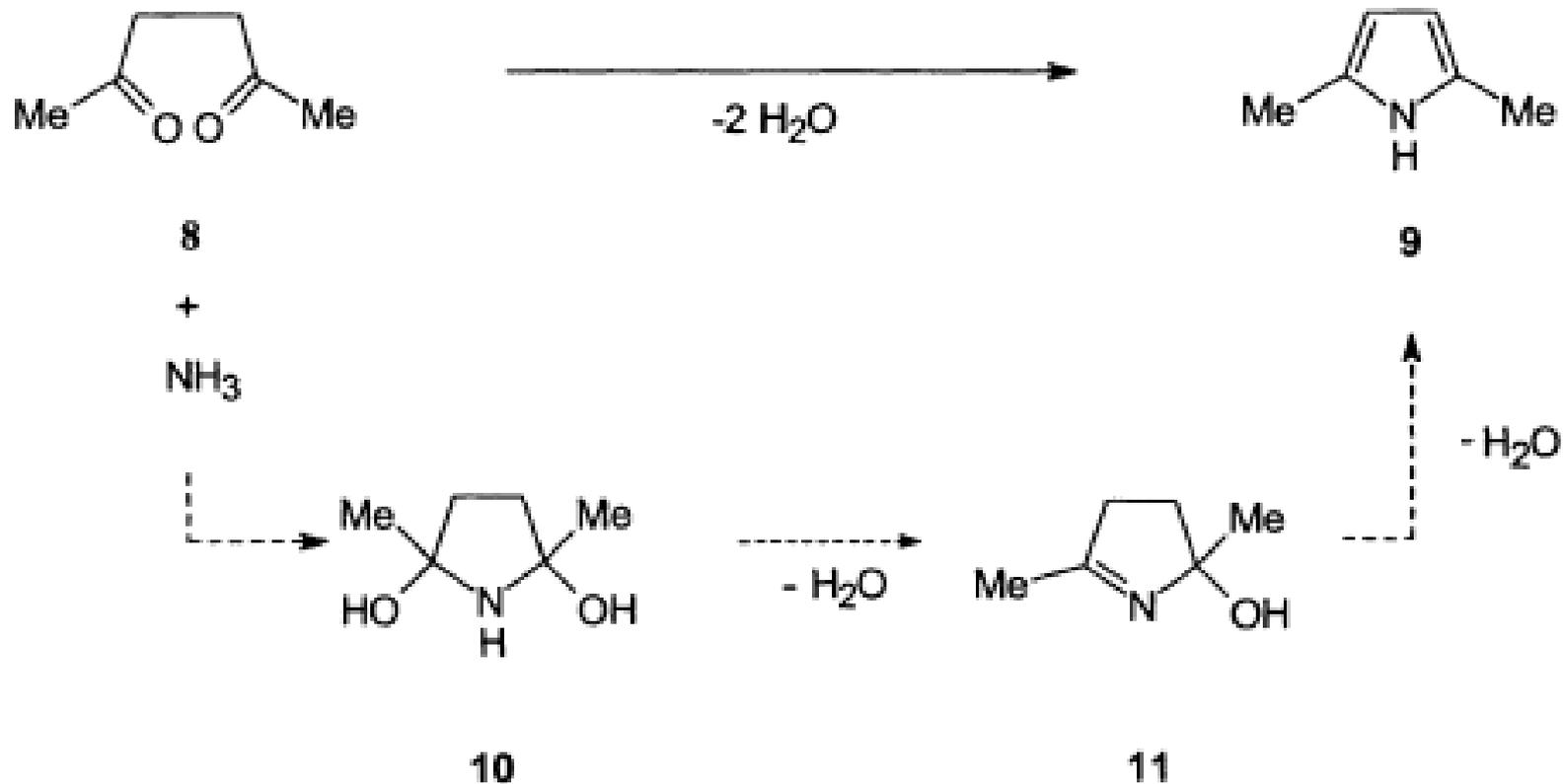
## RUTA 1



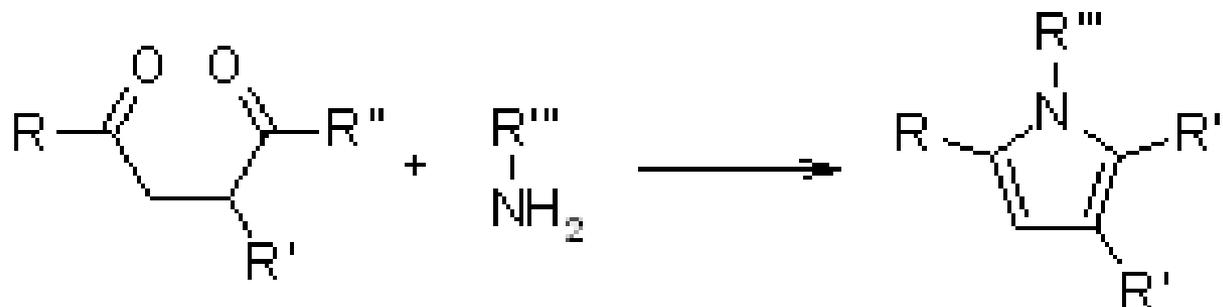
## RUTA 2



# SÍNTESIS DE PAAL-KNORR



## Síntesis de pirroles de Paal-Knorr



**Ludwig Knorr**  
(1859 — 1921)  
Químico Alemán

<https://www.wikidata.org/wiki/Q63983>

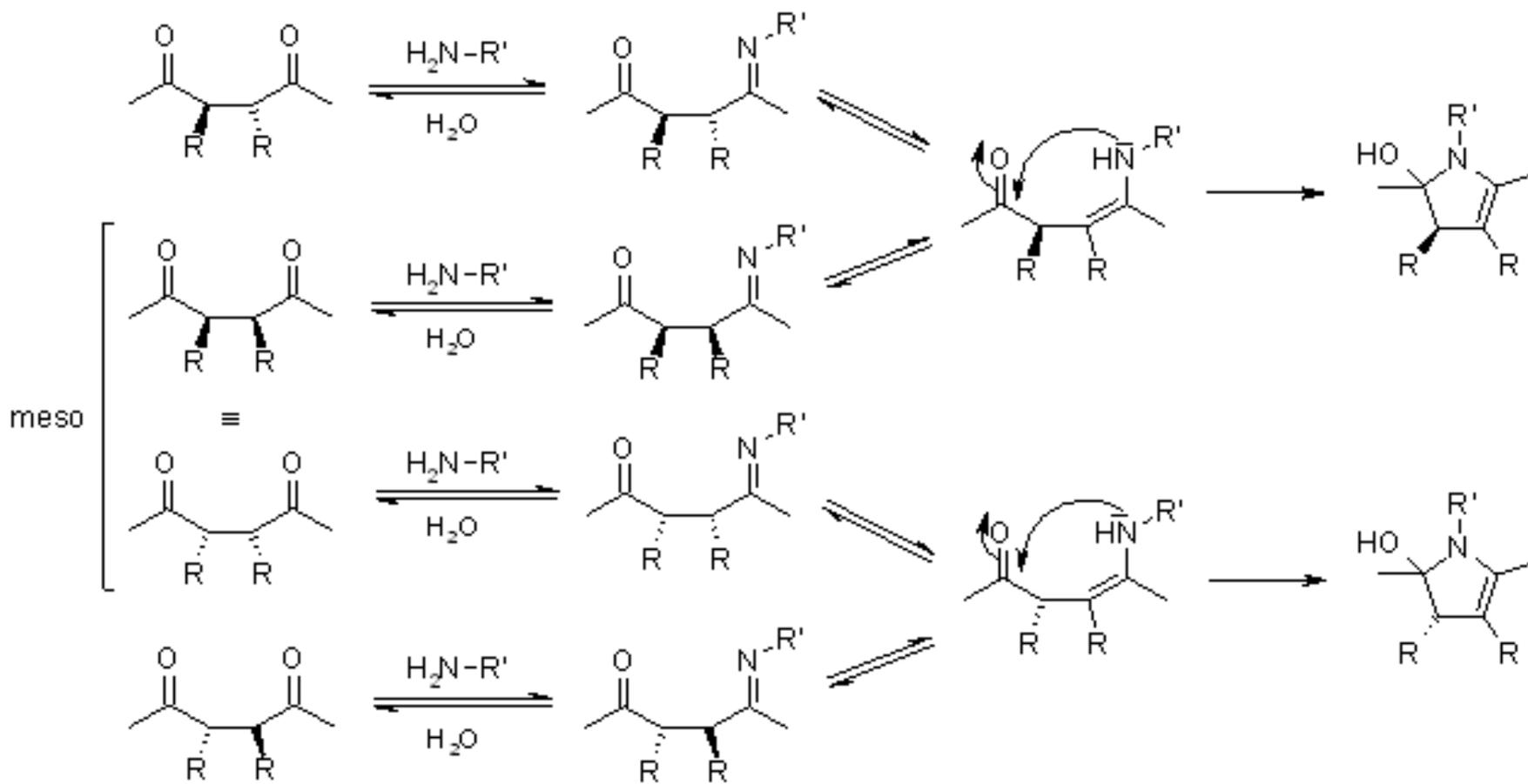
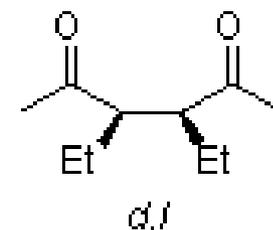
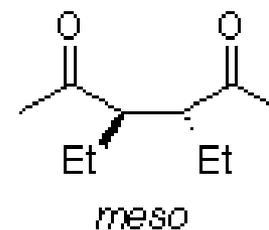


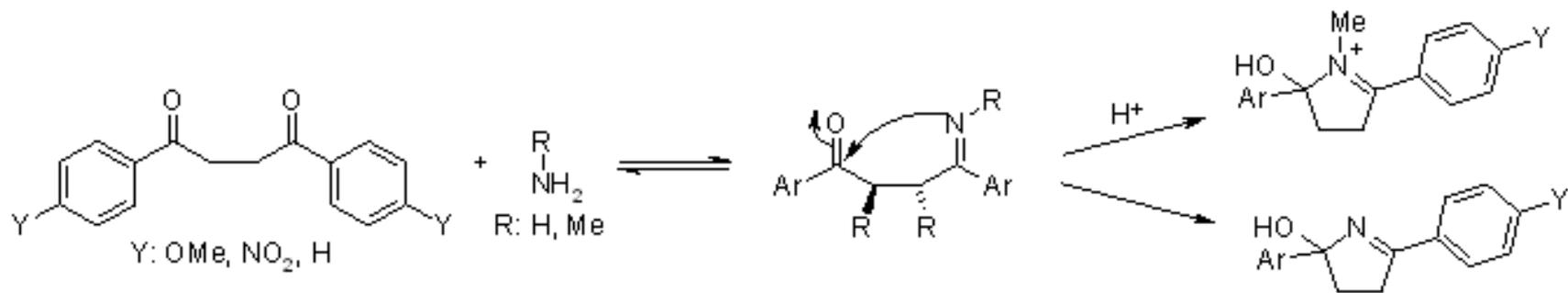
Prof. Dr. phil. habil. et Dr. h. c. **Carl Ludwig Paal**  
(1860 – 1935)  
Químico austriaco

[http://research.uni-leipzig.de/catalogus-professorum-lipsiensium/leipzig/Paal\\_111/](http://research.uni-leipzig.de/catalogus-professorum-lipsiensium/leipzig/Paal_111/)

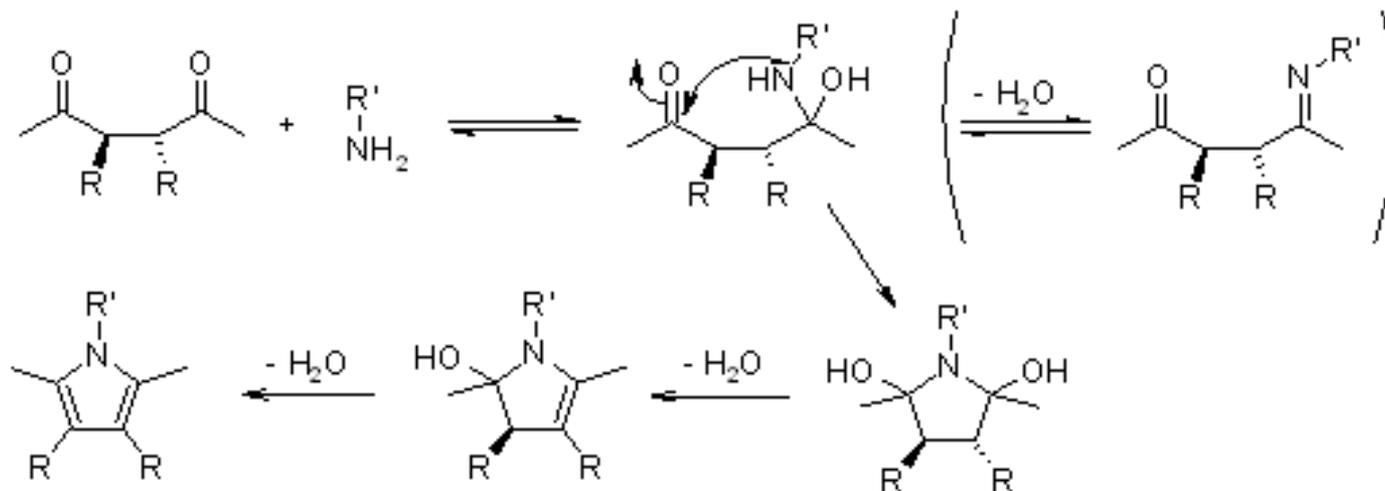
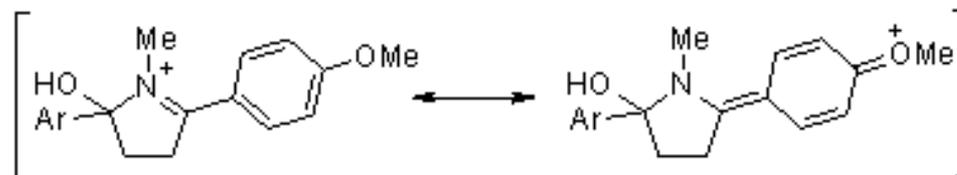


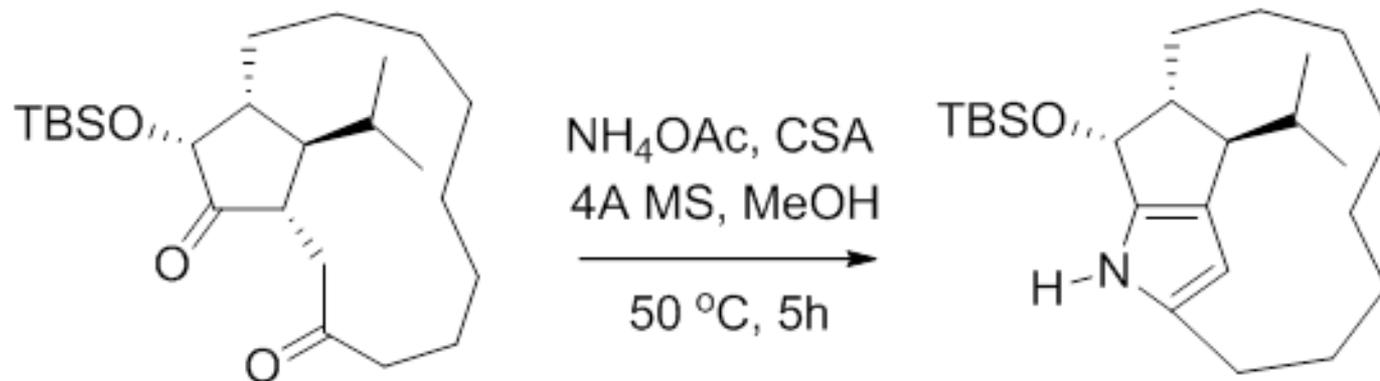
Venkatarman Amarnath has shown (J. Org. Chem., **1991**, 56, 6924) that *meso*- and *dl*-3,4-diethyl-2,5-hexanediones cyclize at unequal rates, and that the stereochemical configuration of the unchanged dione is preserved during the reaction. Any mechanism such as the following one that involves the formation of an enamine before the rate-determining step - the cyclization - must be ruled out.





estabilización

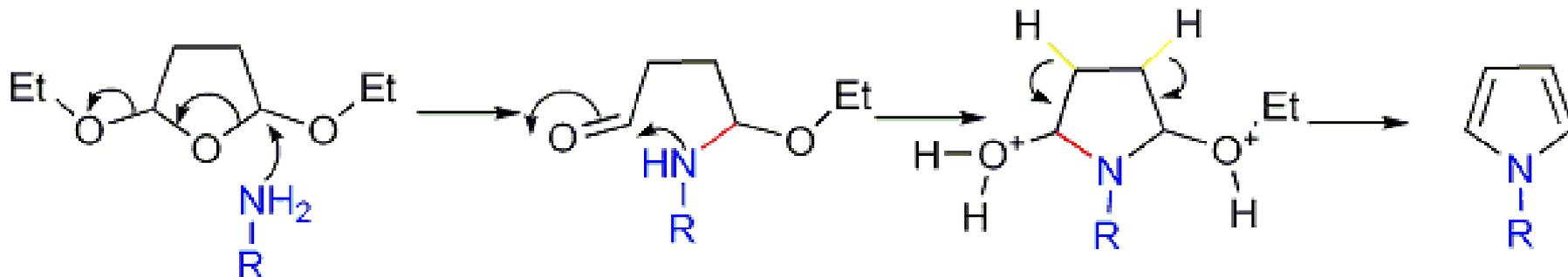
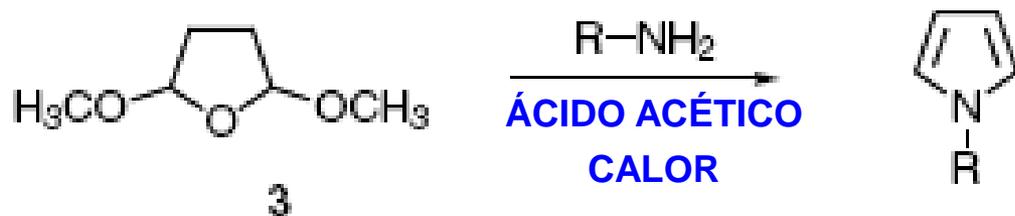




Trost, B. M.; Doherty, G. A. *Journal of the American Chemical Society*, **2000**, 122 (16), 3801–3810

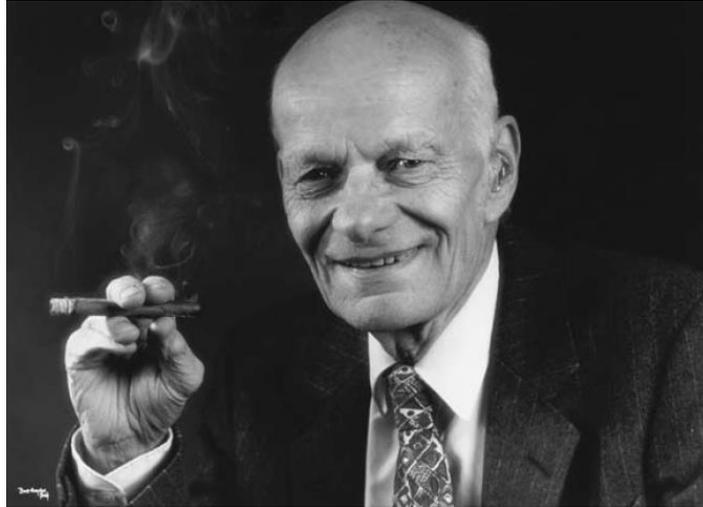


## Reacción de Clauson-Kaas



Clauson-Kaas N., Tyle Z., *Acta Chem. Scand.*, **1952**, 6, 667.  
Elming N., Clauson-Kaas N., *Acta Chem. Scand.*, **1952**, 6, 867.



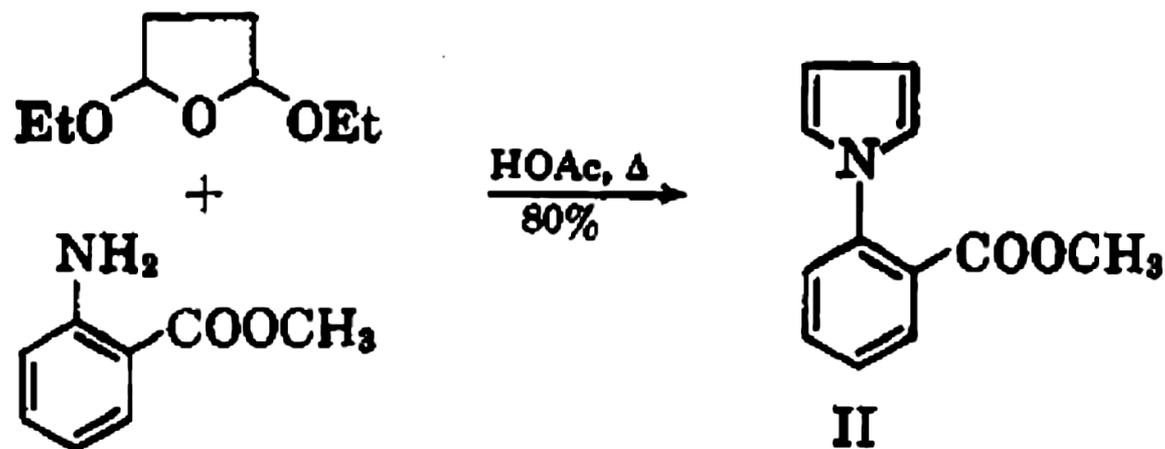


Niels Clauson-Kaas  
(1917-2003)



# N-Functionally Substituted Pyrroles

A. D. JOSEY AND E. L. JENNER

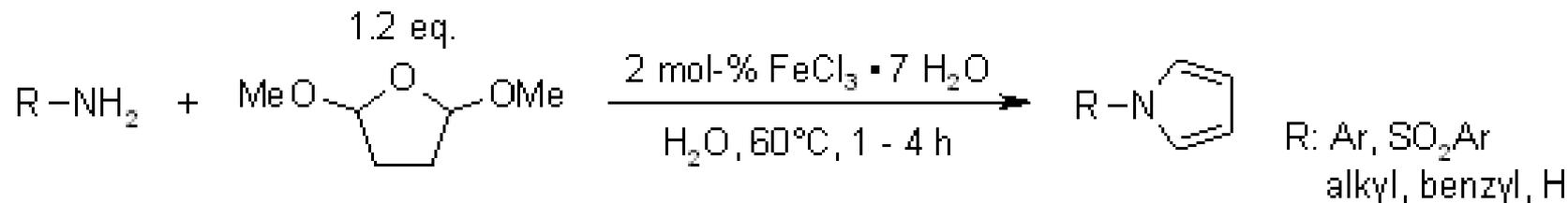


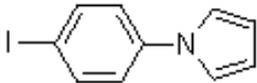
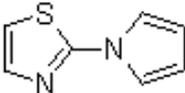
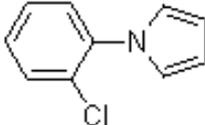
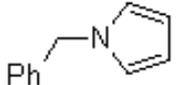
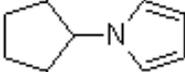
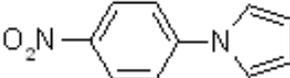
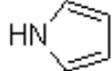
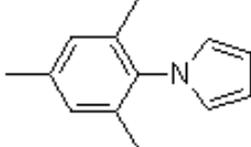
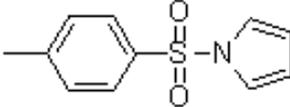
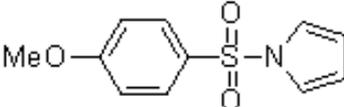
*J. Org. Chem.*, 1962, 27 (7), pp 2466–2470



# Iron-Catalyzed Inexpensive and Practical Synthesis of N-Substituted Pyrroles in Water

N. Azizi, A. Khajeh-Amiri, H. Ghafari, M. Bolourtchian, M. R. Saidi, *Synlett*, **2009**, 2245-2248

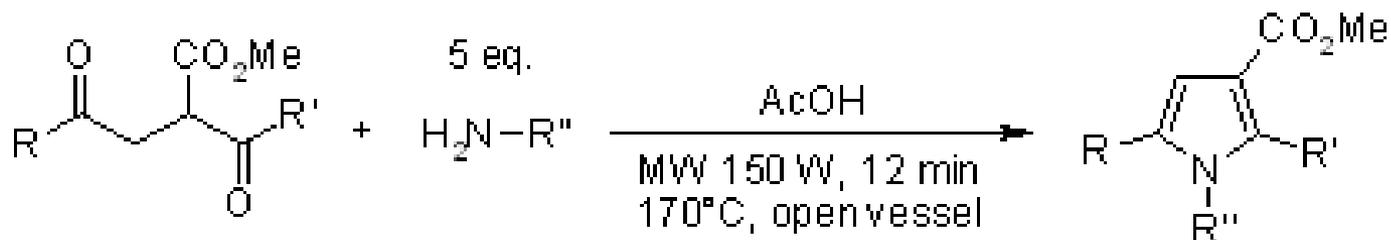


product	yield (% , isol.)	product	yield (% , isol.)
	98		80
	95		78
	90		80
	90		82
	85		85
			78



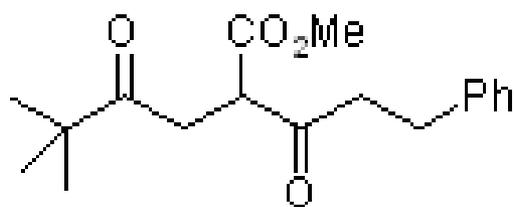
# Microwave-Assisted Paal-Knorr Reaction - Three-Step Regiocontrolled Synthesis of Polysubstituted Furans, Pyrroles and Thiophenes

G. Minetto, L. F. Raveglia, A. Sega, M. Taddei, *Eur. J. Org. Chem.*, **2005**, 5277-5288.



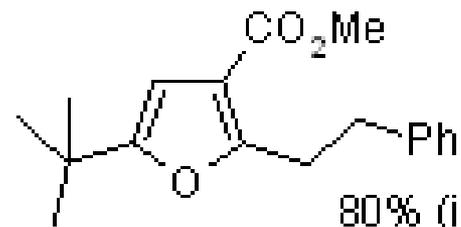
Product	Yield (% <sub>1</sub> , isol.)	Product	Yield (% <sub>1</sub> , isol.)	Product	Yield (% <sub>1</sub> , isol.)
	88		77		79
	82		88		79



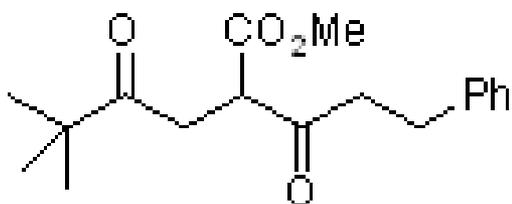


EtOH / 37% HCl  
(20:1)

MW 150 W, 4 min  
100°C, open vessel

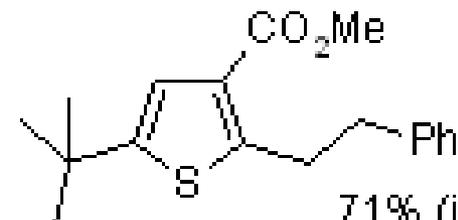


80% (isol.)



3 eq. Lawesson's reagent  
toluene

MW 150 W, 6 min  
open vessel

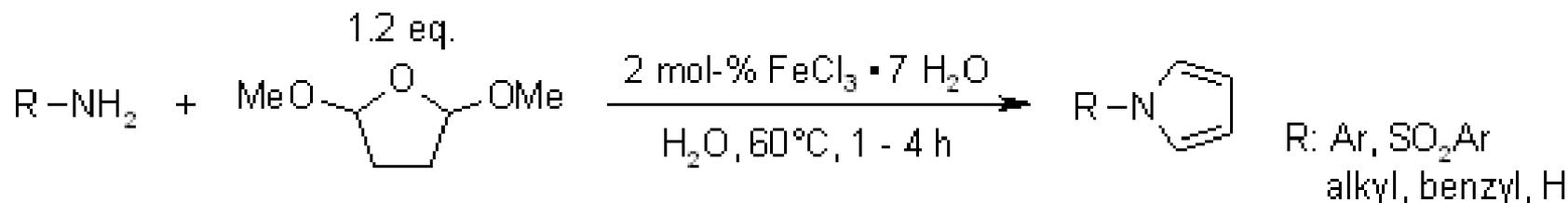


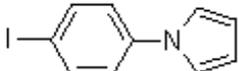
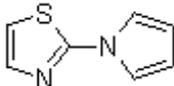
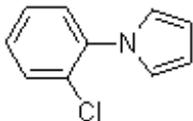
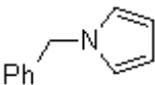
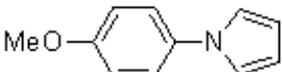
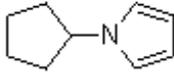
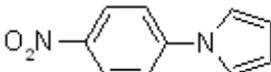
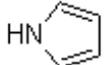
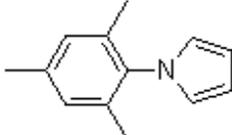
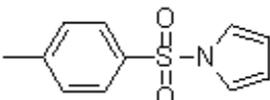
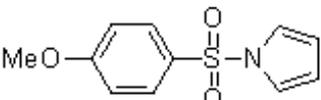
71% (isol.)



# Iron-Catalyzed Inexpensive and Practical Synthesis of N-Substituted Pyrroles in Water

N. Azizi, A. Khajeh-Amiri, H. Ghafari, M. Bolourtchian, M. R. Saidi, *Synlett*, **2009**, 2245-2248

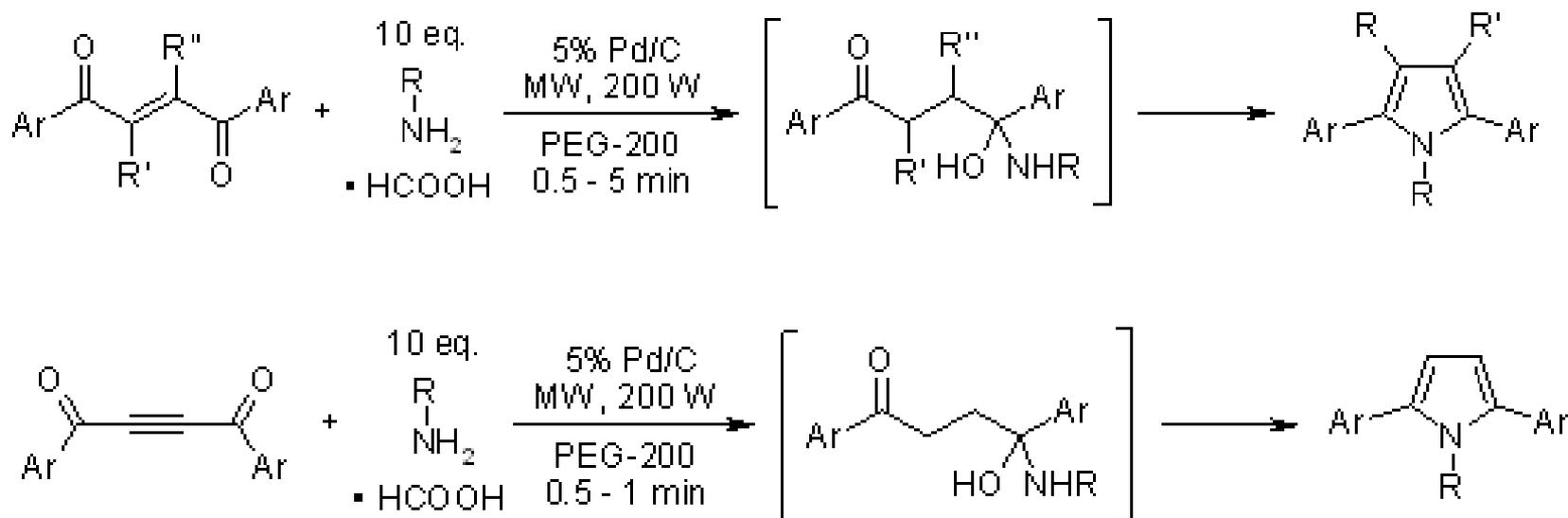


product	yield (% , isol.)	product	yield (% , isol.)
	98		80
	95		78
	90		80
	90		82
	85		85
			78



# Microwave mediated facile one-pot synthesis of polyarylpyrroles from but-2-ene- and but-2-yne-1,4-diones

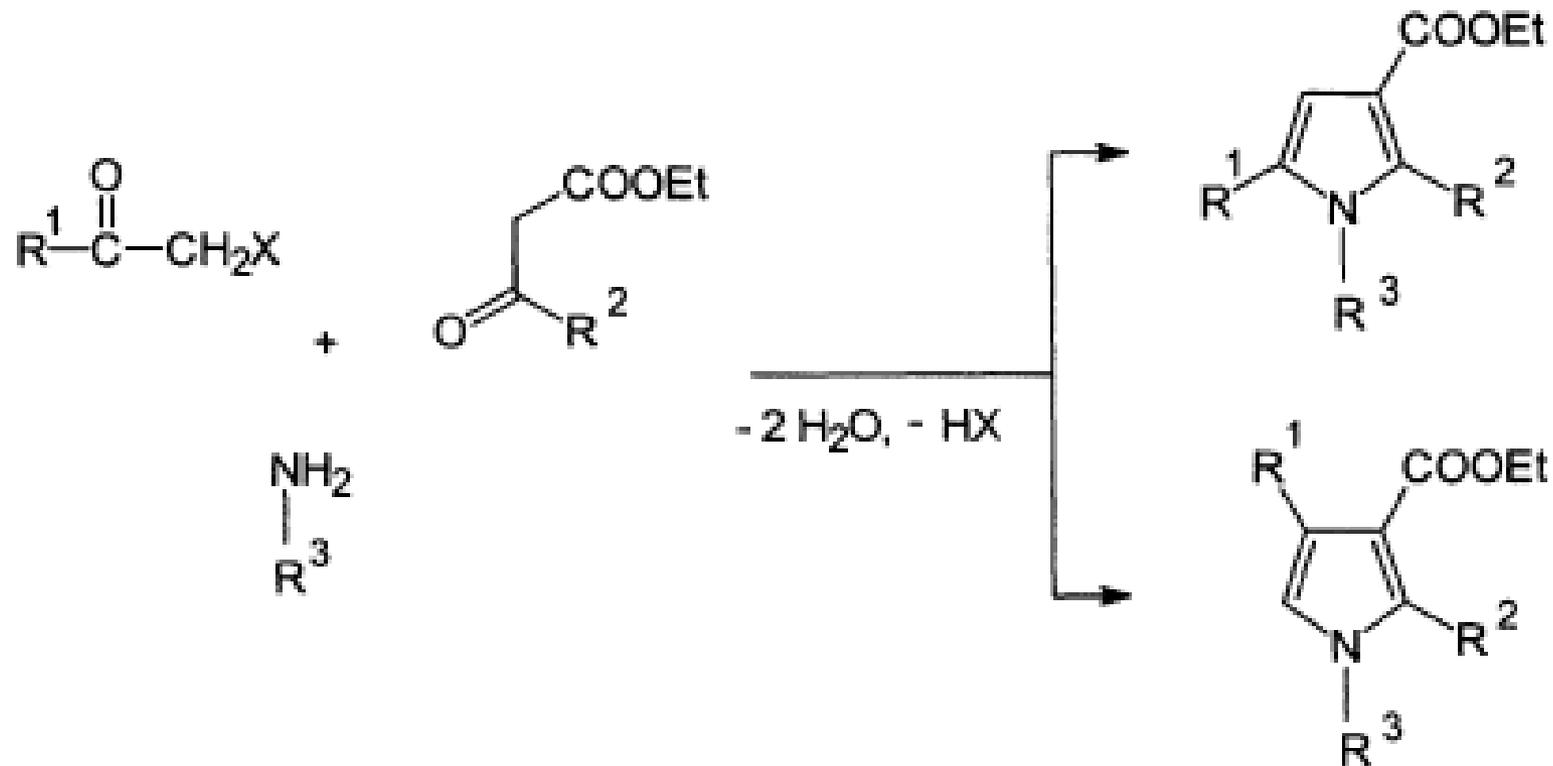
H. S. P. Rao, S. Jothilingam, H. W. Scheeren, *Tetrahedron*, **2004**, *60*, 1625-1630.

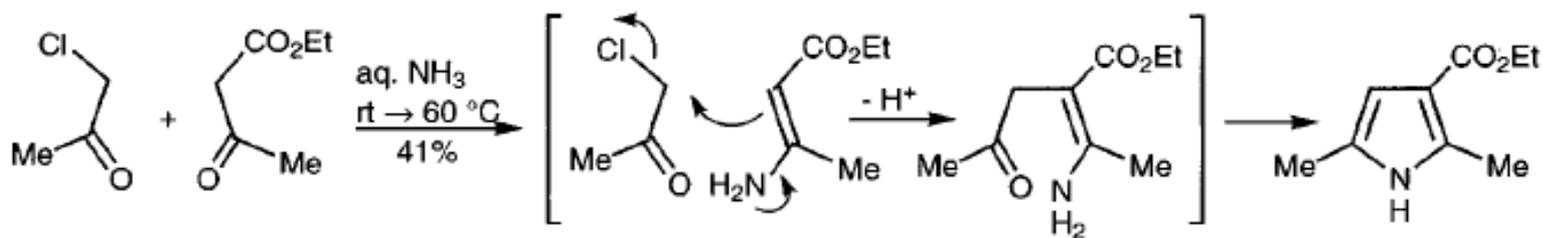
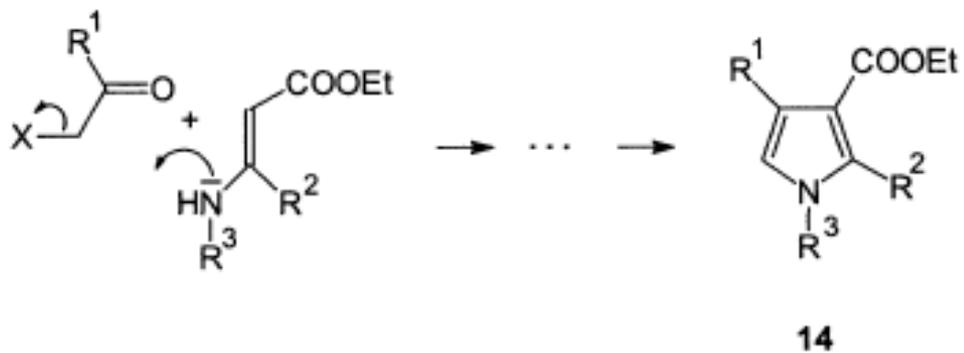
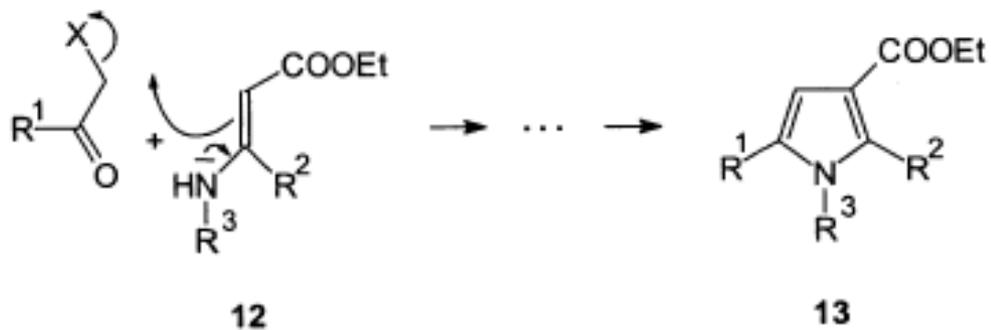


substrate	RNH <sub>2</sub>	t (min)	yield (% , isol.)
	NH <sub>3</sub>	0.5	92
	NH <sub>3</sub>	1.5	85
	Bu-NH <sub>2</sub>	2.0	56
	NH <sub>3</sub>	0.5	92
	NH <sub>3</sub>	1.0	91
	Bu-NH <sub>2</sub>	1.0	60
	Ph-NH <sub>2</sub>	1.0	61
	NH <sub>3</sub>	1.0	95

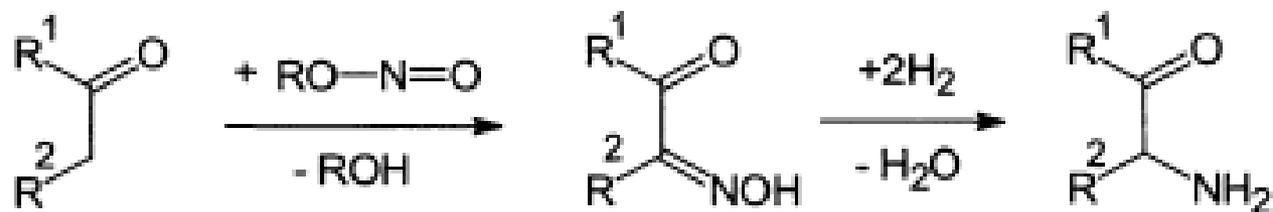
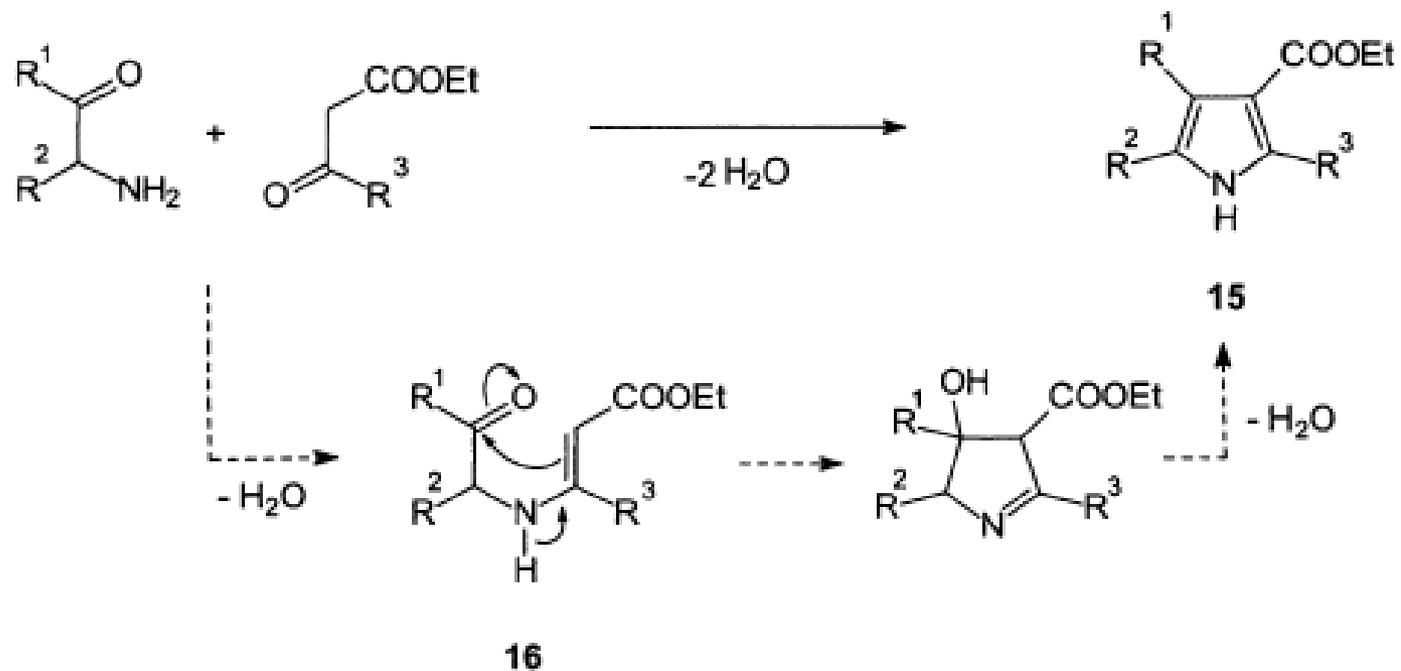


## SÍNTESIS DE HANTZSCH





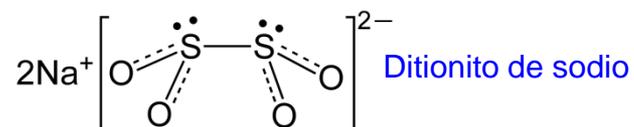
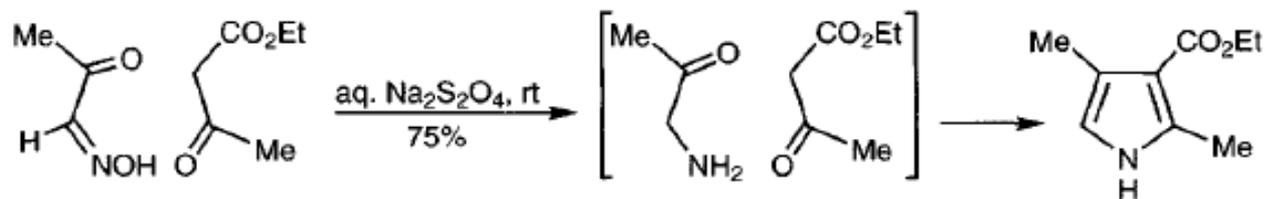
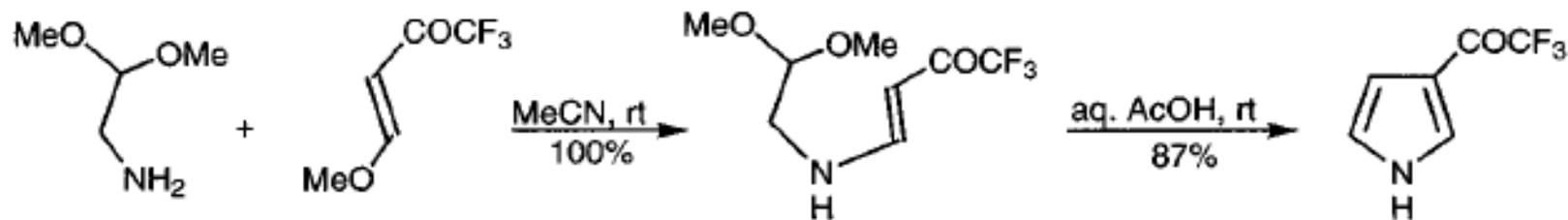
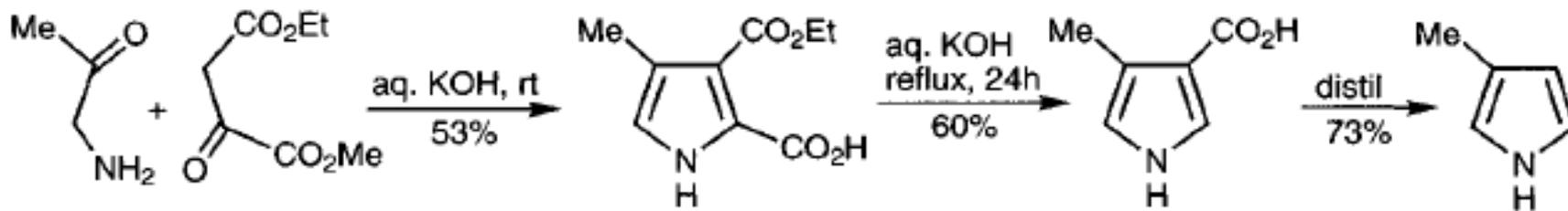
# SÍNTESIS DE KNORR

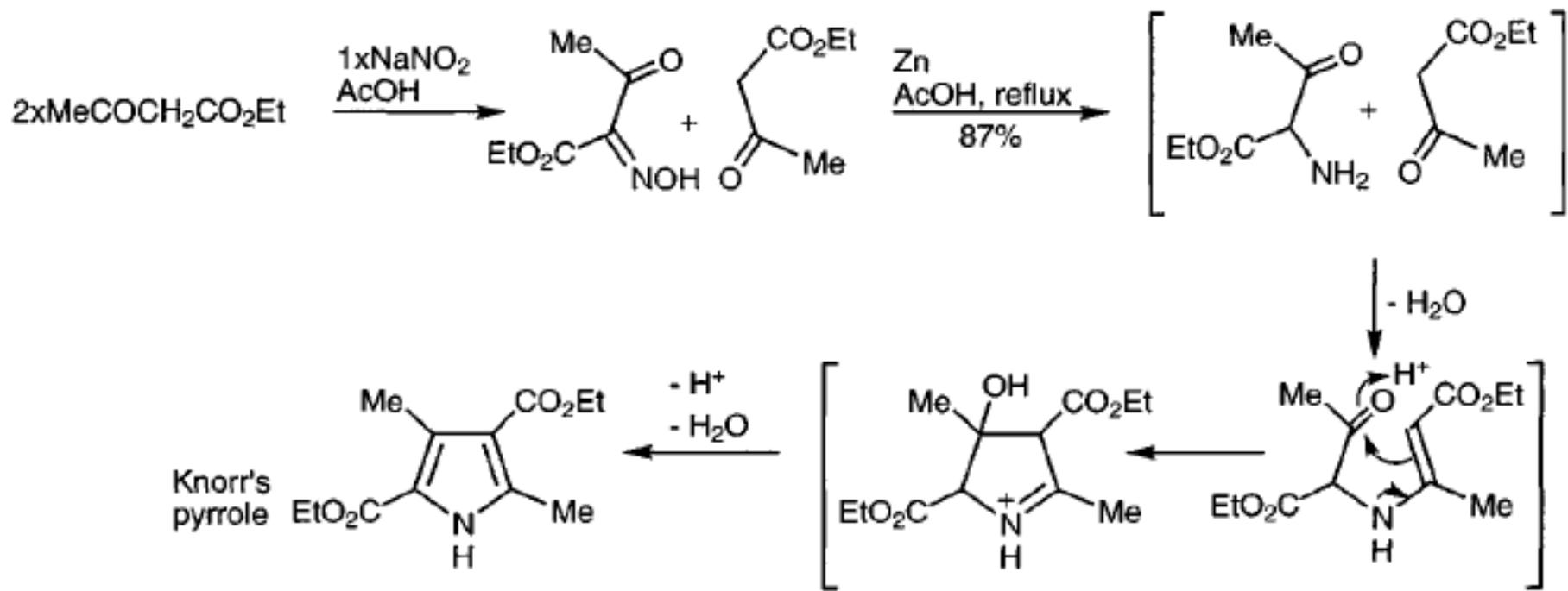


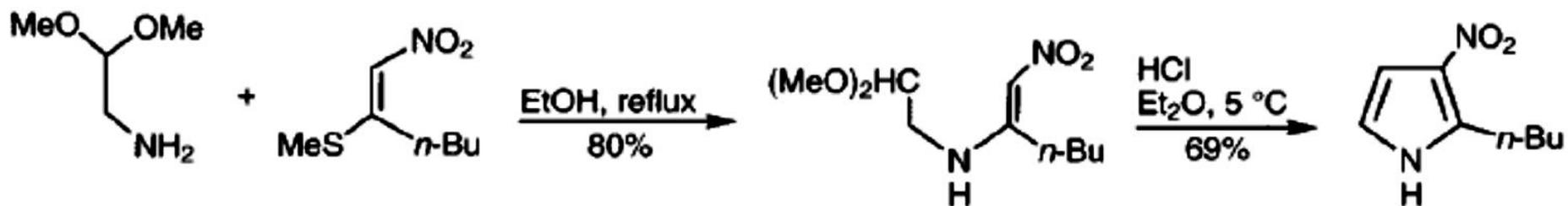
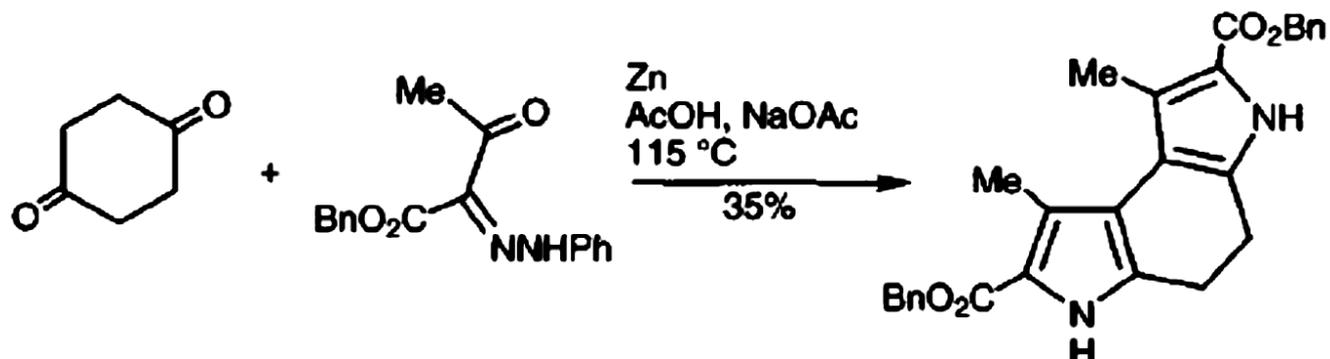


**Ludwig Knorr (1859 – 1921)**

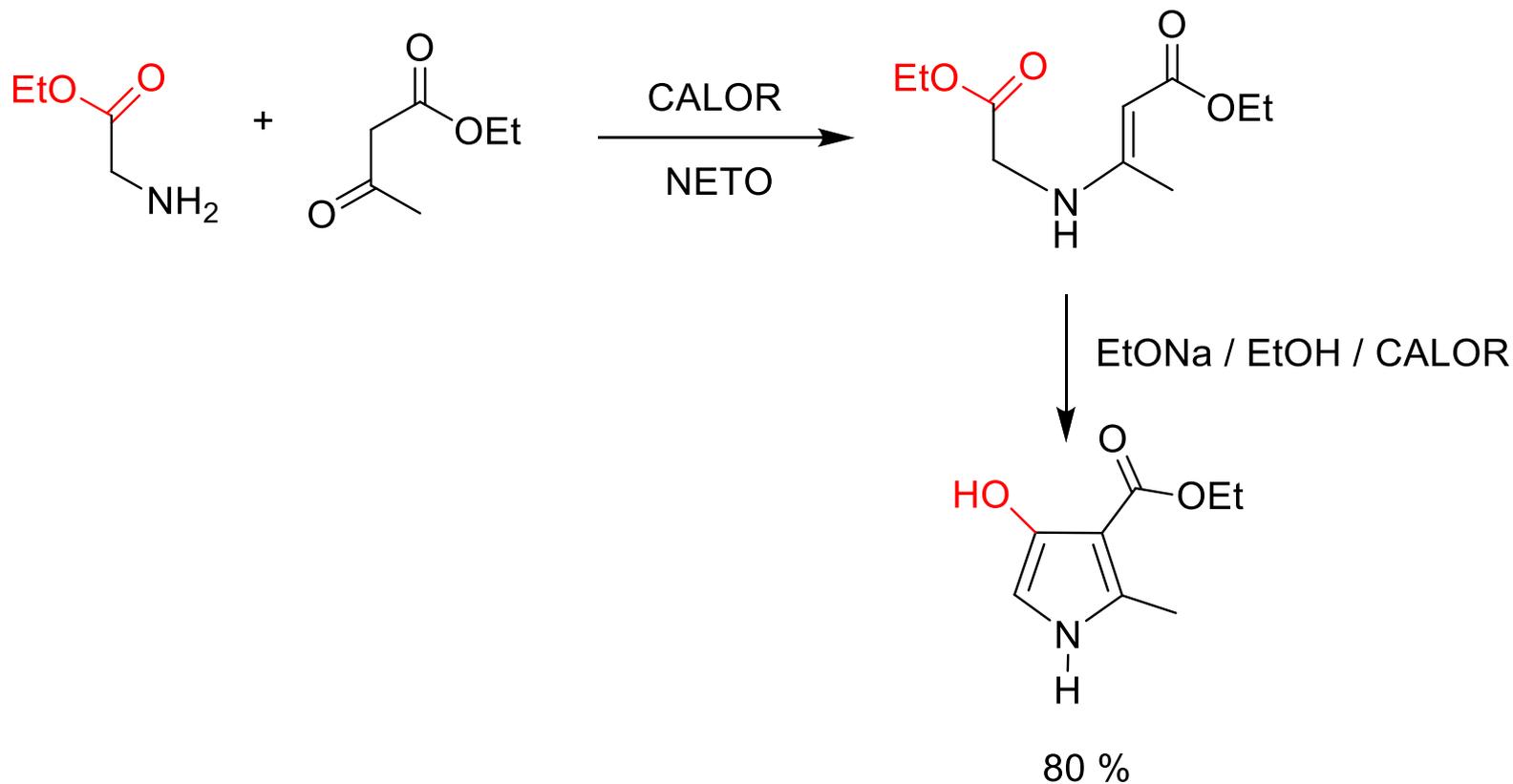








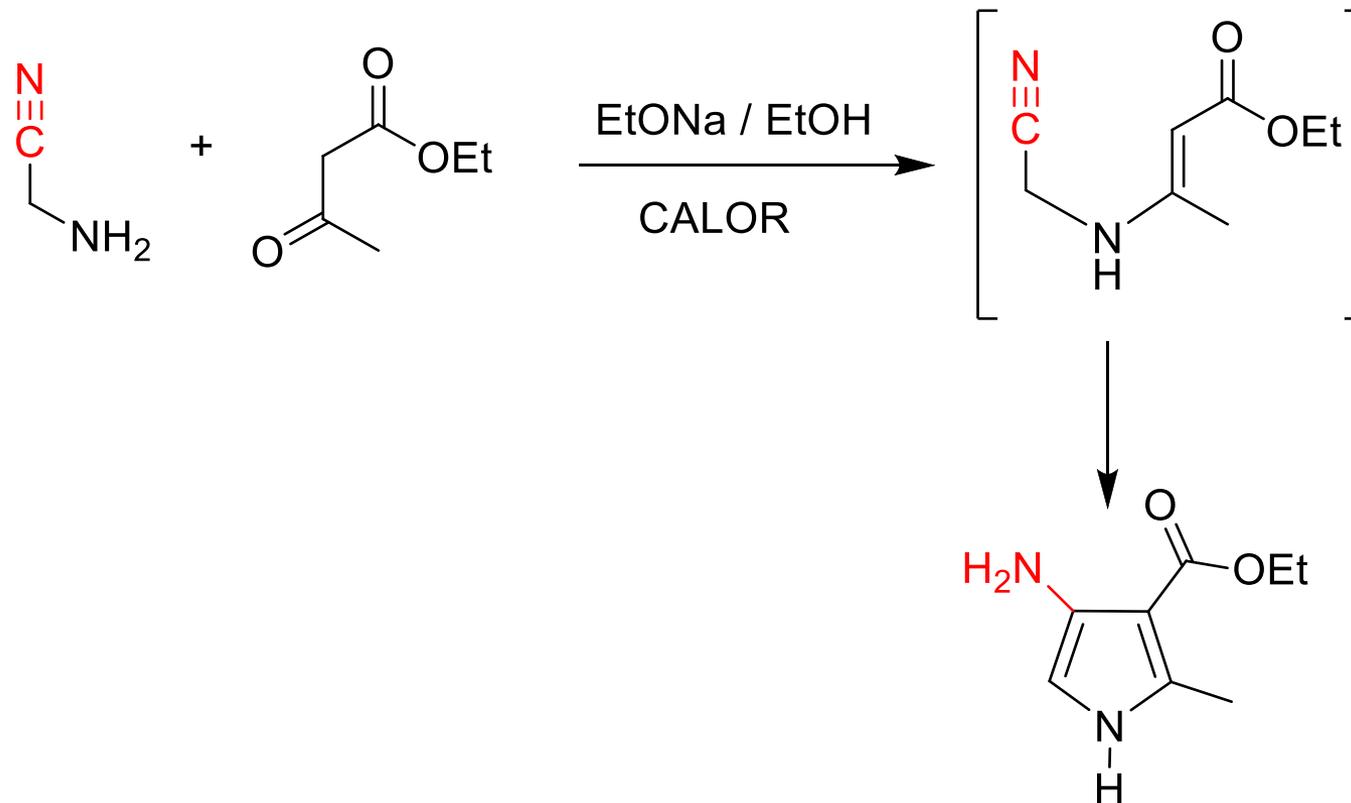
## VERSATILIDAD DE LA REACCIÓN DE KNORR



## HIDROXIPIRROLES

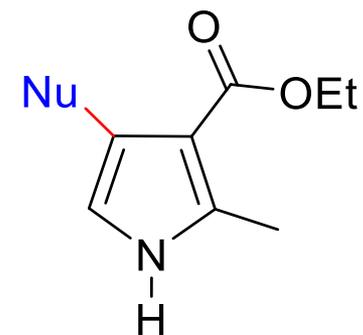
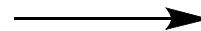
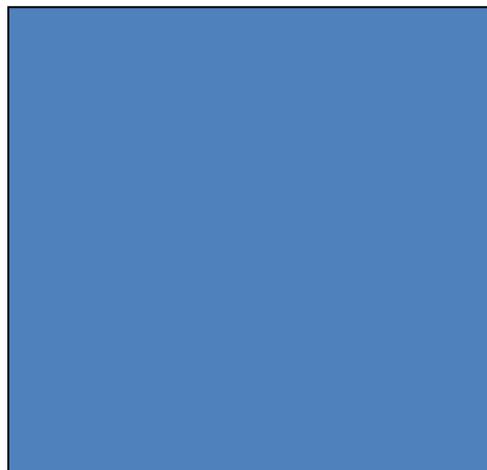
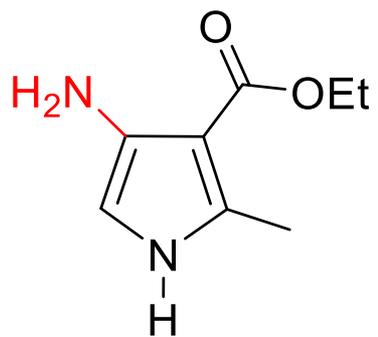


## VERSATILIDAD DE LA REACCIÓN DE KNORR

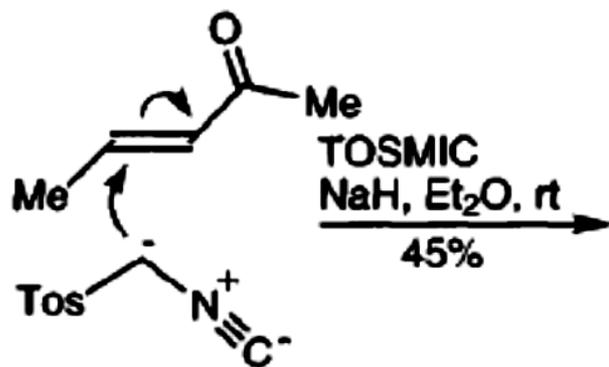


AMINOPIRROLES

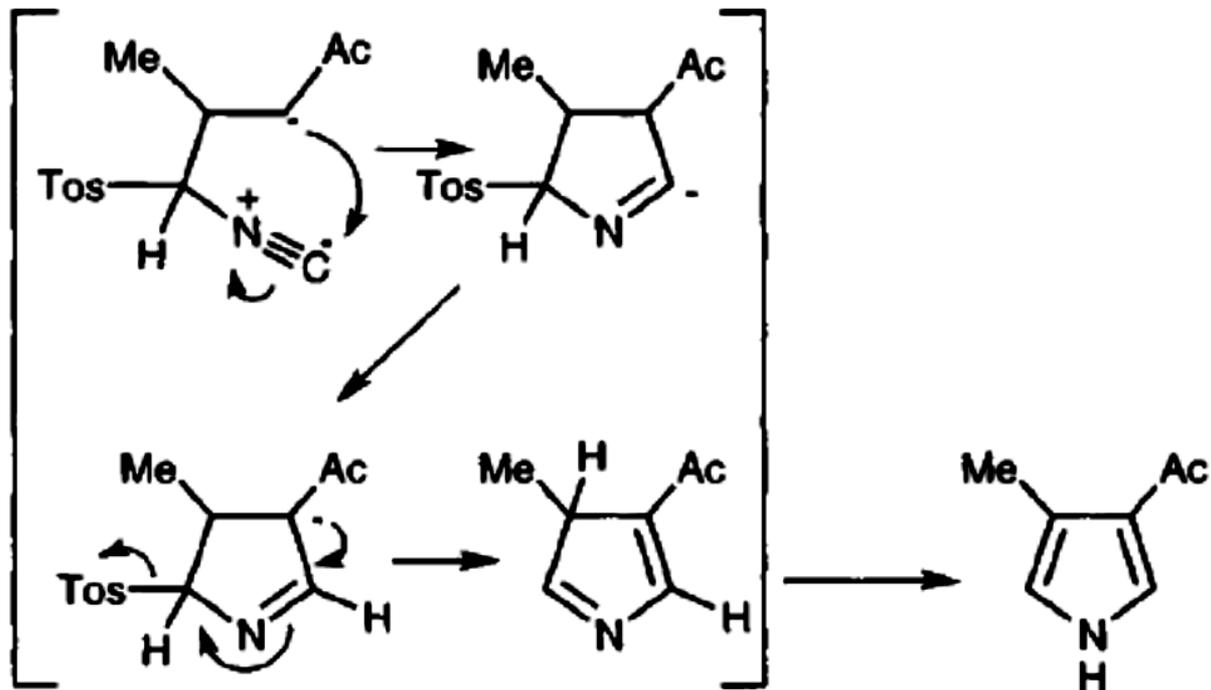




# SÍNTESIS DE van LEUSEN



A.M. van Leusen (Holanda)



SÍNTESIS DE van LEUSEN

Pirroles, imidazoles y Oxazoles

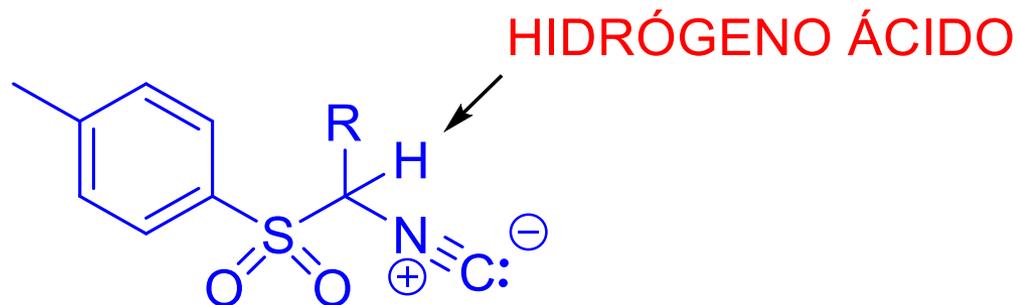
A. M. van Leusen, J. Wildeman, O. H. Oldenziel, *J. Org. Chem.* **1977**, *42*, 1153.

A. M. van Leusen, *Heterocycl. Chem.* **1980**, *5*, S-111

A. D. van Leusen, A. M. van Leusen, *Org. React.* **2003**, *57*, 419

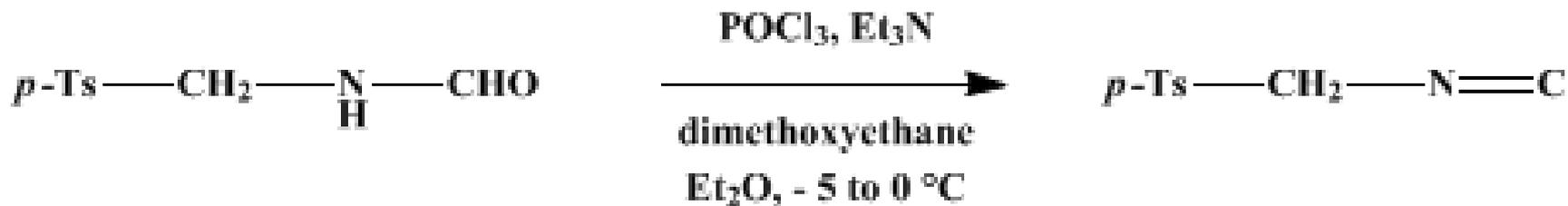
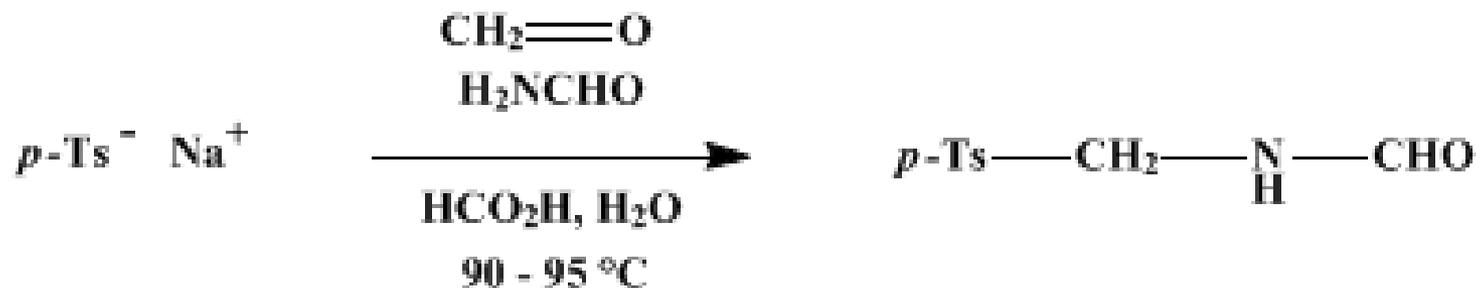


# TOSMIC:



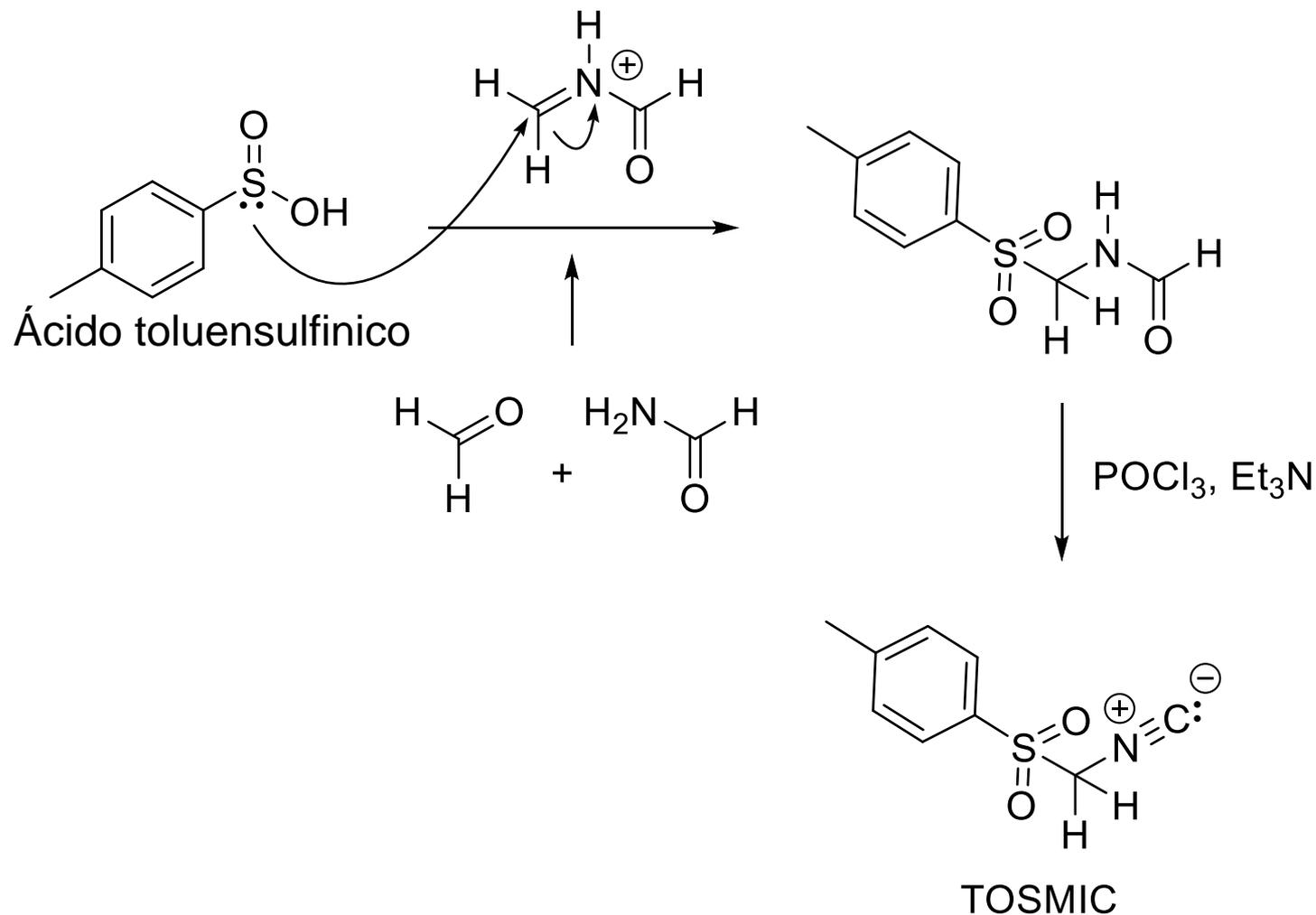
GRUPO SULFONILO

GRUPO ISONITRILO



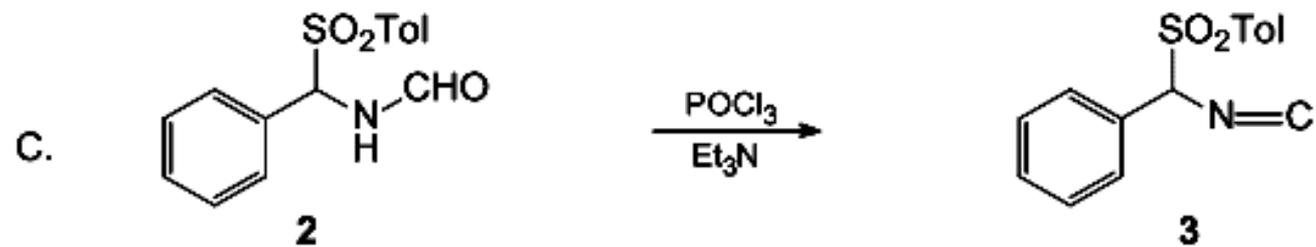
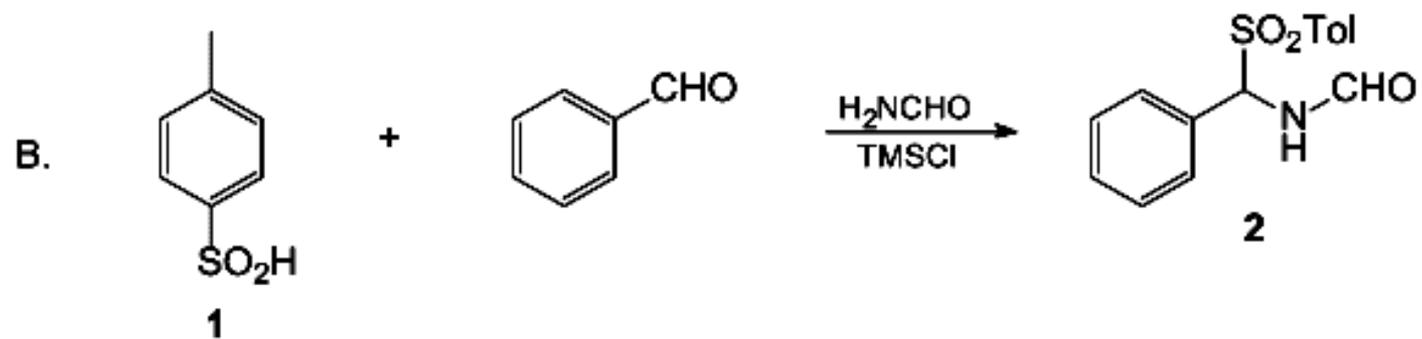
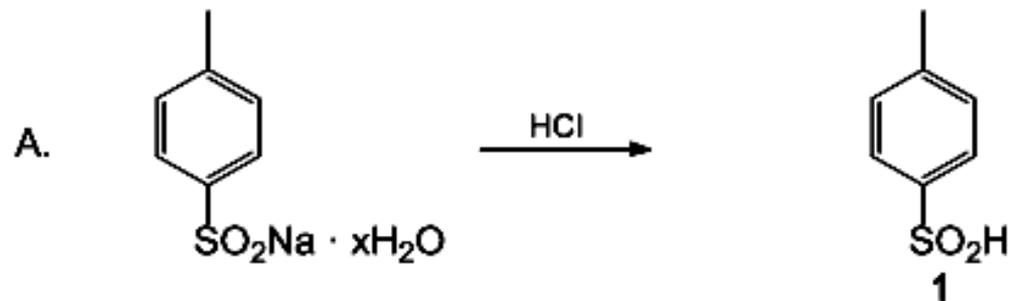
*Org. Synth.* **1977**, *57*, 102

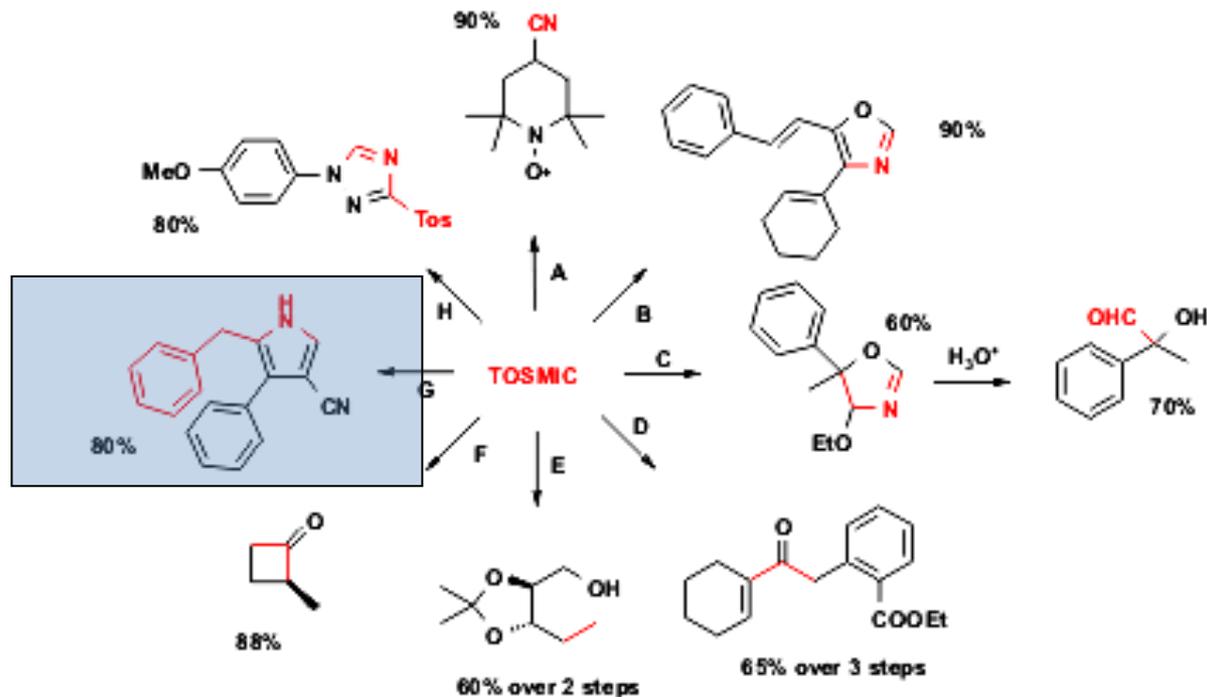




A.M. Van Leusen, *org. Synth.*, 1977, 57, 102.





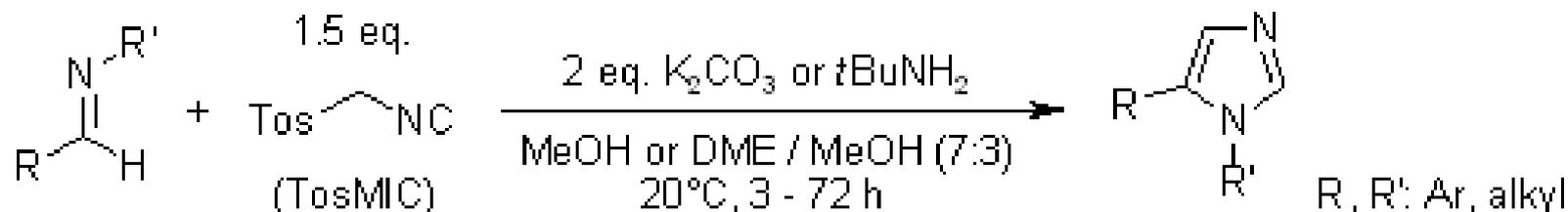


TOSMIC es una molécula muy versátil, un sintón, que permite llevar a cabo muchas reacciones útiles. En las fórmulas de los productos, las partes de color rojo muestran las porciones del producto que se originan a partir del TOSMIC que se usa como reactivo.

- A** (Cianación reductiva selectiva de cetonas): TOSMIC, *t*-BuOK;
- B** (Formación del anillo de oxazol): 1. TOSMIC condensación con ciclohexanona, 2. aldehído cinámico, 2 eq. *n*-BuLi (-70 a 0 °C, 2 h);
- C** (Formación de 4-alcoxi-2-oxazolina): 1. acetofenona, TOSMIC, EtOH; 2. H<sub>3</sub>O<sup>+</sup>;
- D** (Formación de cetonas  $\alpha,\beta$ -insaturadas sustituidas): 1. TOSMIC condensación con ciclohexanona, 2. bromuro de bencilo, *t*-BuOK, DME; 3. H<sub>3</sub>O<sup>+</sup>;
- E** (TOSMIC como reactivo conectivo, reducción): 1. yoduro de alquilo, TOSMIC, PTC, 2. Li, NH<sub>3</sub>(liq.);
- F** (TOSMIC como reactivo conectivo, hidrólisis): 1. TOSMIC, dialquilación 2. H<sub>2</sub>SO<sub>4</sub> (50%), sulfolano, 20 a 100 °C, 2 h;
- G** (pirroles a partir de aceptores de Michael): **TOSMIC bencil-sustituído, NaH, acrilonitrilo;**
- H** (Formación de triazol): sal de diazonio, TOSMIC, K<sub>2</sub>CO<sub>3</sub>, DMSO, MeOH, H<sub>2</sub>O, -10 °C.



**Chemistry of sulfonylmethyl isocyanides. 12. Base-induced cycloaddition of sulfonylmethyl isocyanides to carbon,nitrogen double bonds. Synthesis of 1,5-disubstituted and 1,4,5-trisubstituted imidazoles from aldimines and imidoyl chlorides**



product	base	MeOH / DME	t (h)	yield (% , isol.)	product	base	MeOH / DME	t (h)	yield (% , isol.)
	$\text{K}_2\text{CO}_3$	7:3	16	82		$t\text{BuNH}_2$	1:0	20	94
	$\text{K}_2\text{CO}_3$	7:3	16	43		$c\text{HexNH}_2$	1:0	17	96
	$t\text{BuNH}_2$	0:1	20	70		$\text{K}_2\text{CO}_3$	1:0	20	37

A. M. Van Leusen, J. Wildeman, O. H. Oldenziel, *J. Org. Chem.*, **1977**, *42*, 1153-1159



# An Efficient Method for the Synthesis of 3-Arylpyrroles

Neville P. Pavri and Mark L. Trudell\*<sup>†</sup>

*J. Org. Chem.* 1997, 62, 2649–2651

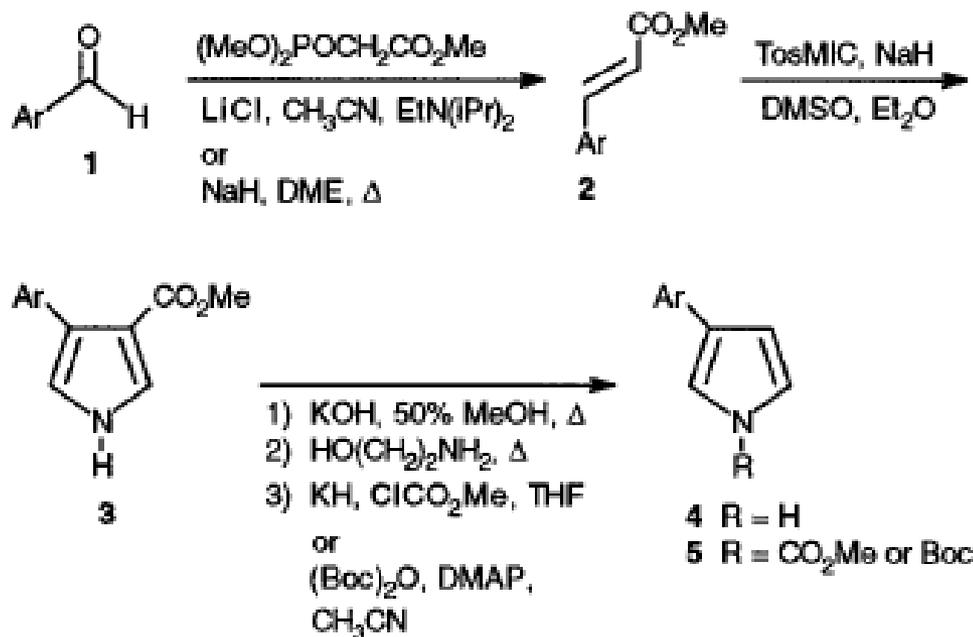
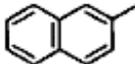
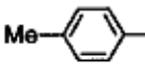
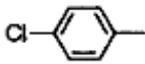
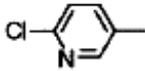
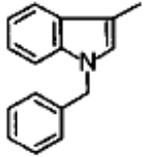


Table 1. Synthesis of 3-Arylpyrrole Derivatives

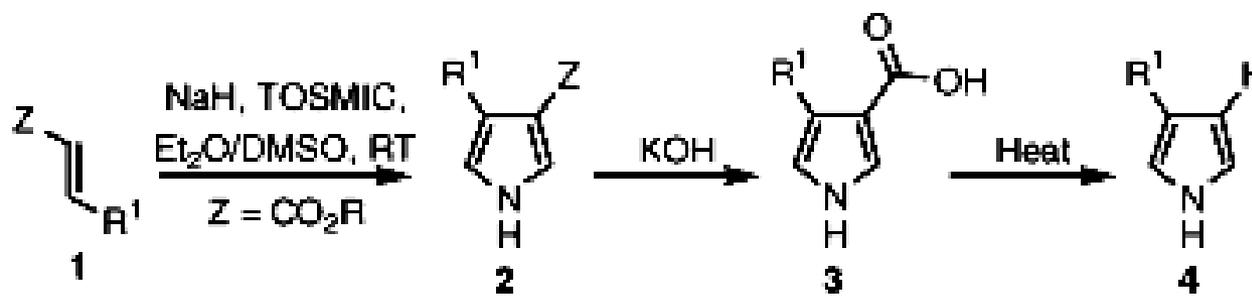
entry	Ar	3 (%) <sup>a</sup>	4 (%) <sup>a</sup>	5 (%) <sup>a</sup>
a		70	82	
b		60	67	
c	Me- 	64	63	88 <sup>b</sup>
d	Cl- 	60	81	84 <sup>b</sup>
e	Cl- 	68	70	86 <sup>c</sup>
f		64	65	
g		60	60	80 <sup>b</sup>
h		48	70	

# One-Step Synthesis of 3-Aryl- and 3,4-Diaryl-(1*H*)-Pyrroles Using Tosylmethyl Isocyanide (TOSMIC)

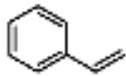
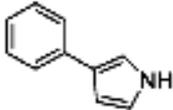
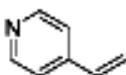
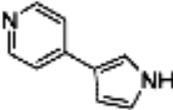
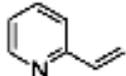
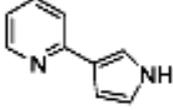
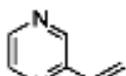
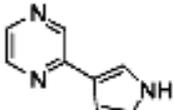
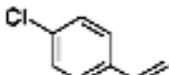
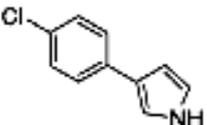
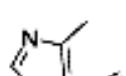
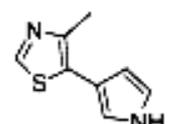
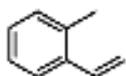
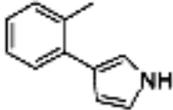
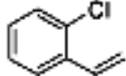
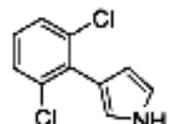
Nicholas D. Smith,\* Dehua Huang, and Nicholas D. P. Cosford

ORGANIC  
LETTERS

2002  
Vol. 4, No. 20  
3537–3539



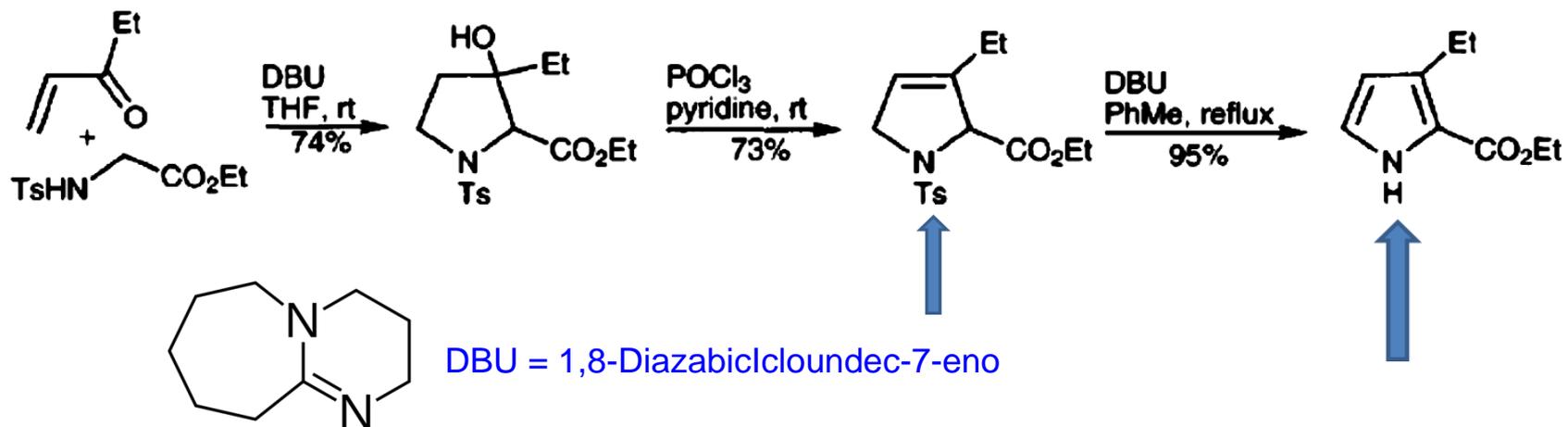
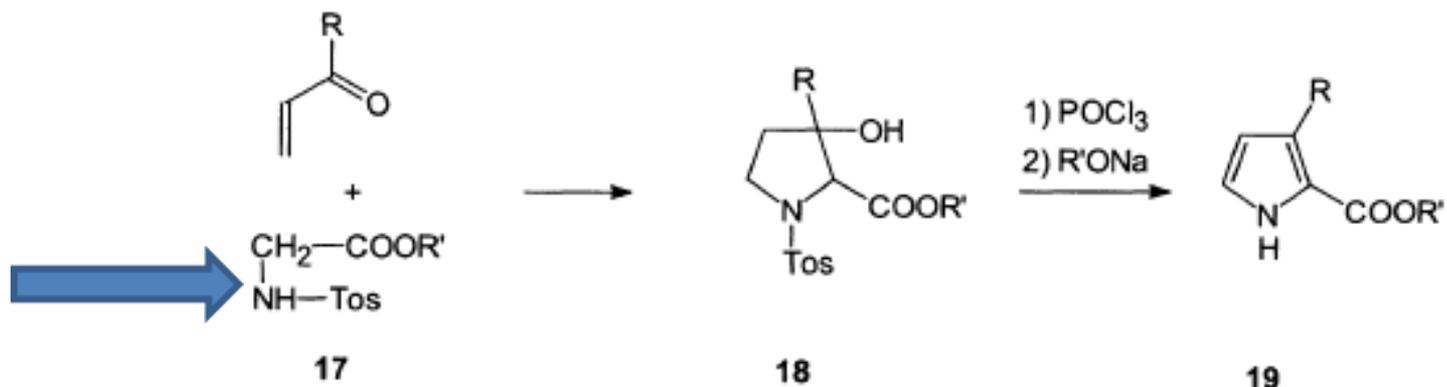
**Table 1.** Synthesis of 3-Aryl Pyrroles Using TOSMIC<sup>a</sup>

entry	substrate	product	T°C/time	yield <sup>b</sup>
1			50°C/18h	47%
2			25°C/2h	67%
3			25°C/2h	74%
4			25°C/1h	76%
5			50°C/6h	58%
6			50°C/2h	39%
7			75°C/2h	44%
8			100°C/18h	48%

<sup>a</sup> TOSMIC (1.3 equiv), NaOtBu (2 equiv), DMSO, *T* in °C. <sup>b</sup> Isolated yield after chromatography.



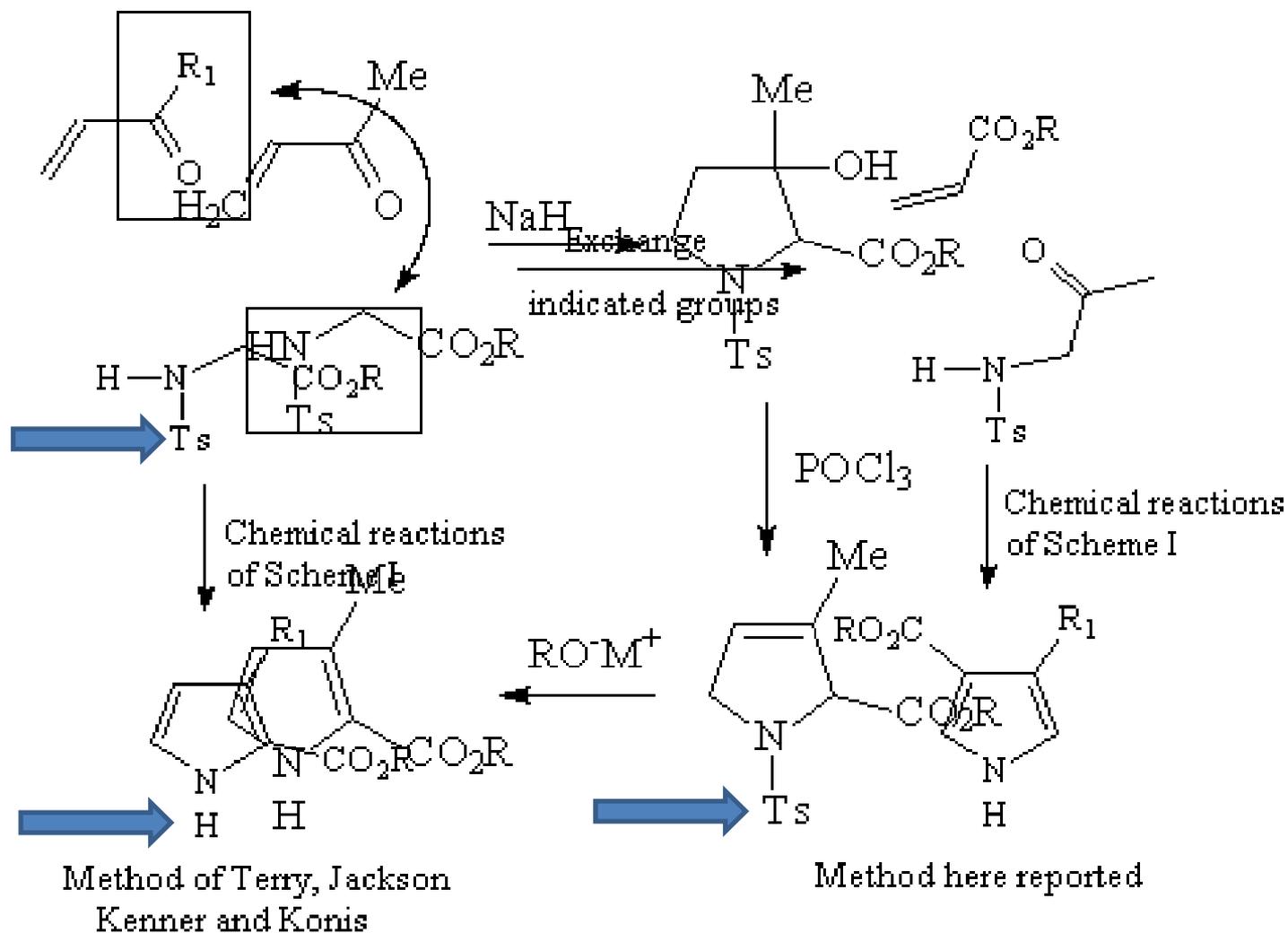
# SÍNTESIS DE KENNER

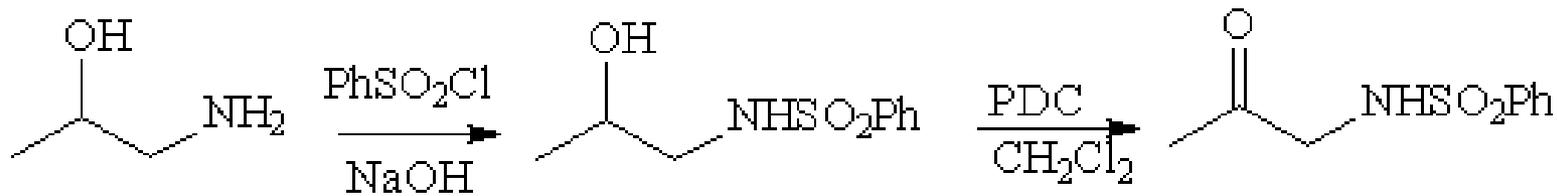


Terry, W.G.; Jackson, A.H., Kenner, G.W.; Konis G., *J. Chem. Soc.*, 1965, 4389

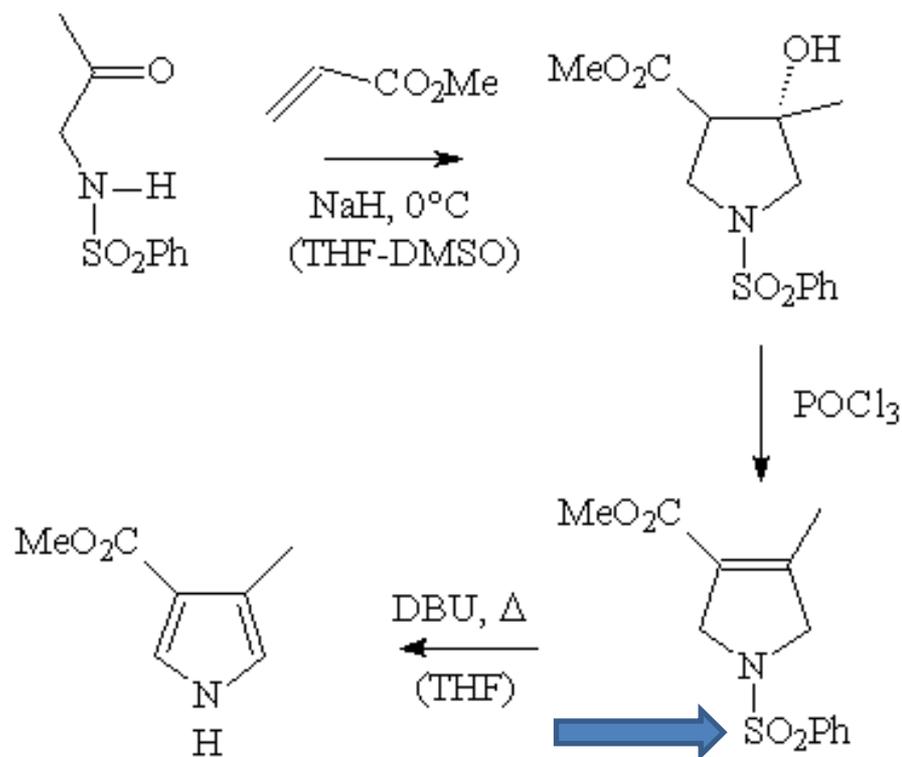


A simple modification to improve the generality of Terry's 3,4-disubstituted pyrrole synthesis  
 G. Fernando Cortés, J. Z. Gustavo Avila and G. Luis Angel Maldonado





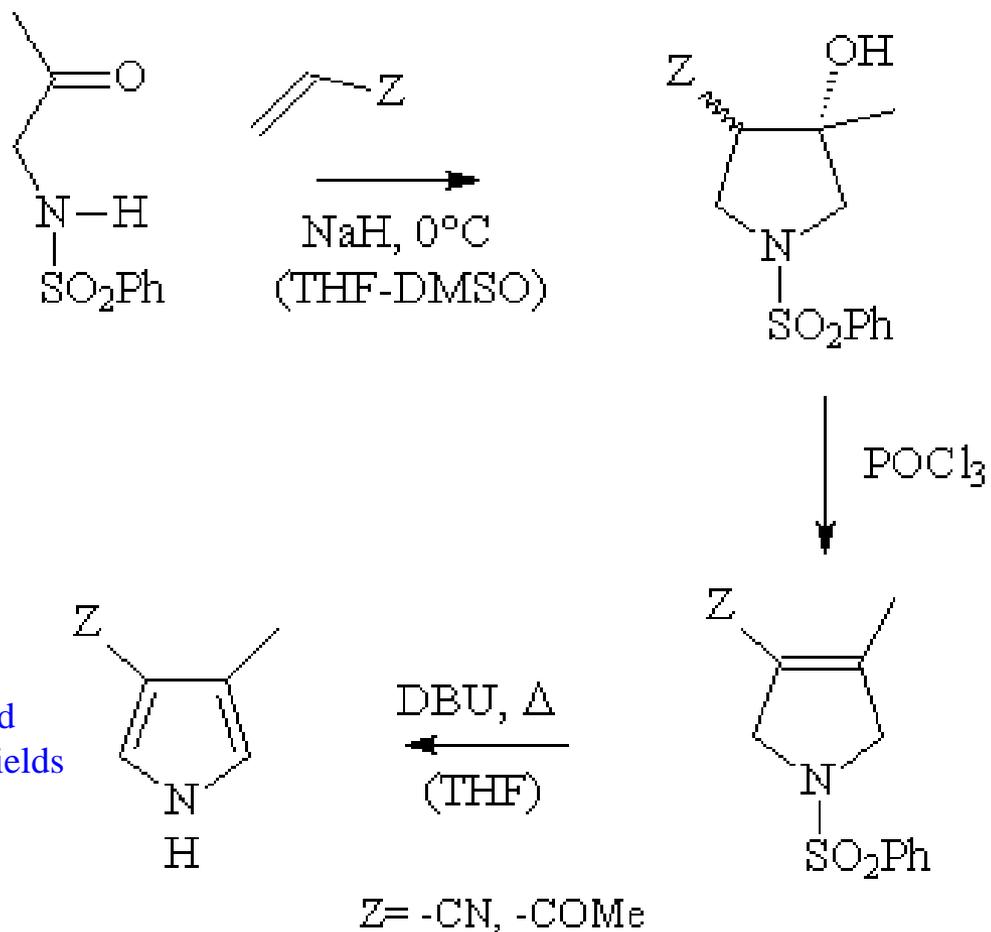
85% overall yield



Pyrrole in ~ 40% overall yield

<https://www.ch.ic.ac.uk/ectoc/echet96/papers/117/index.htm>

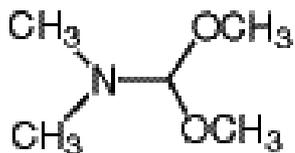
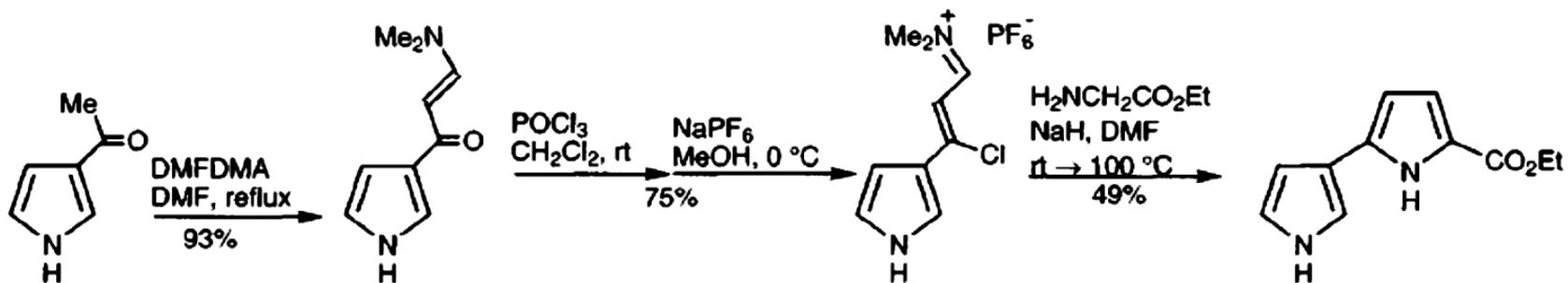
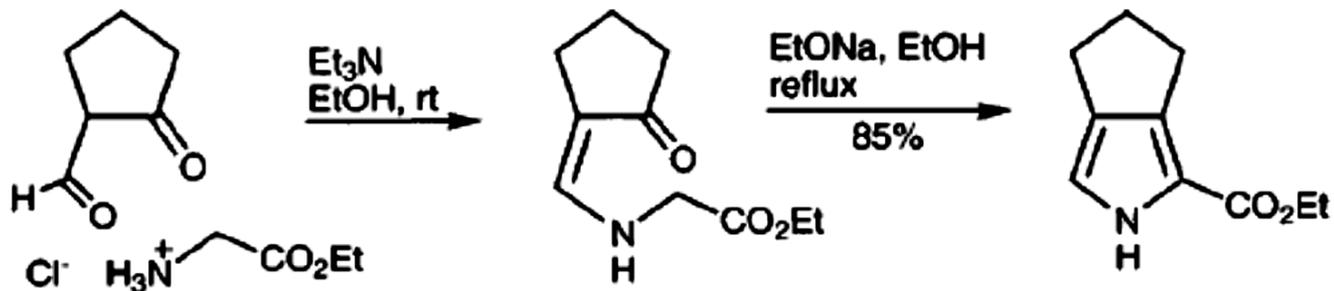




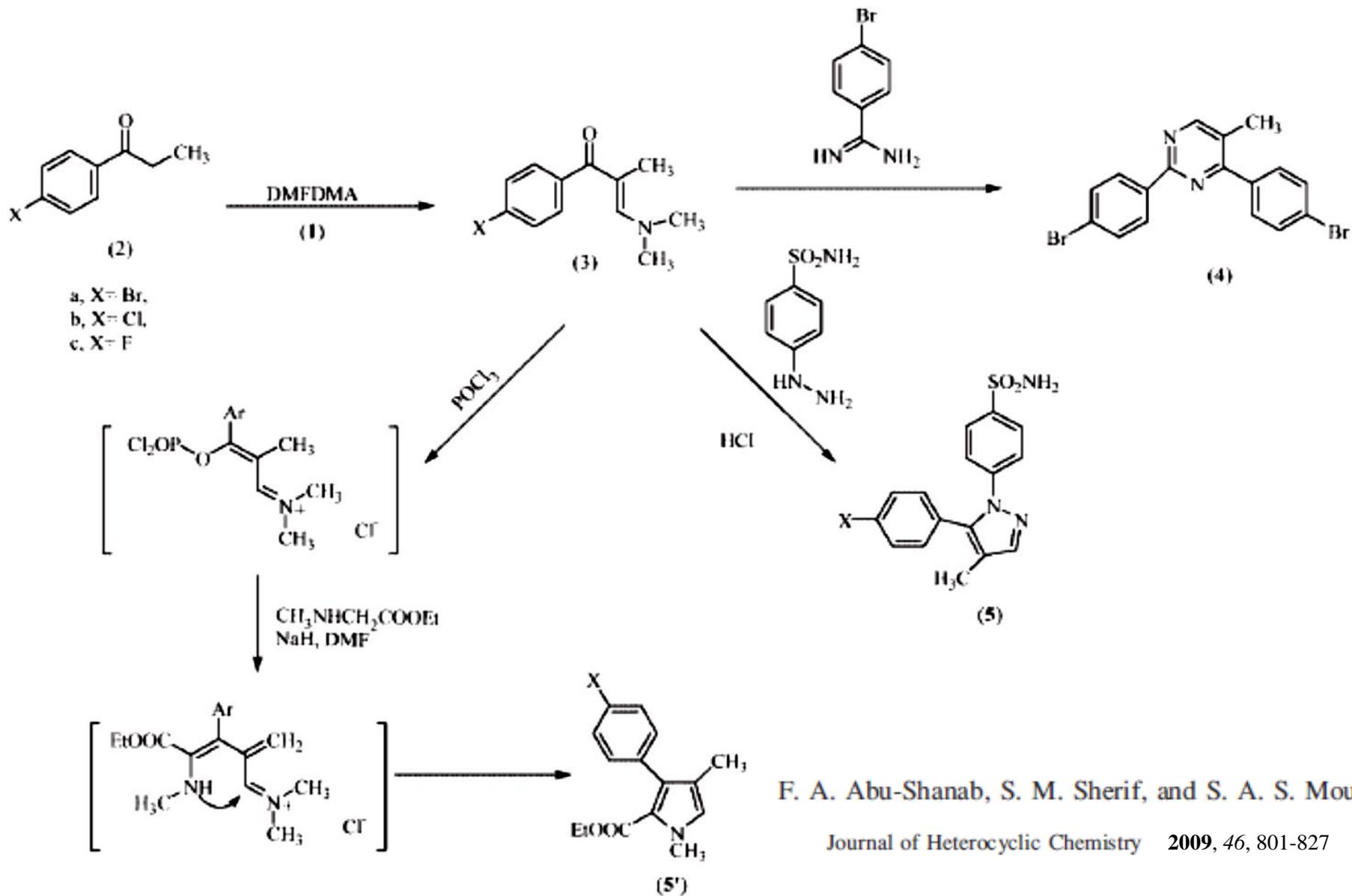
4-Methyl-3-substituted  
pyrroles in comparable yields  
(~ 35-40% overall)



## A PARTIR DE COMPUESTOS 1,3-DICARBONÍLICOS Y ÉSTERES DE LA GLICINA



*N,N*-Dimethylformamide  
Dimethyl Acetal

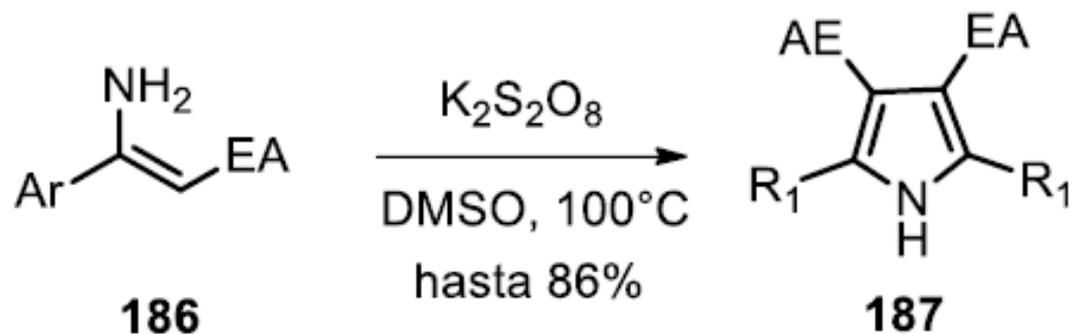


F. A. Abu-Shanab, S. M. Sherif, and S. A. S. Mousa

Journal of Heterocyclic Chemistry 2009, 46, 801-827



A) Gao y Guan, 2016

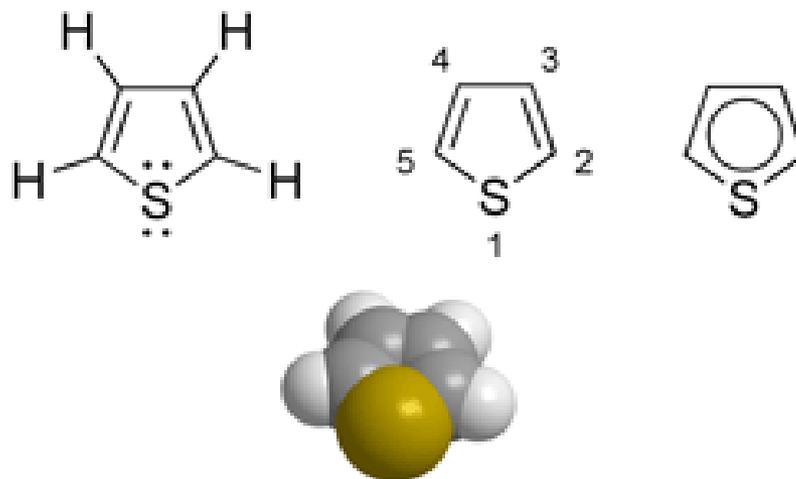


En 2016, Gao y Guan reportaron la síntesis de pirroles polisustituidos **187** a partir de una ciclación oxidativa de enaminas **186** bajo condiciones libres de metales empleando  $K_2S_2O_8$  como único oxidante (A).

Gao, P.; Wang, J.; Bai, Z.-J.; Shen, L.; Yan, Y.-Y.; Yang, D.-S.; Fan, M.-J.; Guan, Z.-H. *Org. Lett.* **2016**, *18*, 6074-6077.

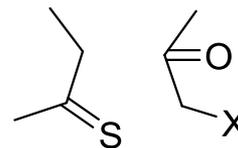
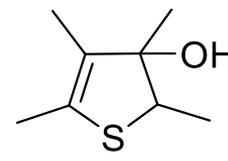
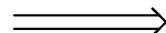
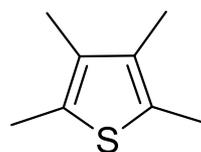
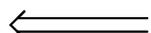
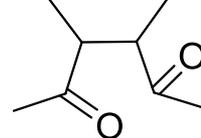
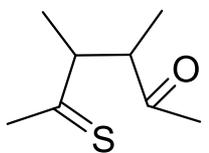
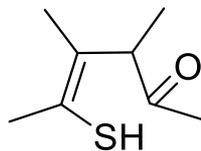
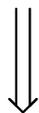
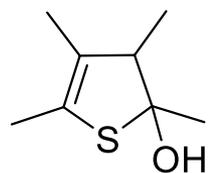


# TIOFENO

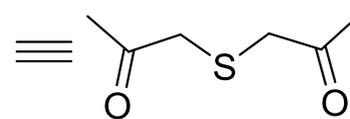
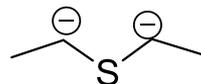
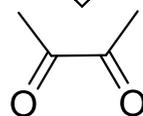
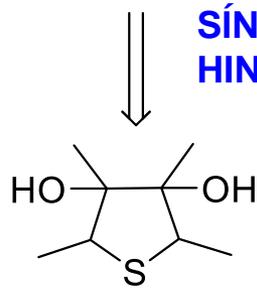


# MÉTODOS DE OBTENCIÓN DE TIOFENO

SÍNTESIS DE PAAL-KNORR



SÍNTESIS DE HINSBERGH

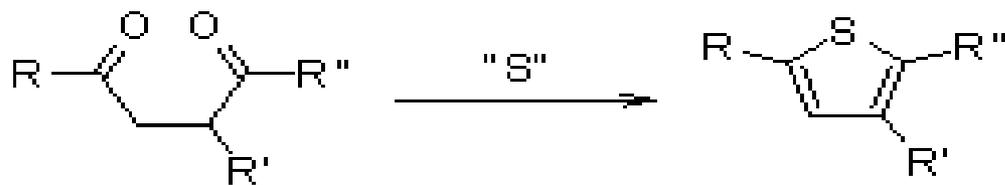


SÍNTESIS DE GEWALD



# Síntesis de Tiofeno de Paal-Knorr

## Síntesis de Tiofeno de Paal ( Carl Paal )



"S":  $\text{H}_2\text{S}/\text{HCl}/\text{H}_2\text{O}$ ,  $\text{P}_4\text{S}_{10}$ ,  
Reactivo de Lawesson



**Ludwig Knorr**  
(1859 – 1921)  
Químico alemán



Tumba de Ludwig Knorr en  
el cementerio del Viejo Sur,  
Munich, Alemania



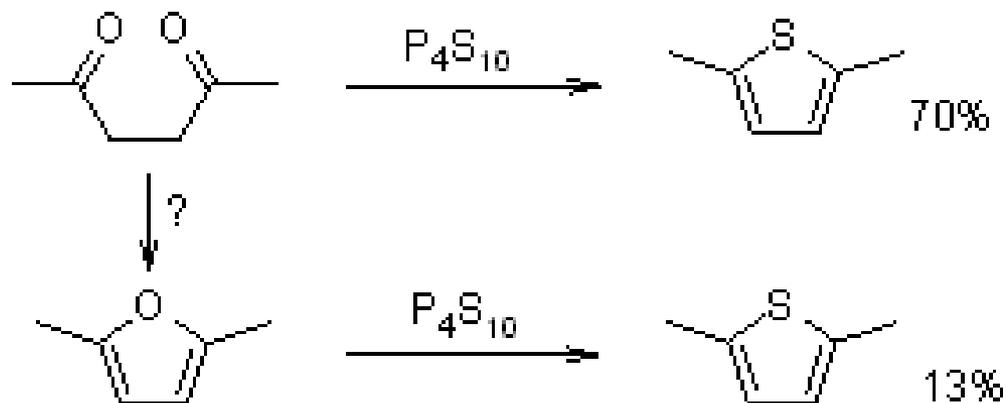
**Carl Ludwig Paal**  
(1860 -1935)  
Químico austriaco



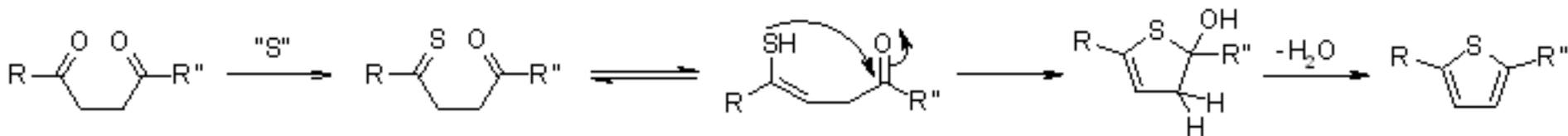
1. Carl Paal: Synthese von Thiophen und Pyrrolderivaten. *Berichte der deutschen chemischen Gesellschaft*. **1885**, 18, Nr. 1, S. 367–371. doi:10.1002/cber.18850180175.
2. Ludwig Knorr.: Einwirkung des Diacetbernsteinsäureesters auf Ammoniak und primäre Aminbasen. *Berichte der deutschen chemischen Gesellschaft*. **1885**, 18, Nr. 1, , S. 299–311. doi:10.1002/cber.18850180154.

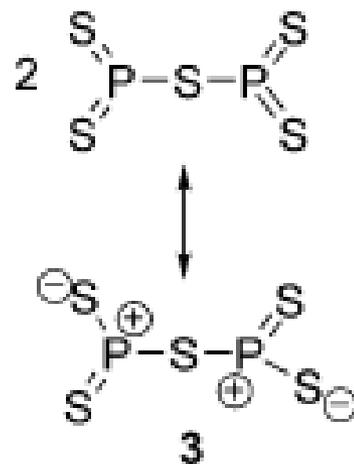
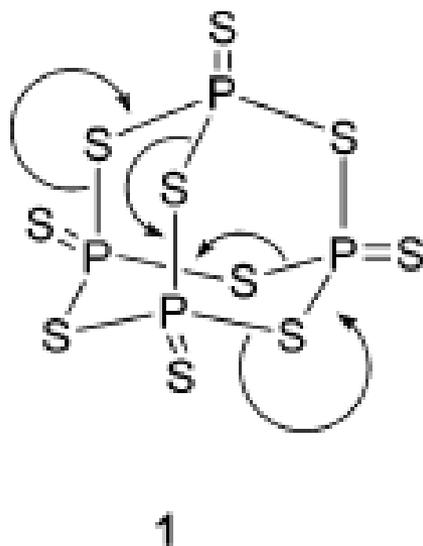
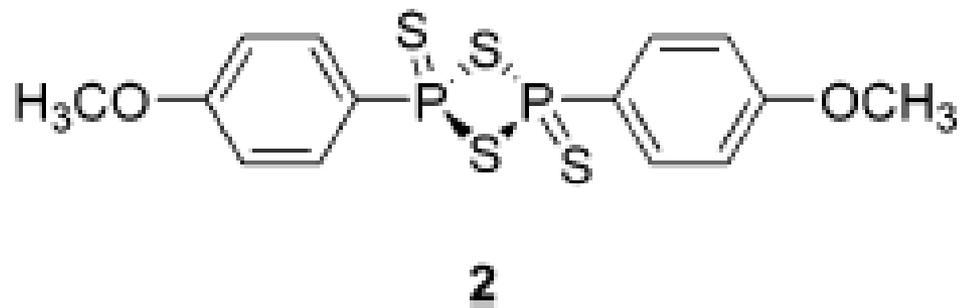
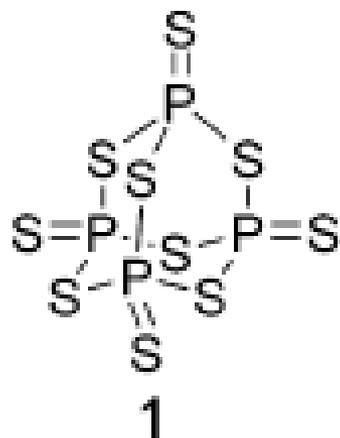


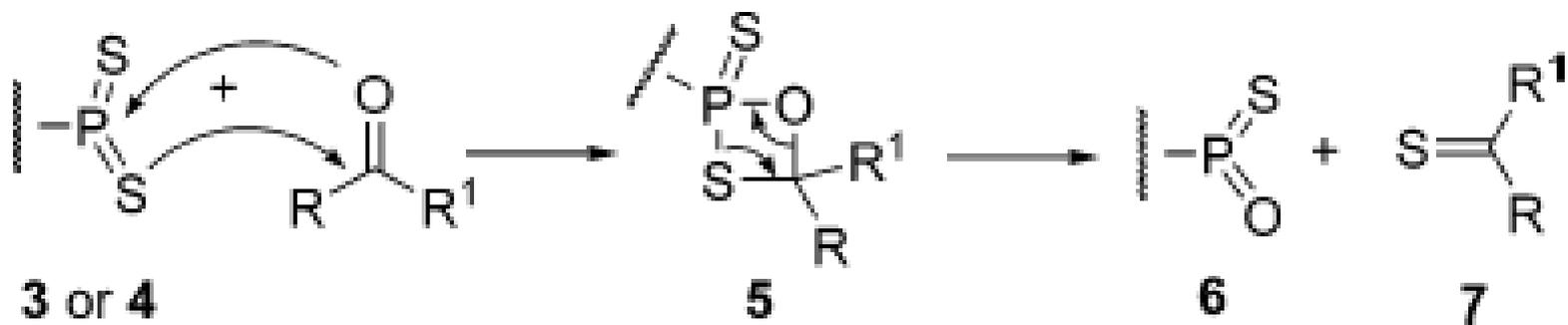
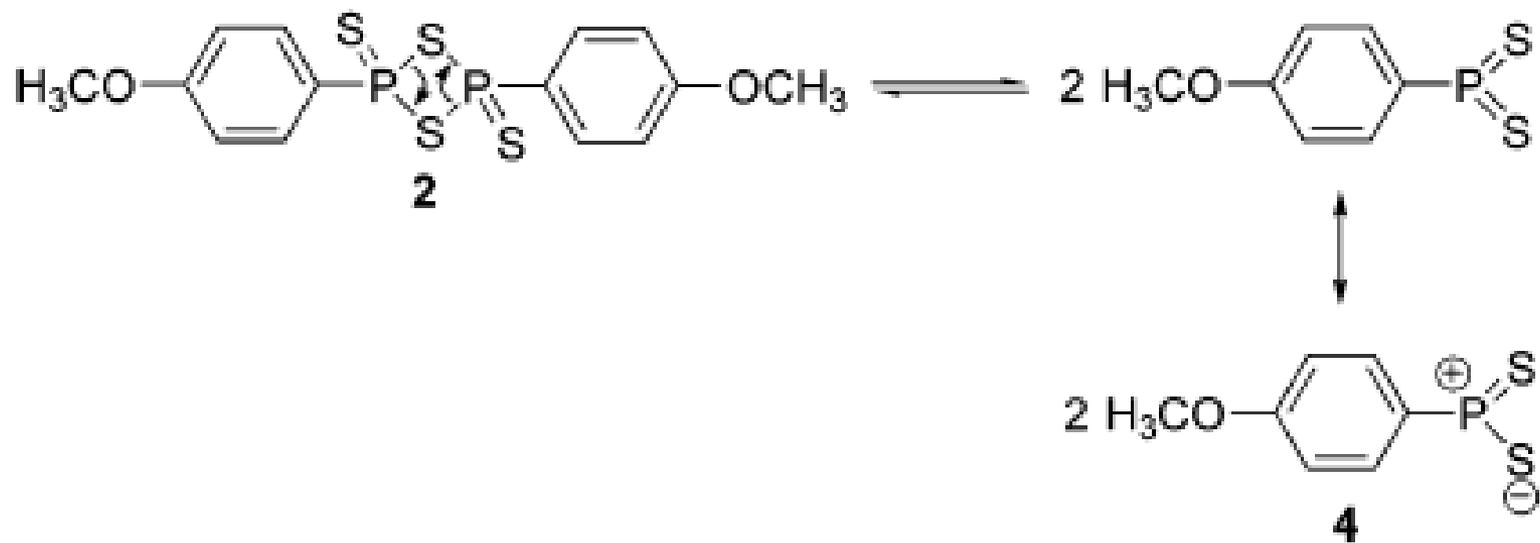
## SÍNTESIS DE PAAL-KNORR



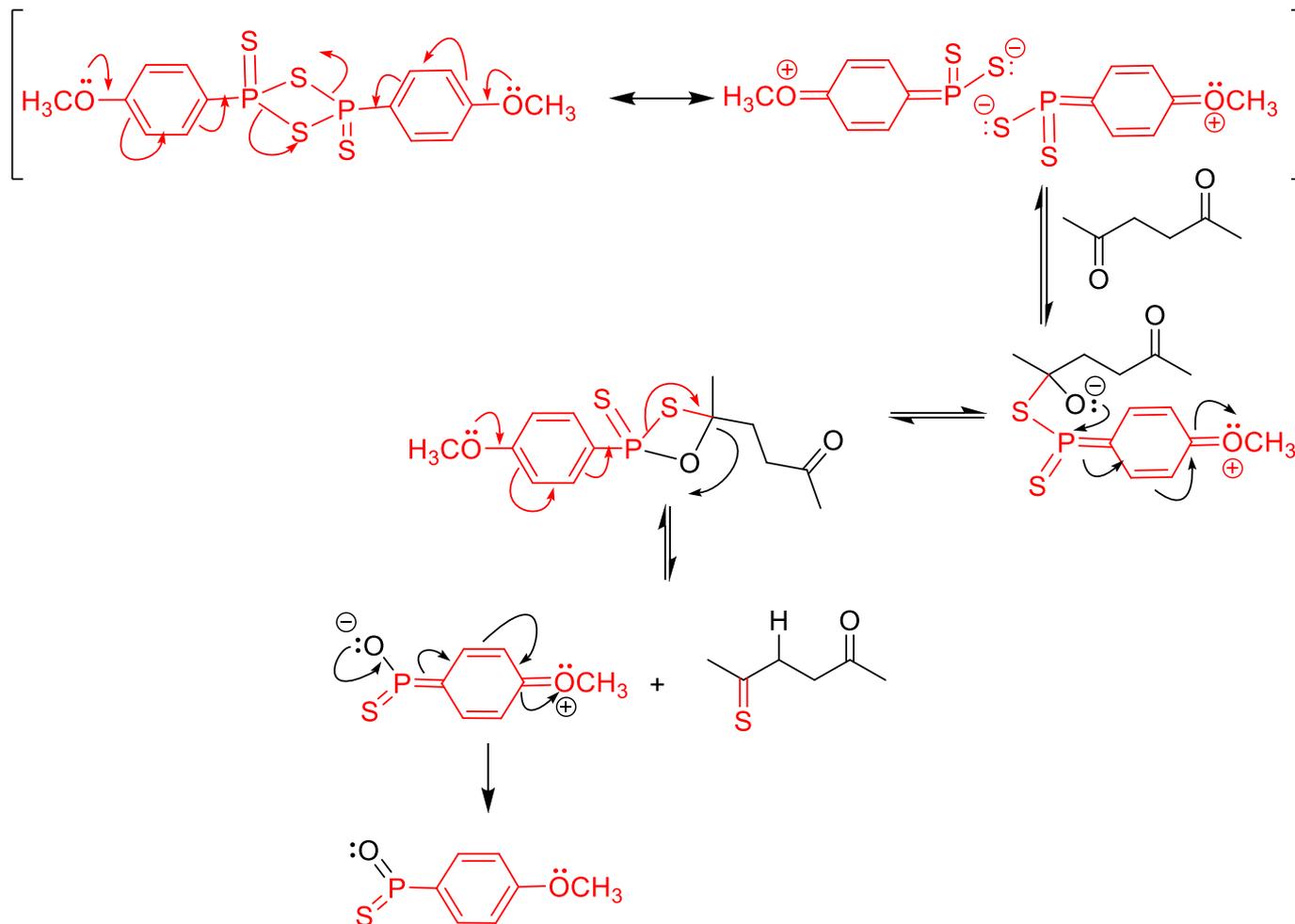
Mecanismo de reacción más probable

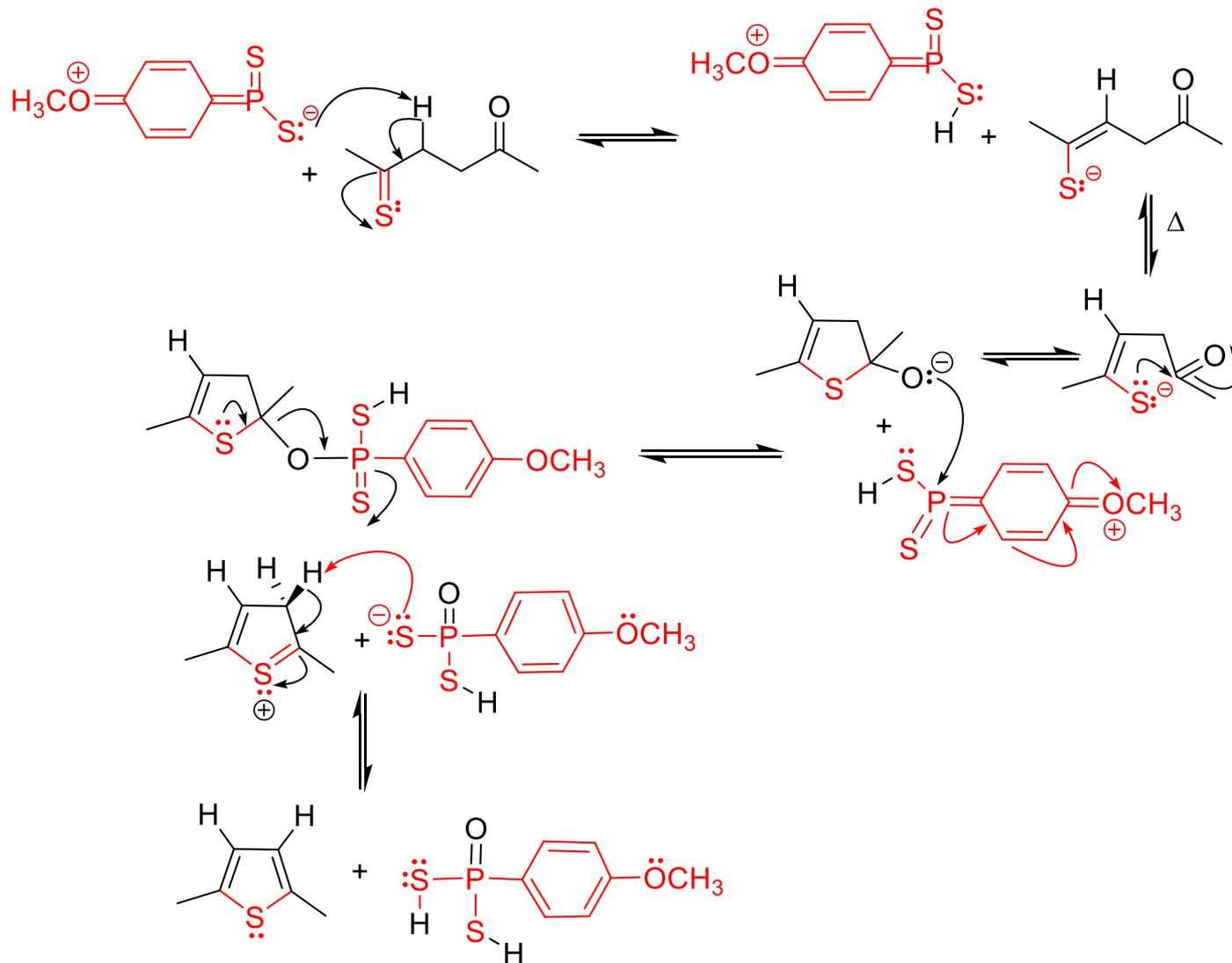






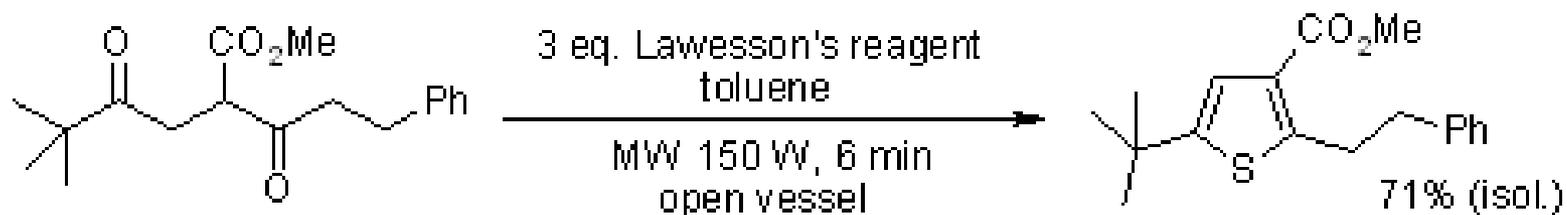
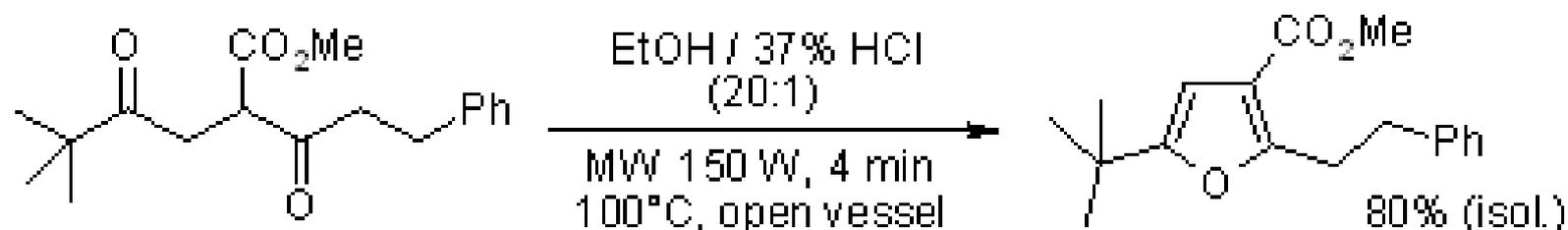
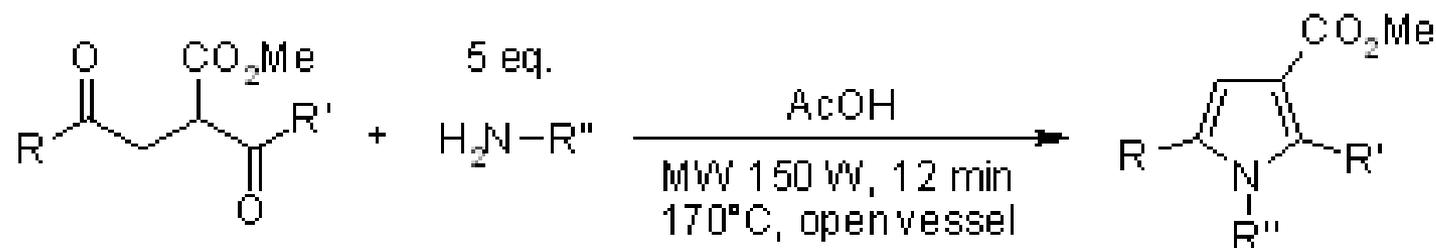
# REACCIÓN CON EL REACTIVO DE LAWESON



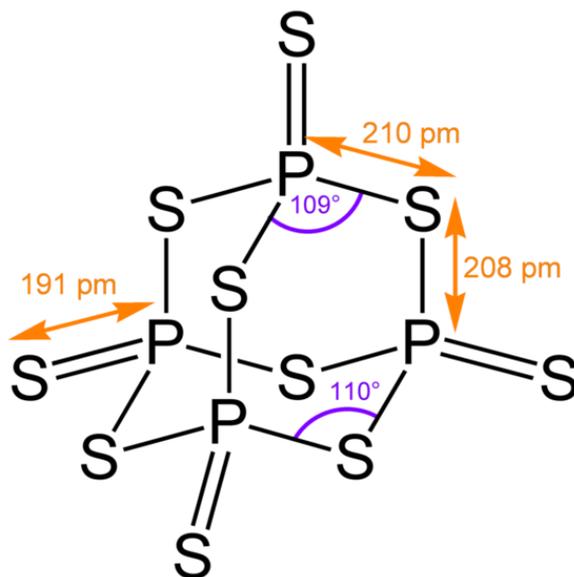


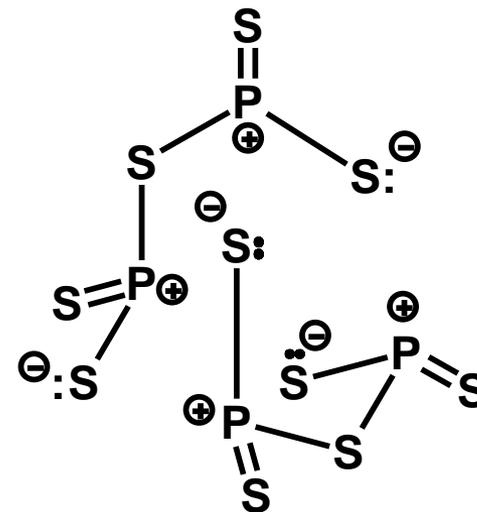
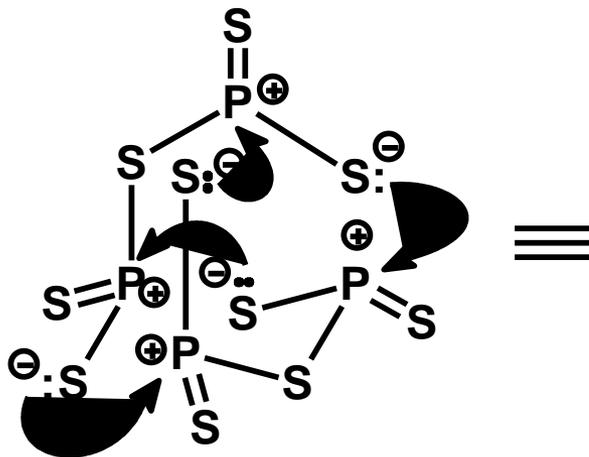
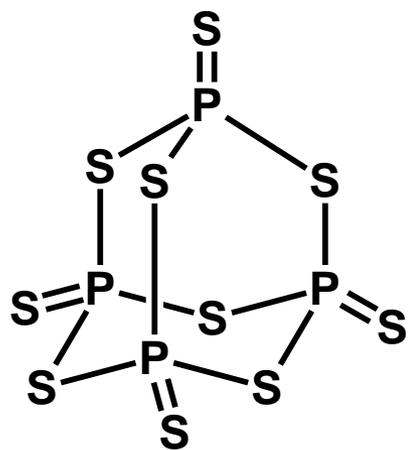
# Microwave-Assisted Paal-Knorr Reaction - Three-Step Regiocontrolled Synthesis of Polysubstituted Furans, Pyrroles and Thiophenes

G. Minetto, L. F. Raveglia, A. Segá, M. Taddei, *Eur. J. Org. Chem.*, **2005**, 5277-5288.

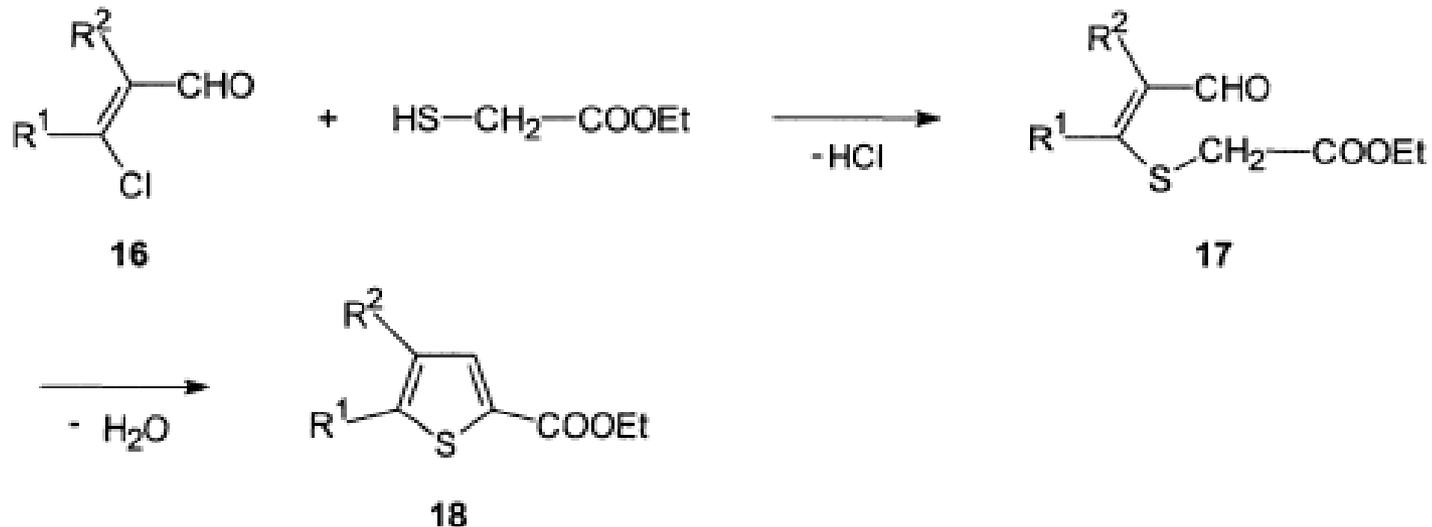


# Pentasulfuro de fósforo

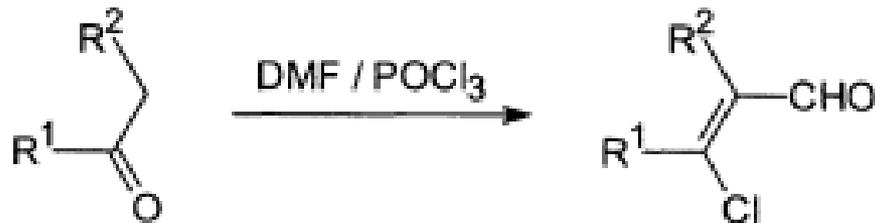




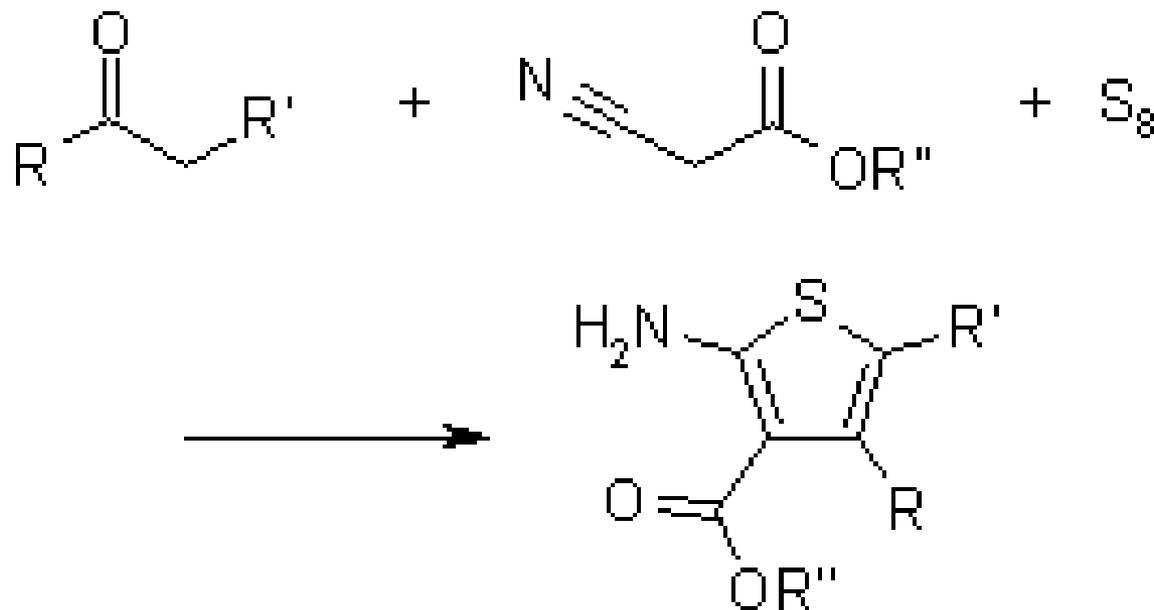
## SÍNTESIS DE FIESSELMANN



Los sustratos clorovinil aldehídos, se obtienen a partir de cetonas con  $\alpha$ -metilenos, por acción de DMF/ $\text{POCl}_3$  (la reacción de VILSMEIER-HAACK-ARNOLD):



# Síntesis de Gewald

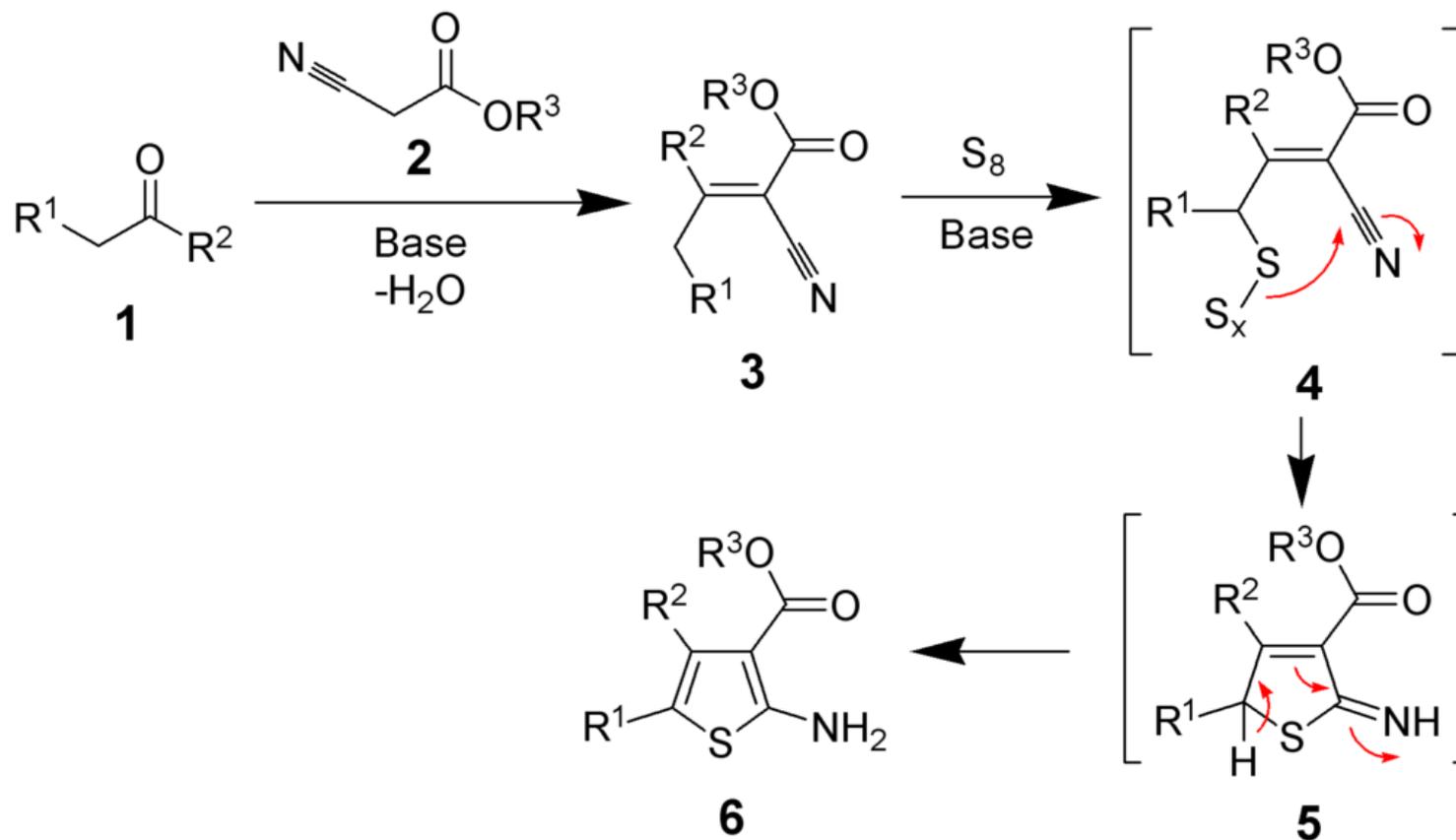


<https://www.organic-chemistry.org/namedreactions/gewald-reaction.shtm>

Gewald, K.; Schinke, E.; Böttcher, H. *Ber.* **1966**, *99*, 94-100



# Mecanismo de la reacción de Gewald



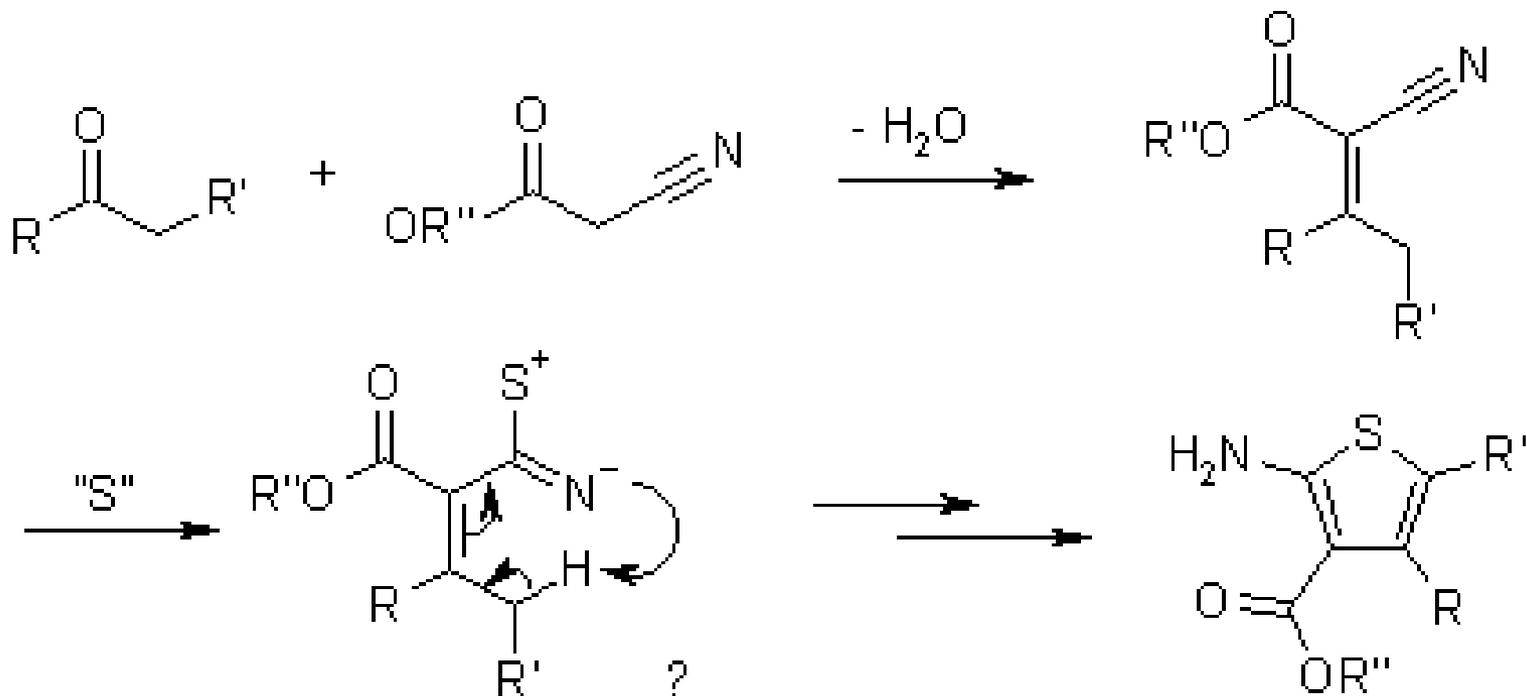
[https://en.wikipedia.org/wiki/Gewald\\_reaction#/media/File:Gewald\\_Reaction\\_Mechanism.png](https://en.wikipedia.org/wiki/Gewald_reaction#/media/File:Gewald_Reaction_Mechanism.png)

Sabnis, R. W.; Rangnekar, D. W.; Sonawane, N. D. *J. Heterocyclic Chem.* **1999**, *36*, 333.



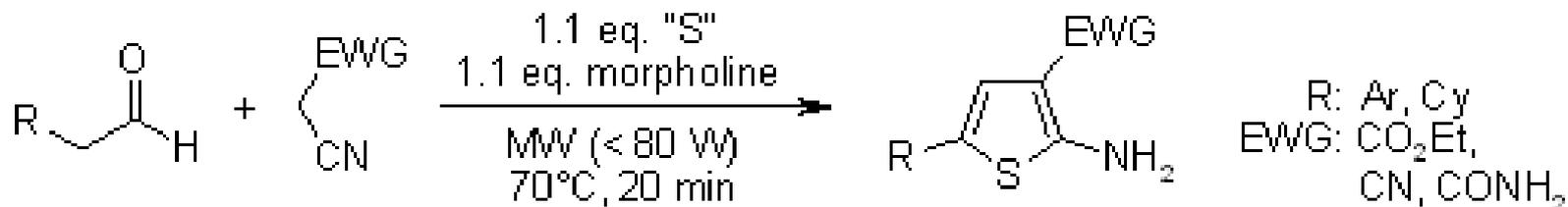
## Mecanismo de la reacción de Gewald

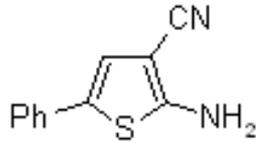
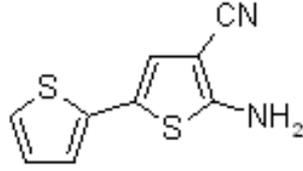
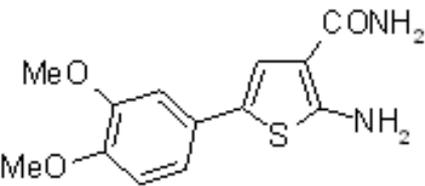
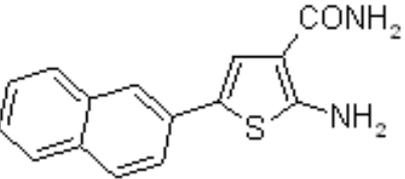
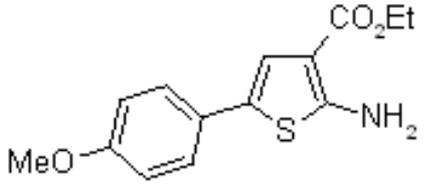
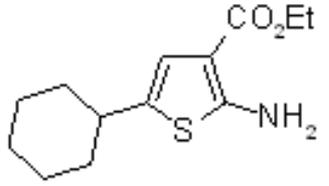
El primer paso del proceso es una condensación de Knoevenagel, pero los siguientes pasos no se conocen con detalle, pero es probable que ocurran de la siguiente manera:



# Microwave-Assisted Synthesis of 5-Substituted 2-Aminothiophenes Starting from Arylacetaldehydes

G. Revelant, S. Dunand, S. Hesse, G. Kirsch, *Synthesis*, **2011**, 2935-2940.

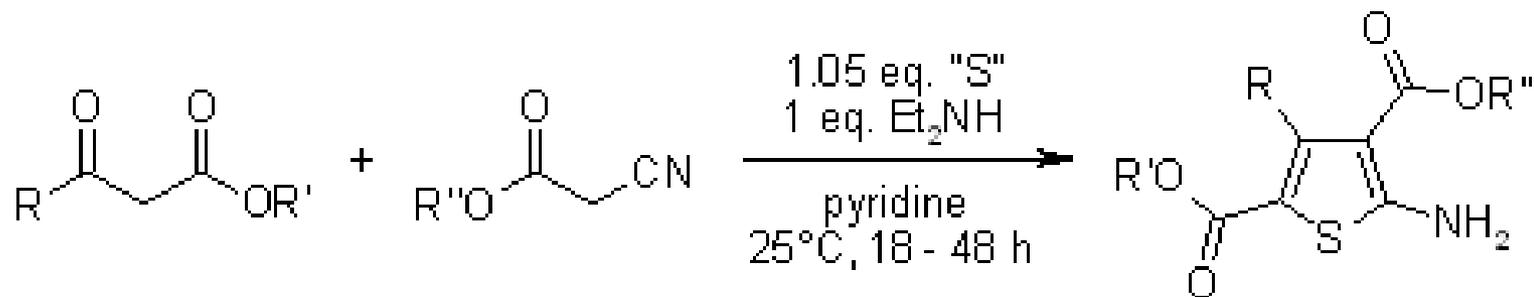


product	yield (% , isol.)	product	yield (% , isol.)
	96		50
	95		74
	50		63



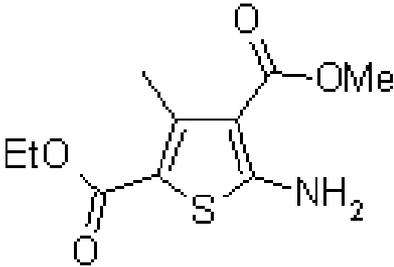
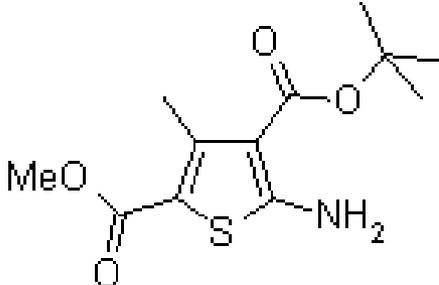
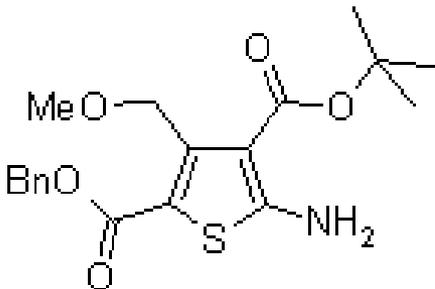
## Practical synthesis of tetrasubstituted thiophenes for use in compound libraries

B. P. McKibben, C. H. Cartwright, A. L. Castelhana, *Tetrahedron Lett.*, **1999**, 5471-5474.

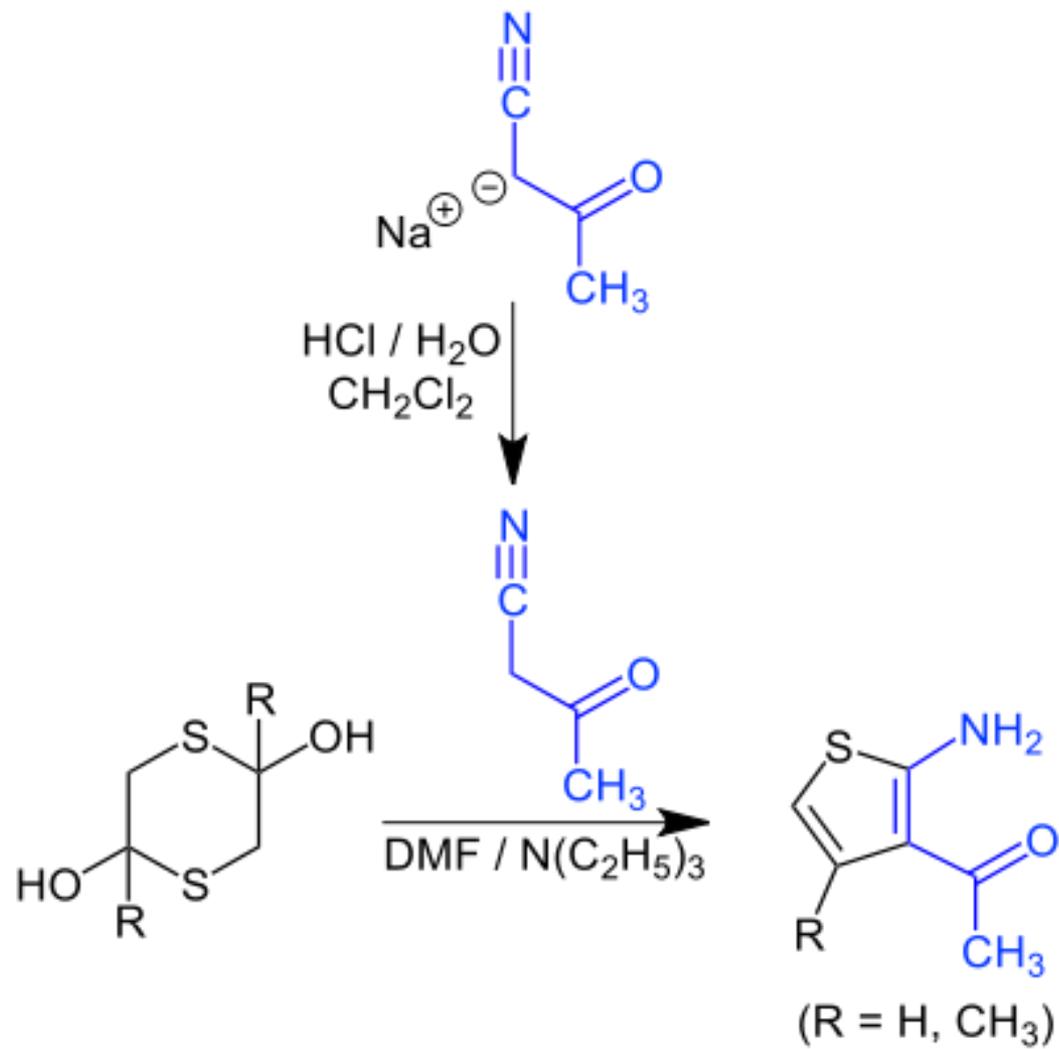


Se han desarrollado condiciones de reacción optimizadas para la reacción de Gewald a temperatura ambiente para obtener tiofenos tetra-sustituidos con buen rendimiento.



Product	t (h)	Yield (%. isol.)
	18	52
	48	69
	48	71



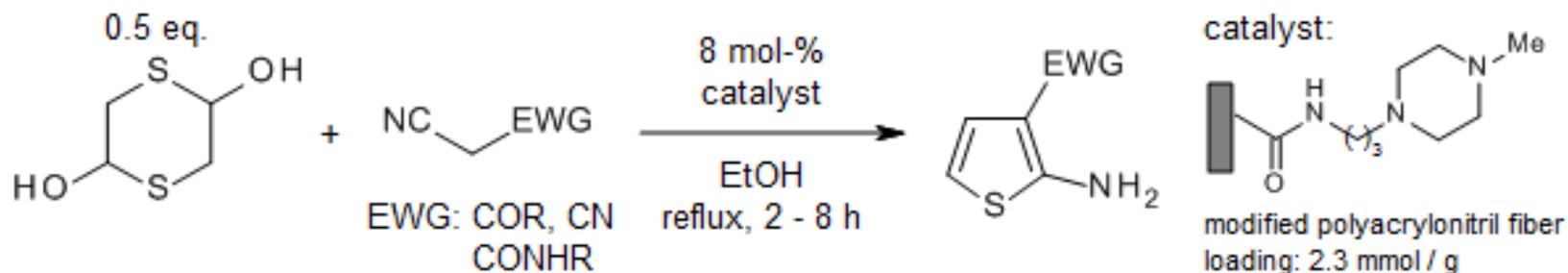


Gernot A. Eller, Wolfgang Holzer *Molecules* **2006**, 11, 371-376



# An Efficient Synthesis of 2-Aminothiophenes via the Gewald Reaction Catalyzed by an *N*-Methylpiperazine-Functionalized Polyacrylonitrile Fiber

L. Ma, L. Yuan, C. Xu, G. Li, M. Tao, W. Zhang, *Synthesis*, **2013**, 45, 45-52.



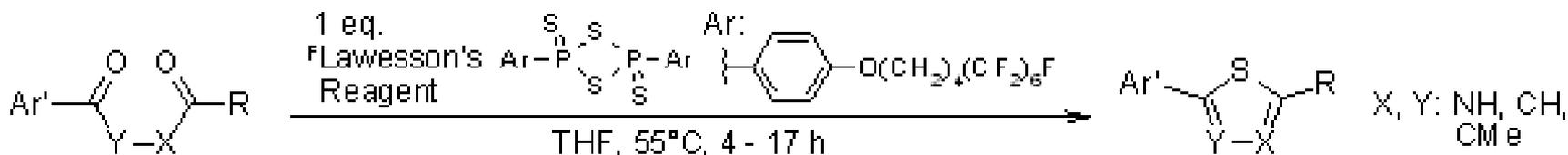
product	run:	t (h)	yield (% , isol.)	product	t (h)	yield (% , isol.)
	1	4	89		6	81
	4	4	87			
	7	4	86		5	85
	10	4	85			
		4	87			

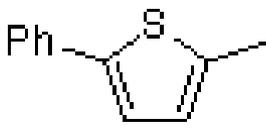
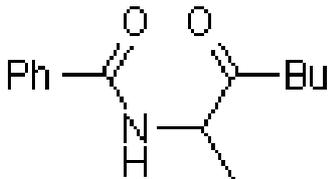
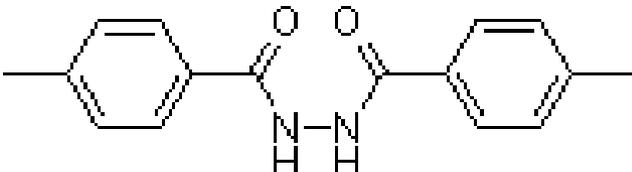
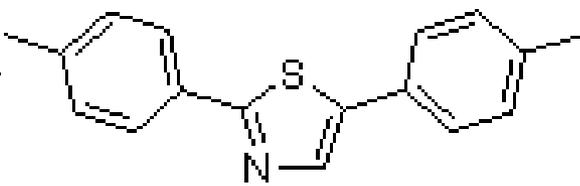


## Thionation Using Fluorous Lawesson's Reagent

Z. Kaleta, B. T Makowski, T. Soos, R. Dembinski, *Org. Lett.*, **2006**, 8, 1625-1628

La tionación de amidas, 1,4-dicetonas, de *N*-(2-oxoalquil)amidas y *N,N'*-acilhidrazinas con el uso del reactivo de Lawesson fluorado dio lugar a las tioamidas, tiofenos, 1,3-tiazoles, y a 1,3,4-tiadiazoles con rendimientos altos

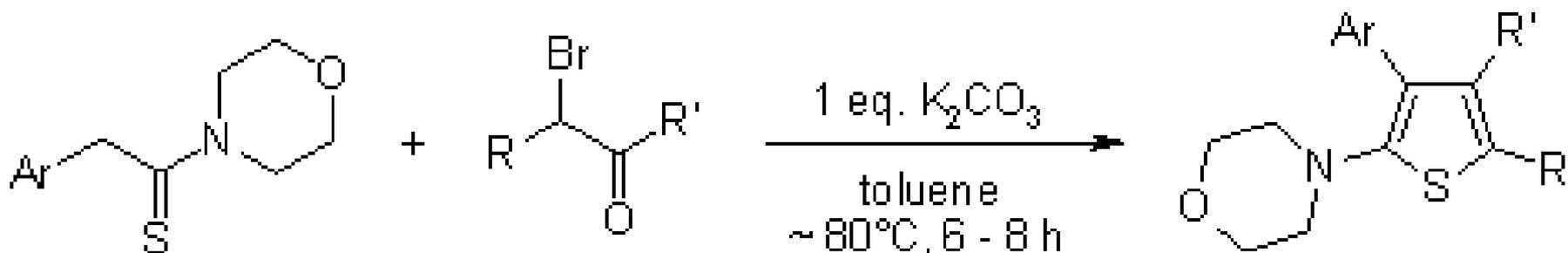


reactant	product	t (h)	yield (% , isol.)
		4	88
		6	48
		6	93



## An efficient and facile one-step synthesis of highly substituted thiophenes

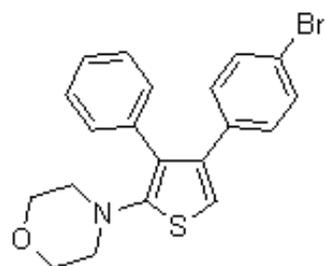
F. Matloubi Moghaddam, H. Zali Bionee, *Tetrahedron*, **2004**, *60*, 6085-6089



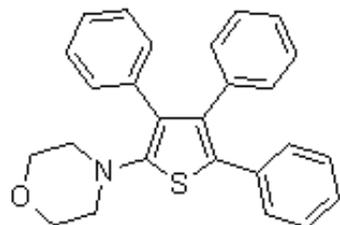
Se desarrolló un método eficiente, de un solo paso, para formar tiofenos con una alta sustitución en el anillo, el cual utiliza como materias primas tiomorfolidos y derivados de  $\alpha$ -halocetonas



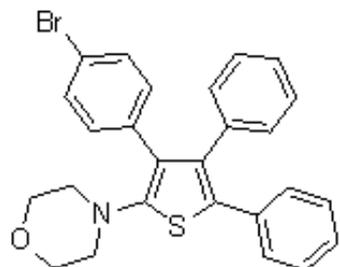
**Product**      **T (°C)**    **t (h)**    **Yield (% , isol.)**



70      7      75

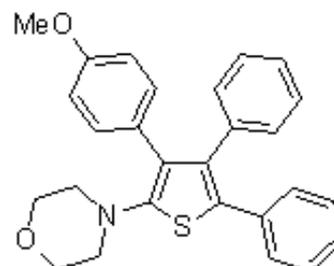


75      6.5      80

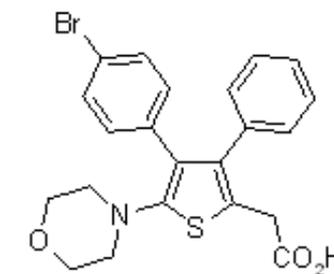


80      7      55

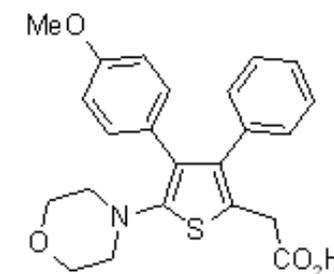
**Product**      **T (°C)**    **t (h)**    **Yield (% , isol.)**



75      7      69



60      7      60



55      6      55



# Síntesis de Hinsberg

Oscar Hinsberg, Ber. 43, 901 (1910)

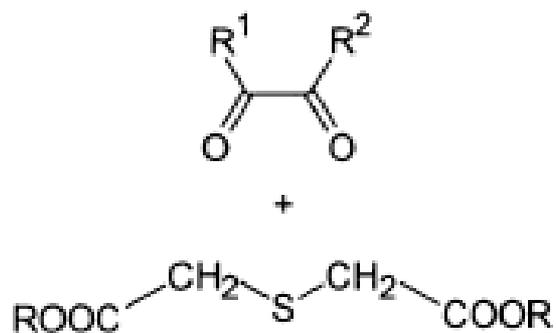


Oscar Heinrich Daniel Hinsberg  
(1857 – 1939)  
Químico alemán

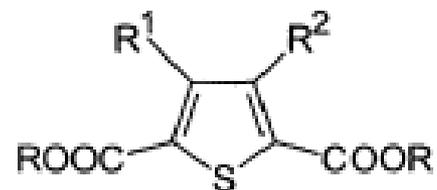
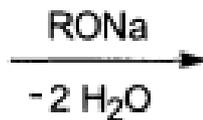
<https://www.kumc.edu/dc/pc/hinsberg.jpg>



## SÍNTESIS DE HINSBERG

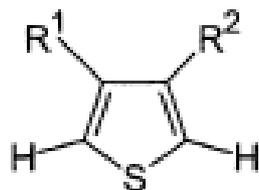


21



22

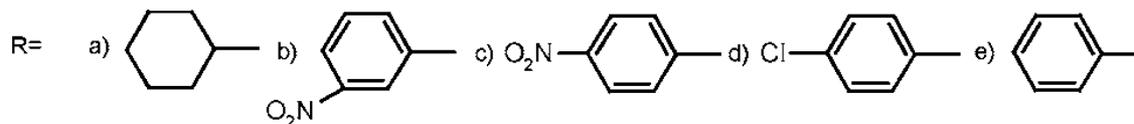
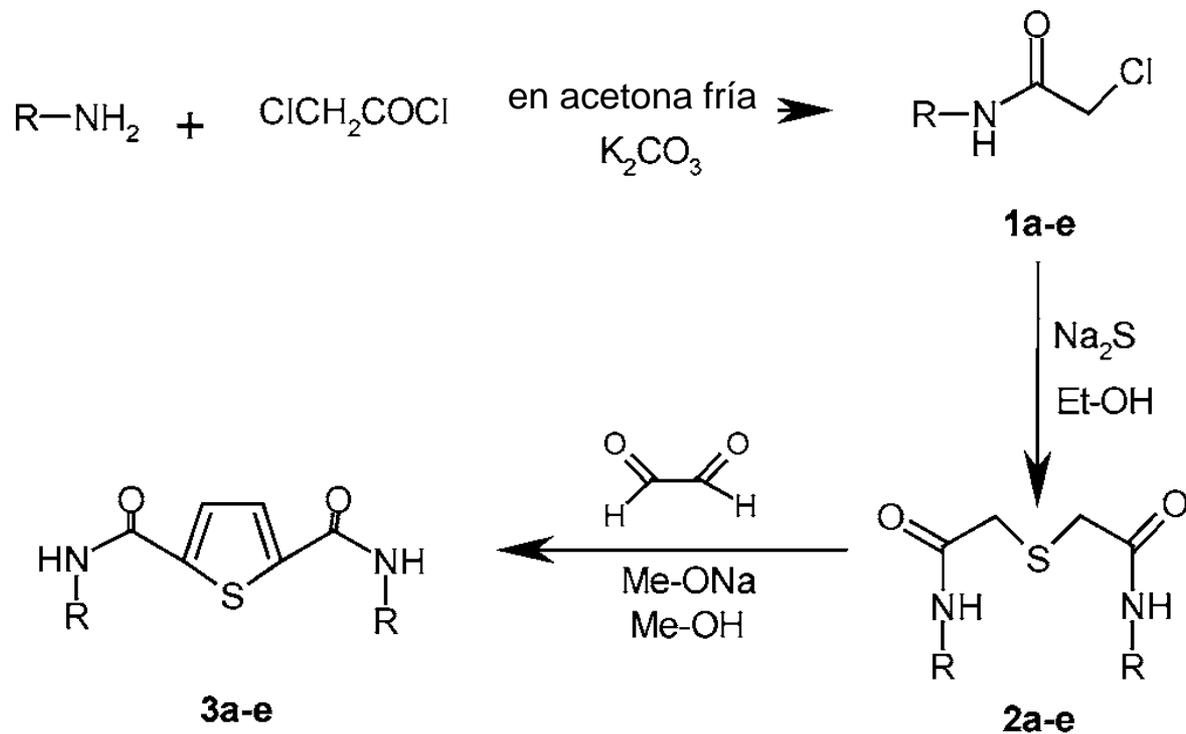
- 1) NaOH
- 2)  $\text{H}^{\oplus}$ ,  $\text{H}_2\text{O}$
- 3)  $\Delta$ ,  $-\text{CO}_2$



23



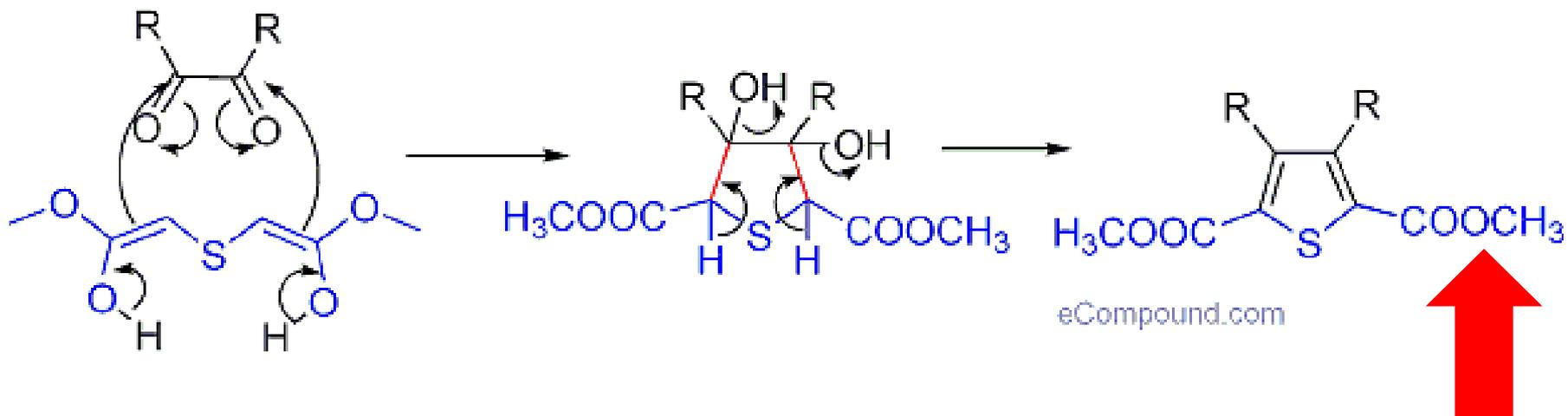
## Bis-aryl(alquil)amidas del ácido tiofen-2,5-dicarboxílico



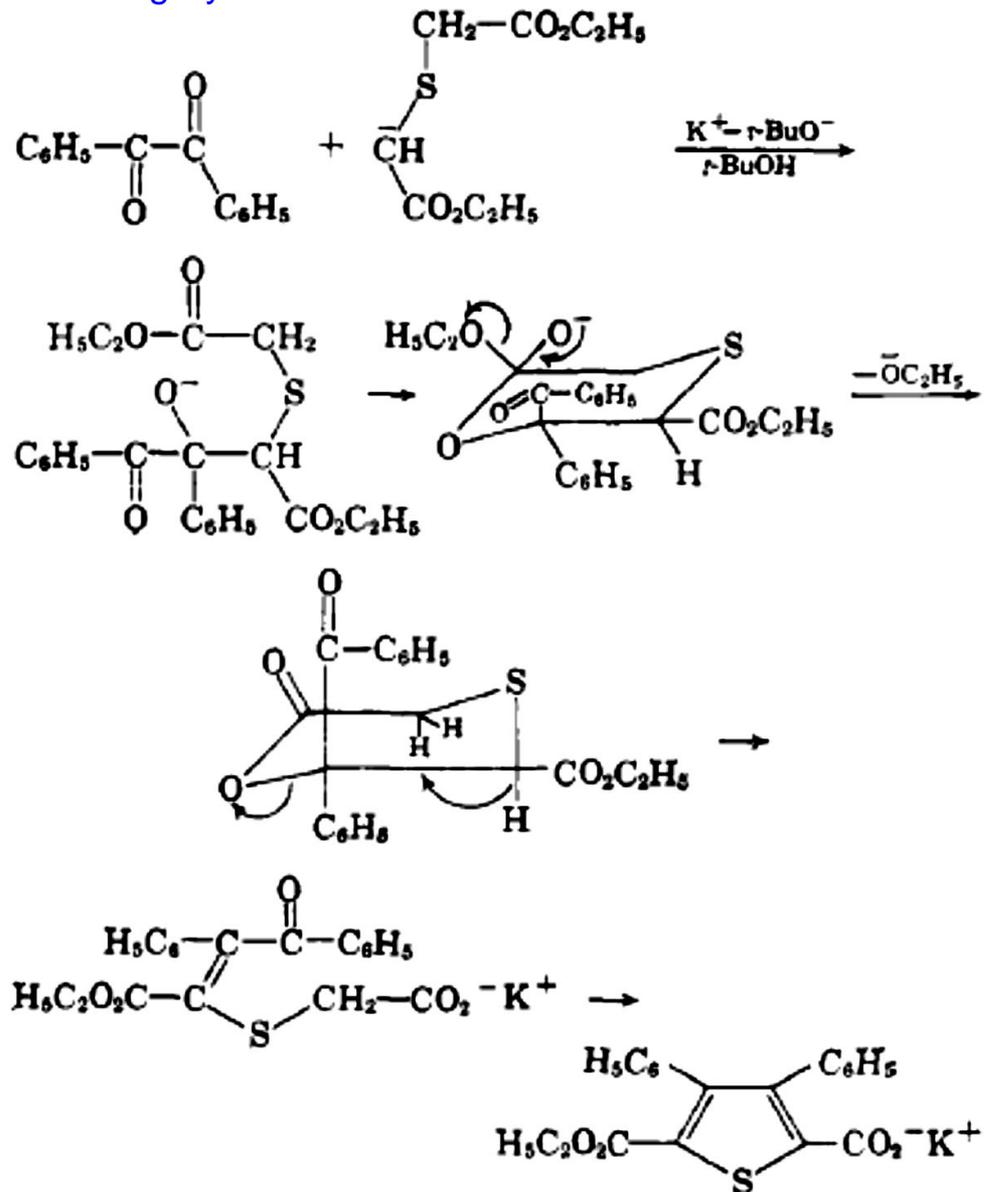
Kopar, M. R.; Cans, A. Z.; Çetin, A.; Heteroatom Chemistry, **2005**, 16, [6], 503 - 506



## Síntesis de tiofenos de Hinsberg



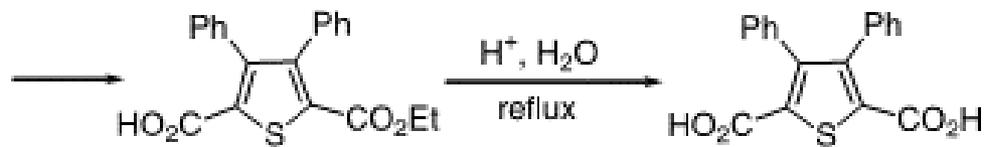
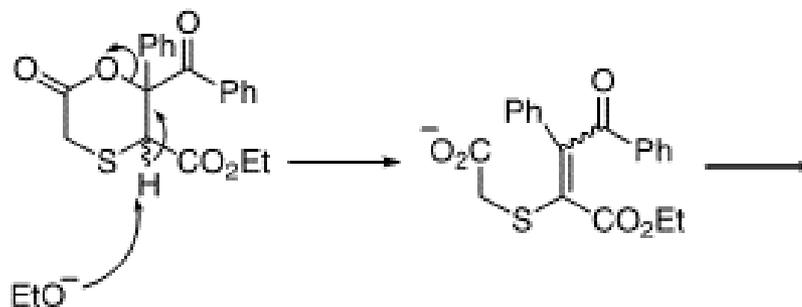
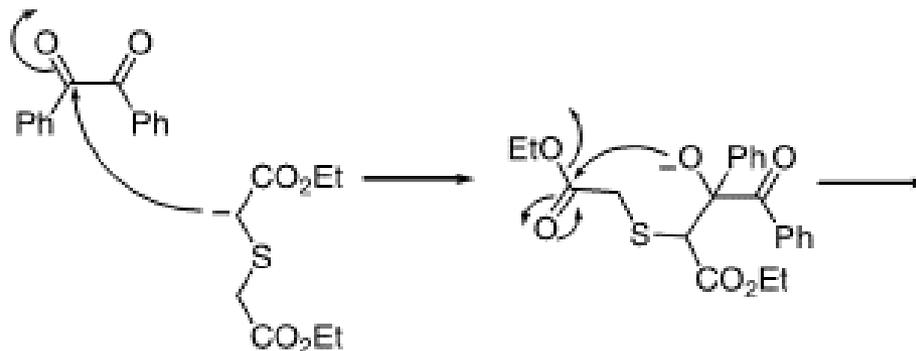
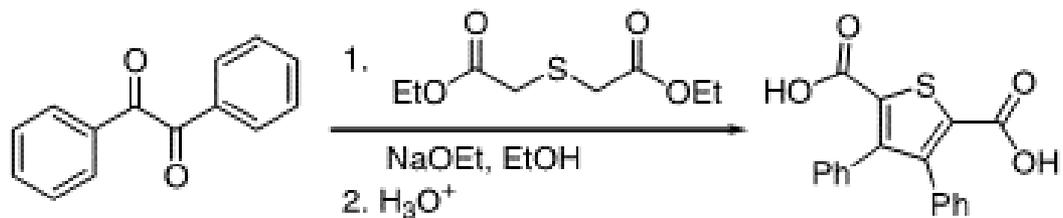
# The Mechanism of the Hinsberg Thiophene Ring Synthesis



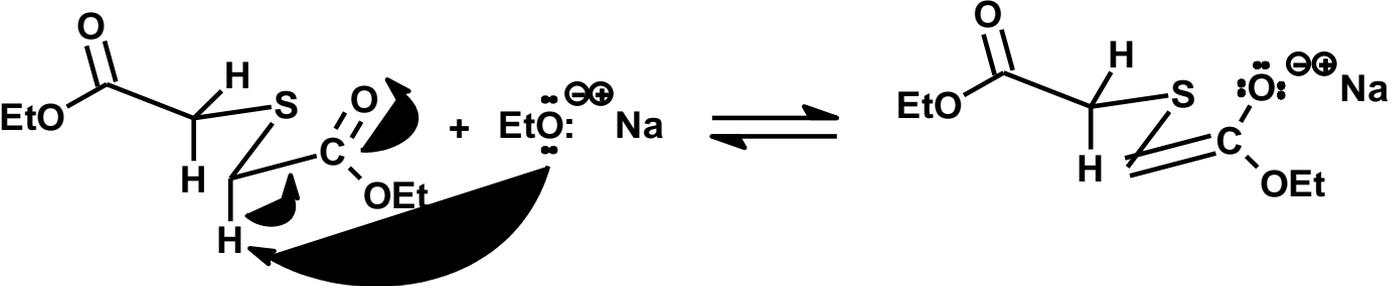
Hans Wynberg and H. J. Kooreman

Journal of the American Chemical Society,  
1965, 87:8, 1739-1742

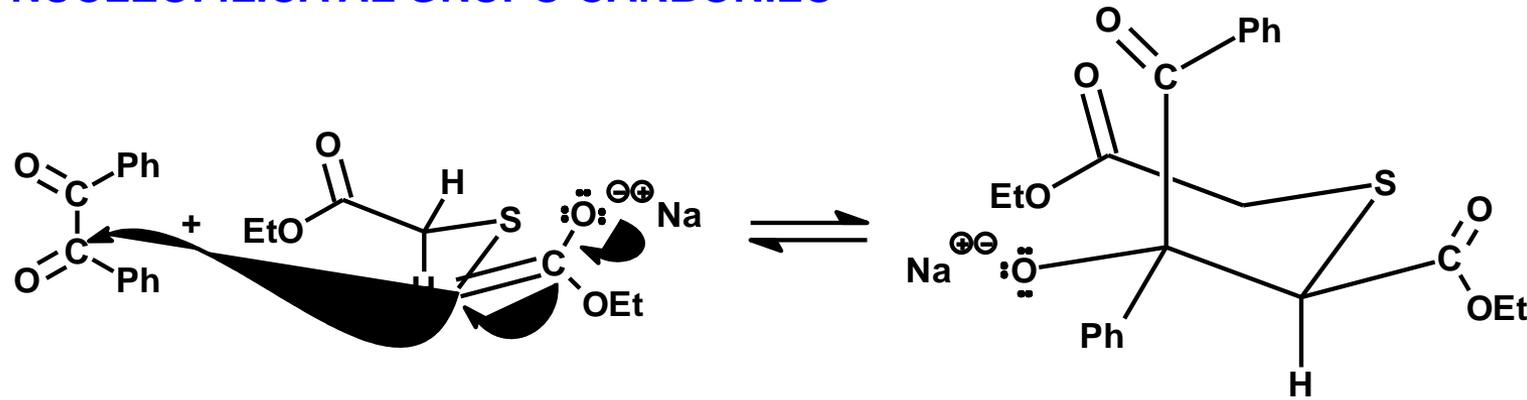




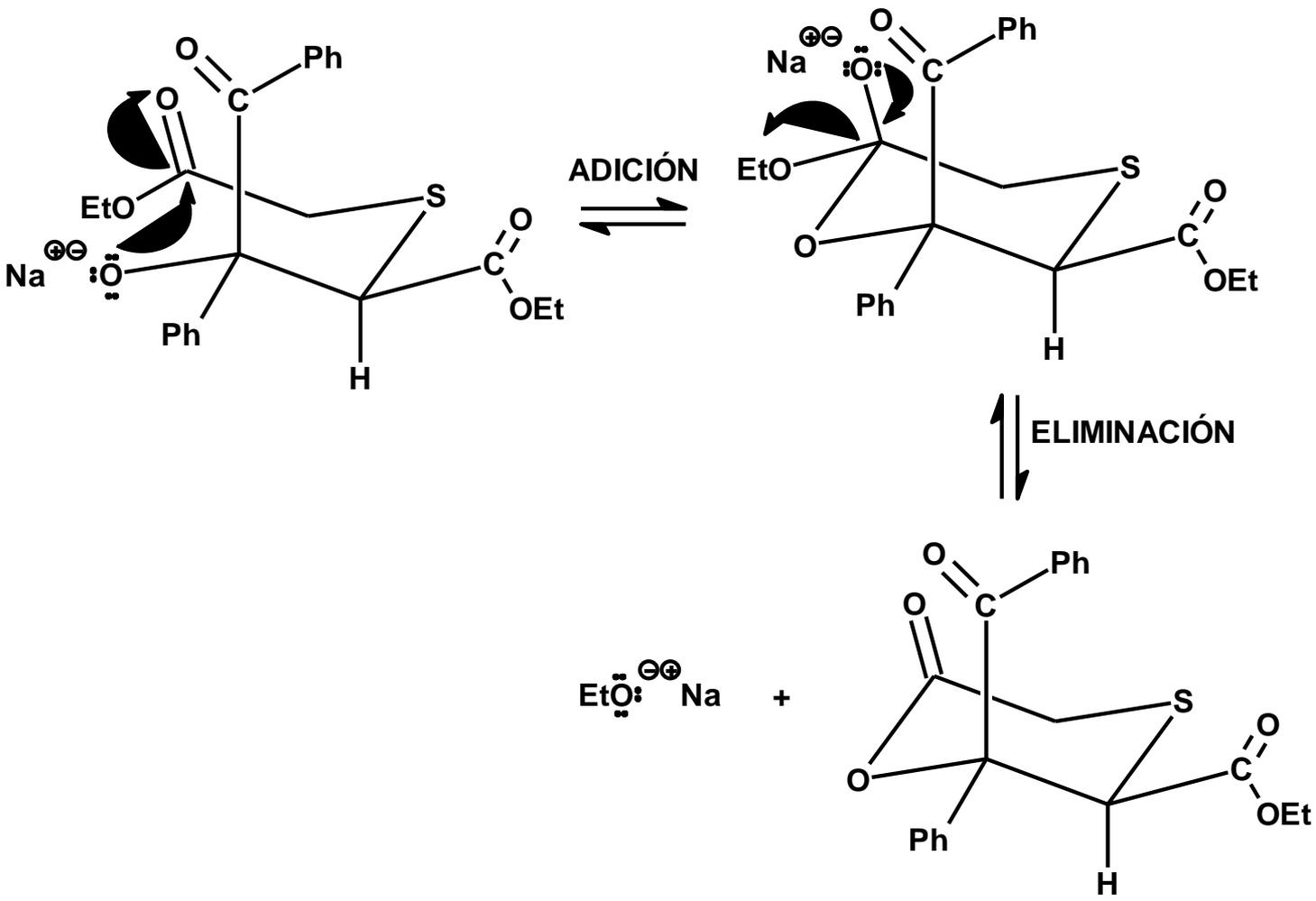
**MECANISMO HINSBERG  
REACCIÓN ÁCIDO-BASE**



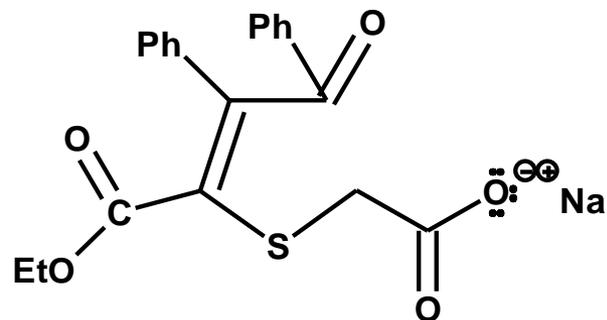
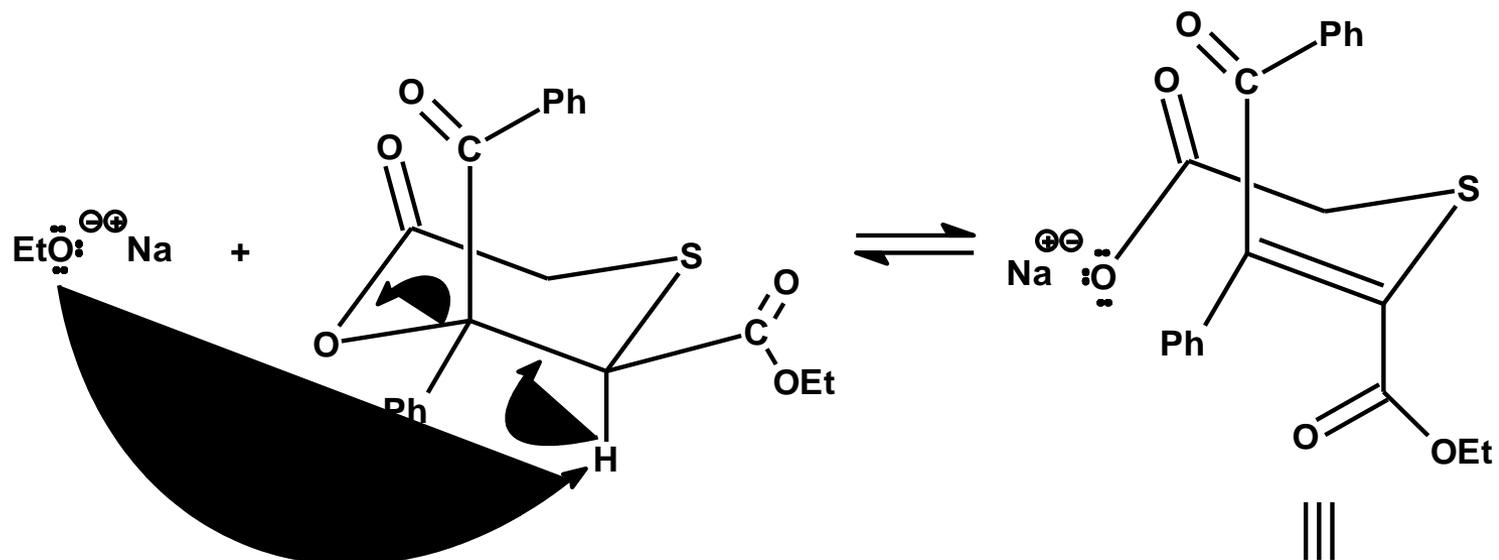
**ADICIÓN NUCLEOFÍLICA AL GRUPO CARBONILO**



# REACCIÓN DE TRANSESTERIFICACIÓN INTRAMOLECULAR

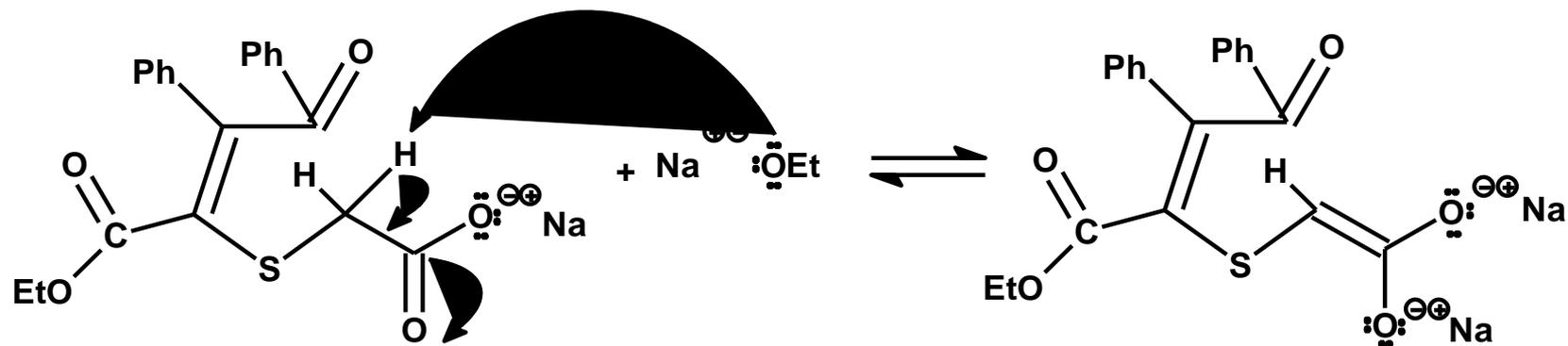


# REACCIÓN ÁCIDO-BASE

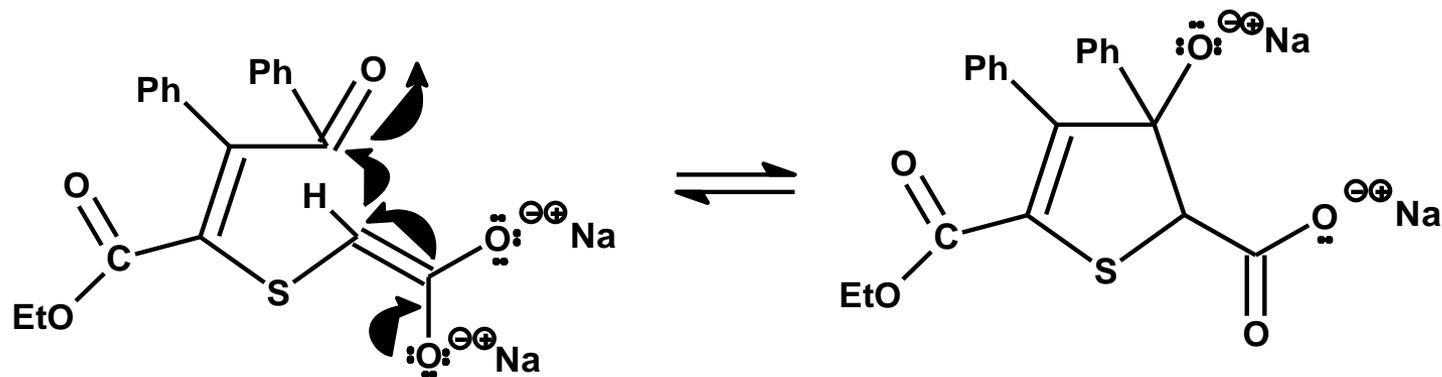


## SEGUNDA ADICIÓN NUCLEOFÍLICA AL GRUPO CARBONILO

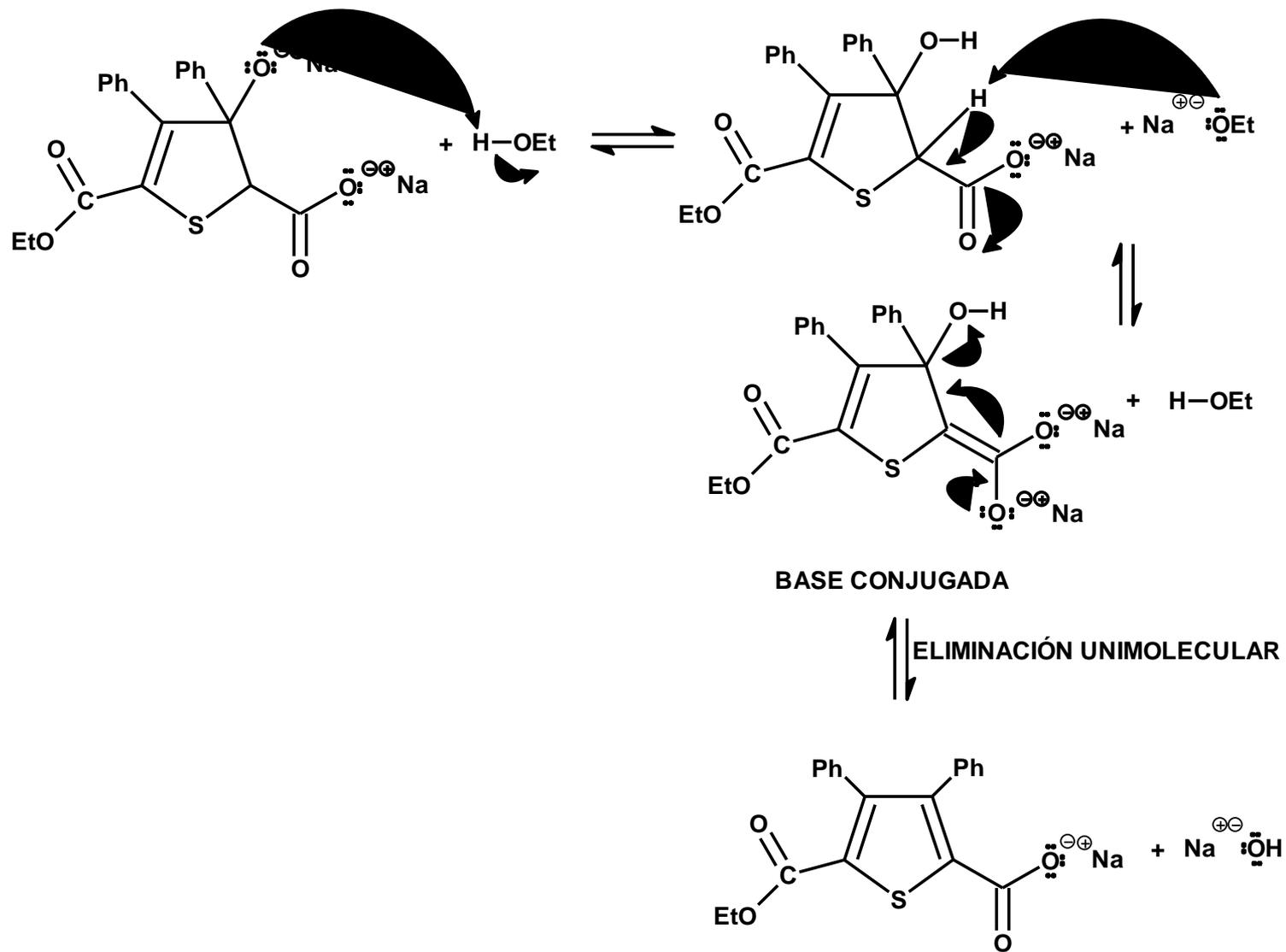
### a) REACCIÓN ÁCIDO-BASE



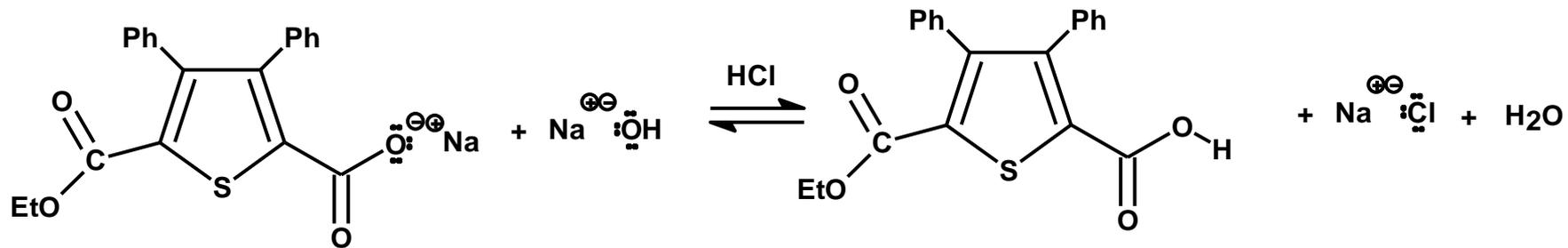
### b) ADICIÓN AL GRUPO CARBONILO

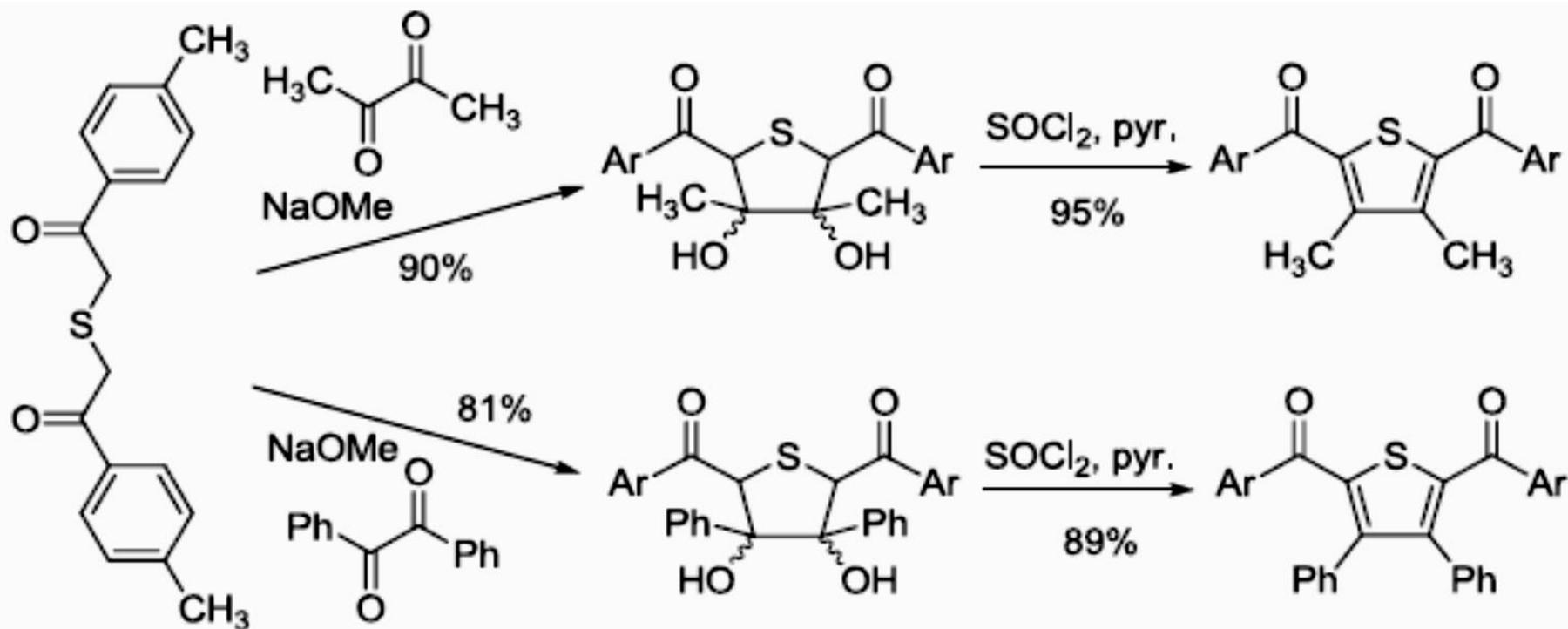


## ELIMINACIÓN E1bc:



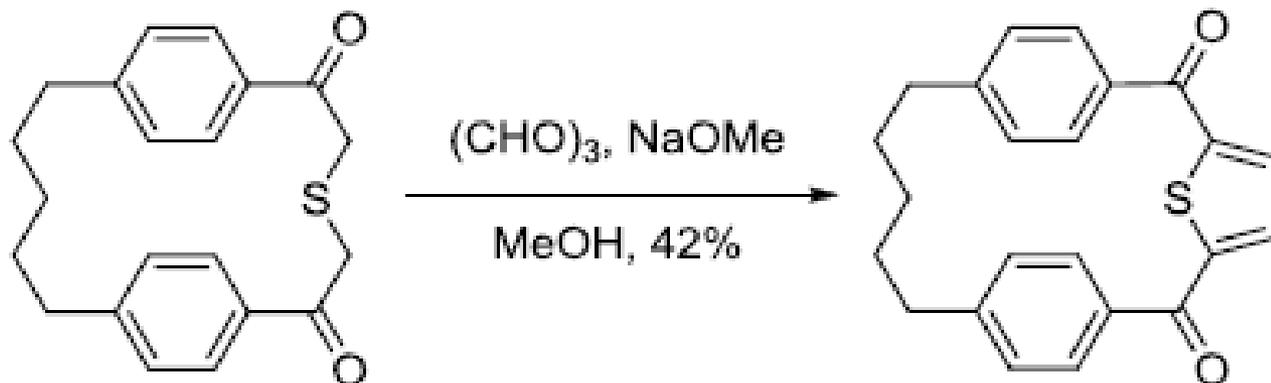
## LIBERACIÓN DE LA SAL DE CARBOXILATO:



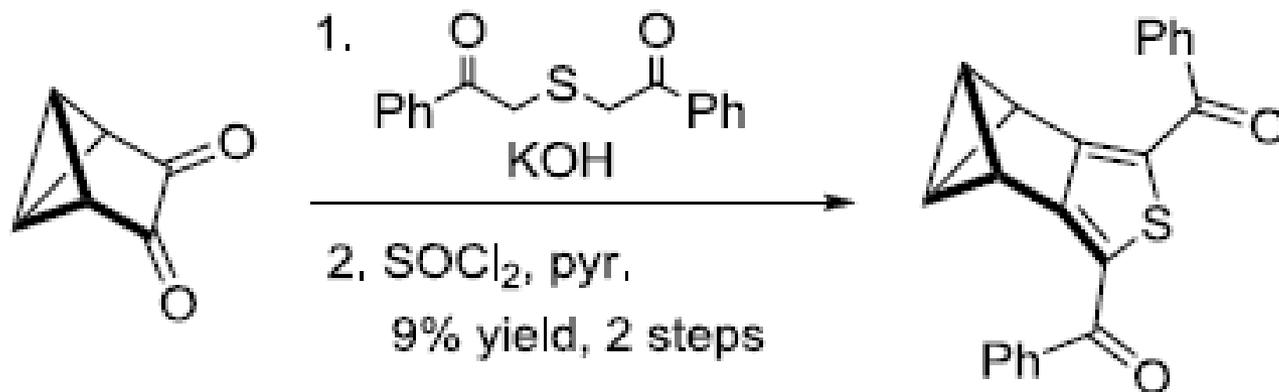


Miyahara, Y.; Inazu, T.; Yoshino, T. *Bull. Chem. Soc. Jpn.* 1980, 53, 1187–1188.



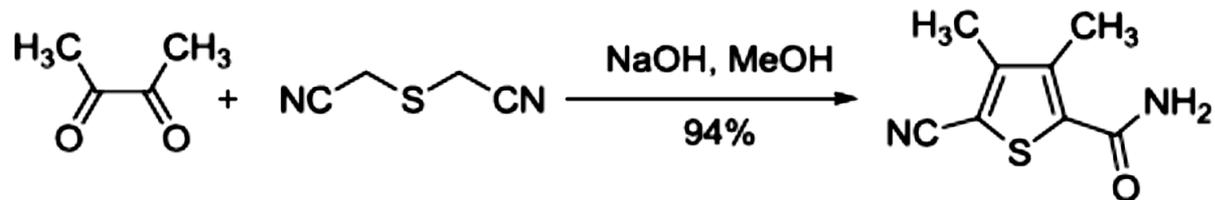


Miyahara, Y.; Inazu, T.; Yoshino, T. *J. Org. Chem.* **1984**, *49*, 1177–1182.

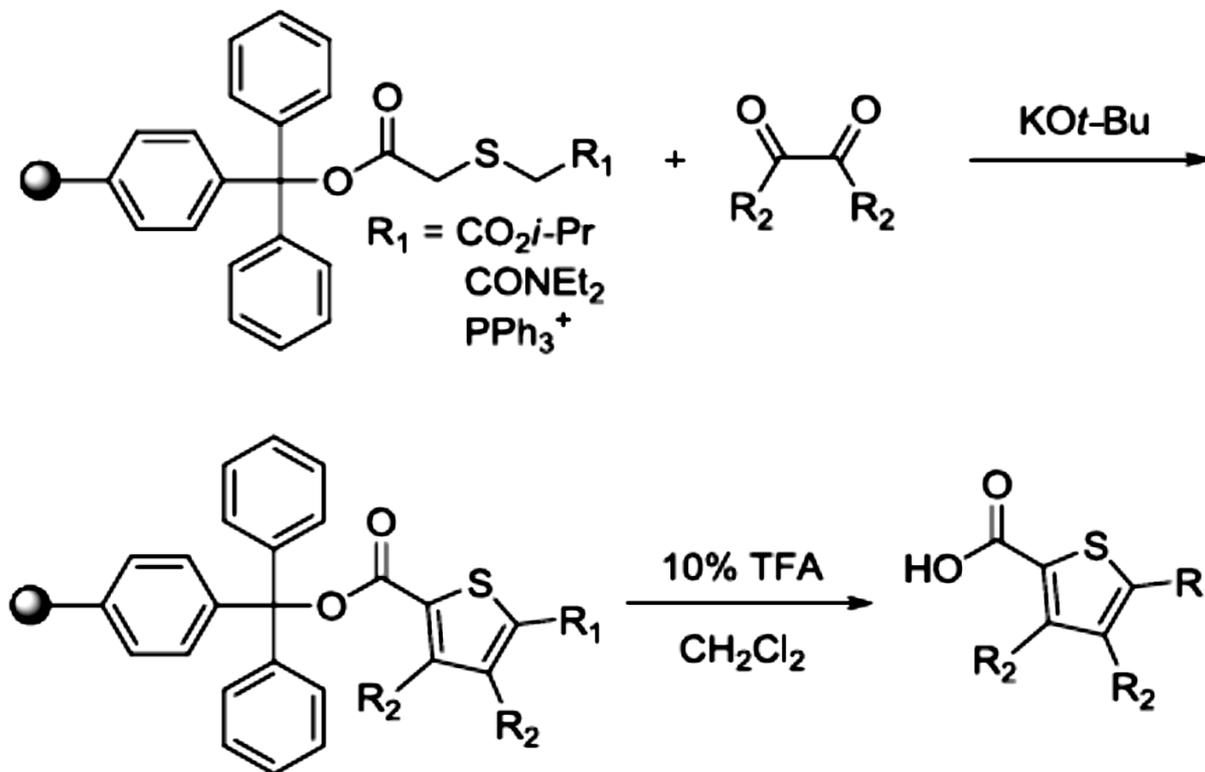


Christl, M.; Krimm, S.; Kraft, A. *Angew. Chem. Int. Ed.* **1990**, *29*, 675–677.





Beye, N.; Cava, M. P. *J. Org. Chem.* 1994, 59, 2223–2226.



Traversone, A.; Brill, W. K.-D. *Tetrahedron Lett.* 2007, 48, 3535–3538.



Anita Kongor, Manthan Panchal, Viren Mehta, Keyur Bhatt, Dehin Bhagat,  
Devayani Tipre, Vinod K. Jain  
Basketing nanopalladium into calix[4]pyrrole as an efficient catalyst for Mizoroki-  
Heck reaction

Arabian Journal of Chemistry

Volume 10, Issue 8, December 2017, Pages 1125-1135

<https://doi.org/10.1016/j.arabjc.2016.06.019>

Yukun Cheng, Channing K. Klein and Ian A. Tonks

Synthesis of pentasubstituted 2-aryl pyrroles from boryl and stannyl  
alkynes *via* one-pot sequential Ti-catalyzed [2 + 2 + 1] pyrrole  
synthesis/cross coupling reactions

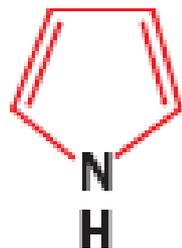
*Chem. Sci.*, 2020,11, 10236-10242



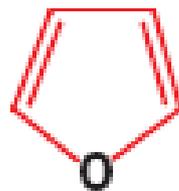
# REACCIONES DE FURANO, PIRROL Y TIOFENO

## COMPUESTOS $\pi$ EXCESIVOS

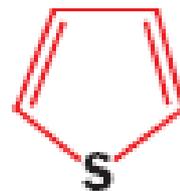




pirrol



furano



tiofeno

ENERGÍAS DE  
RESONANCIA  
(Kcal / mol):

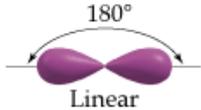
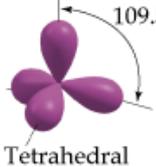
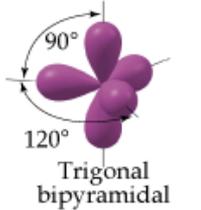
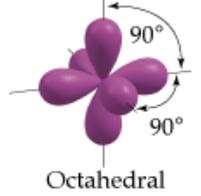
21

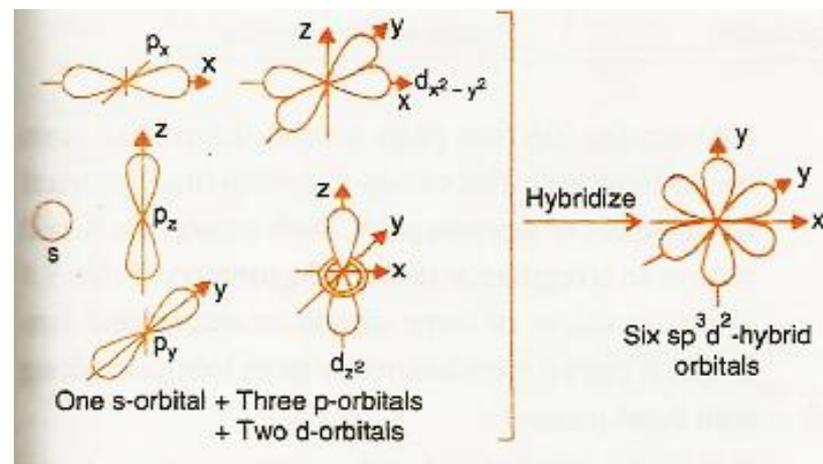
16

28



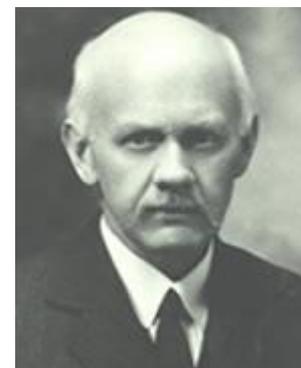
$sp^3d^2$

TABLE 9.4 Geometrical Arrangements Characteristic of Hybrid Orbital Sets			
Atomic Orbital Set	Hybrid Orbital Set	Geometry	Examples
$s, p$	Two $sp$	 Linear	$\text{BeF}_2, \text{HgCl}_2$
$s, p, p$	Three $sp^2$	 Trigonal planar	$\text{BF}_3, \text{SO}_3$
$s, p, p, p$	Four $sp^3$	 Tetrahedral	$\text{CH}_4, \text{NH}_3, \text{H}_2\text{O}, \text{NH}_4^+$
$s, p, p, p, d$	Five $sp^3d$	 Trigonal bipyramidal	$\text{PF}_5, \text{SF}_4, \text{BrF}_3$
$s, p, p, p, d, d$	Six $sp^3d^2$	 Octahedral	$\text{SF}_6, \text{ClF}_5, \text{XeF}_4, \text{PF}_6^-$



<https://www.quora.com/In-FeF6-3-how-can-Fe-have-five-unpaired-electrons-while-simultaneously-contributing-two-3D-orbitals-to-form-hybrid-orbitals>

## Enlace covalente coordinado

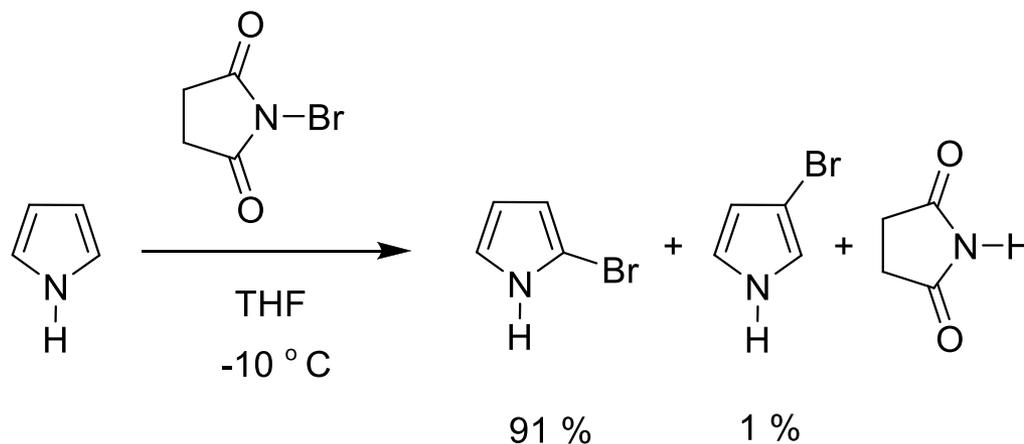
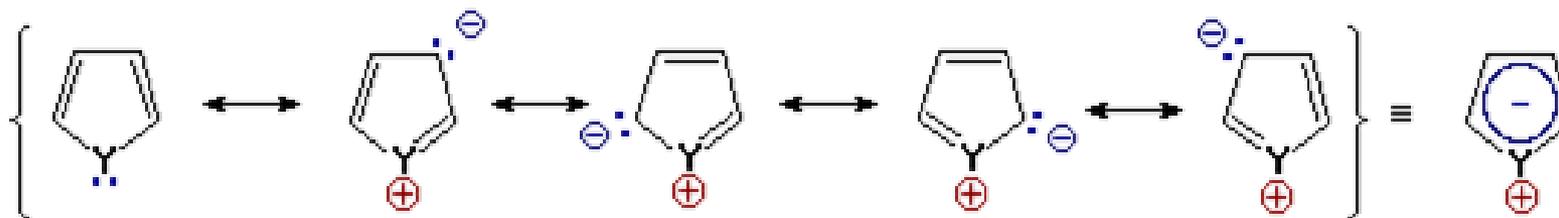


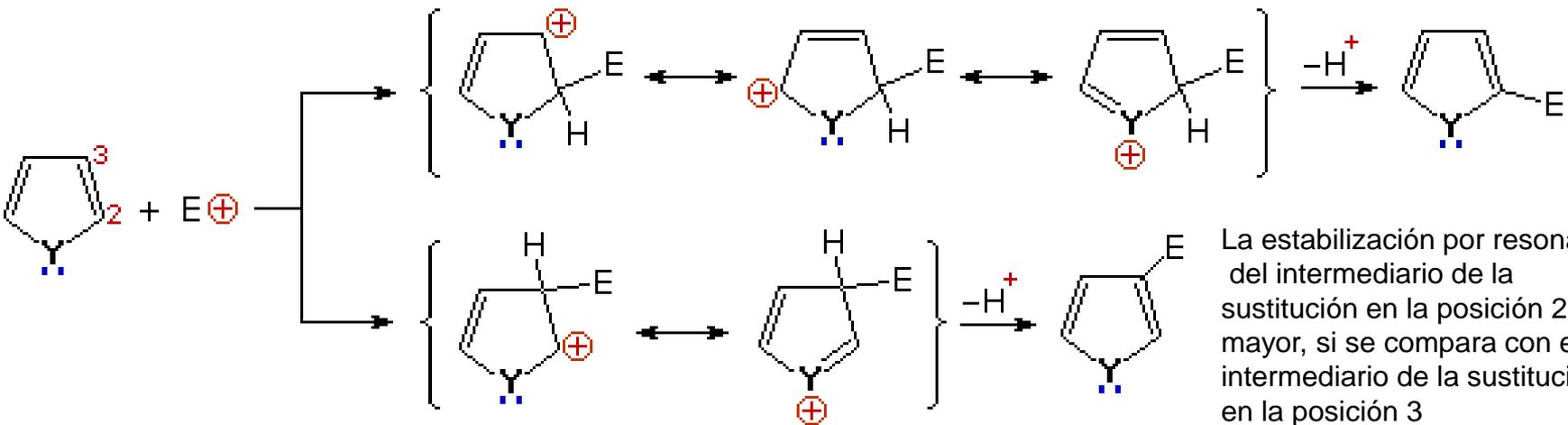
Nevil Vincent Sidgwick  
Químico inglés  
(1873 - 1952)

[http://www.oneonta.edu/faculty/viningwj/Chem111/Chapters\\_9%20and\\_11\\_study\\_guide%20.htm](http://www.oneonta.edu/faculty/viningwj/Chem111/Chapters_9%20and_11_study_guide%20.htm)

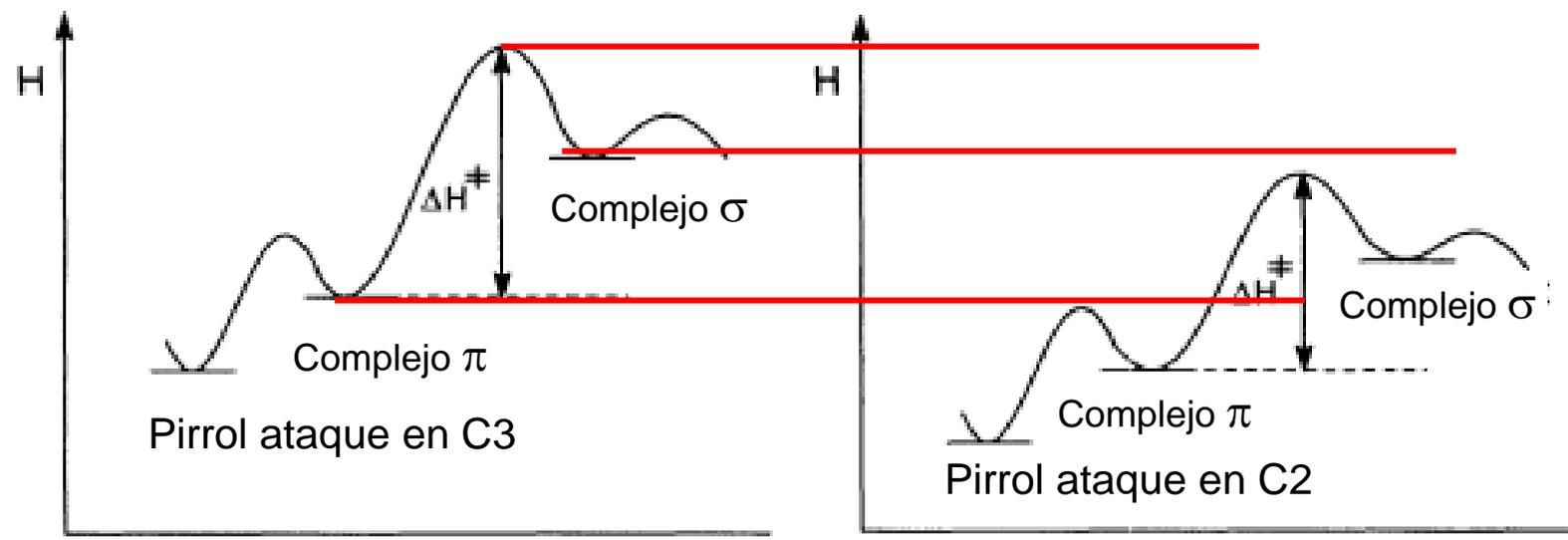


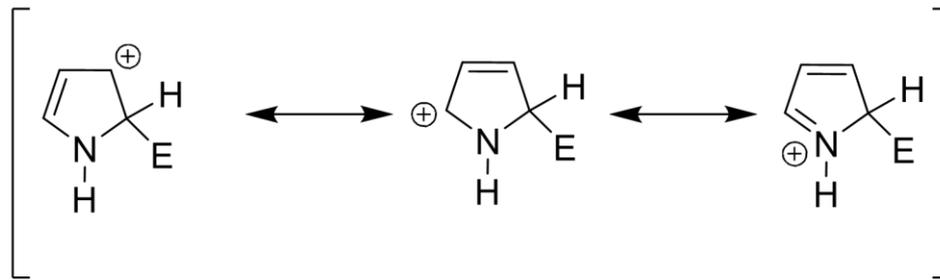
# COMPUESTOS $\pi$ -EXCESIVOS: FORMAS RESONANTES CON CARGA



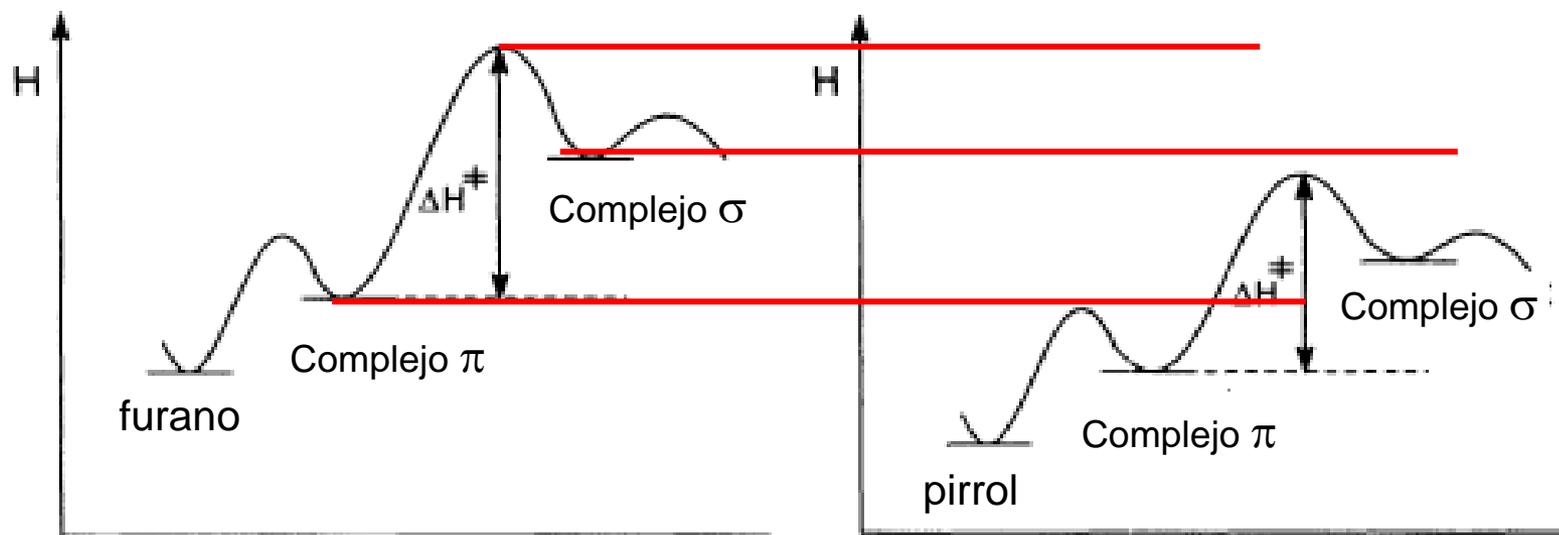
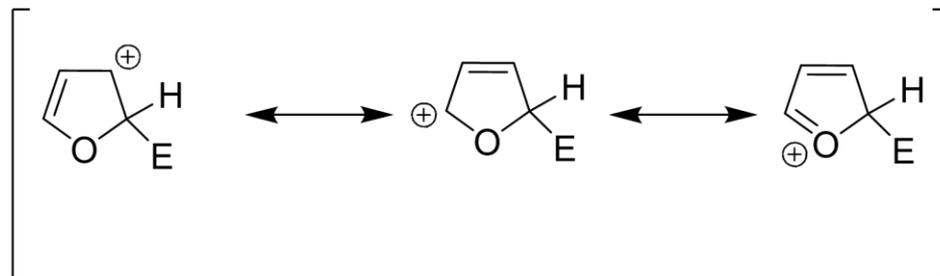


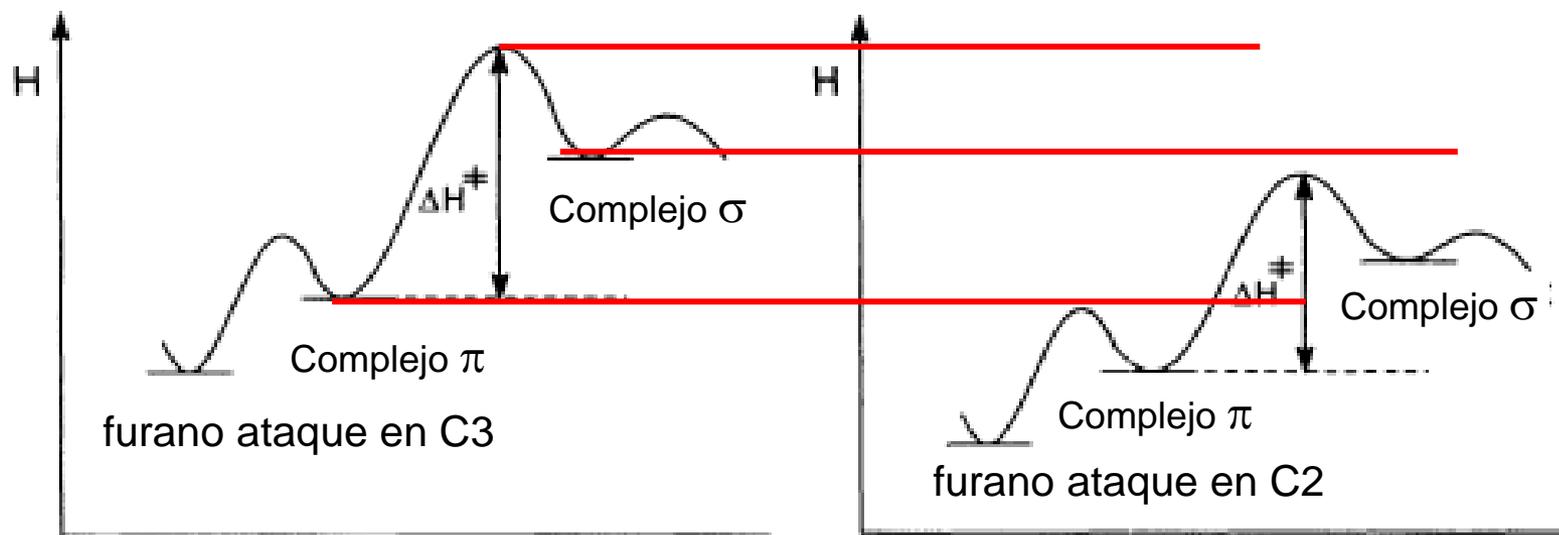
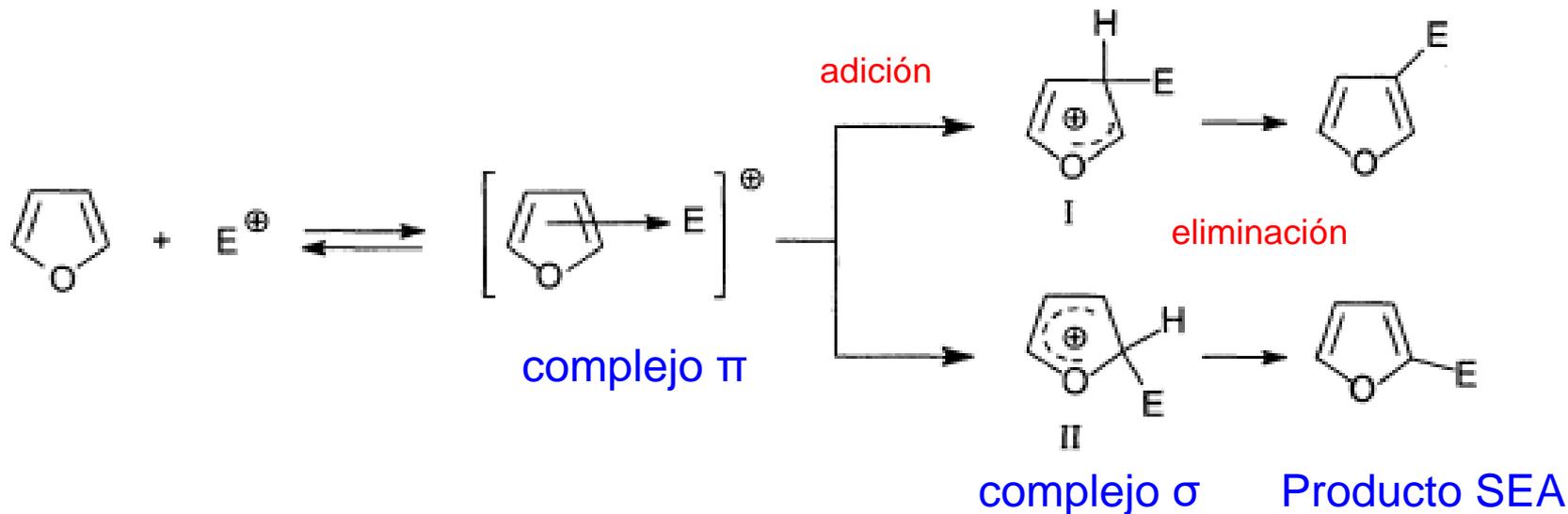
La estabilización por resonancia del intermediario de la sustitución en la posición 2 es mayor, si se compara con el intermediario de la sustitución en la posición 3



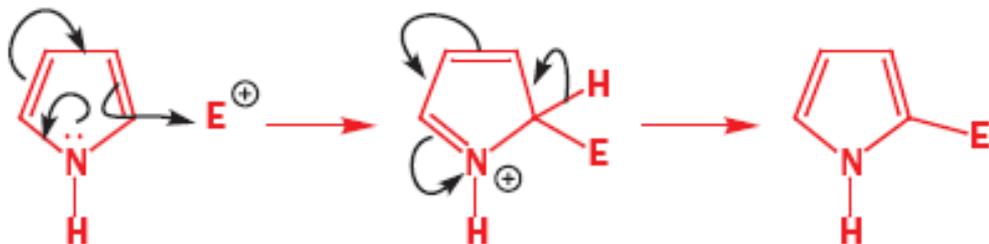


Sistema más estable

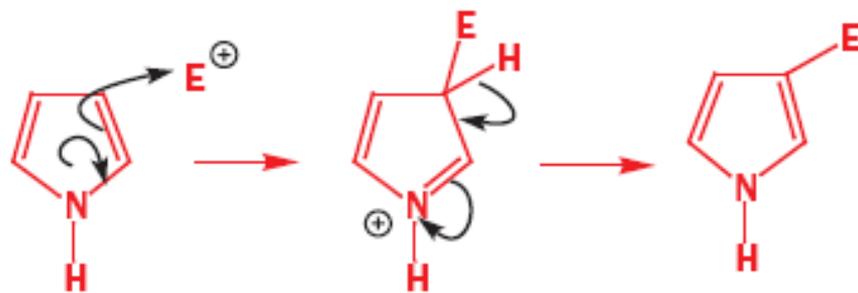




## Reacción con electrófilo en la posición 2

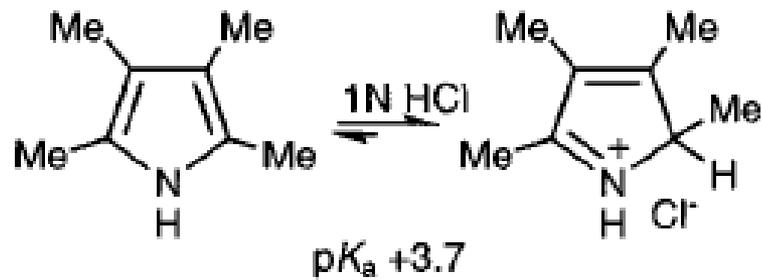
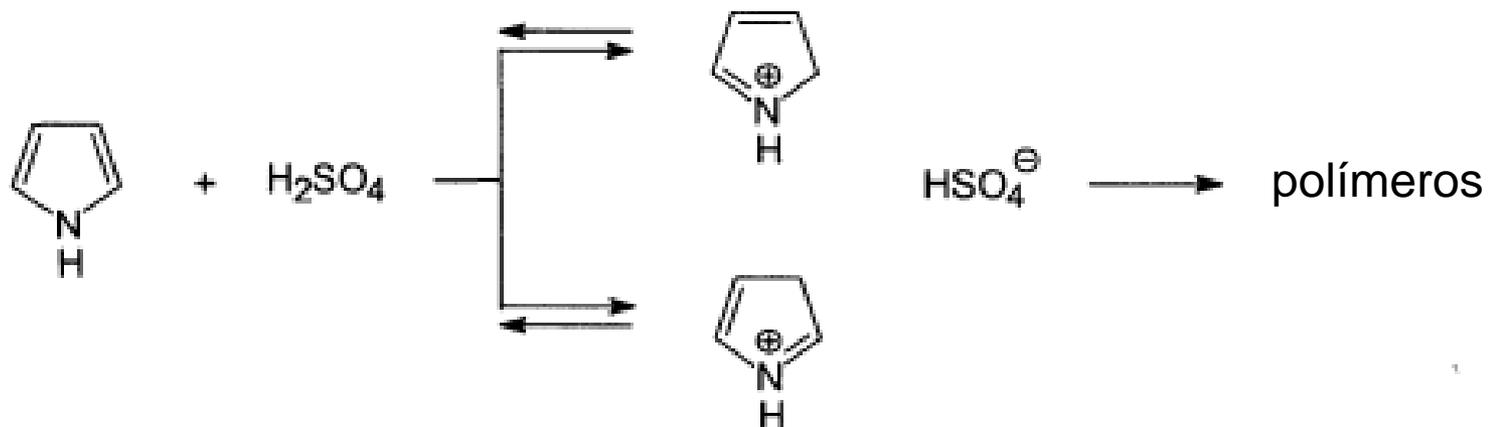


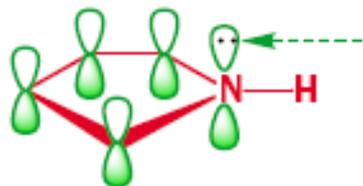
## Reacción con electrófilo en la posición 3



Más estable      Menos estable

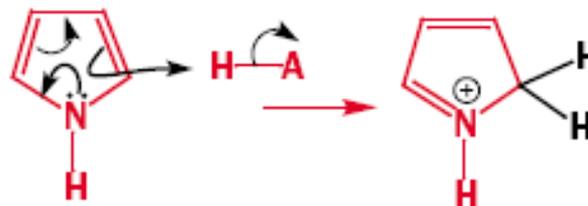
# POLIMERIZACIÓN





El par de electrones del N permite que el pirrol complete la capa de orbitales moleculares de enlace

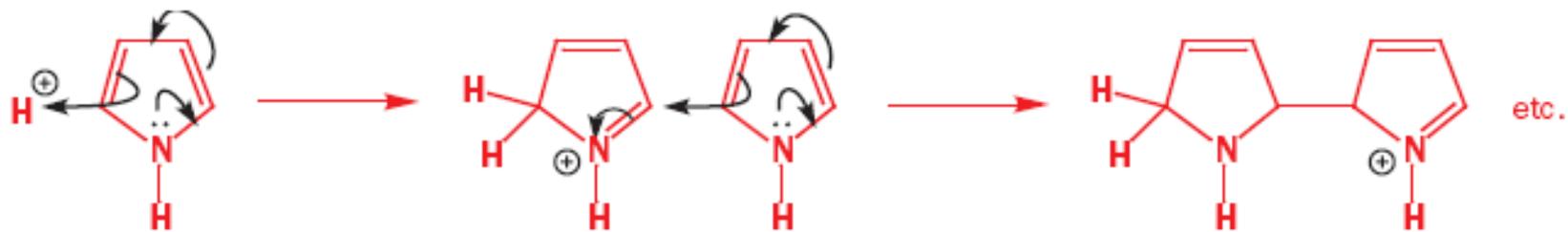
pKa del pirrol  $\cong$  4



pirrol aromático

Catión del pirrol  
No aromático

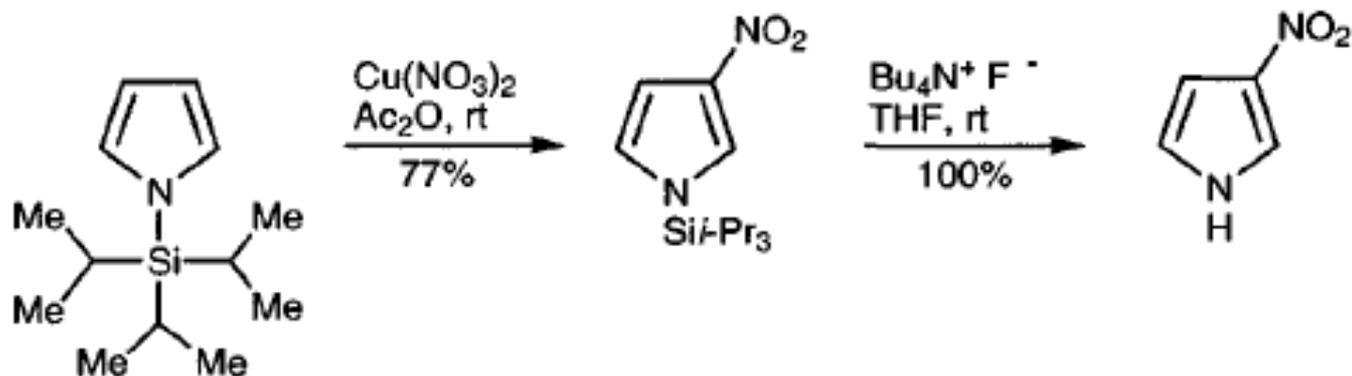
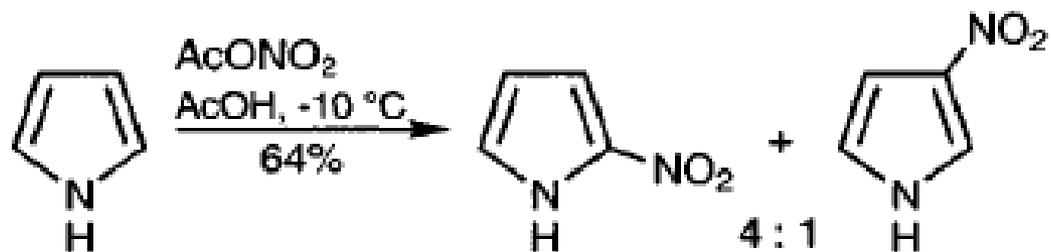
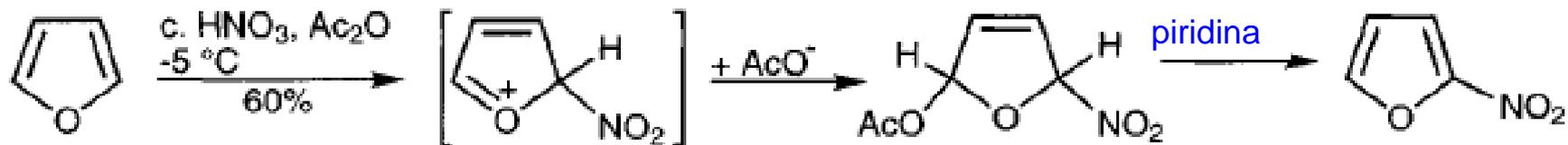




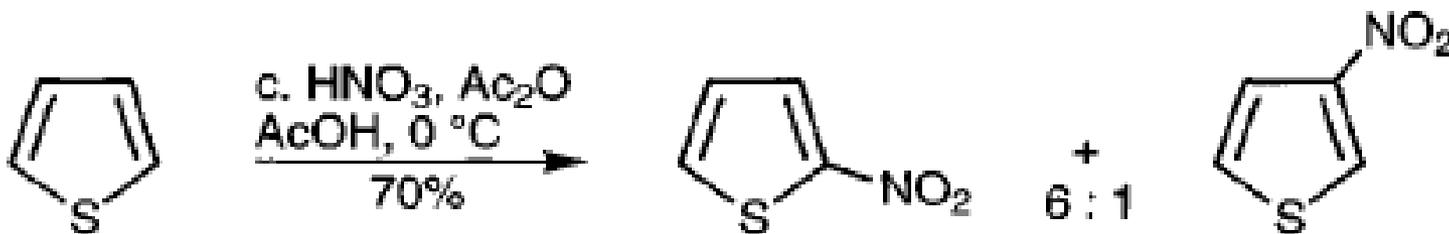
La reacción continúa para dar el polímero



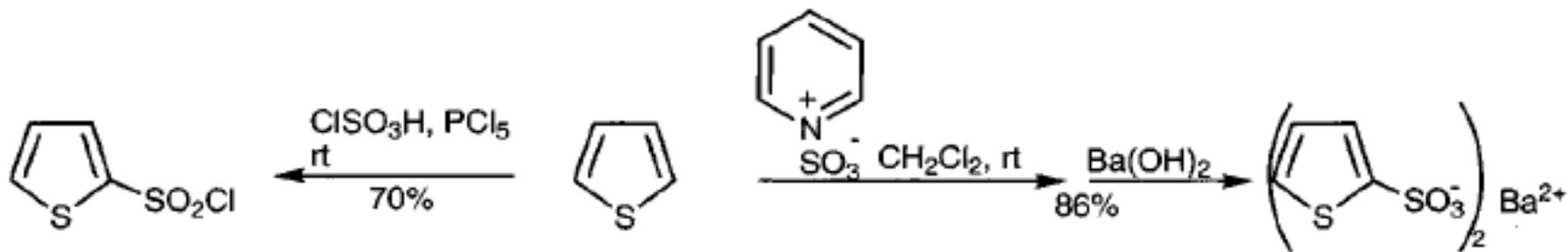
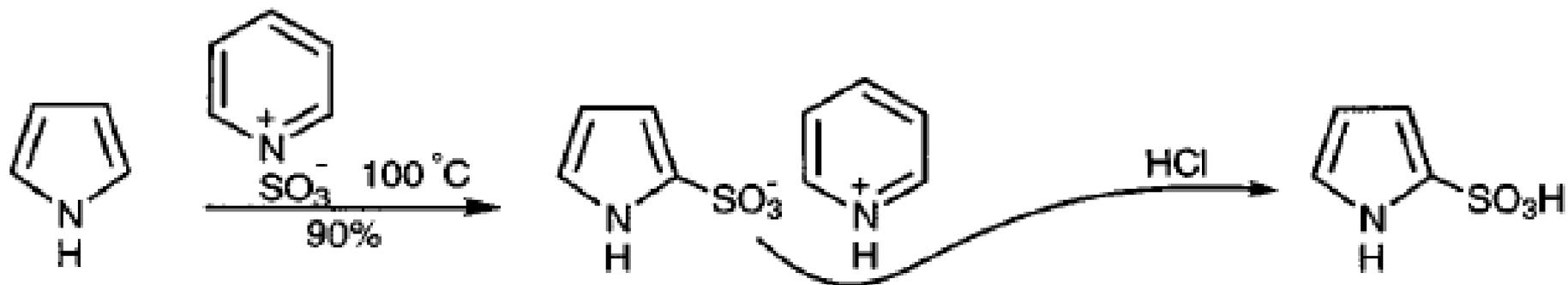
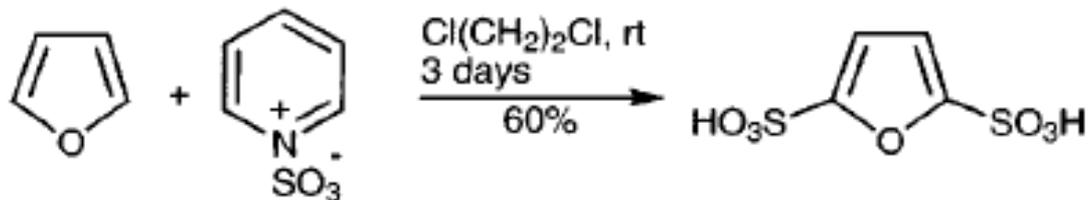
# NITRACIÓN



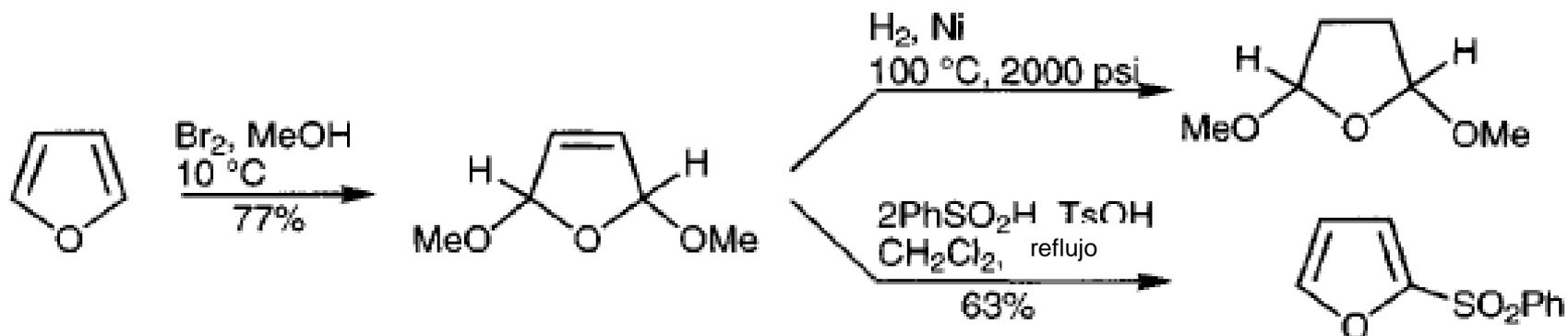
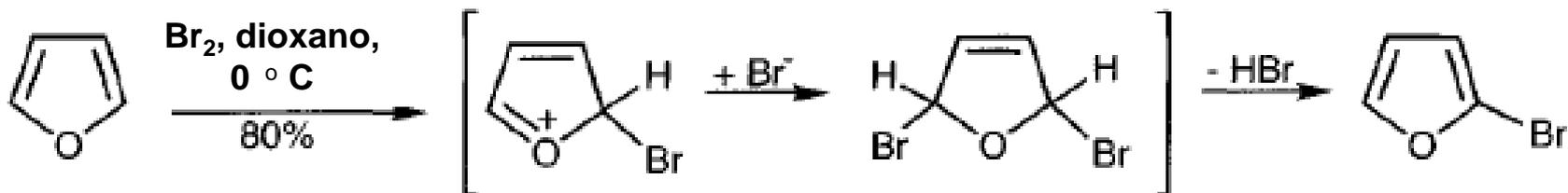
## Nitración tiofeno



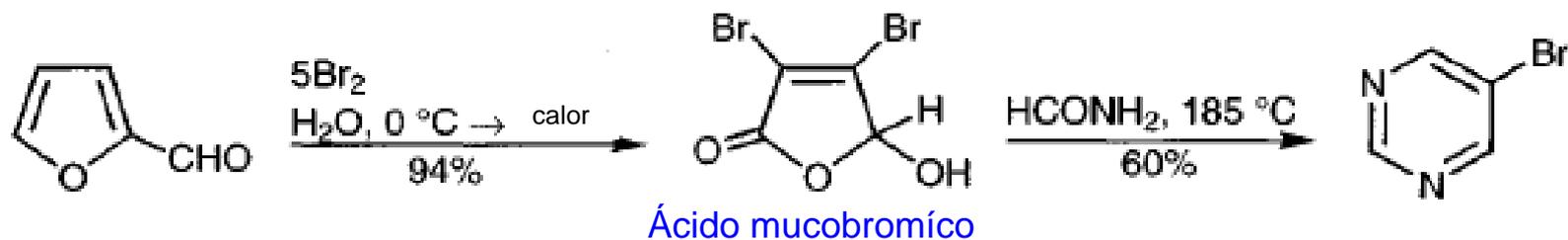
# SULFONACIÓN



# HALOGENACIÓN



## TAREA: MECANISMOS DE LAS DOS REACCIONES



# Guillermo de Ockham

- Filósofo Inglés
- Principal exponente de la Baja Escolástica
- Excomulgado de la iglesia



Navaja De Ockham  Separación entre fe y razón

**Navaja:** *'Entia non sunt multiplicanda sine necessitate'* o 'Los entes no deben ser multiplicados sin necesidad'

La opción más sencilla, es probablemente la correcta

<http://triflnew.blogspot.com/2015/09/navaja-de-ockham.html>

En su forma más simple, el principio de Ockham indica que las explicaciones nunca deben multiplicar las causas sin necesidad. Cuando dos o más explicaciones se ofrecen para un fenómeno, la explicación completa más simple es preferible; es decir, no deben multiplicarse las entidades sin necesidad.



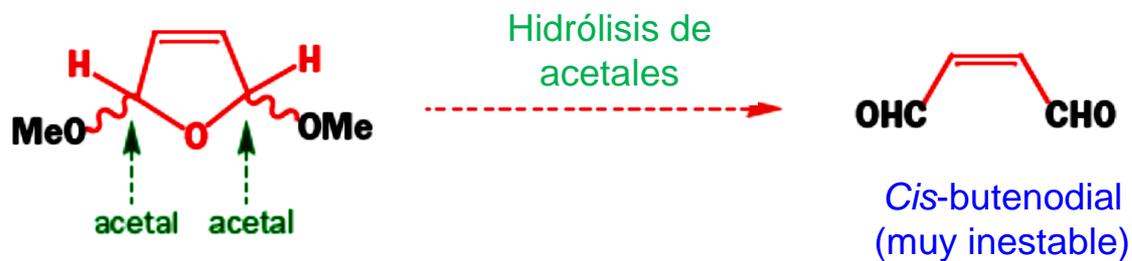
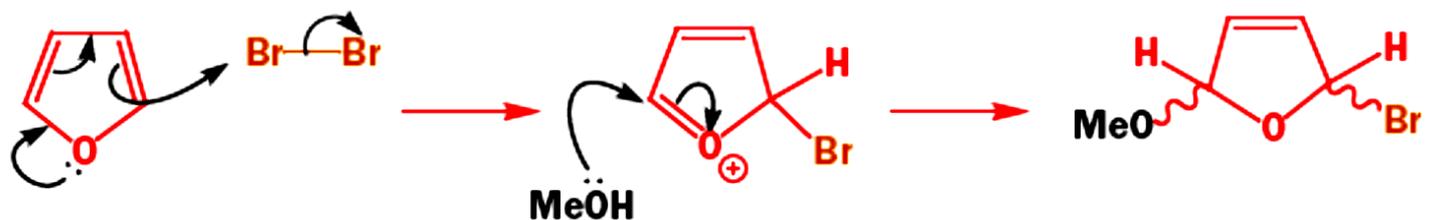
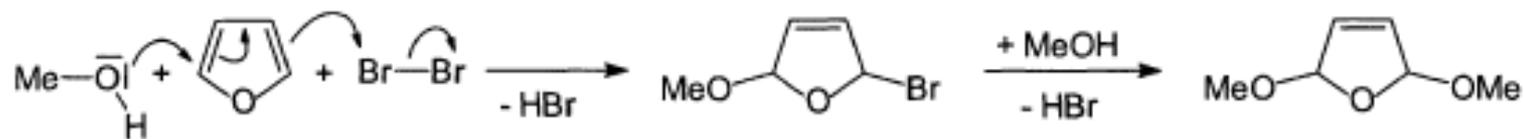




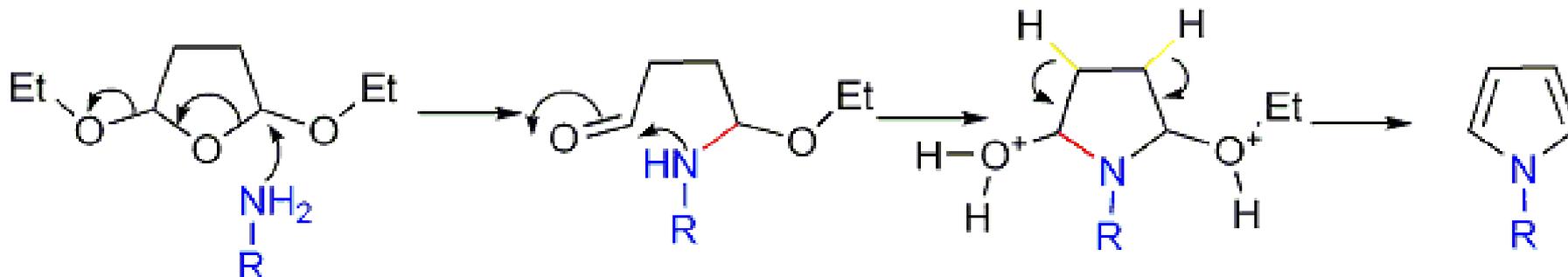
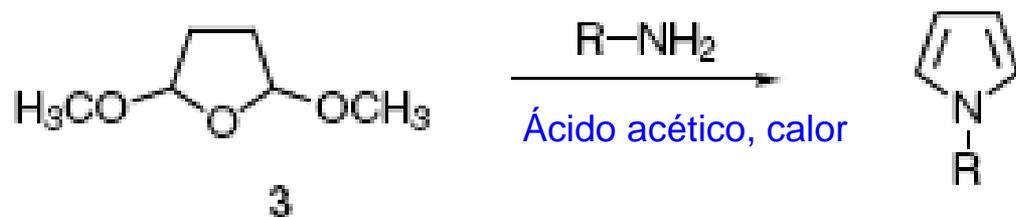




# HALOGENACIÓN. REACCIONES DE ADICIÓN



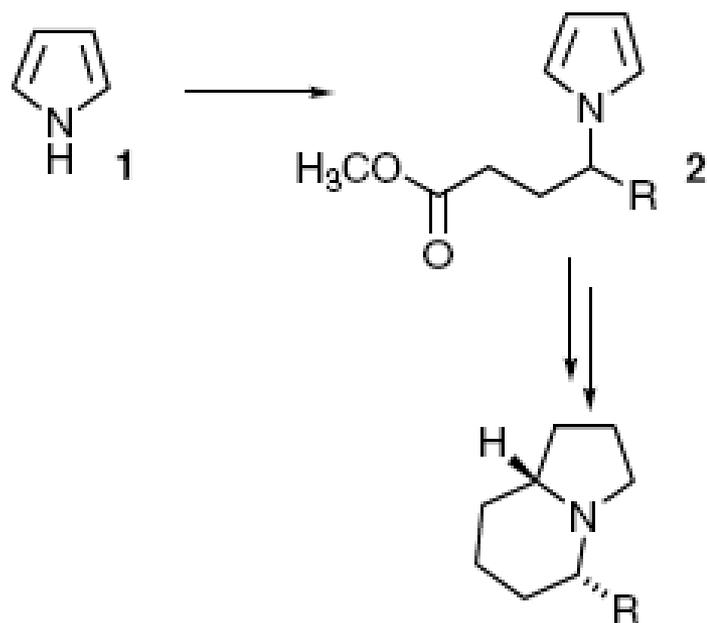
## Reacción de Clauson-Kaas



# A new and high yielding synthesis of unstable pyrroles via a modified Clauson-Kaas reaction

Brendon S. Gourlay,<sup>a</sup> Peter P. Molesworth,<sup>a</sup> John H. Ryan<sup>b</sup> and Jason A. Smith<sup>a,\*</sup>

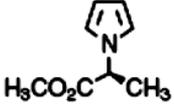
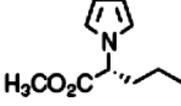
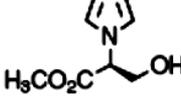
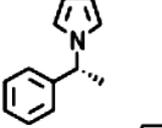
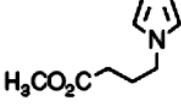
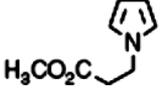
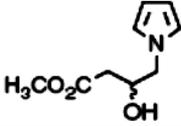
Tetrahedron Letters 47 (2006) 799–801



R =  $n\text{-C}_8\text{H}_{17}$  ( $\pm$ )-indolizidine 209D

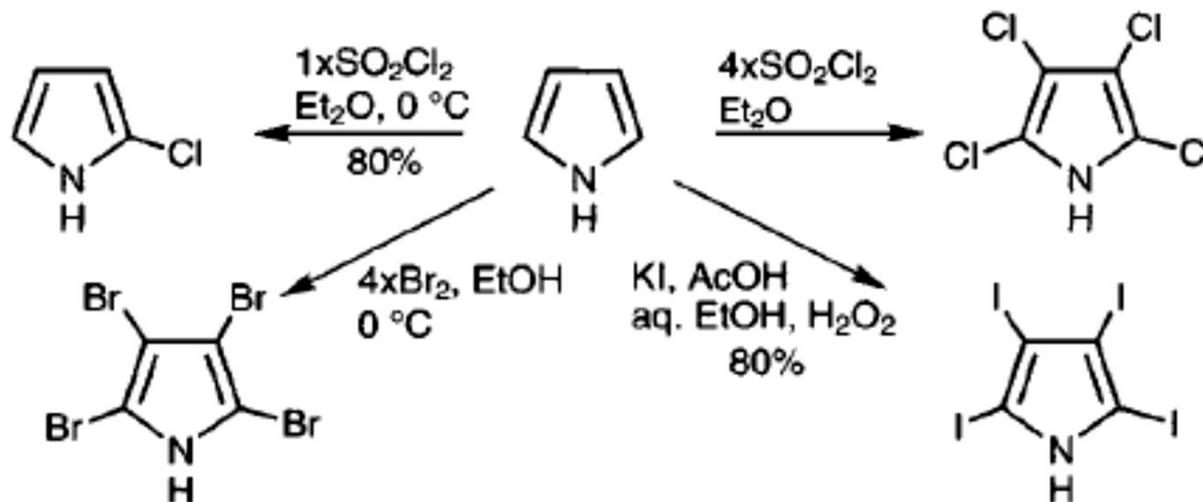
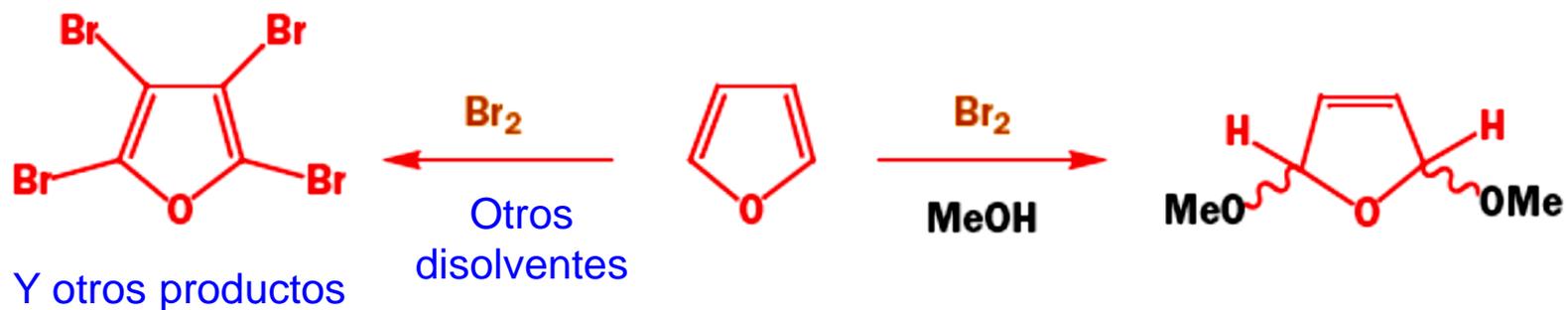


**Table 1.** Yields and ee's of pyrroles from the modified Clauson-Kaas reaction

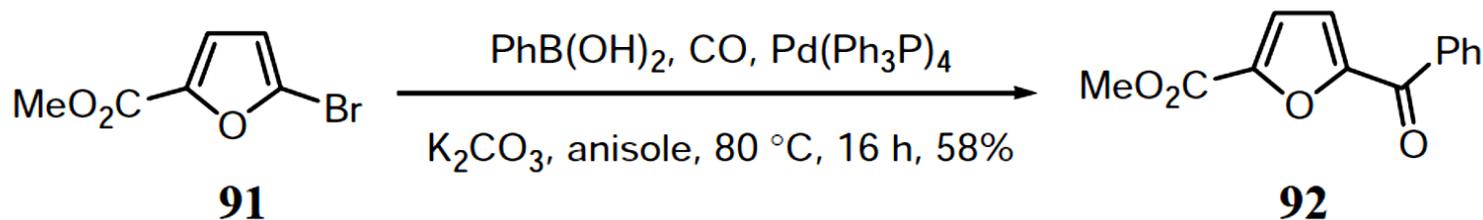
Entry	Amine	Product	Yield/% <sup>a</sup> (ee/%) <sup>b</sup>
1	L-Alanine methyl ester hydrochloride		93 (99)
2	D-Norvaline methyl ester hydrochloride		94 (99)
3	L-Serine methyl ester hydrochloride		89 (99)
4	R-(−)-Phenylethylamine		91 (99)
5	γ-Aminobutyric acid methyl ester hydrochloride		91
6	β-Alanine methyl ester hydrochloride		90
7	(±)-4-Amino-3-hydroxybutyric acid methyl ester hydrochloride		93

<sup>a</sup> Yields quoted are isolated yields.<sup>b</sup> ee's Determined by chiral GC on an Agilent Technologies Cyclosil B capillary (30 m, 0.25 mm, 0.25 μm) featuring a 30% heptakis (2,3-di-*O*-methyl-6-*O*-*tert*-butyldimethylsilyl)-β-cyclodextrin in DB-1701 stationary phase.

# HALOGENACIÓN



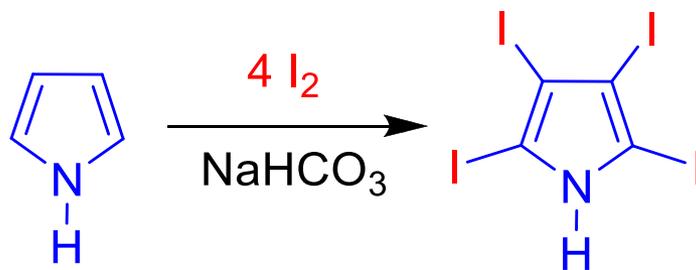
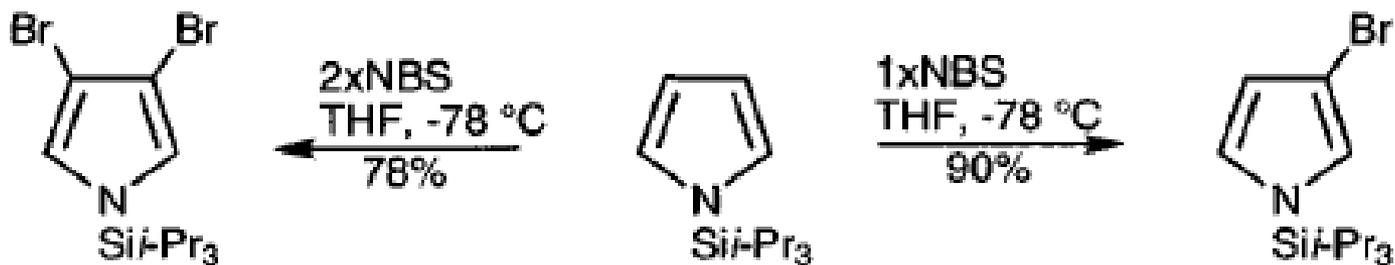
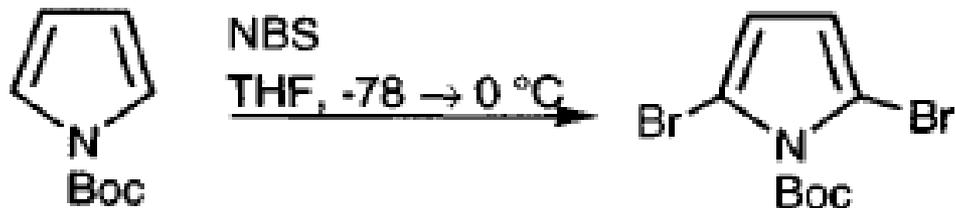
La reacción de acoplamiento cruzado de tres componentes catalizada por Pd entre reactivos de aril metal, monóxido de carbono y aril electrófilos es una ruta sencilla y conveniente para el síntesis de biaril cetonas asimétricas. La reacción de electrófilos deficientes en electrones, generalmente sufre de una reacción secundaria que da el producto de acoplamiento directo sin inserción de monóxido. Miyaura desarrolló un eficiente carbonilativo catalizado por Pd reacción de acoplamiento cruzado de tres componentes de un ácido arilborónico con aril electrófilos incluyendo un sustrato de bromofurano. Usando Pd (Ph<sub>3</sub>P)<sub>4</sub> como catalizador, el asimétrico biaril cetona **92** se sintetiza a partir de 2-bromofurano **91**. Es notable que el PdCl<sub>2</sub> (dppf), el catalizador de elección para otros haluros de arilo, proporciona un producto de acoplamiento directo exclusivo sin inserción de CO



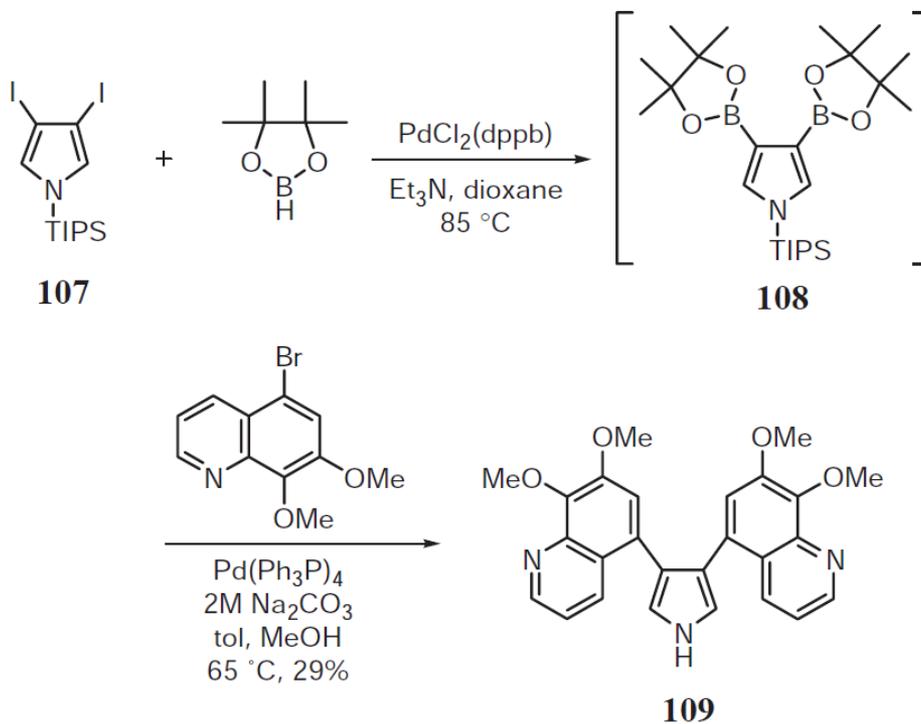
Ishiyama, T.; Kizaki, H.; Hayashi, T.; Suzuki, A.; Miyaura, N. *J. Org. Chem.* **1998**, *63*, 4726–31



# HALOGENACIÓN



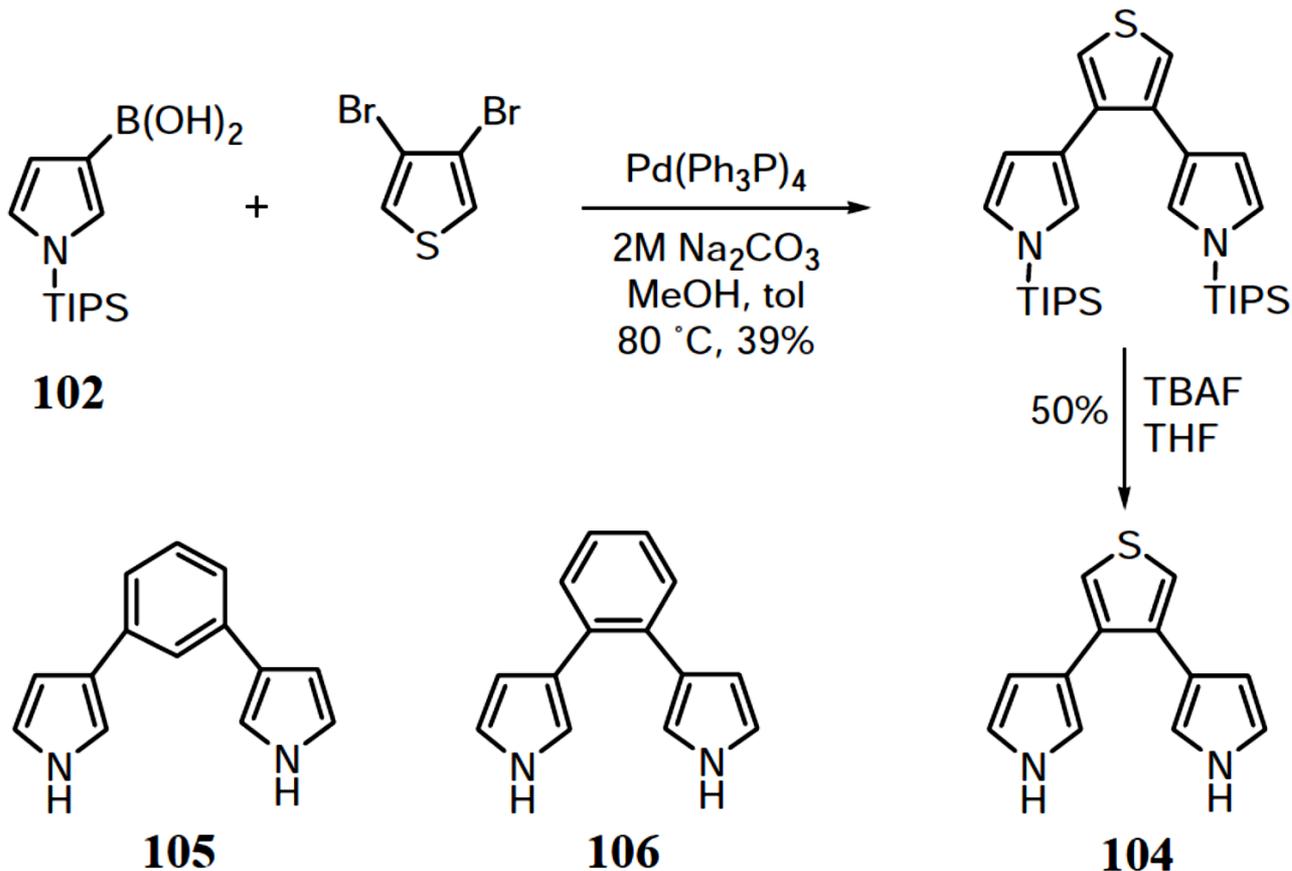
Banwell y sus colaboradores han convertido diiodopirrol 107 en bis-boronato 108, el cual sin purificación se acopló con éxito para producir la bis-quinolina pirrol 109



Banwell, M. G.; Bray, A. M.; Edwards, A. J.; Wong, D. J. *J. Chem. Soc., Perkin Trans. 1* **2002**, 1340–3.

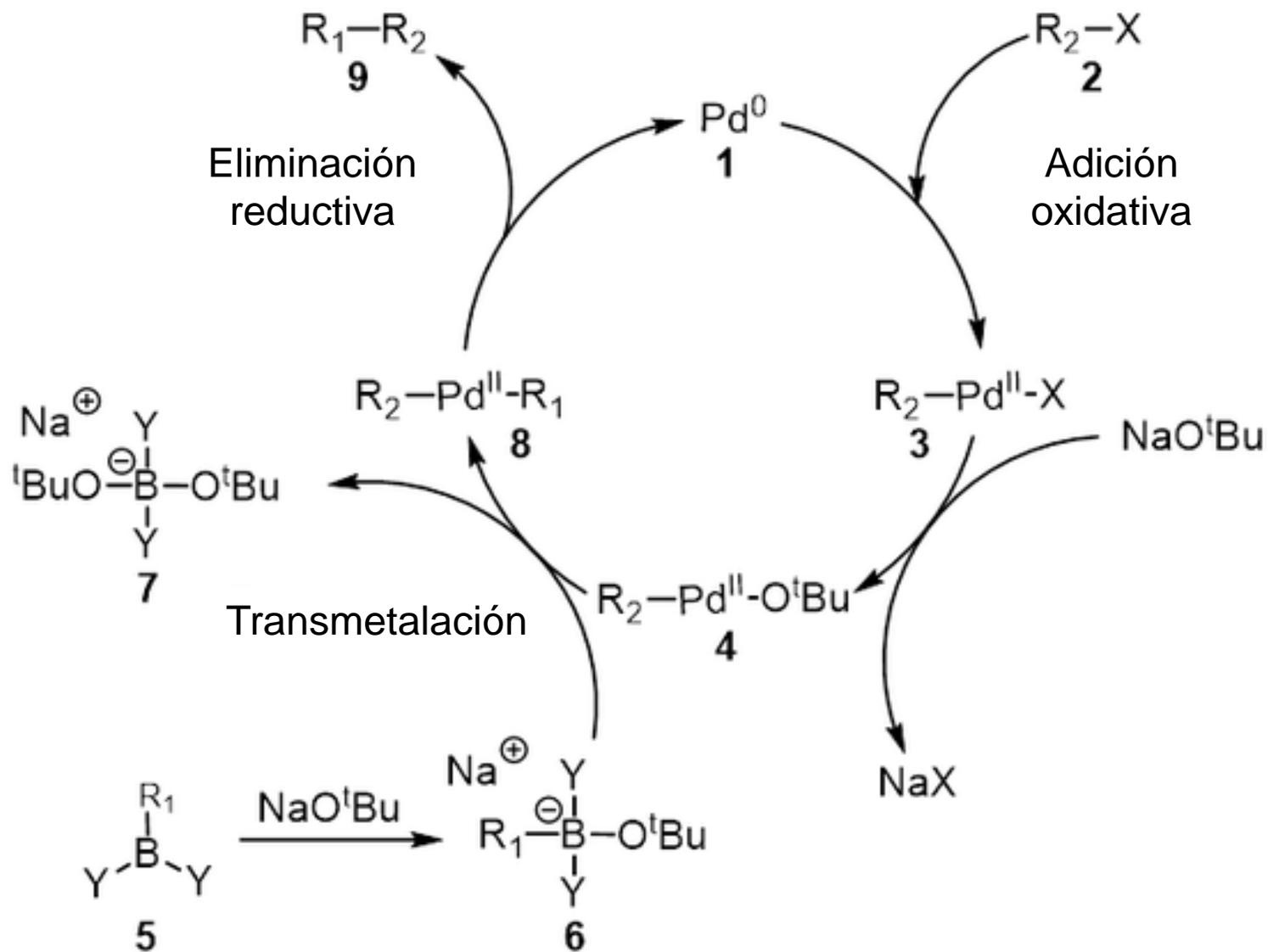


Swager ha utilizado ácido pirrol-3-borónico 102, que fue preparado a partir de 6 por NBS bromación (88%), litiación (BuLi) y boronación (B(OMe)<sub>3</sub>; aq MeOH) (50% en total), en las reacciones de Suzuki para sintetizar bis-pirroles 104-106, en una ruta sintética para obtener polímeros electrocrómicos

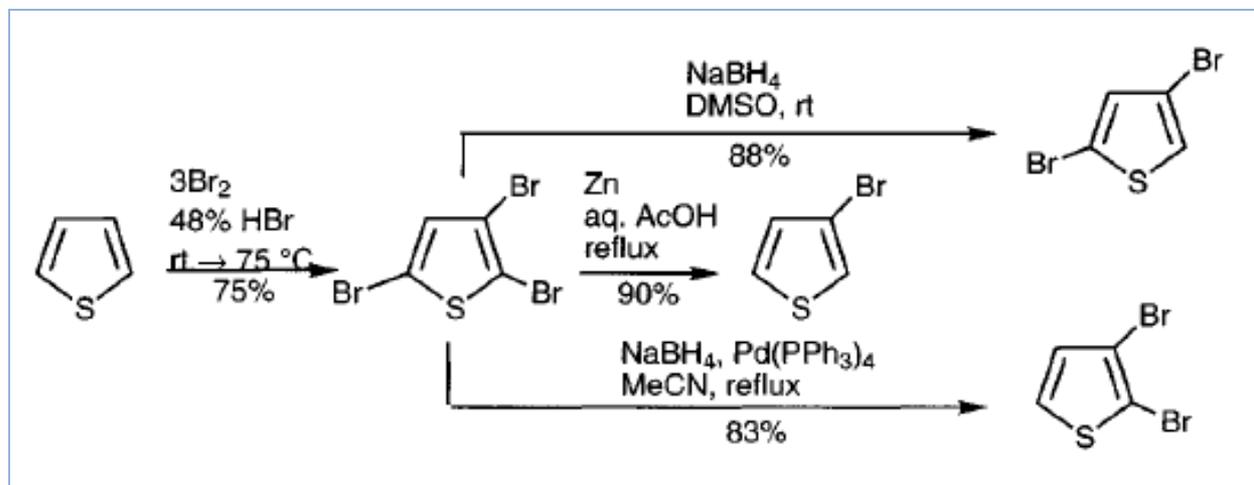
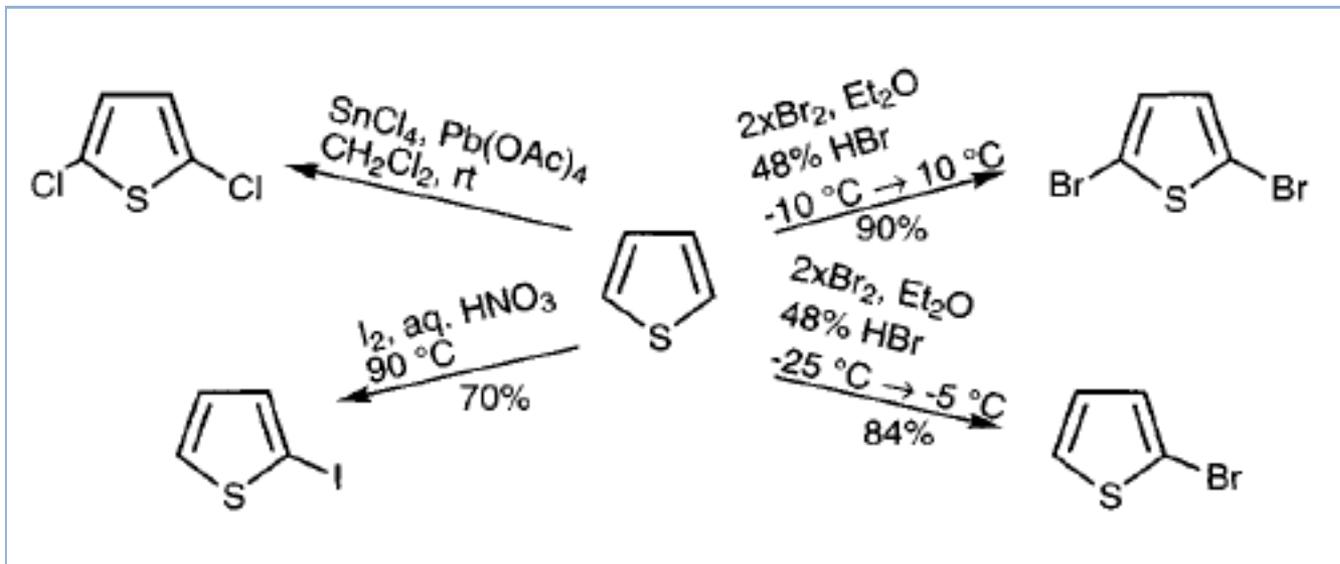


Nadeau, J. M.; Swager, T. M. *Tetrahedron* **2004**, *60*, 7141-6.

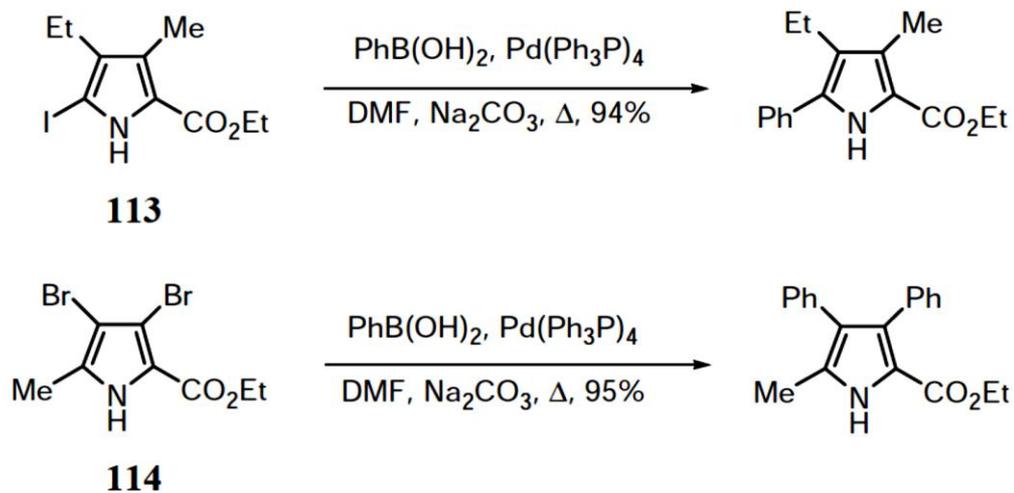




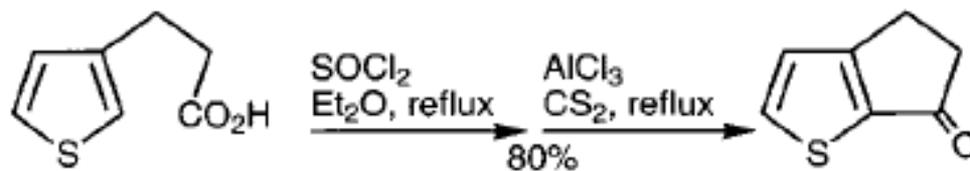
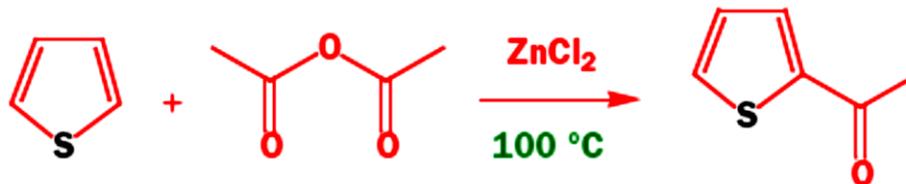
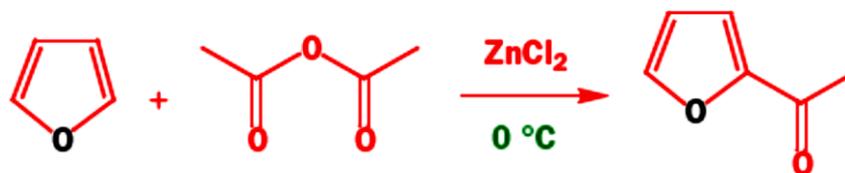
# HALOGENACIÓN



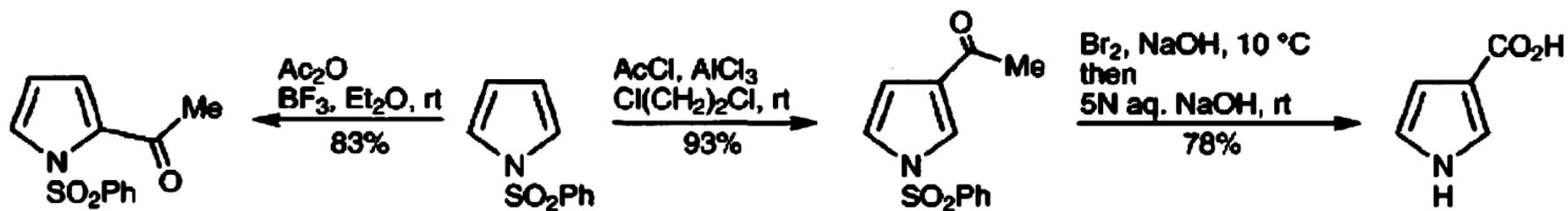
El componente pirrol también se puede emplear como haluro de arilo en el acoplamiento de Suzuki con ácidos aril borónicos. Por tanto, Chang ha efectuado varias de estas reacciones utilizando ácido fenilborónico y halopirrol como 113 y 114.



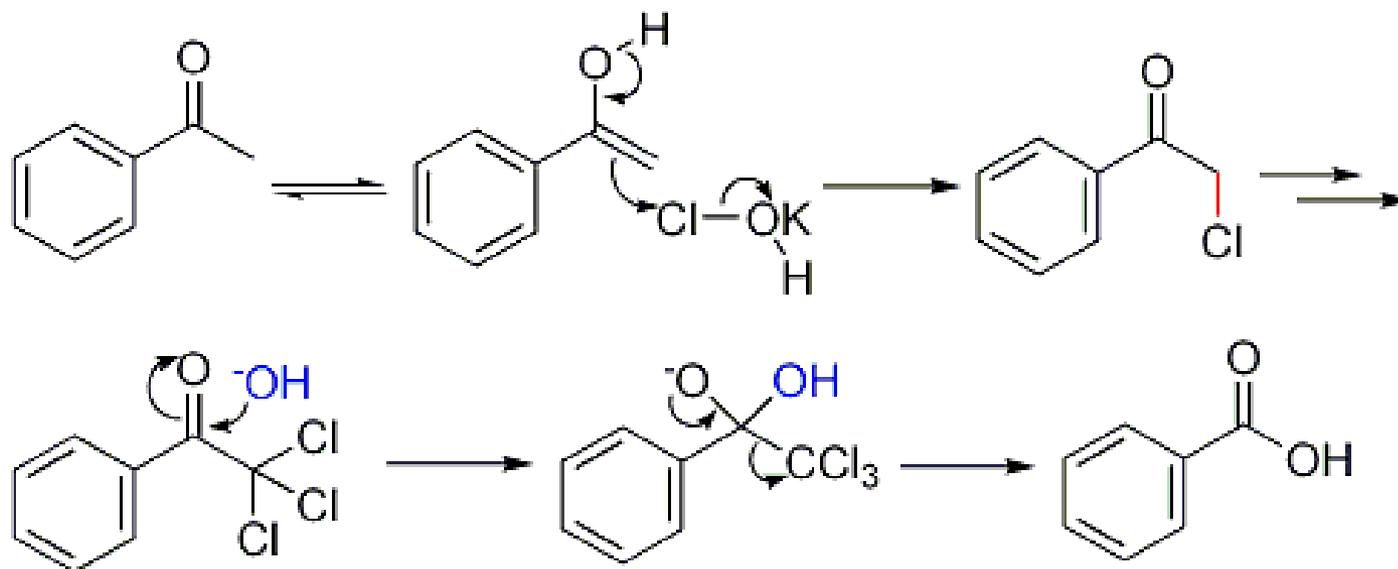
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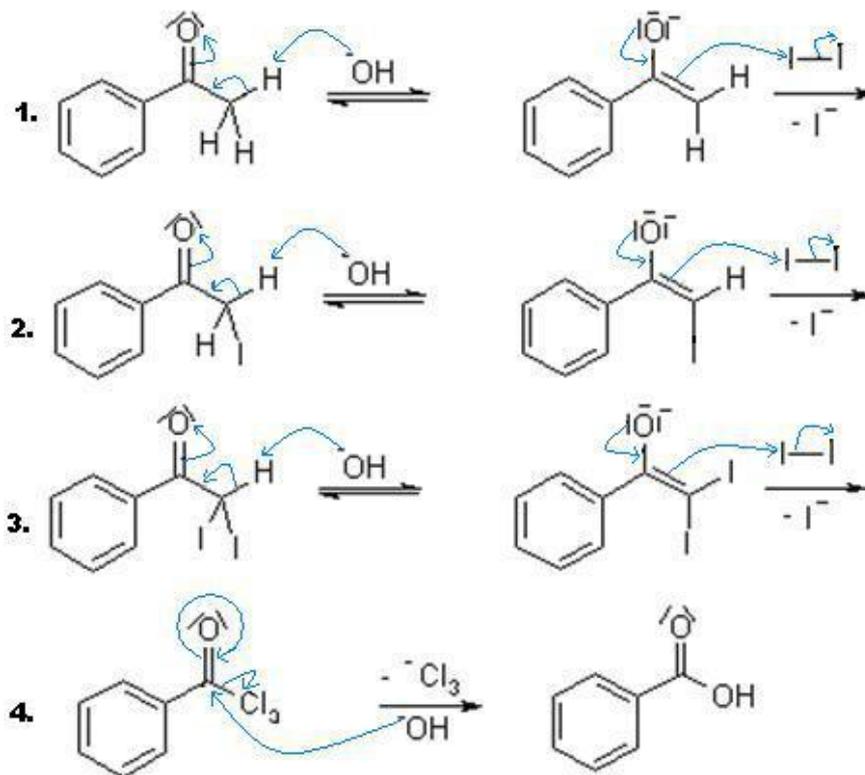
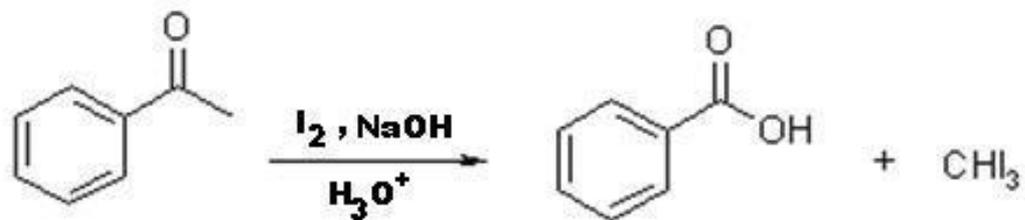
# ACILACIÓN



## REACCIÓN DEL CLOROFORMO

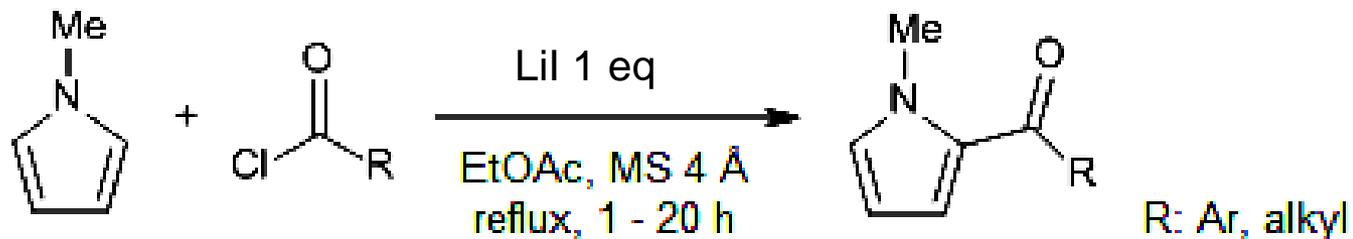


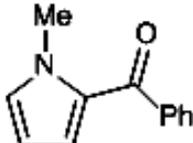
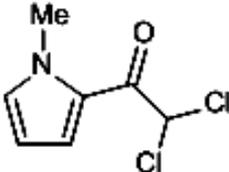
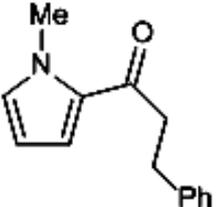
# REACCIÓN DEL YODOFORMO



## Iodide as an Activating Agent for Acid Chlorides in Acylation Reactions

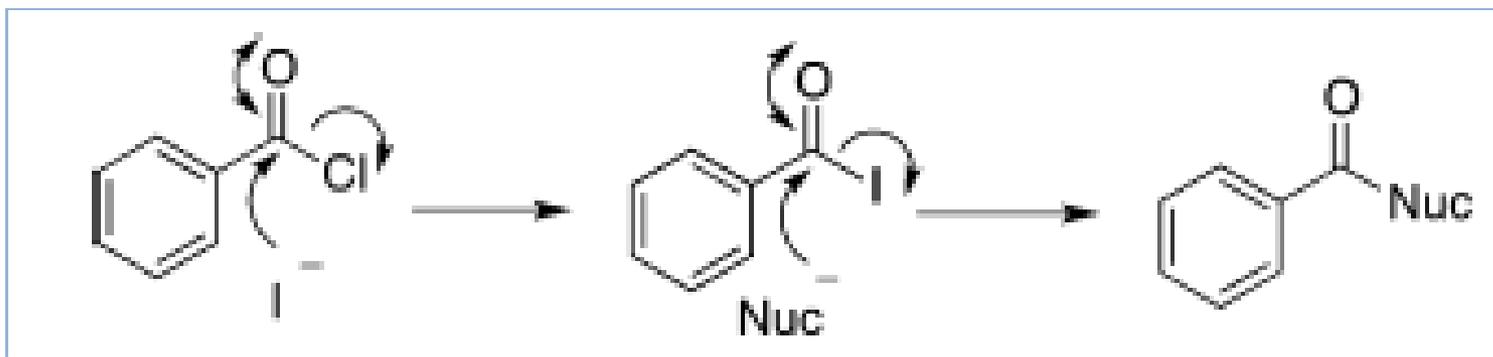
1.3 eq.



product	t (h)	yield (% isol.)
	1	68
	1	63
	4	50



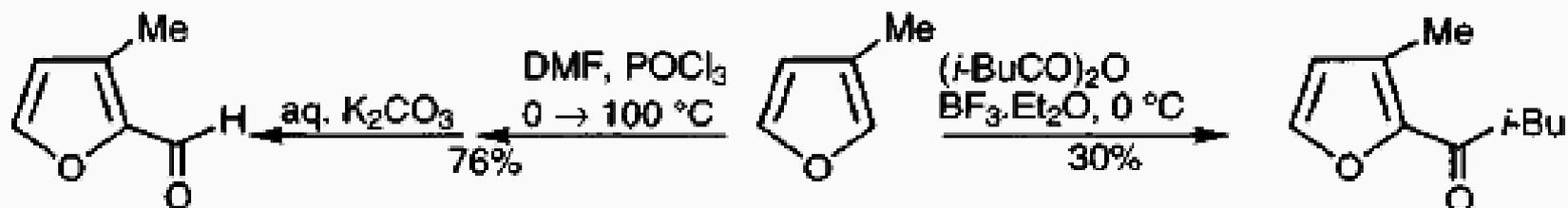
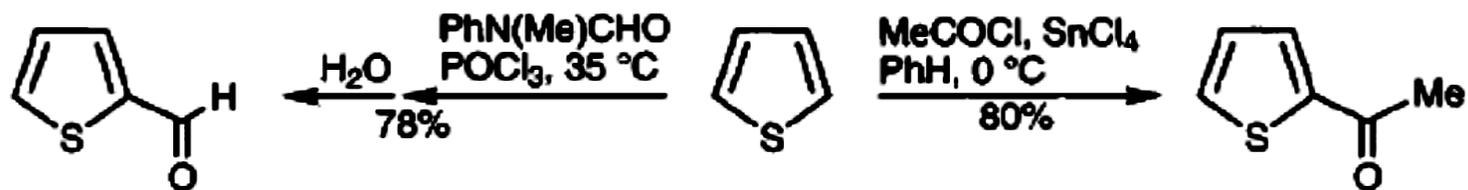
La activación ocurre por la formación del yoduro de acilo correspondiente



Yoduro de acilo



# ACILACIÓN



Anton Vilsmeier descubrió la reacción de Vilsmeier-Haack junto con Albrecht Haack



Anton Vilsmeier  
(1894 – 1962)  
Químico alemán



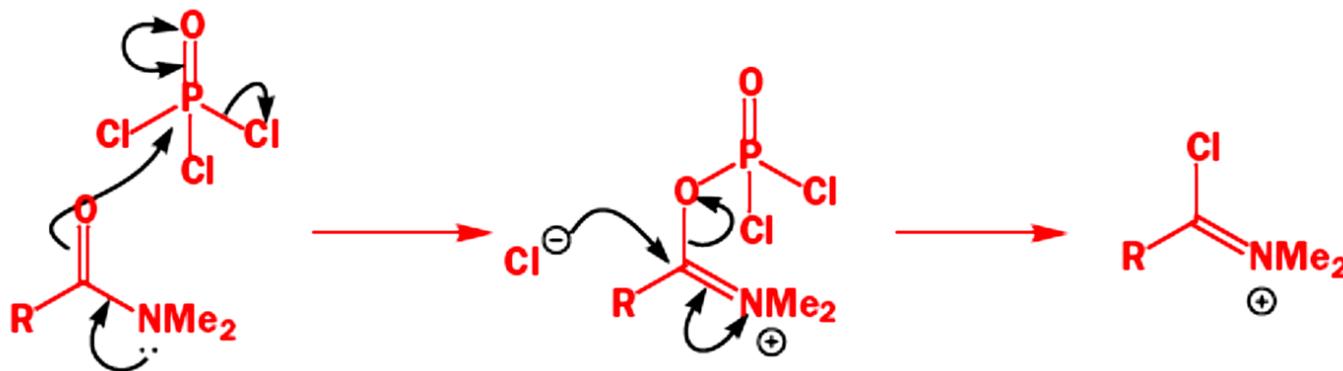
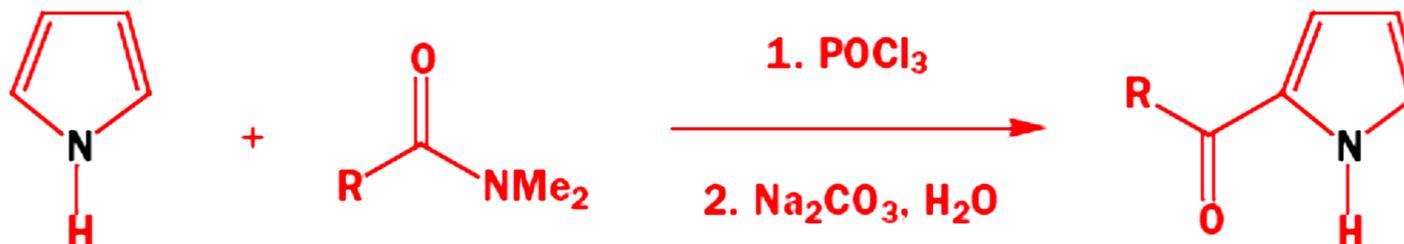
Albrecht Haack  
(1898-1976)  
Químico alemán



*Student und Assistent an der FAU:  
Dr. Anton Vilsmeier, Entdecker der  
nach ihm benannten chemischen Re-  
aktion. Foto: Archiv BASF*



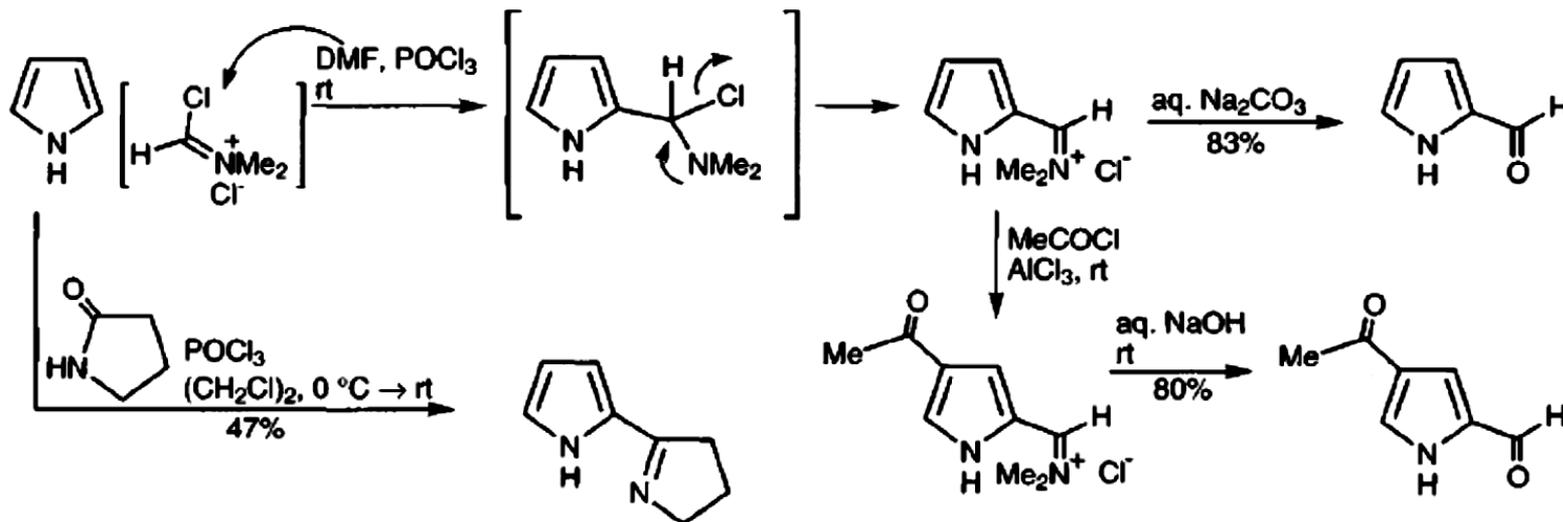
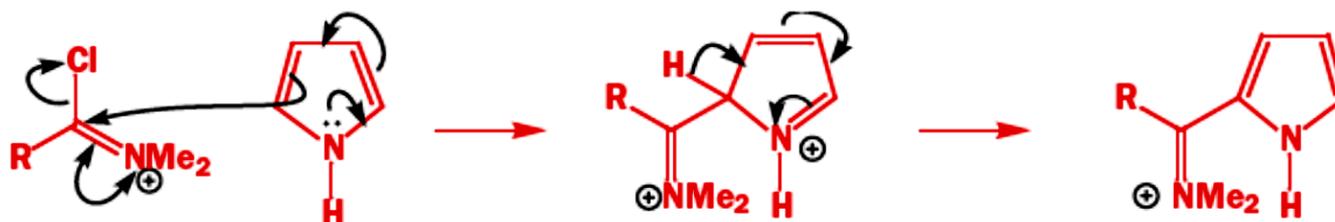
## REACCIÓN DE ACILACIÓN DE VILSMEIER-HAACK (ANTON VILSMEIER and ALBRECHT HAACK)



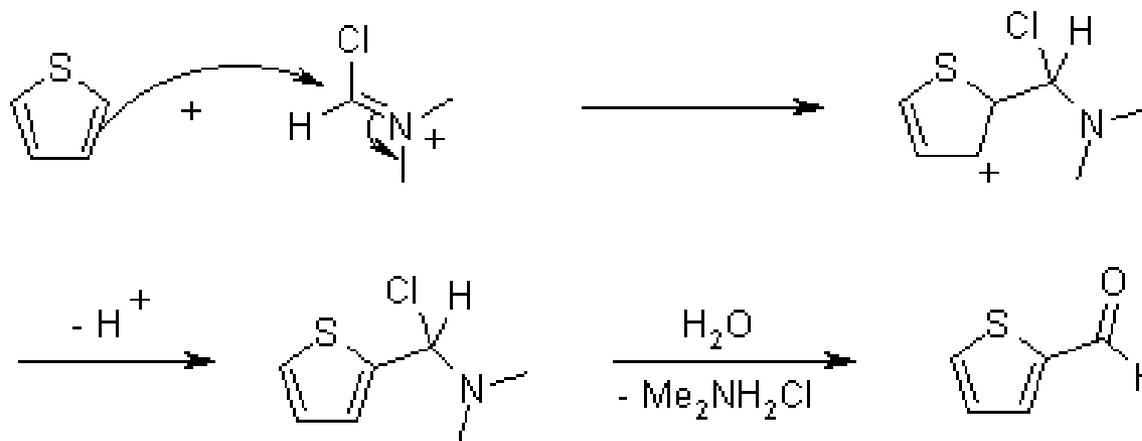
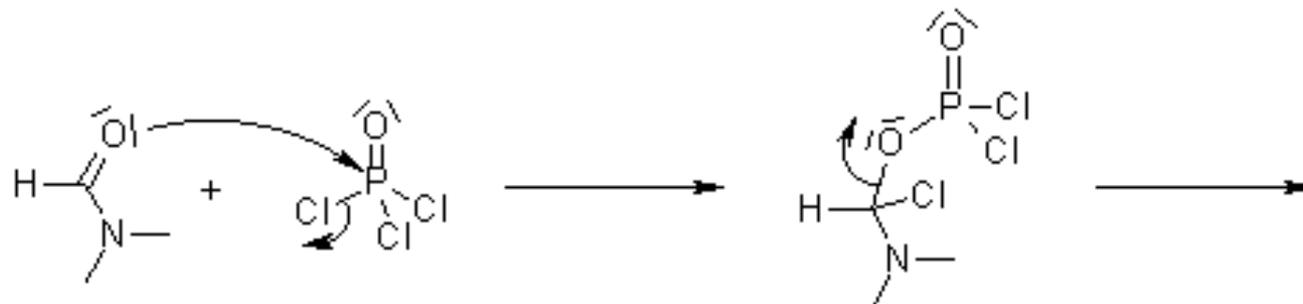
Vilsmeier, Anton; Haack, Albrecht *Berichte der Deutschen Chemischen Gesellschaft zu Berlin*. 1927,60: 119–122.  
Meth-Cohn, O.; Stanforth, S. P., *Compr. Org. Synth.* 1991,2, 777–794. [doi:10.1016/B978-0-08-052349-1.00049-4](https://doi.org/10.1016/B978-0-08-052349-1.00049-4).  
Campañe, E.; Archer, W. L. *Organic Syntheses*. 33,27. [doi:10.15227/orgsyn.033.0027](https://doi.org/10.15227/orgsyn.033.0027); *Collective Volume, 4*, p. 331



# REACCIÓN DE ACILACIÓN DE VILSMEIER-HAACK



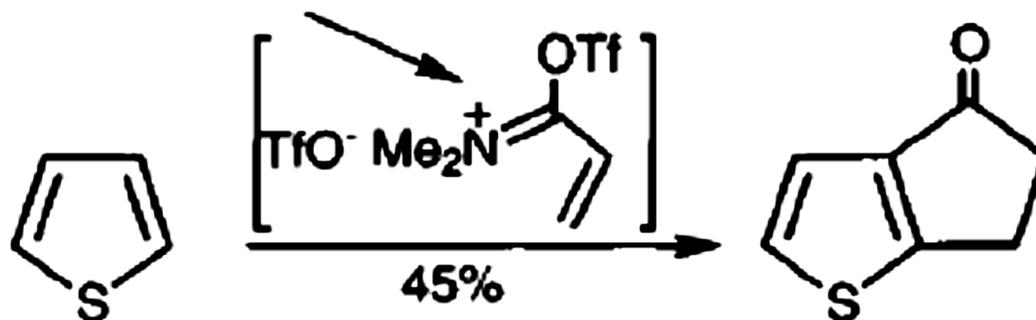
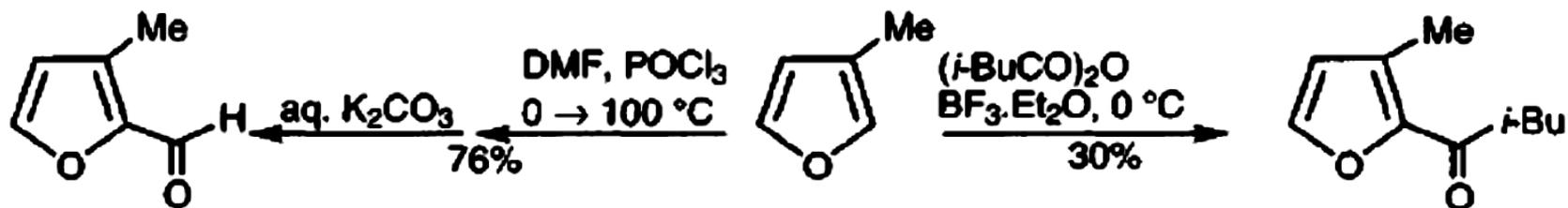
# REACCIÓN DE ACILACIÓN DE VILSMEIER-HAACK



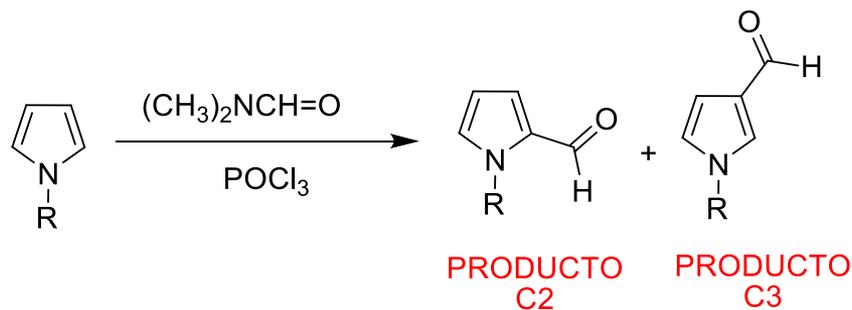
<https://www.organic-chemistry.org/namedreactions/vilsmeier-reaction.shtm>



## REACCIÓN DE ACILACIÓN DE VILSMEIER-HAACK



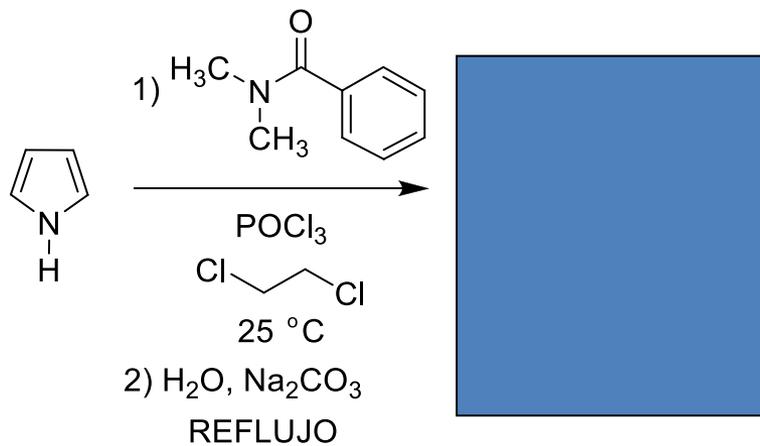
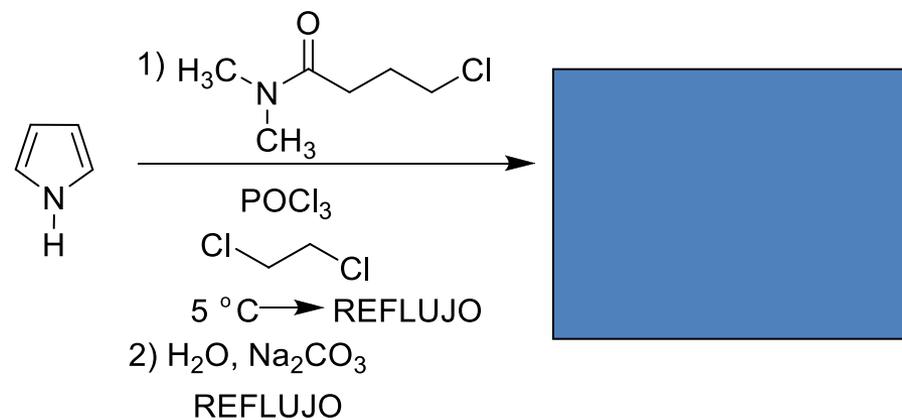
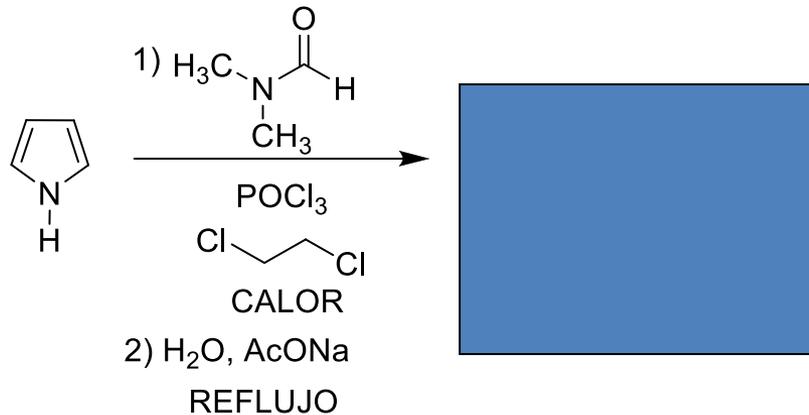
# INFLUENCIA DEL IMPEDIMENTO ESTÉRICO. FORMILACIÓN DE VILSMEIR-HAACK



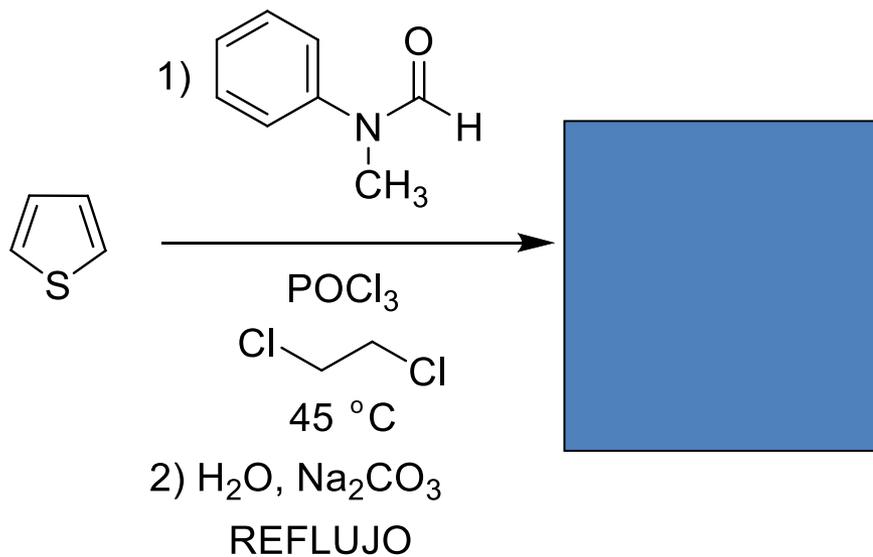
R:	<b>PROPORCIÓN 2 A 3</b>
—CH <sub>3</sub>	<b>&gt; 99 : &lt;1</b>
$\begin{array}{c} \text{H} \\   \\ \text{—C—CH}_3 \\   \\ \text{H} \end{array}$	<b>12 : 1</b>
$\begin{array}{c} \text{H} \\   \\ \text{—C—CH}_3 \\   \\ \text{CH}_3 \end{array}$	<b>1.9 : 1</b>
$\begin{array}{c} \text{CH}_3 \\   \\ \text{—C—CH}_3 \\   \\ \text{CH}_3 \end{array}$	<b>1 : 14</b>

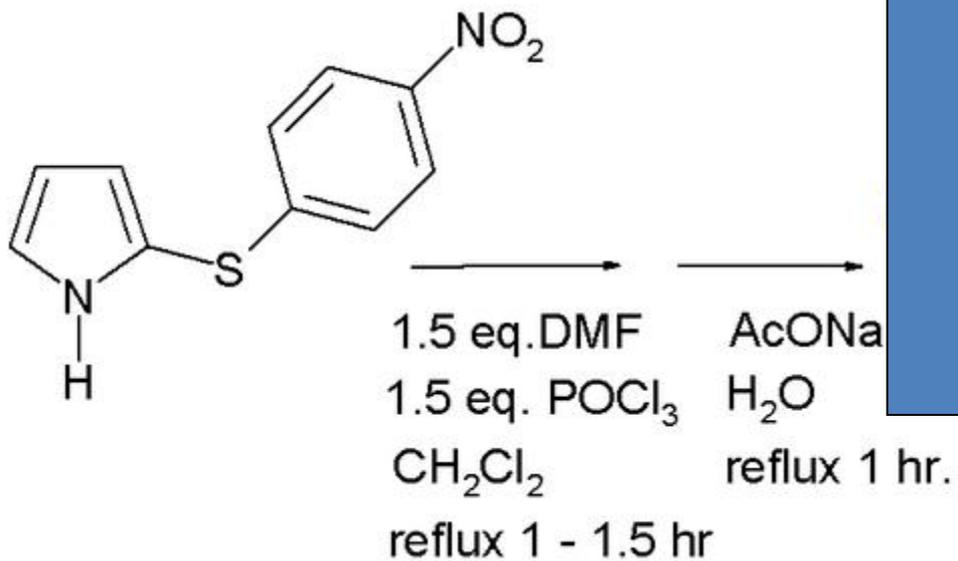


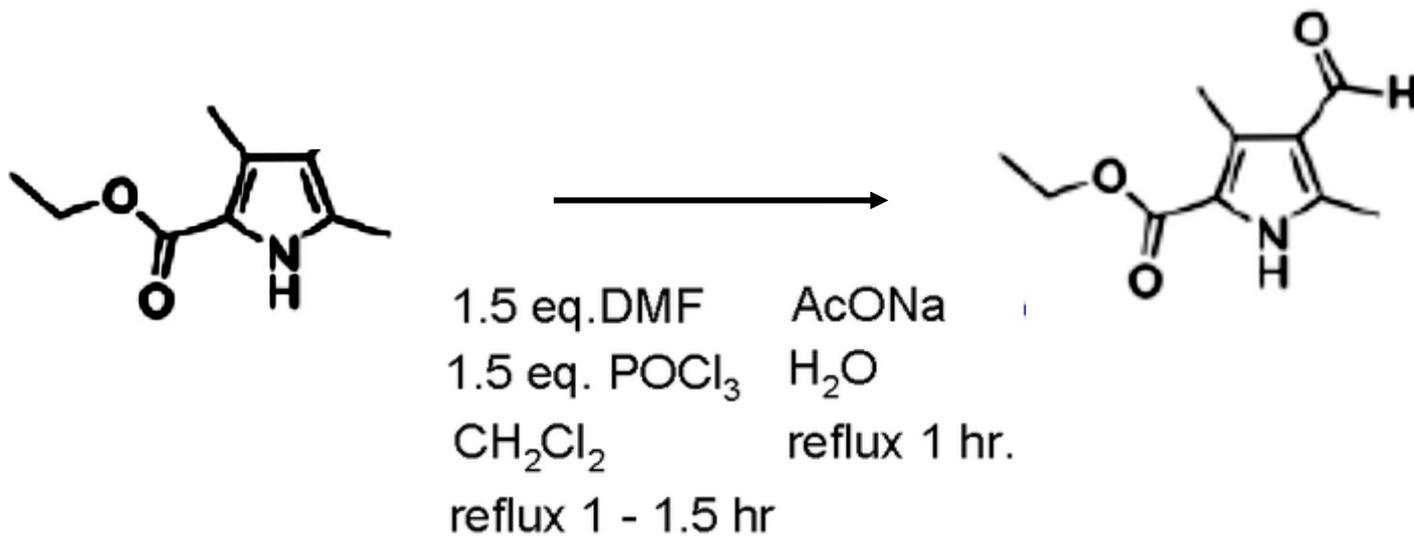
# VILSMEIR-HAACK



# REACCIÓN DE ACILACIÓN DE VILSMEIER-HAACK

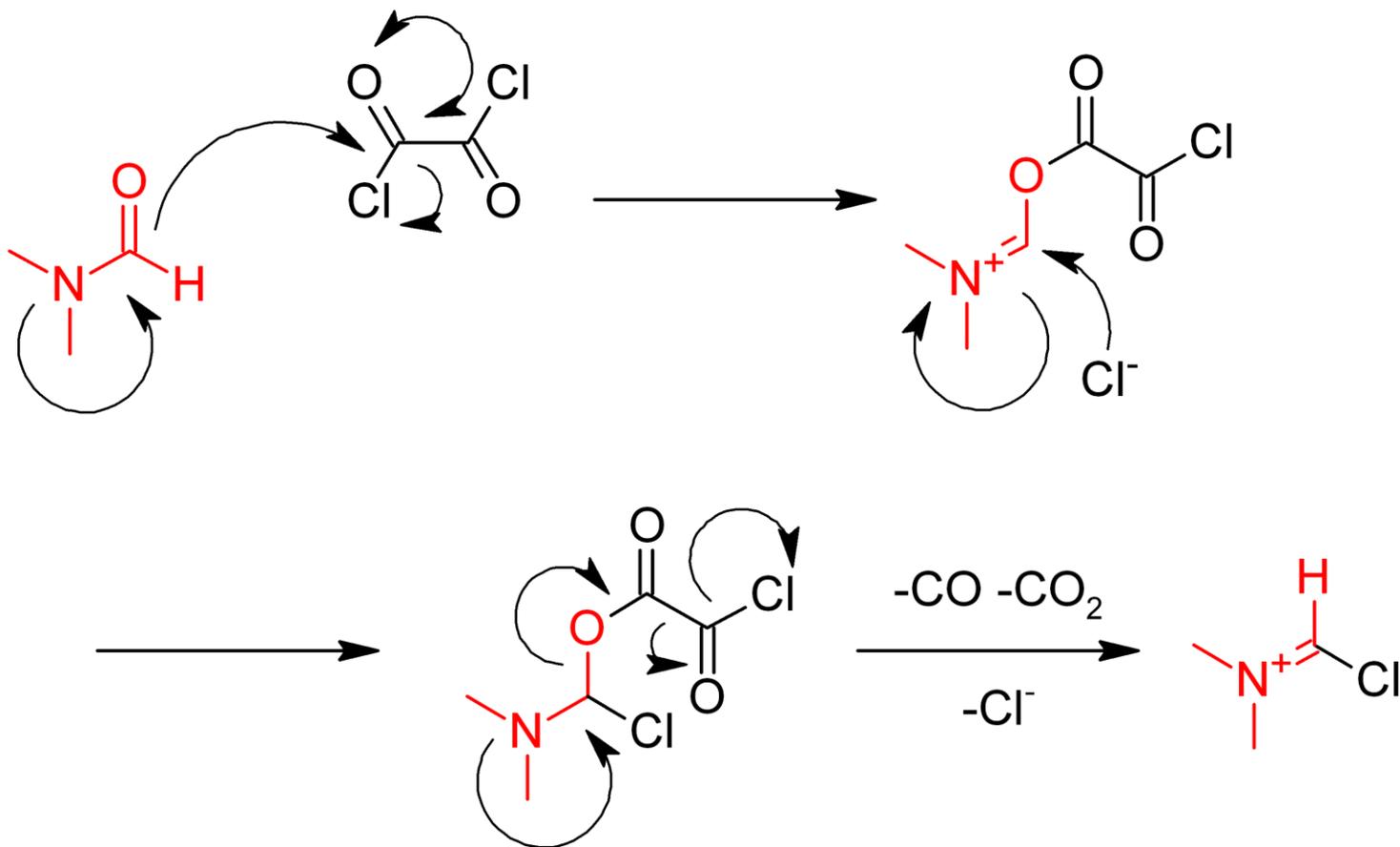








## Bestand: Reaction of oxalyl chloride with DMF

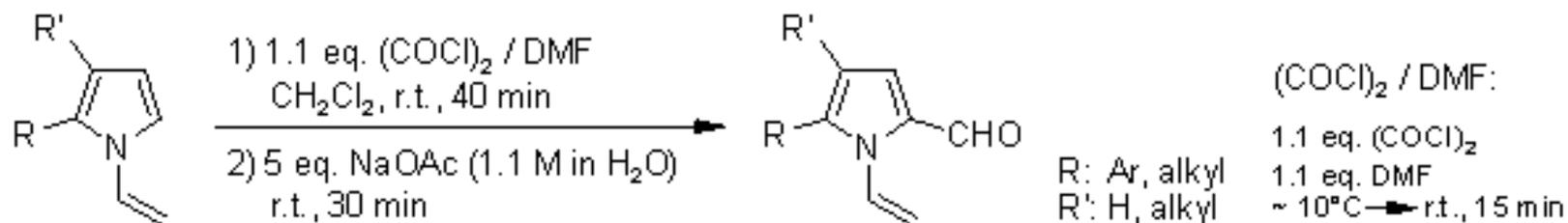


[https://nl.m.wikipedia.org/wiki/Bestand:Reaction\\_of\\_oxalyl\\_chloride\\_with\\_DMF.png](https://nl.m.wikipedia.org/wiki/Bestand:Reaction_of_oxalyl_chloride_with_DMF.png)



## An Efficient Route to 1-Vinylpyrrole-2-carbaldehydes

A. I. Mikhaleva, A. V. Ivanov, E. V. Skital'tseva, I. A. Ushakov, A. M. Vasil'tsov, B. A. Trofimov, *Synthesis*, 2009, 587-590.

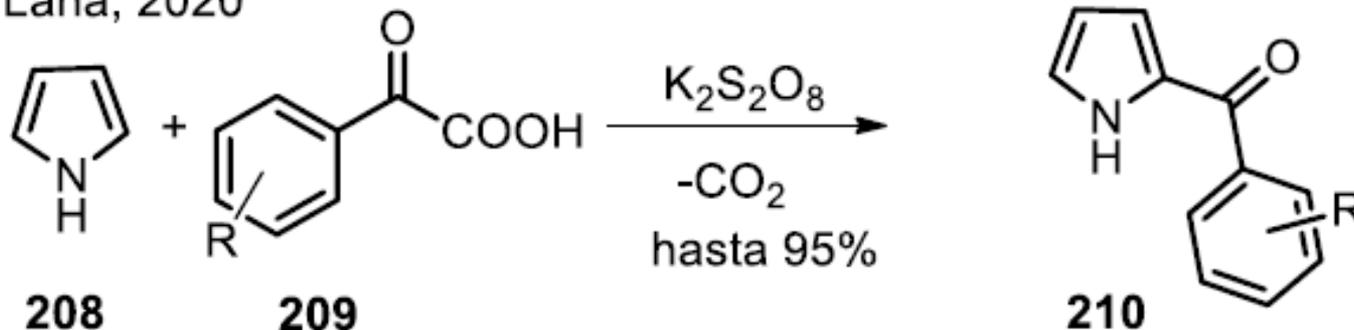


Product	Yield (% , isol.) $(\text{COCl})_2$ / DMF	Yield (% , isol.) $\text{POCl}_3$ / DMF <sup>1)</sup>
	48	28 <sup>2)</sup>
	93	66
	83	-
	97	88

- 1) A. I. Mikhaleva, A. B. Zaitsev, A. V. Ivanov, E. Yu. Schmidt, A. M. Vasil'tsov, B. A. Trofimov, *Tetrahedron Lett.*, **2006**, 47, 3693.  
 2) Previously unknown



C) Laha, 2020

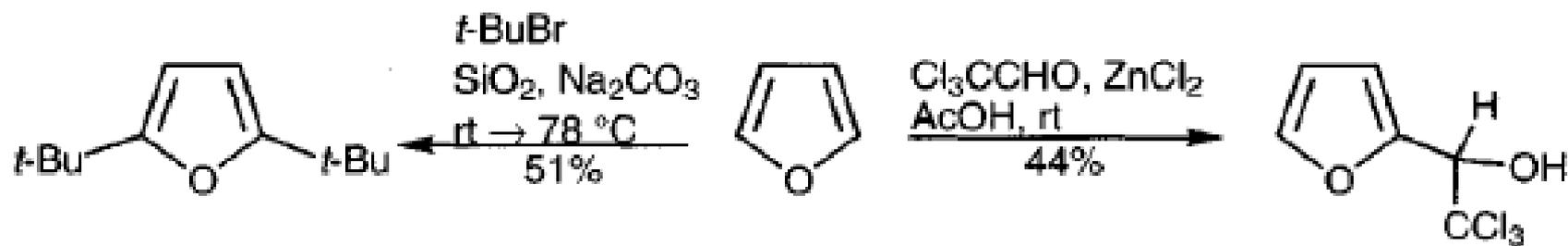


Recientemente, Laha y colaboradores describieron la monoacilación regioselectiva de tipo Minisci sobre pirroles ricos electrónicamente **208** a partir de ácidos acil-glioxálicos **209** bajo condiciones libres de Ag. Experimentos de control confirmaron la formación de un radical acilo, aunque el mecanismo de reacción requiere de estudios complementarios (C).

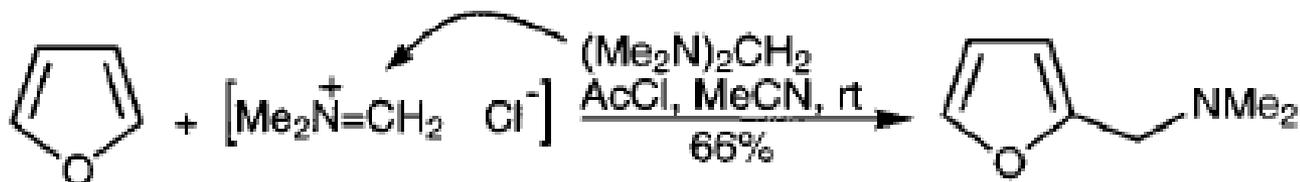
Laha, J. K.; Hunjan, M. K.; Hedge, S.; Gupta, A. *Org. Lett.* **2020**, 22, 1442-1447



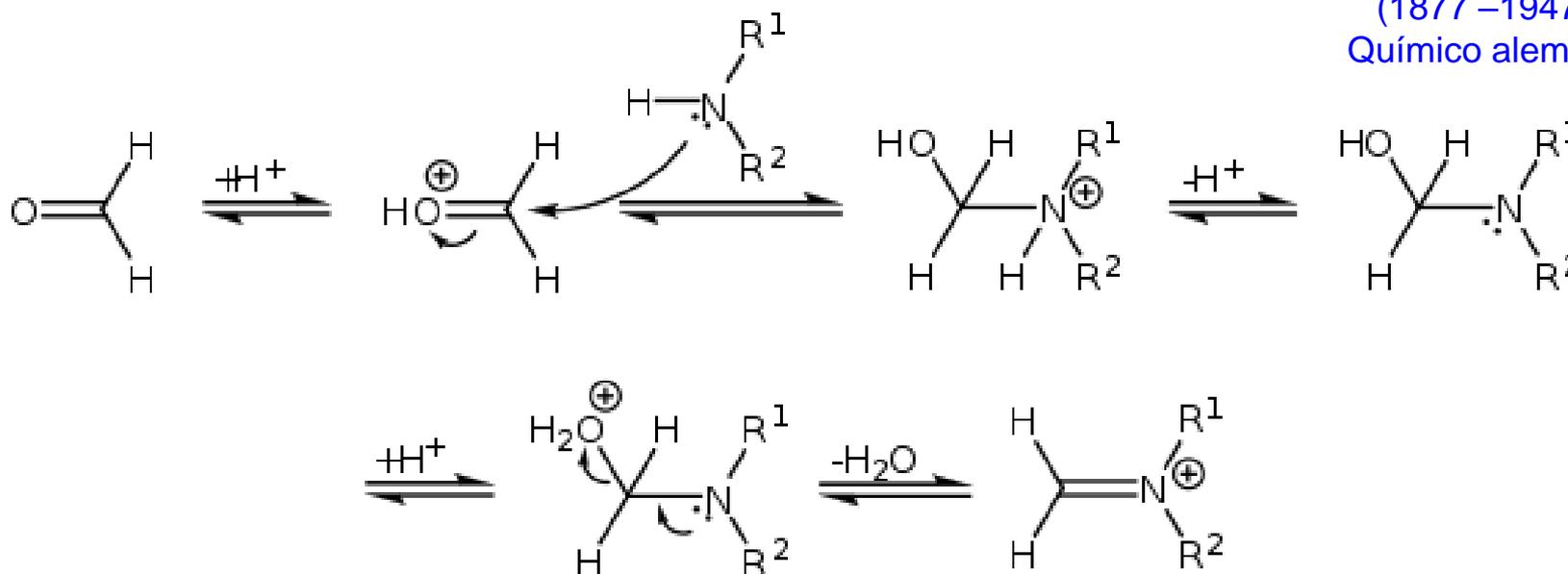
# ALQUILACIÓN



## REACCIÓN DE MANNICH (Carl Ulrich Franz Mannich )



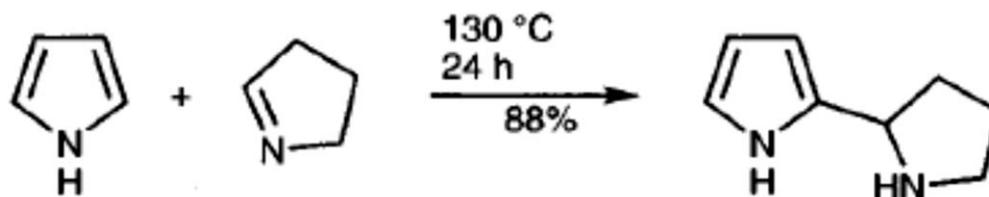
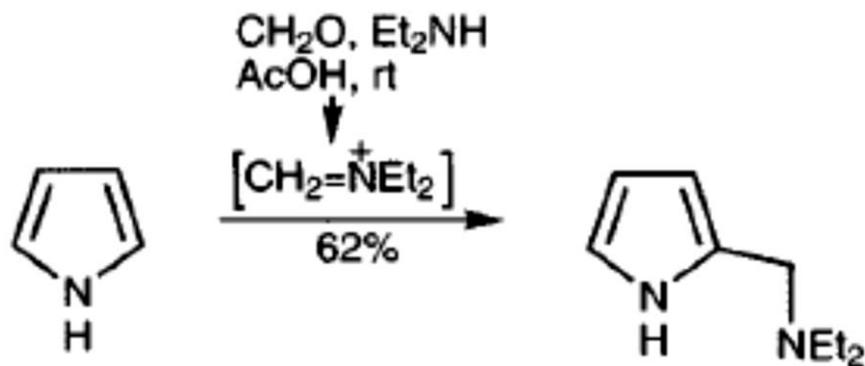
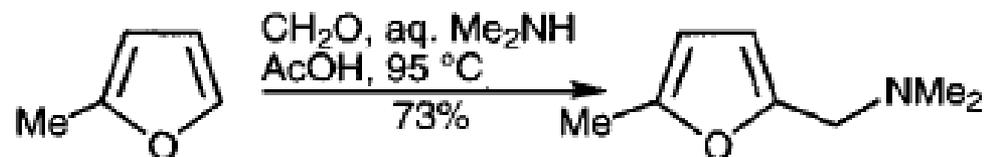
Carl Ulrich Franz Mannich  
(1877 –1947)  
Químico alemán



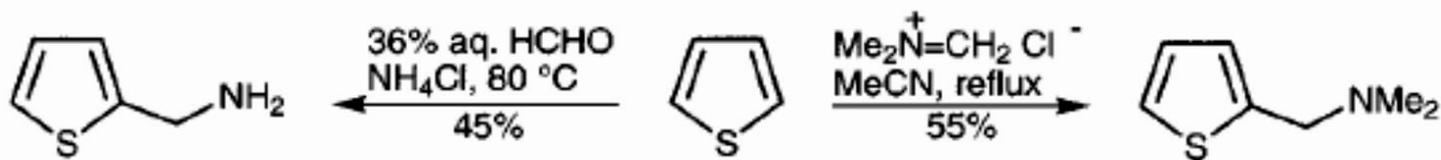
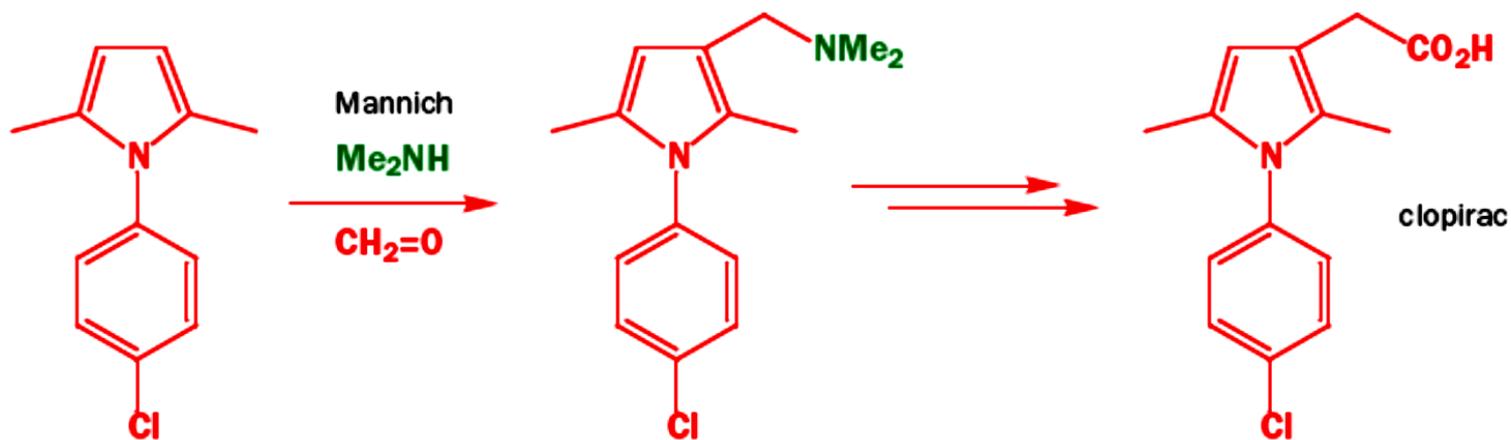
<http://www.liveinternet.ru/users/kakula/post316185121/>



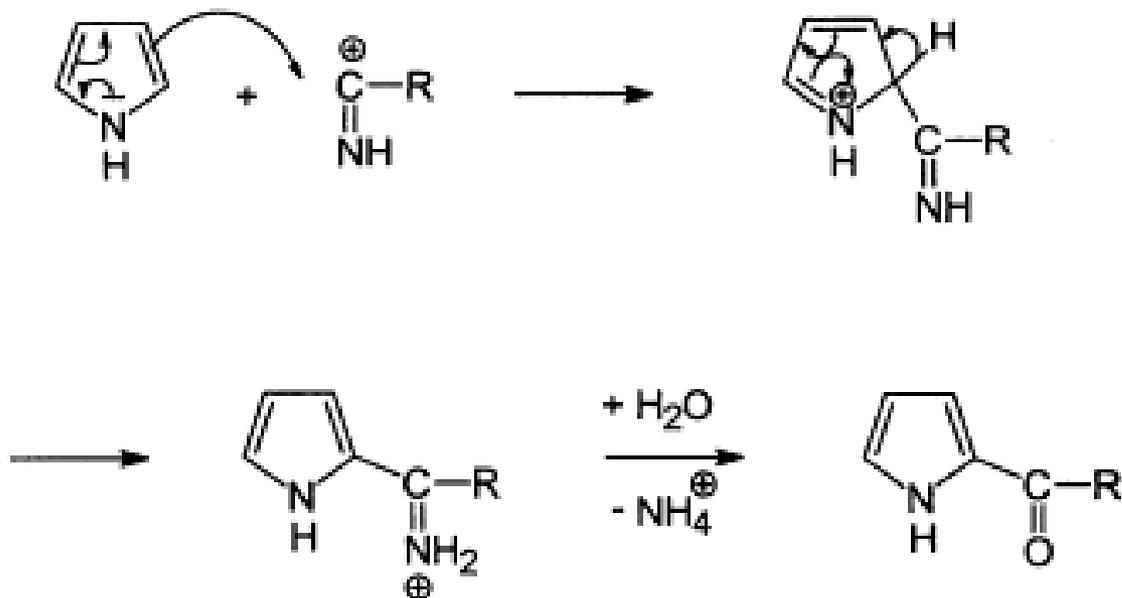
## REACCIÓN DE MANNICH



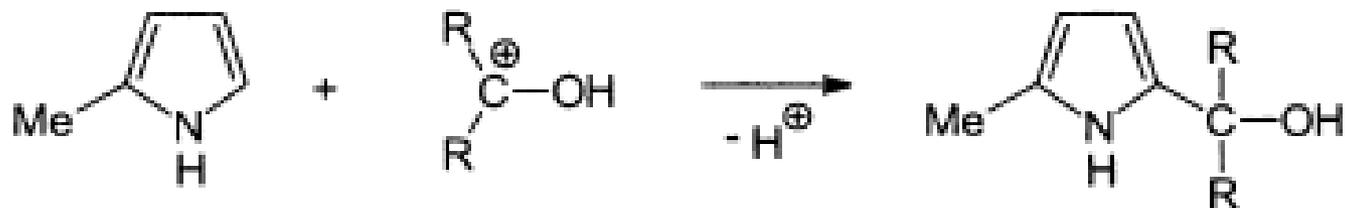
# REACCIÓN DE MANNICH



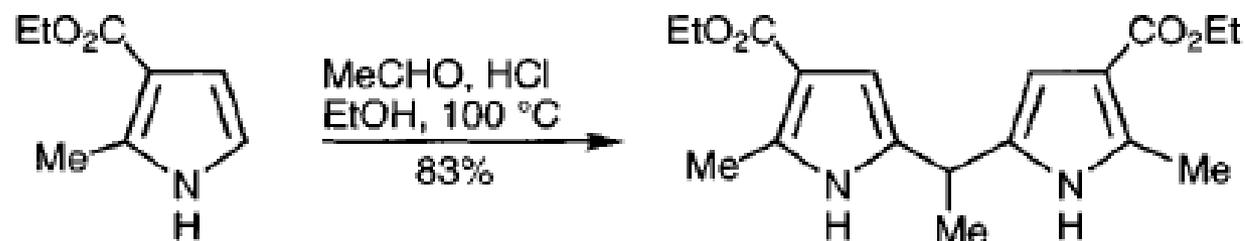
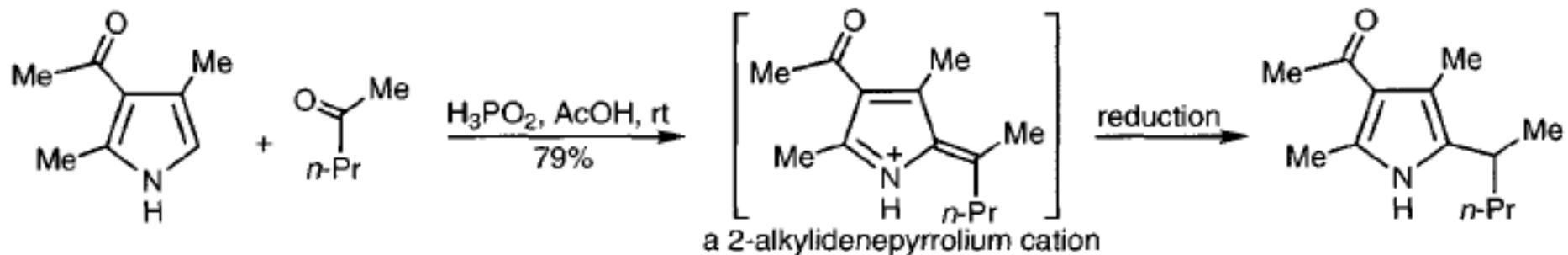
## REACCIÓN DE ACILACIÓN DE HOUBEN-HOESCH



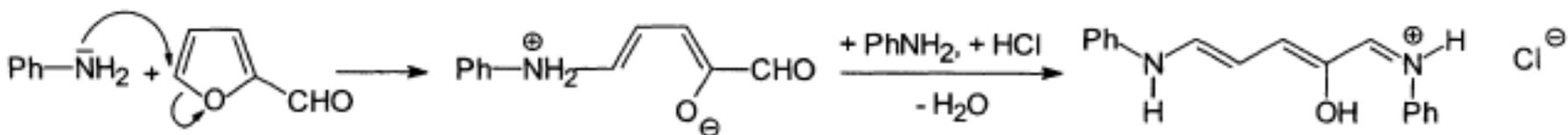
# REACCIONES CON ALDEHÍDOS



# REACCIONES CON ALDEHÍDOS

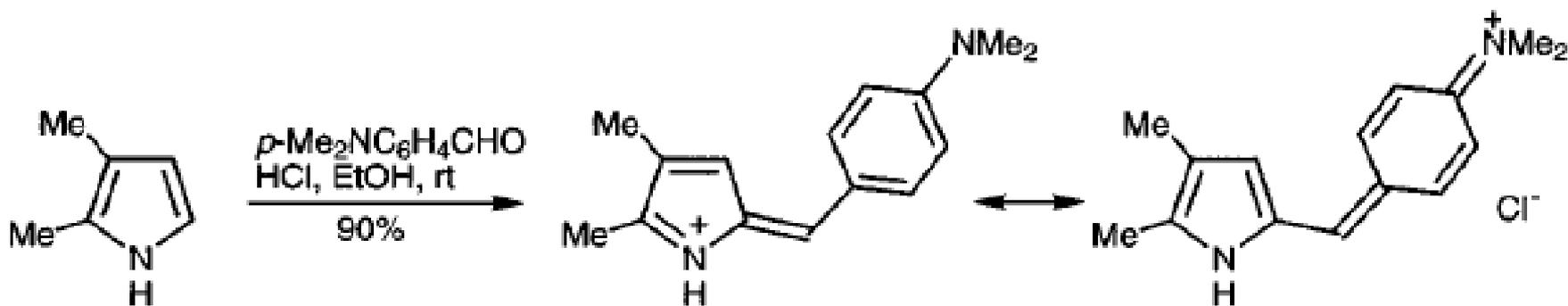


# REACCIONES CON ALDEHÍDOS

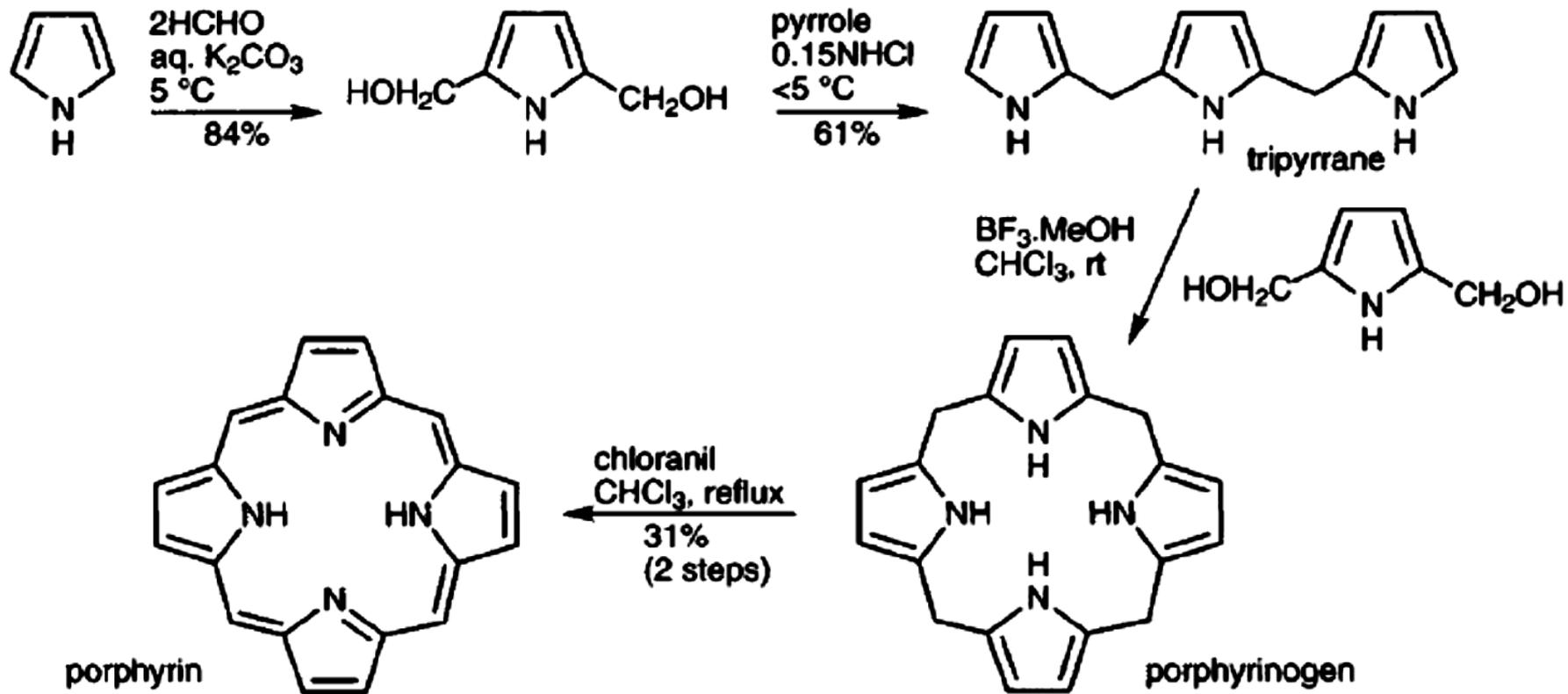


Colorante polimetino  
(rojo)

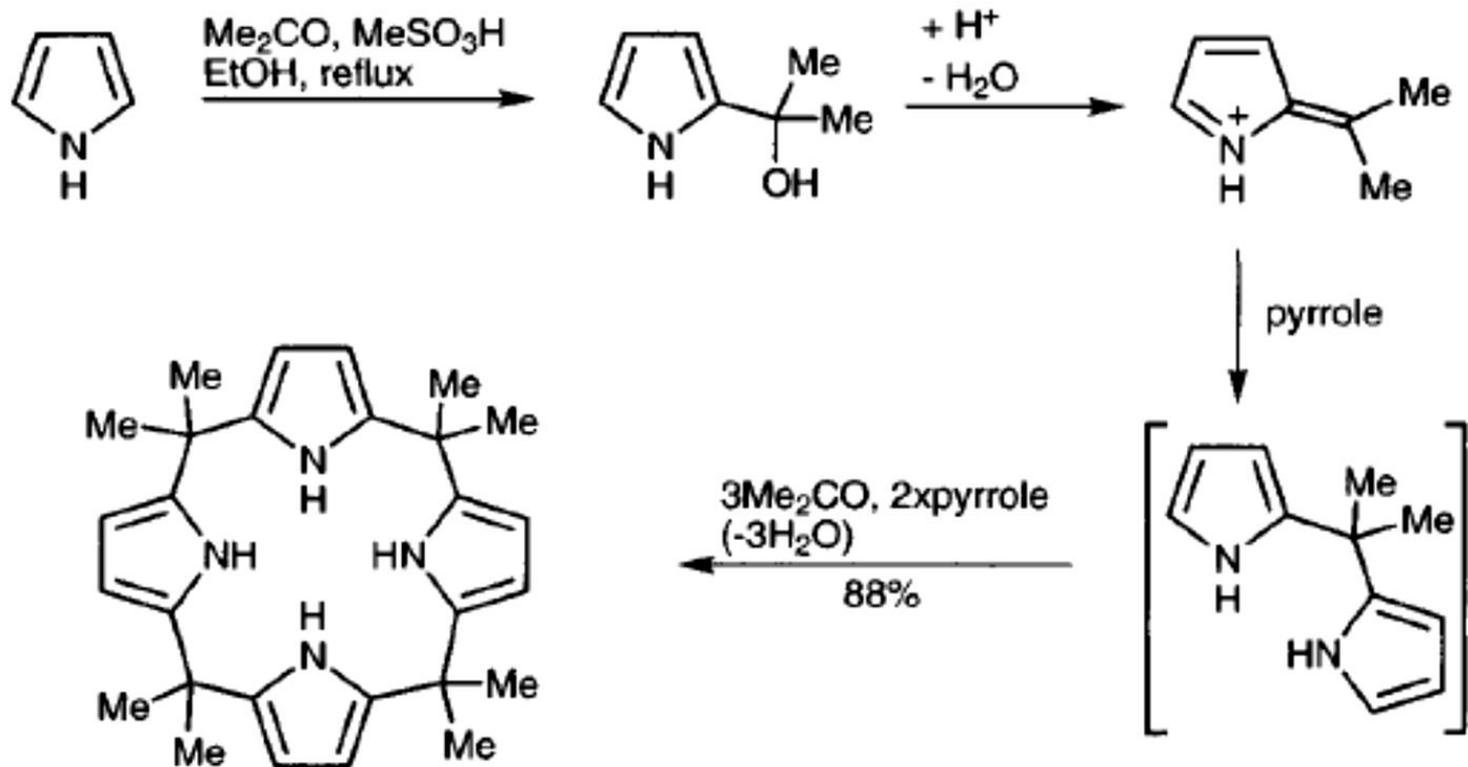
Con el reactivo de Ehrlich, *i.e.* una solución del 4-(dimetilamino)benzaldehído en presencia de HCl, la reacción procede para dar una sal de azafulvenio de color púrpura:  $\text{NMe}_2$



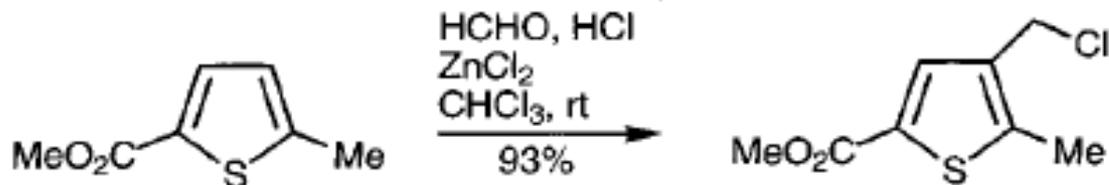
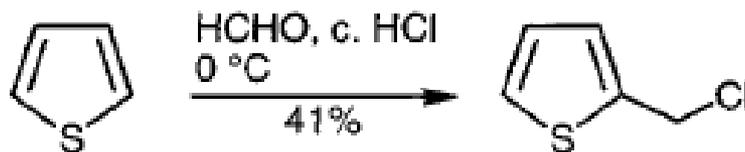
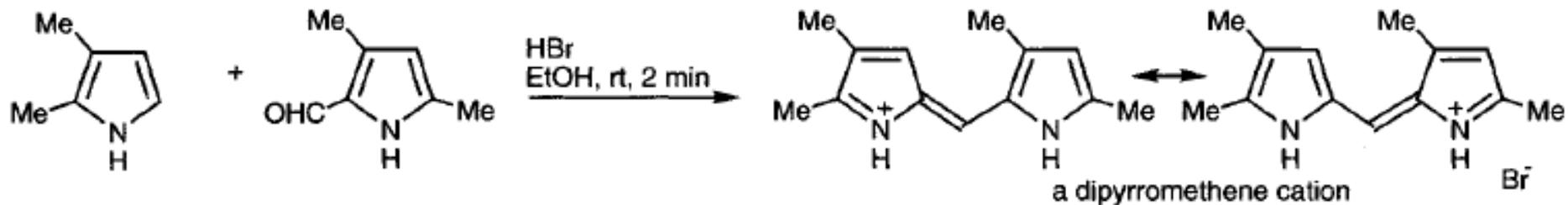
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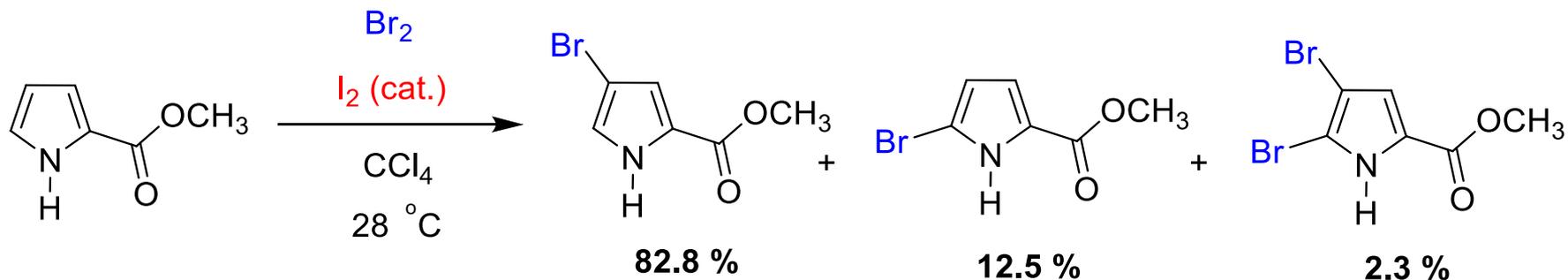
# REACCIONES CON CETONAS



# REACCIONES CON ALDEHÍDOS



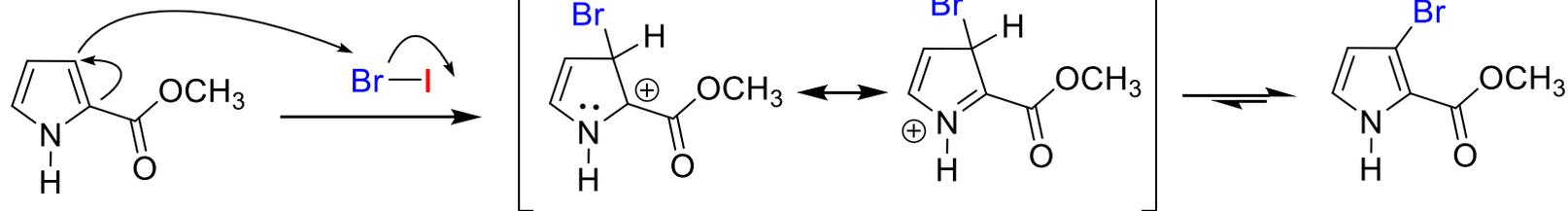
# REACCIONES DE DISUSTITUCIÓN (SEAr)



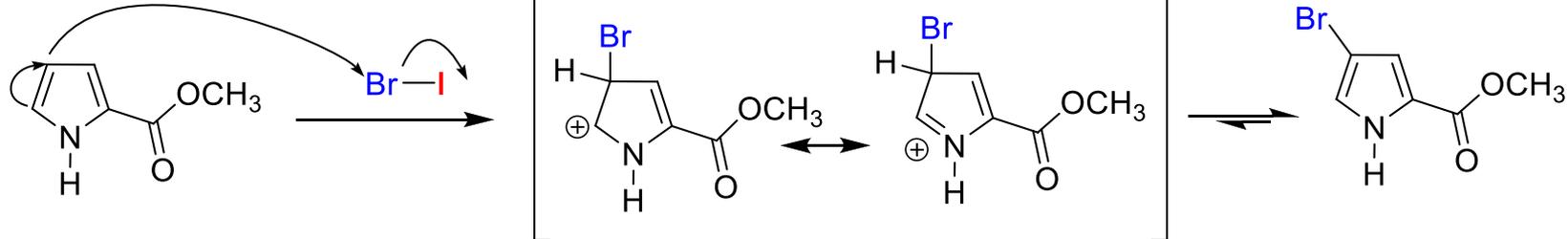
CLASE DEL 12-10-2021



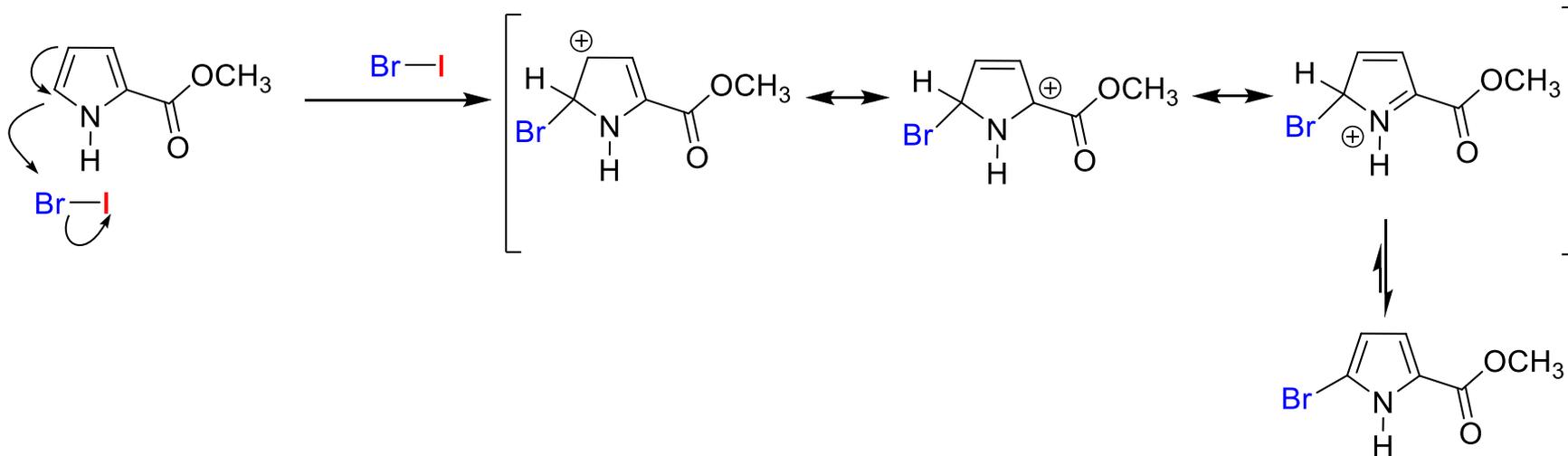
ATAQUE C3



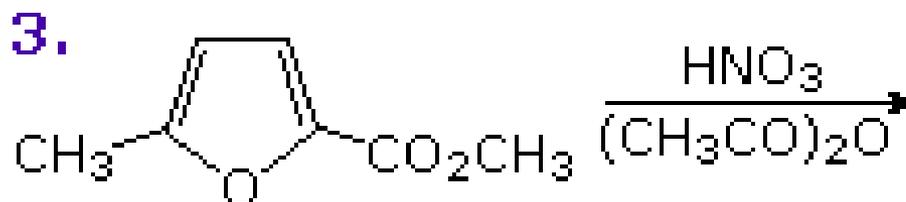
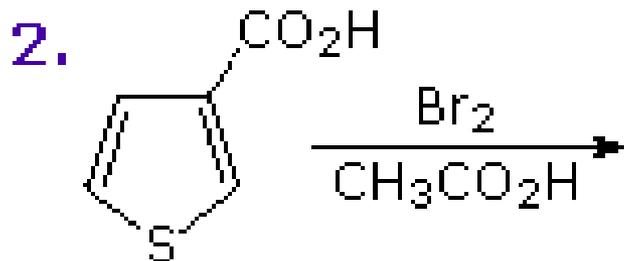
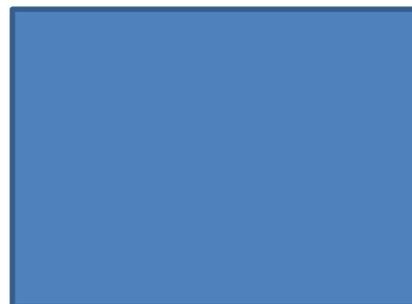
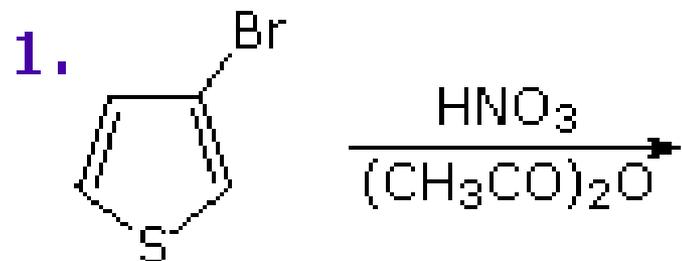
ATAQUE C4



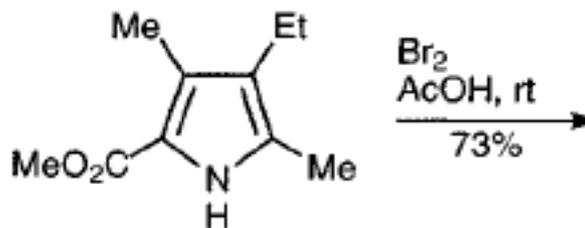
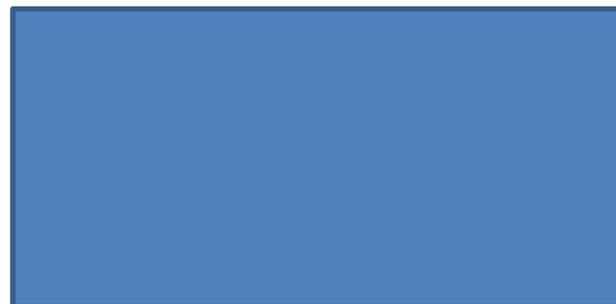
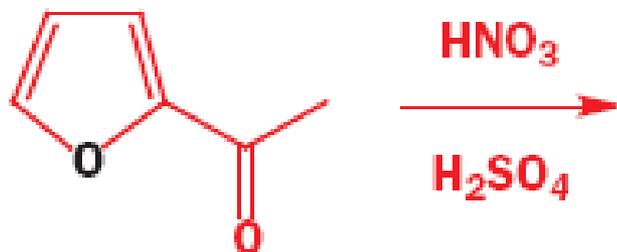
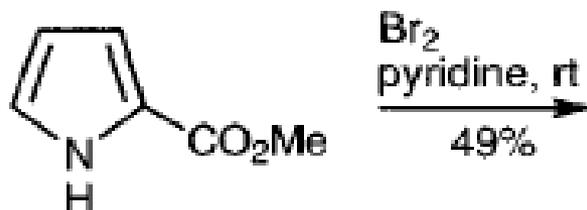
ATAQUE C5

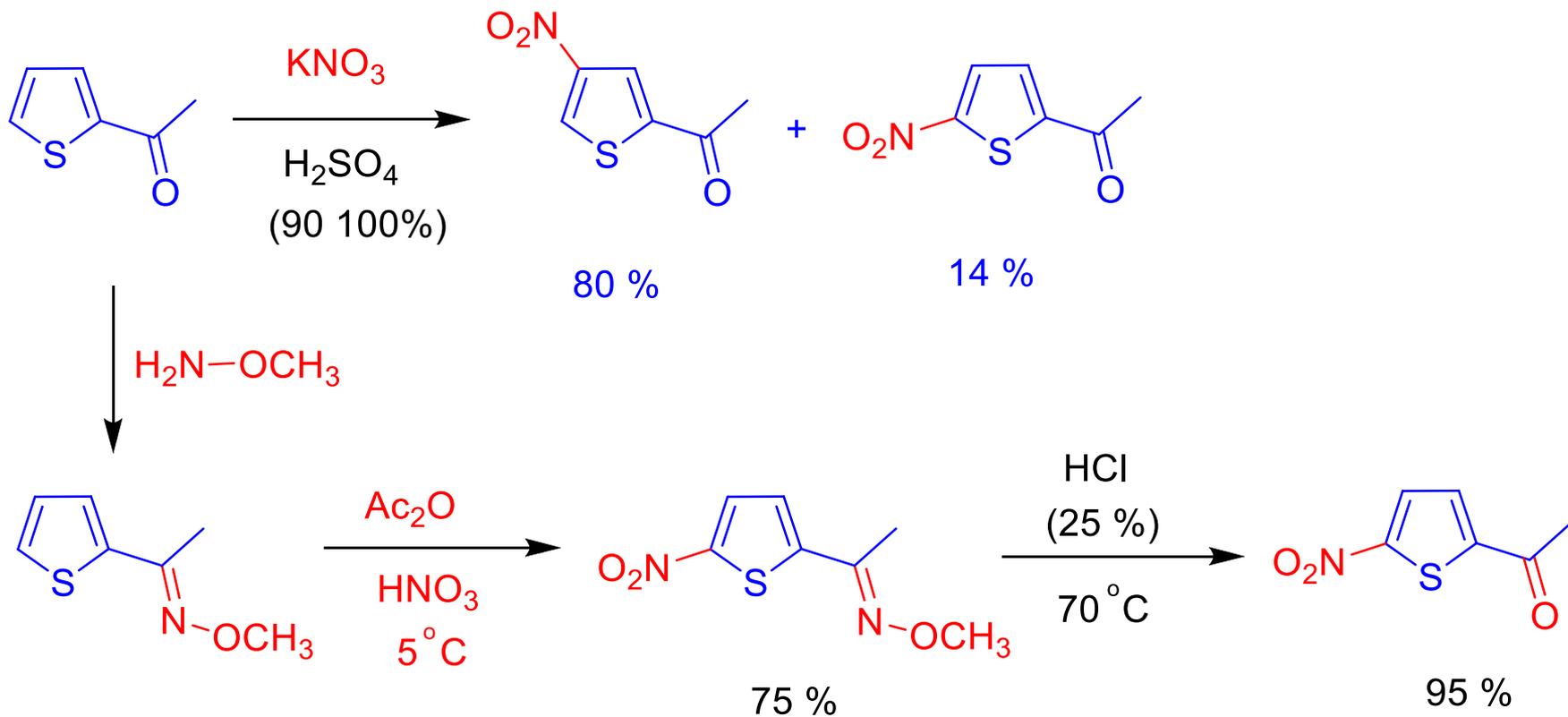


# REACCIONES DE DISUSTITUCIÓN (SEA)



# REACCIONES DE DISUSTITUCIÓN (SEA)

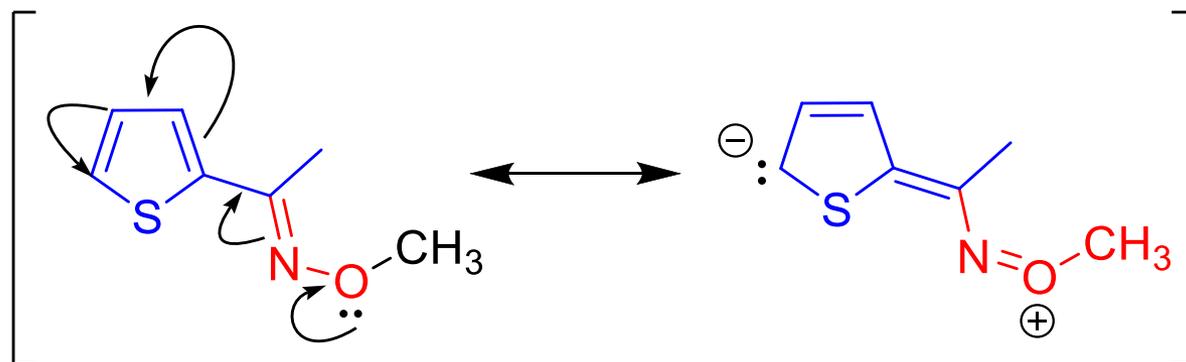
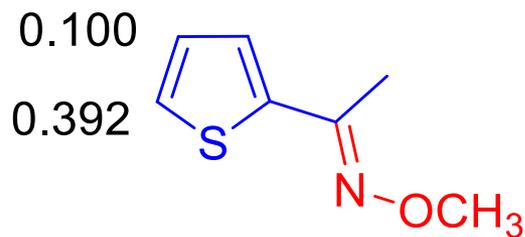
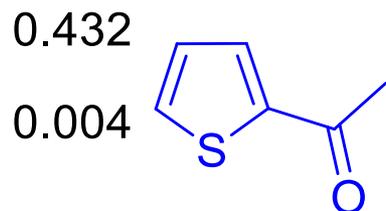




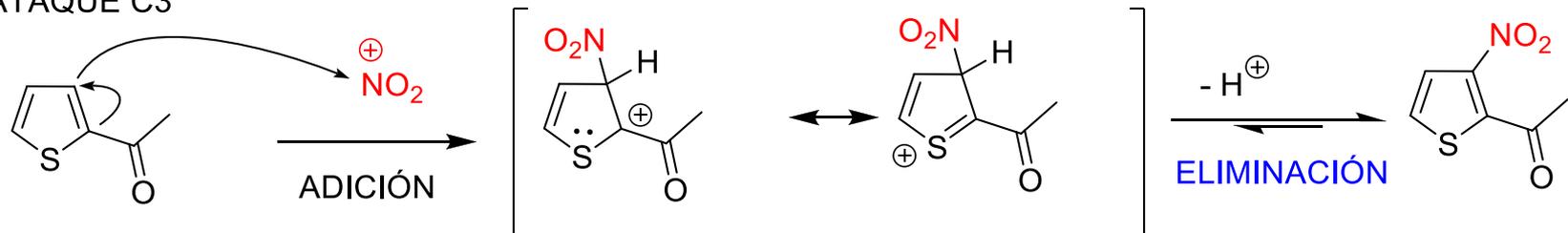
Goda, H.; et. al., *Synthesis*, 849(1992)



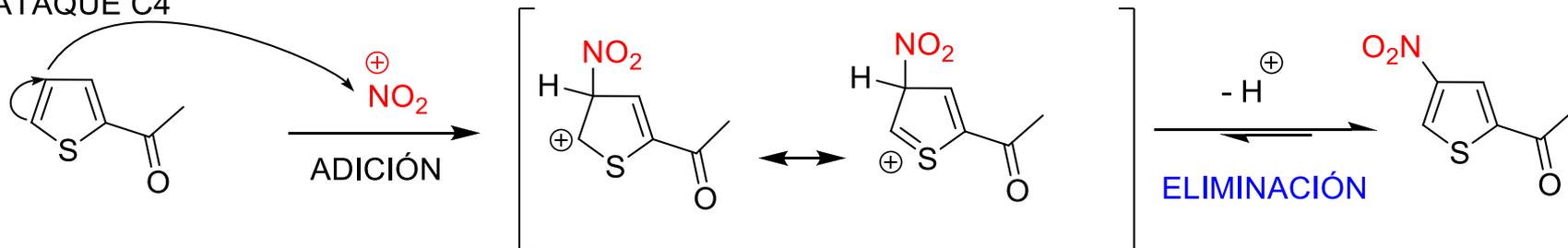
## ENERGÍA DE LOS HOMOS



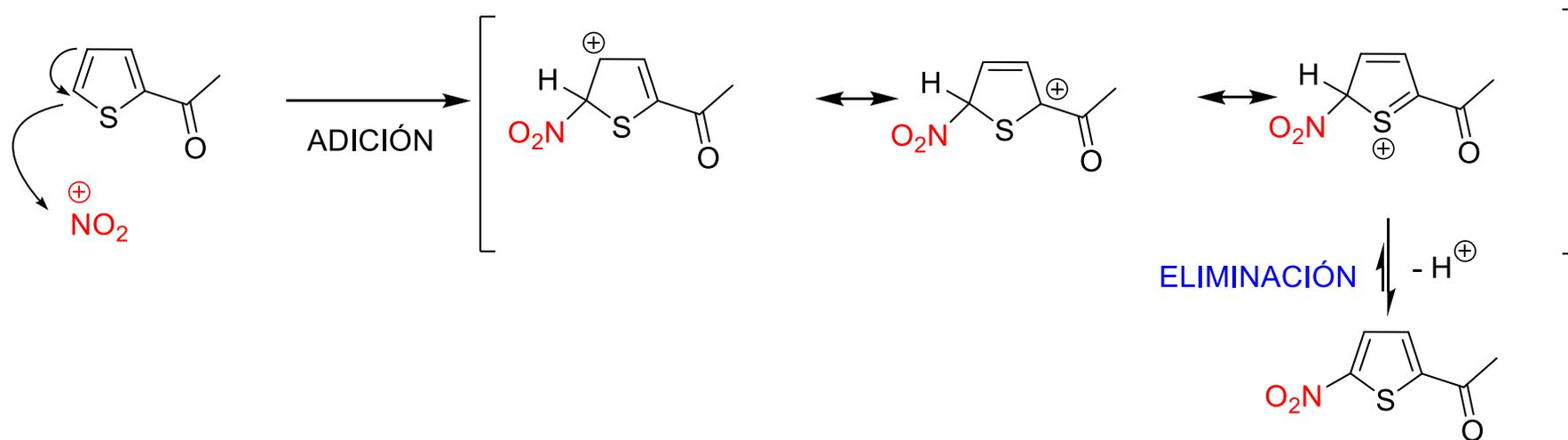
### ATAQUE C3

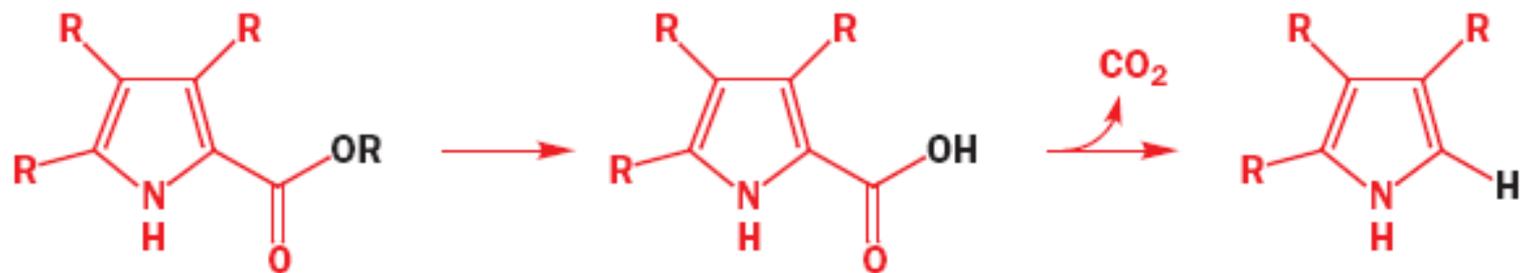


### ATAQUE C4

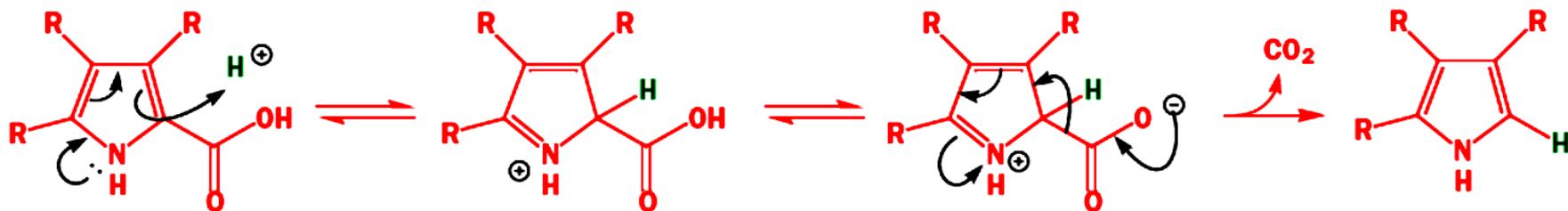


### ATAQUE C5

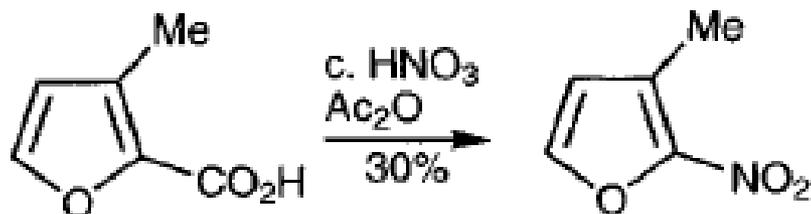
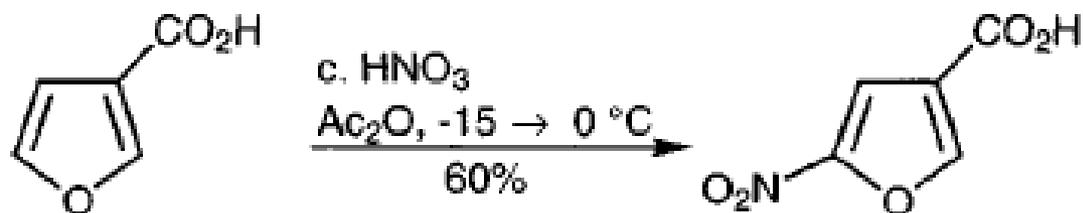
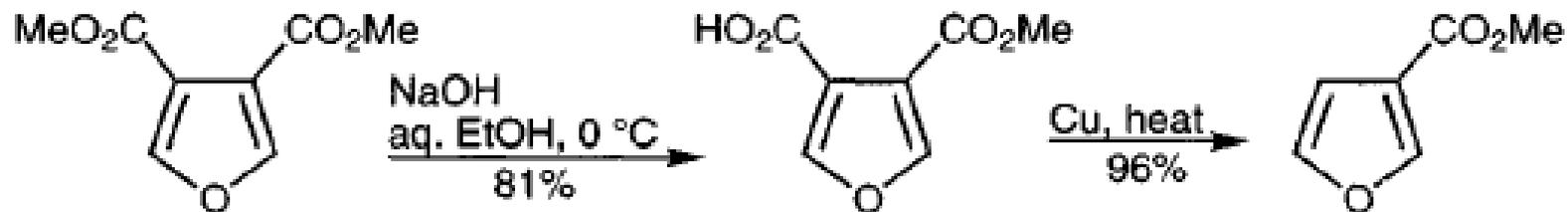


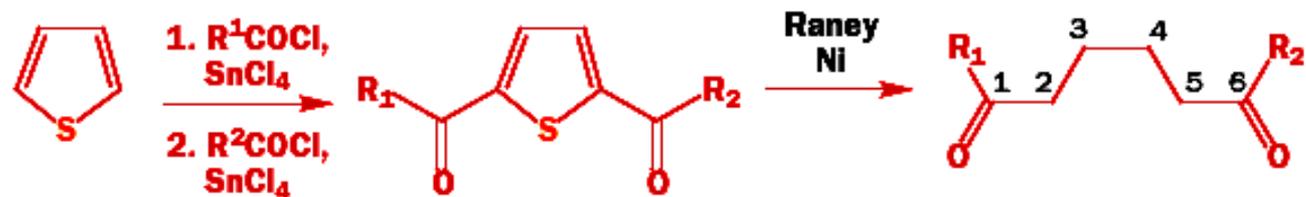
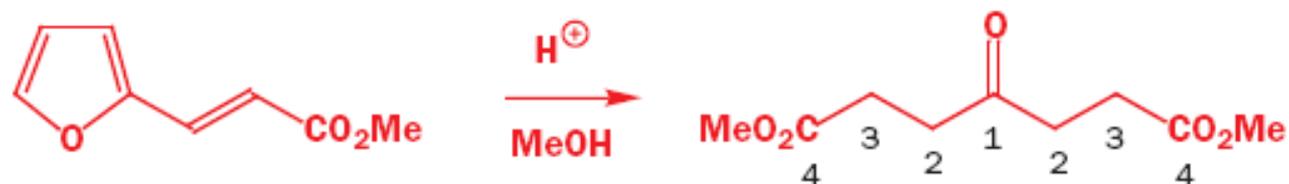


## MECANISMO DE LA REACCIÓN DE DESCARBOXILACIÓN

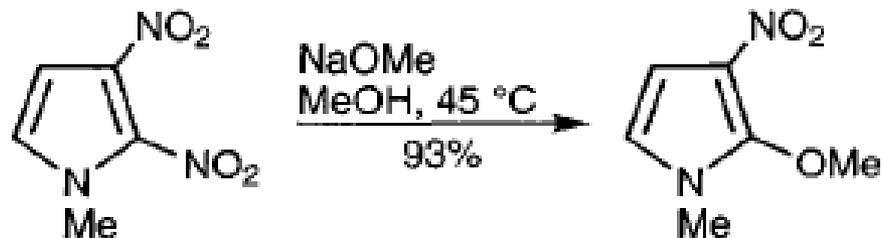
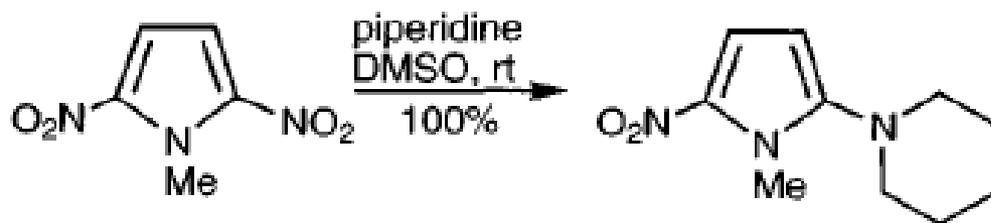
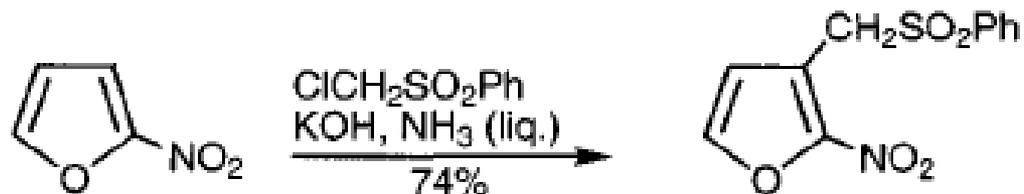


# REACCIONES DE DISUSTITUCIÓN (SEA)





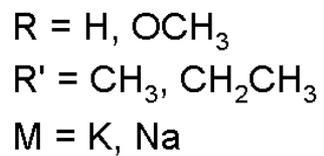
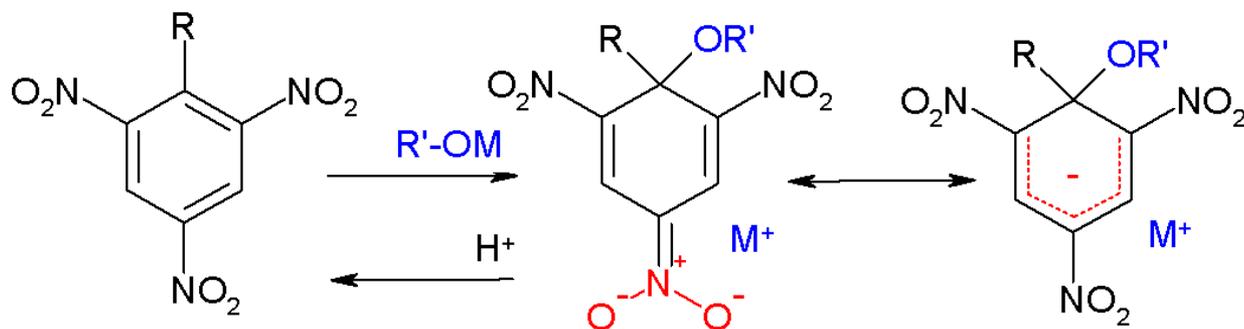
## REACCIONES CON REACTIVOS NUCLEOFÍLICOS (S<sub>N</sub>Ar)



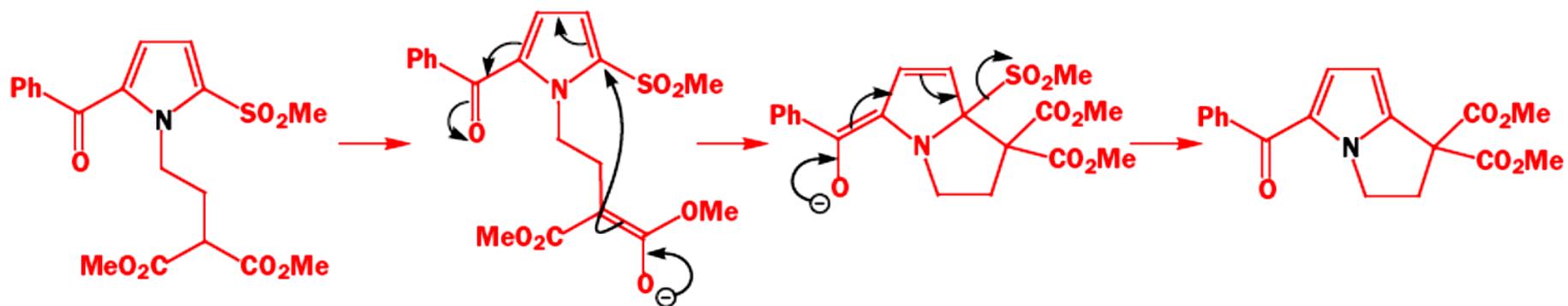
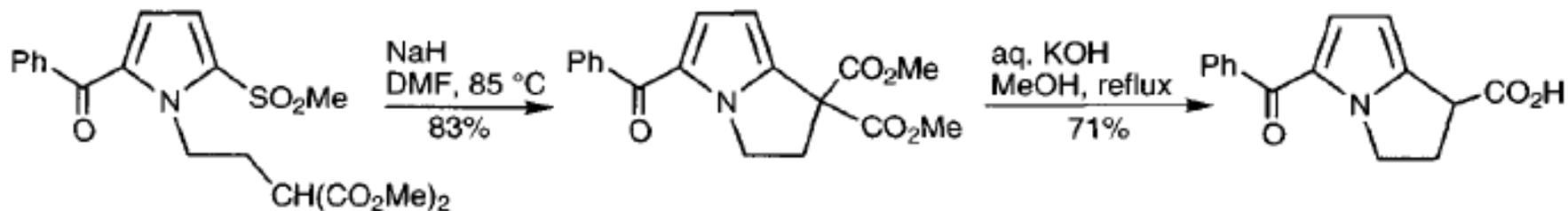


Jakob Meisenheimer  
(1876 –1934)  
Químico alemán

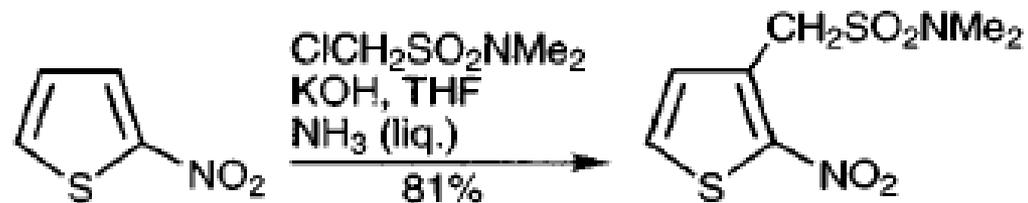
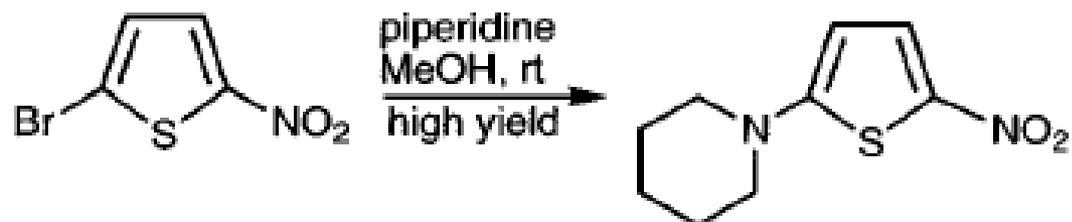
## Reacción de Meisenheimer (SNAr)



## REACCIONES CON REACTIVOS NUCLEOFÍLICOS (SNA)



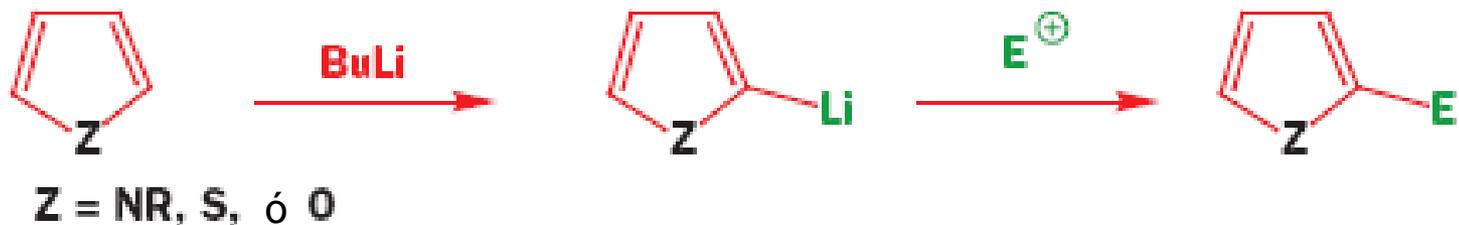
## REACCIONES CON REACTIVOS NUCLEOFÍLICOS ( $S_NAr$ )



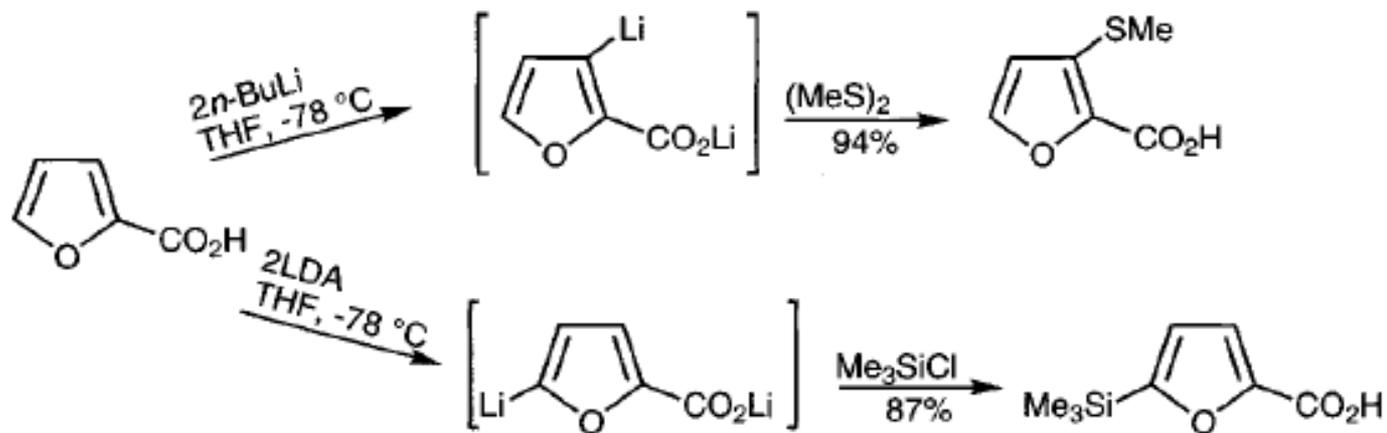
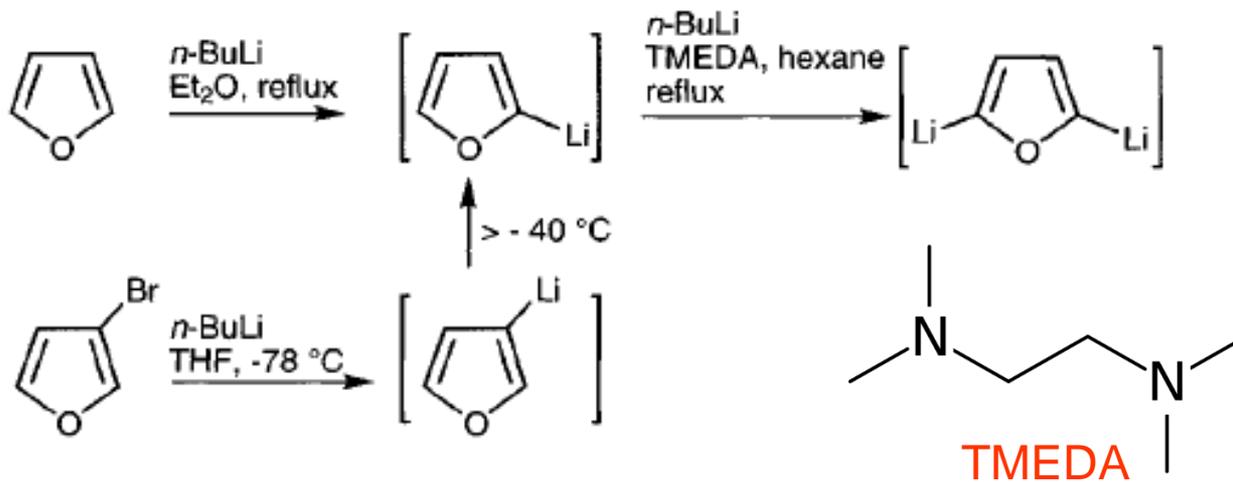
$S_NAr$  Vicaria



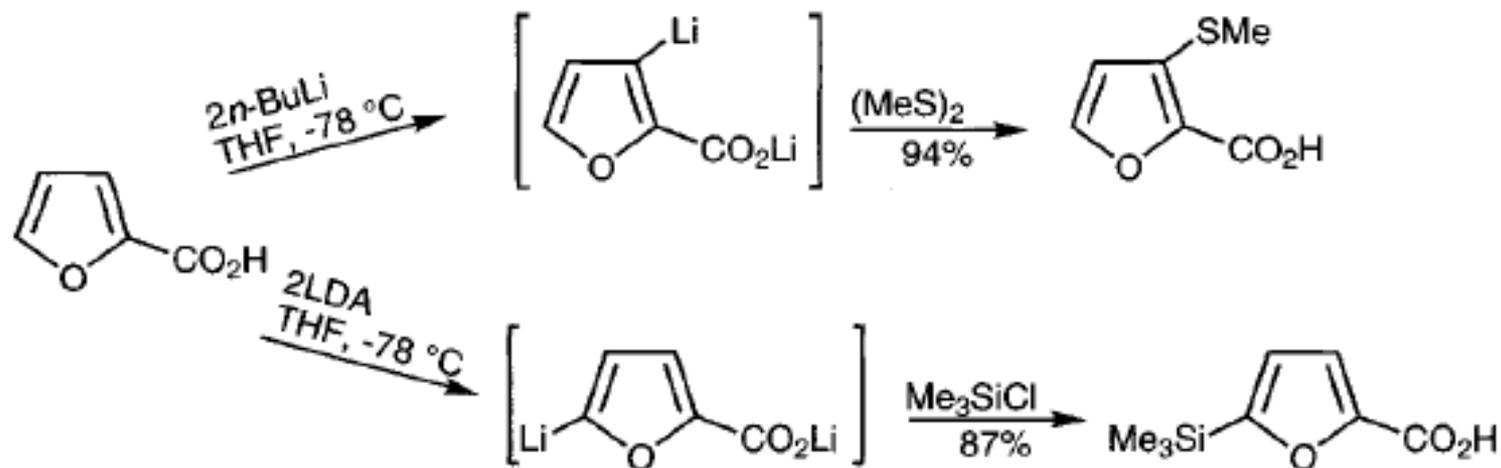
# REACCIONES CON BASES FUERTES. FORMACIÓN DE CARBANIONES



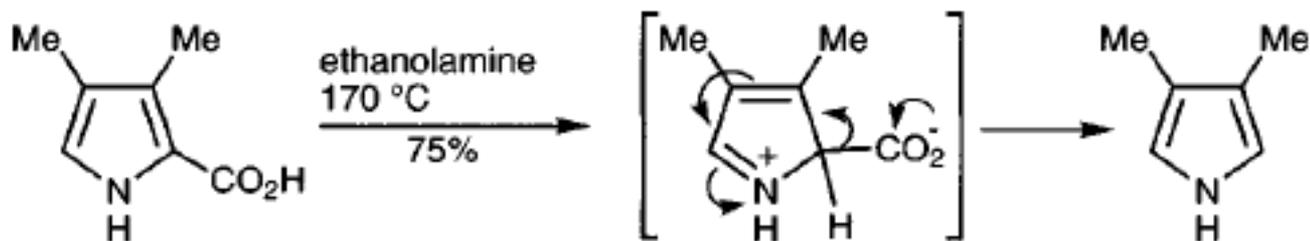
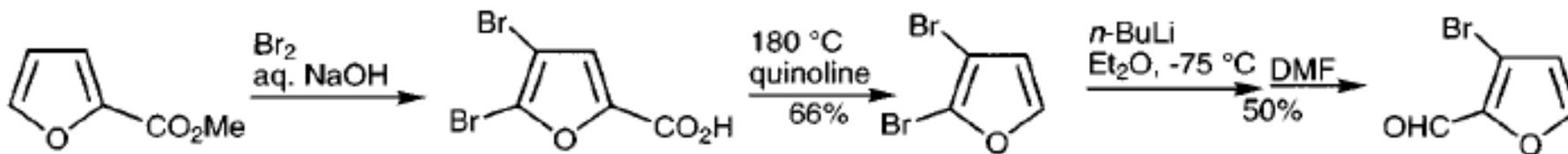
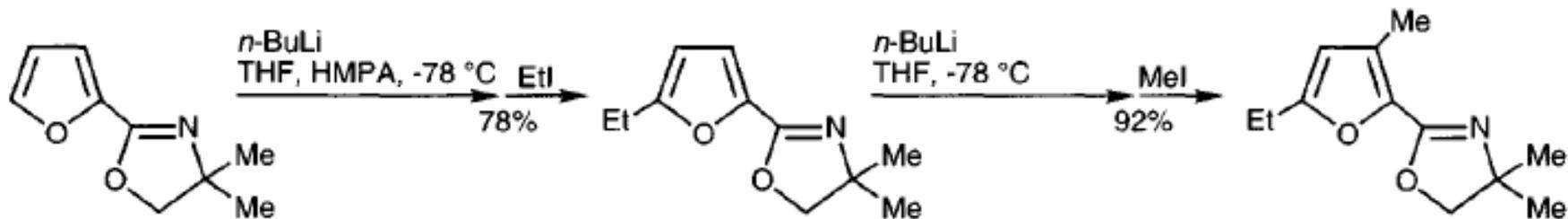
# REACCIONES CON BASES FUERTES. FORMACIÓN DE CARBANIONES



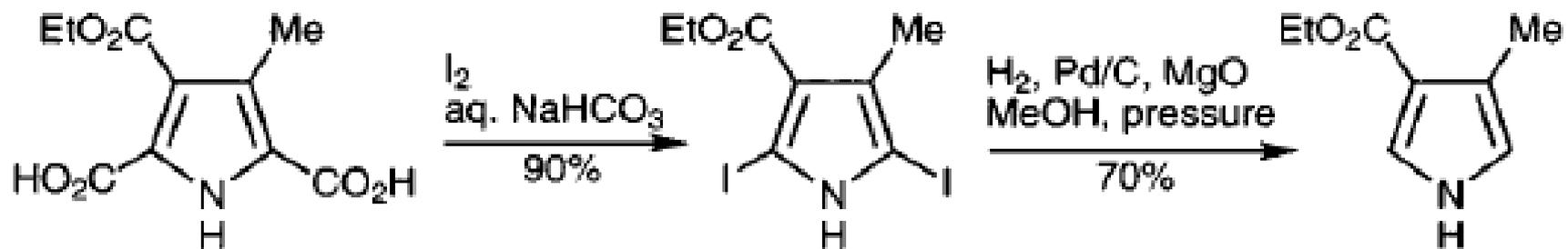
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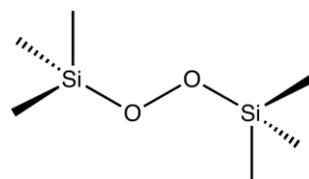
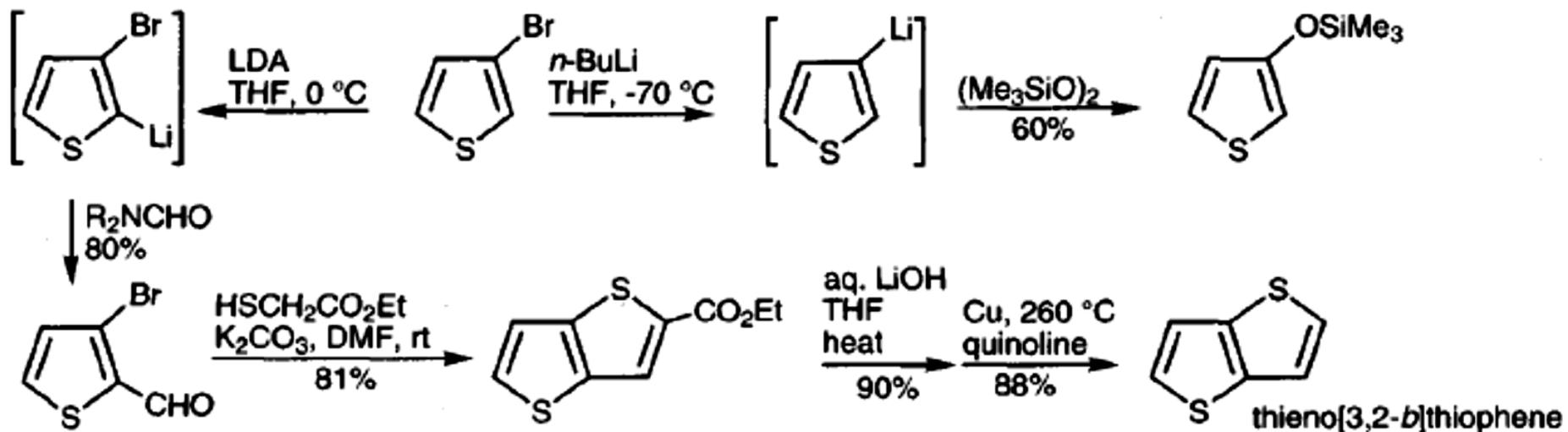
# REACCIONES CON BASES FUERTES. FORMACIÓN DE CARBANIONES



## REACCIONES CON BASES FUERTES. FORMACIÓN DE CARBANIONES

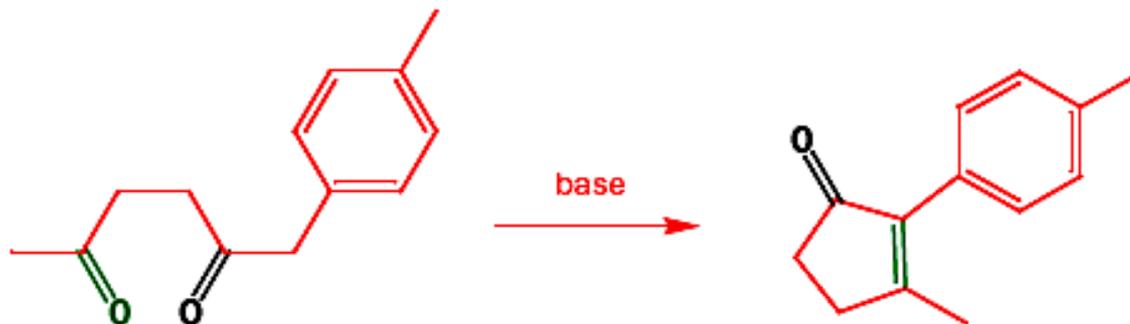
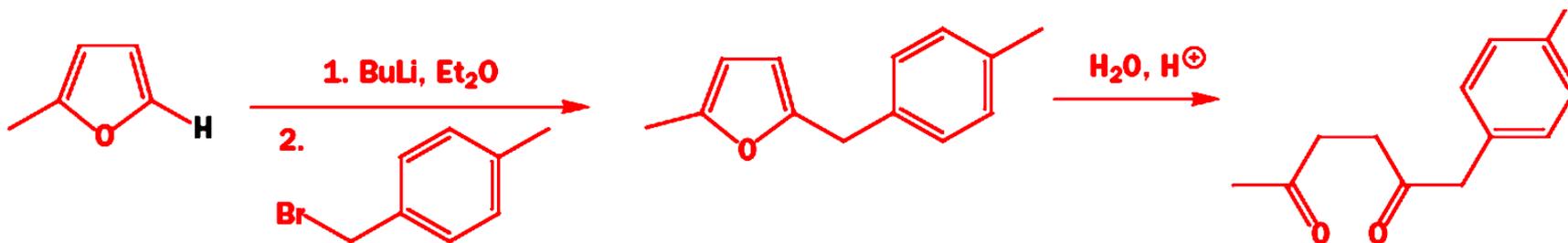
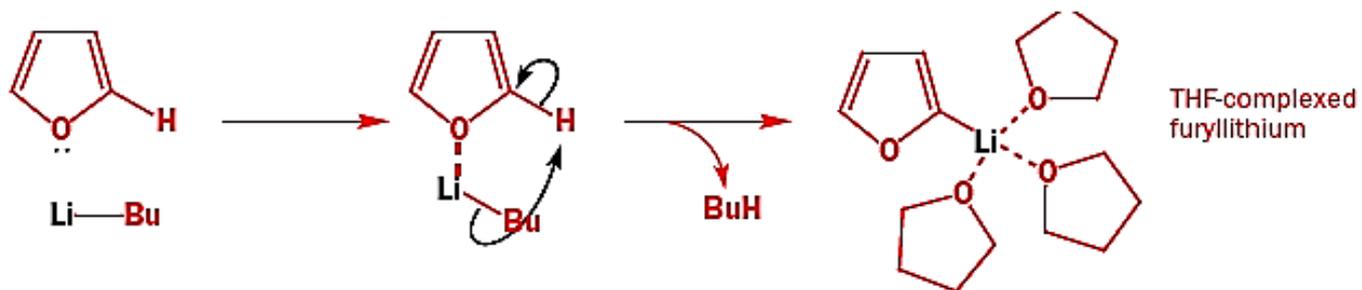


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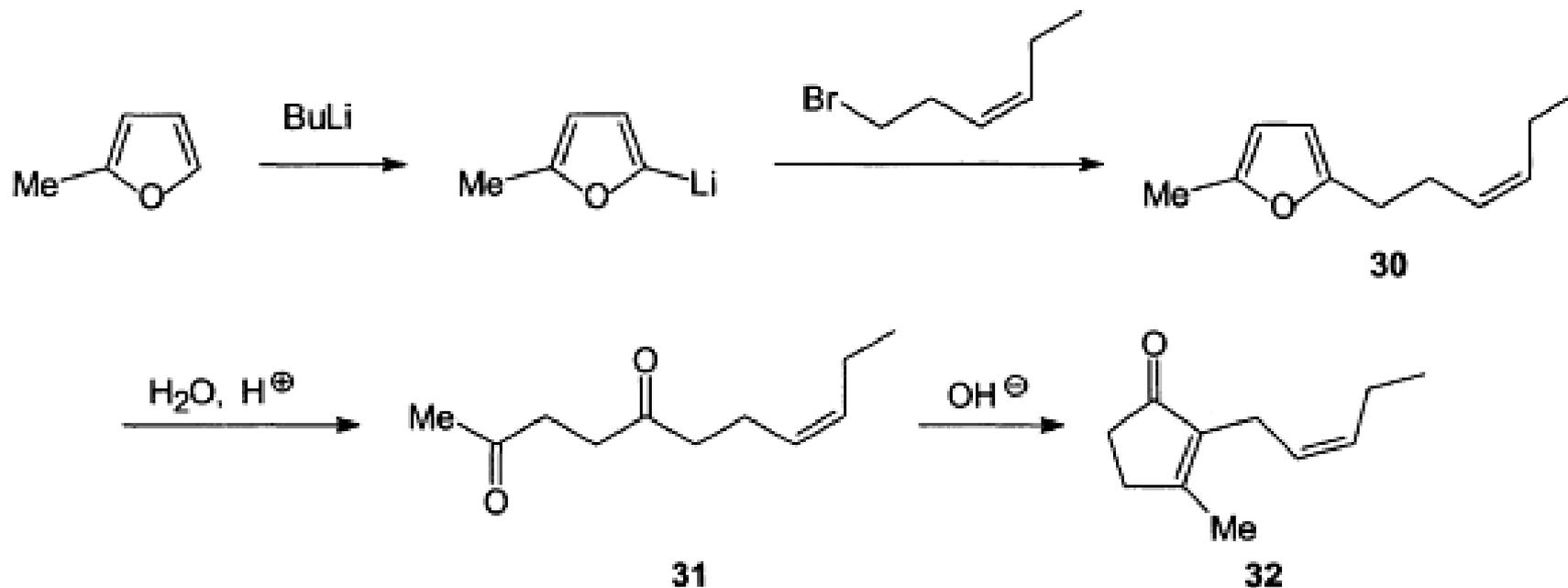


Bis(trimethylsilyl) peroxide

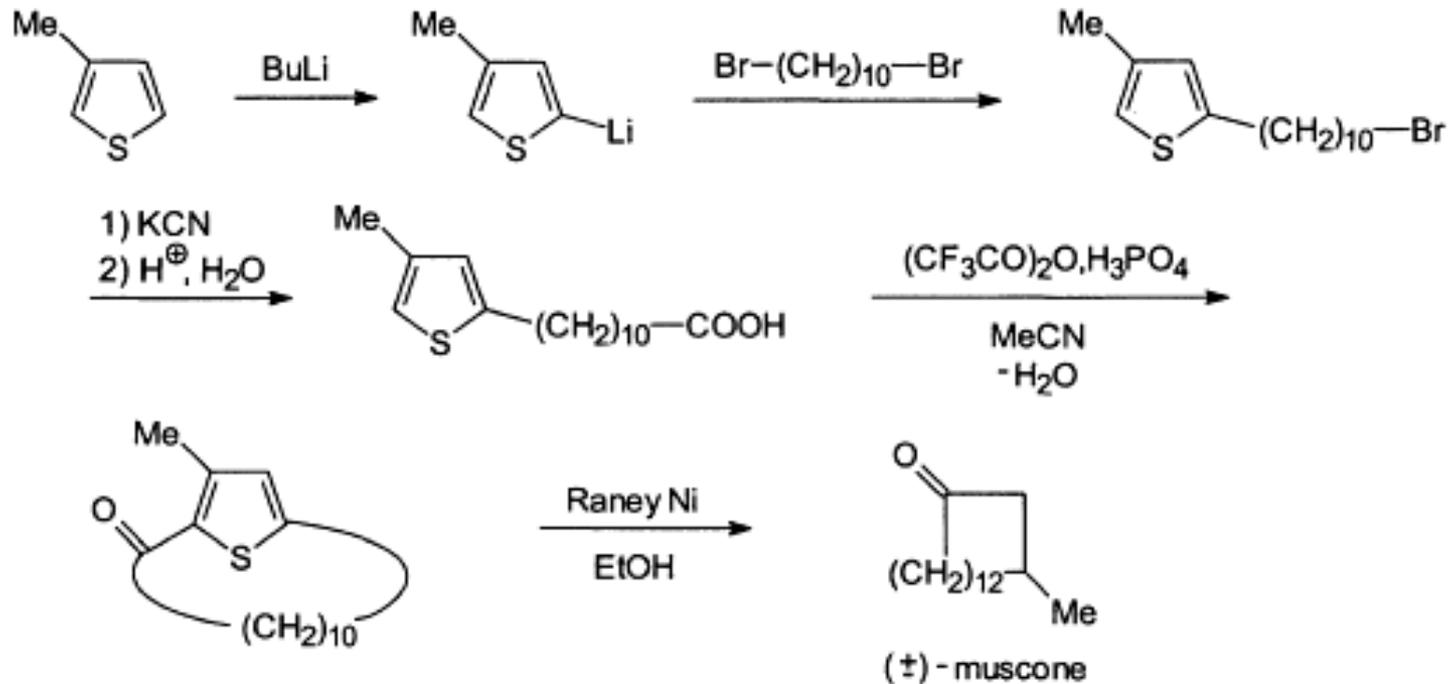
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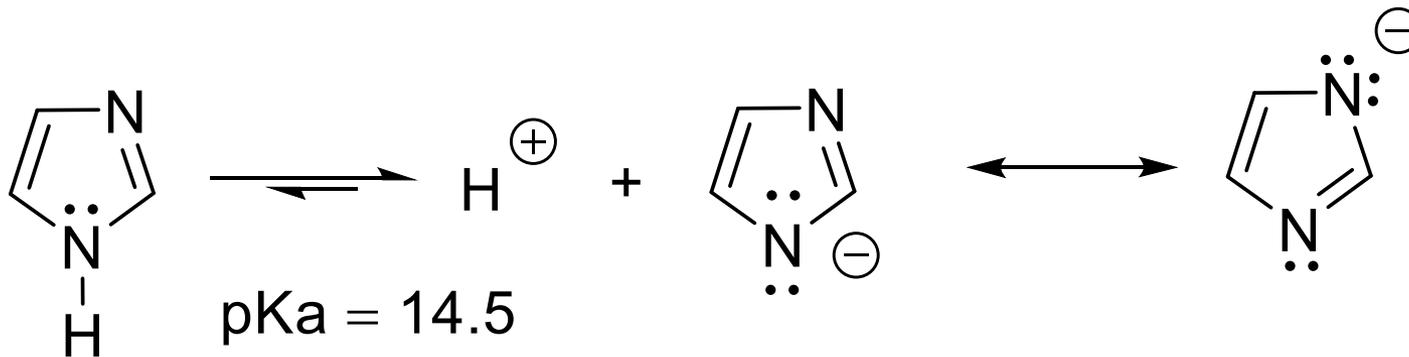
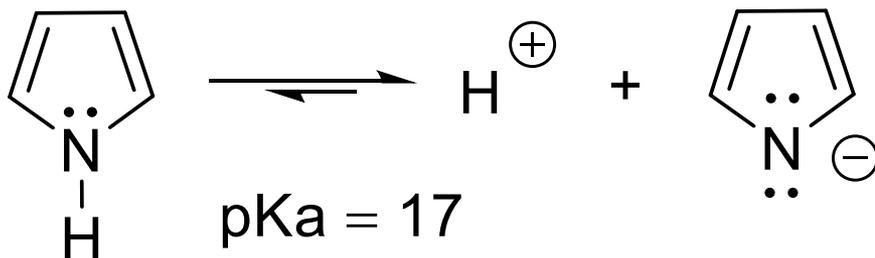
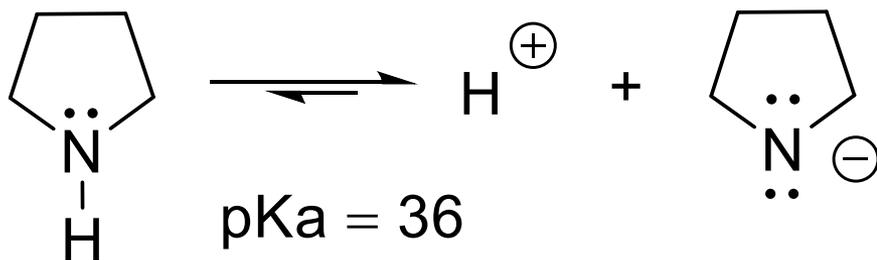
# REACCIONES CON BASES FUERTES. FORMACIÓN DE CARBANIONES



# REACCIONES CON BASES FUERTES. FORMACIÓN DE CARBANIONES

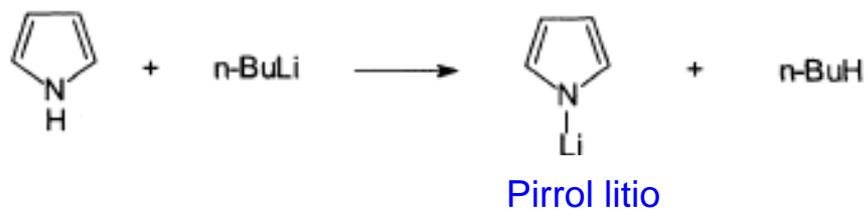
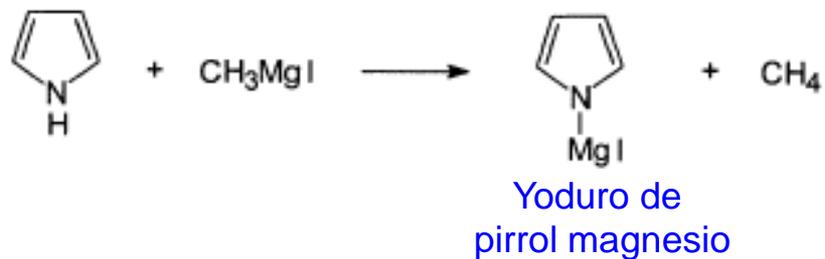


## Ácidoz anillos heterocíclicos derivados del N

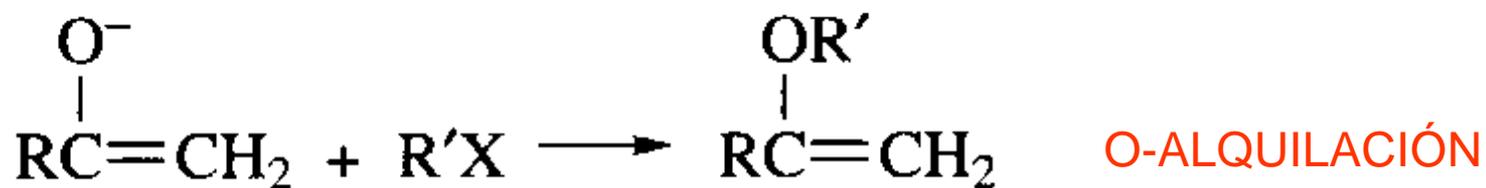
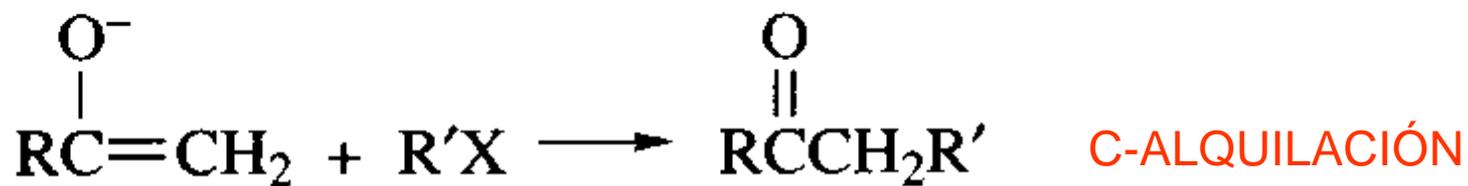
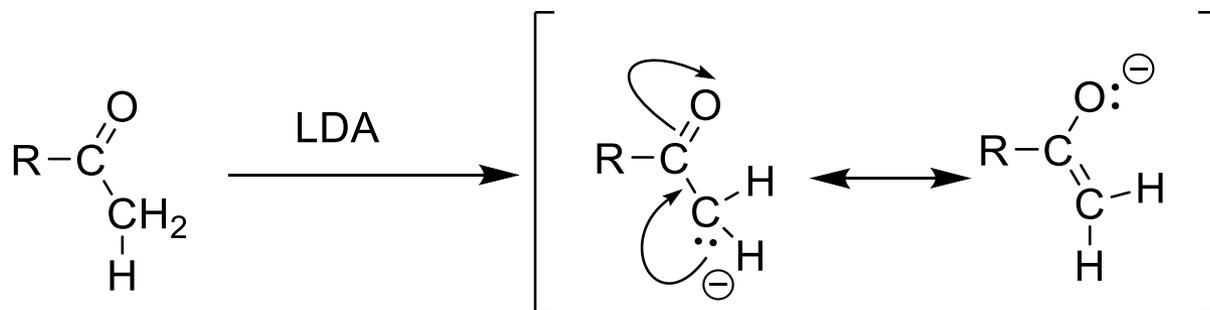


# REACCIONES CON BASES FUERTES. FORMACIÓN DE CARBANIONES

## ANIONES AMBIVALENTES



## ANIONES AMBIVALENTES



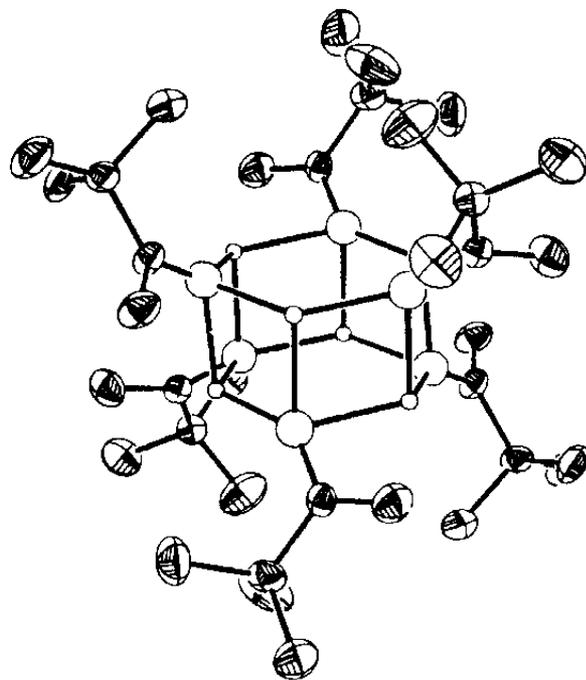


Fig. 1.1. Unsolvated hexameric aggregate of lithium enolate of methyl *t*-butyl ketone; large circles = oxygen, small circles = lithium. (Reproduced with permission from Ref. 44. Copyright 1986 American Chemical Society.)

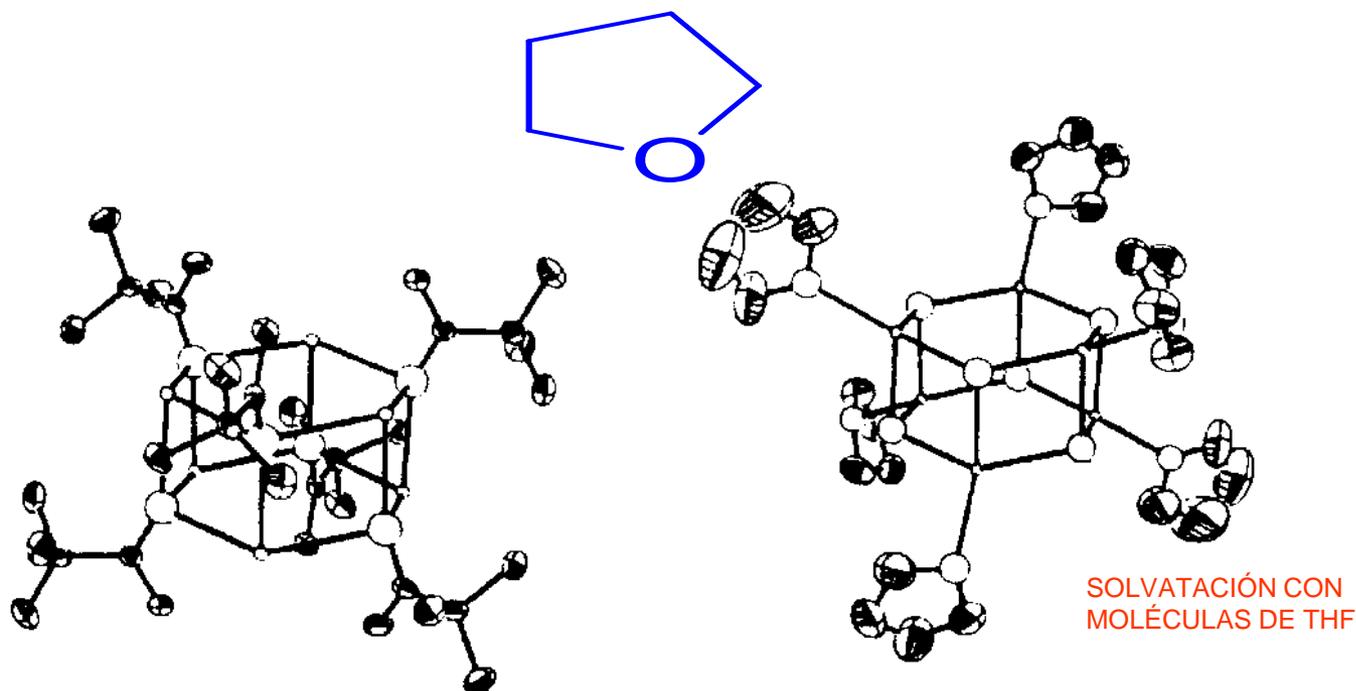
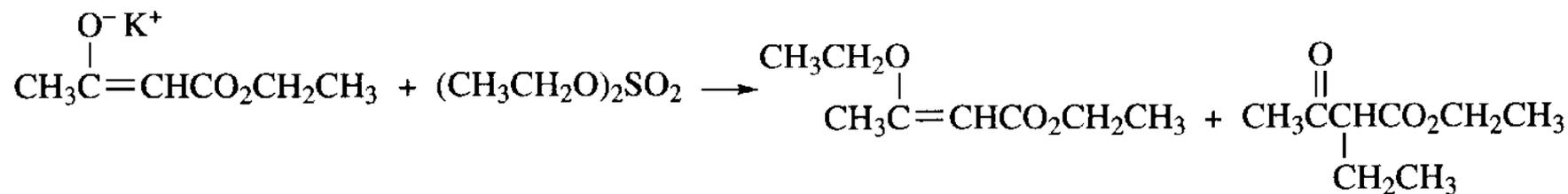


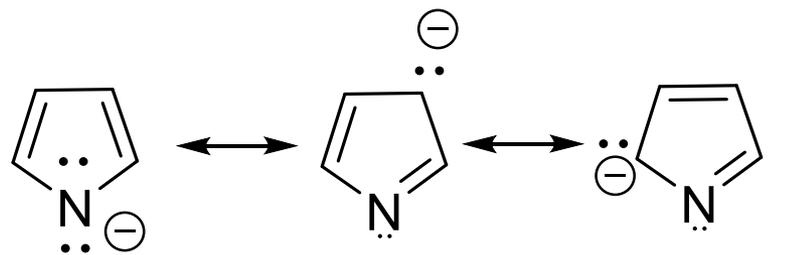
Fig. 1.2. Potassium enolate of methyl *t*-butyl ketone; large circles = oxygen, small circles = potassium. (a) Left-hand plot shows only methyl *t*-butyl ketone residues. (b) Right-hand plot shows only the solvating THF molecules. The crystal is a composite of these two structures. (Reproduced with permission from Ref. 44. Copyright 1986 American Chemical Society.)



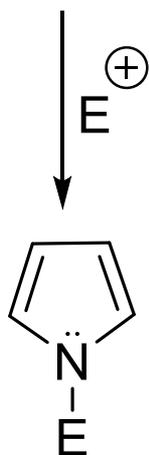
EN HMPA	83 %	15 %
EN t-BuOH	0 %	94 %
EN THF	0 %	94 %



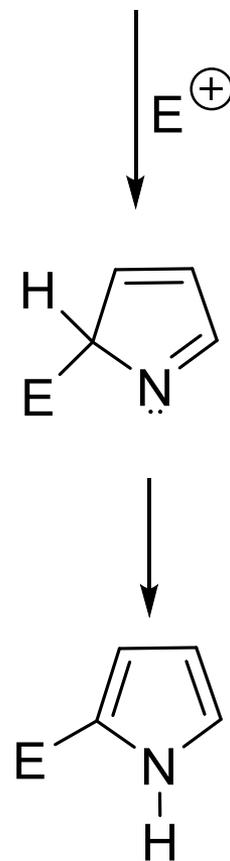
# ANIÓN PIRROL



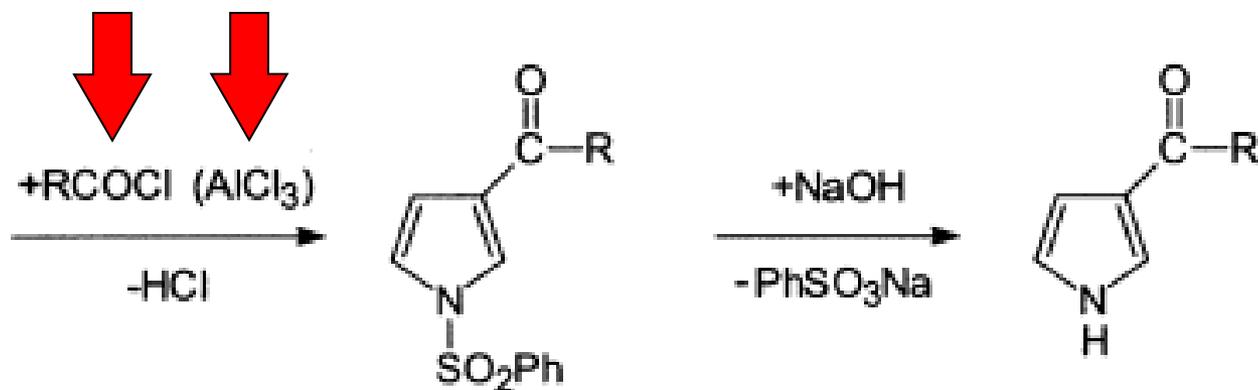
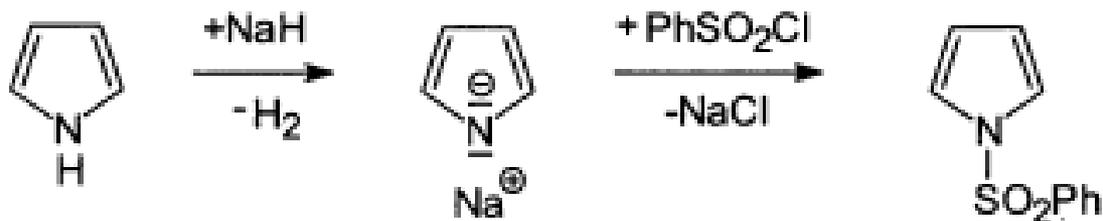
N-SUSTITUCIÓN



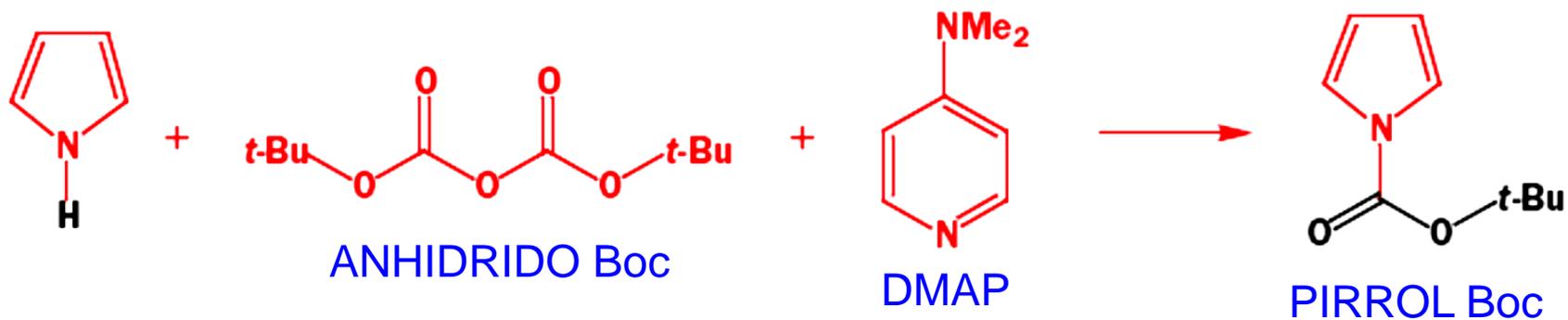
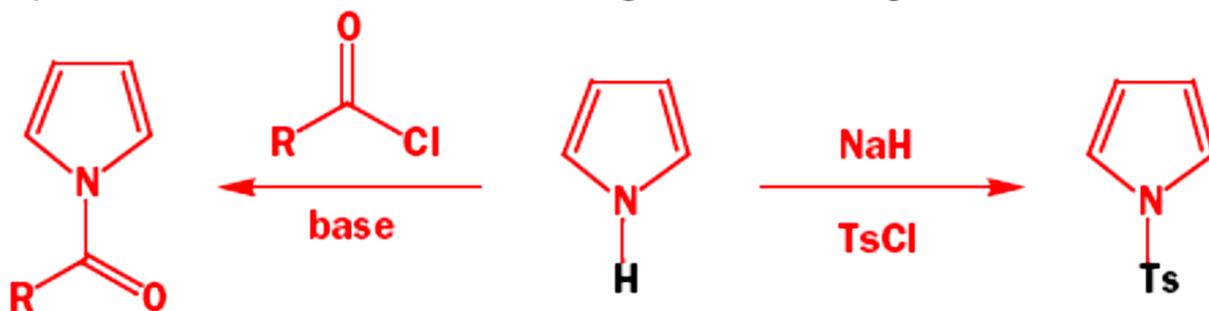
C-SUSTITUCIÓN



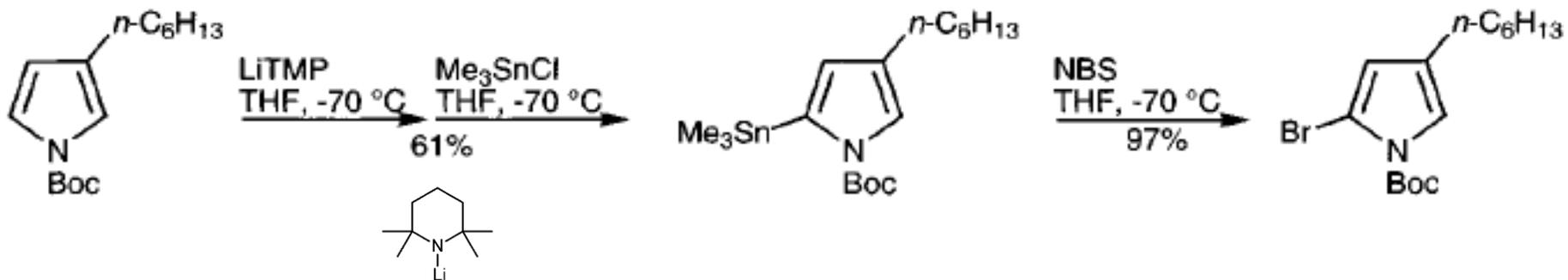
# REACCIONES CON BASES FUERTES. FORMACIÓN DE CARBANIONES



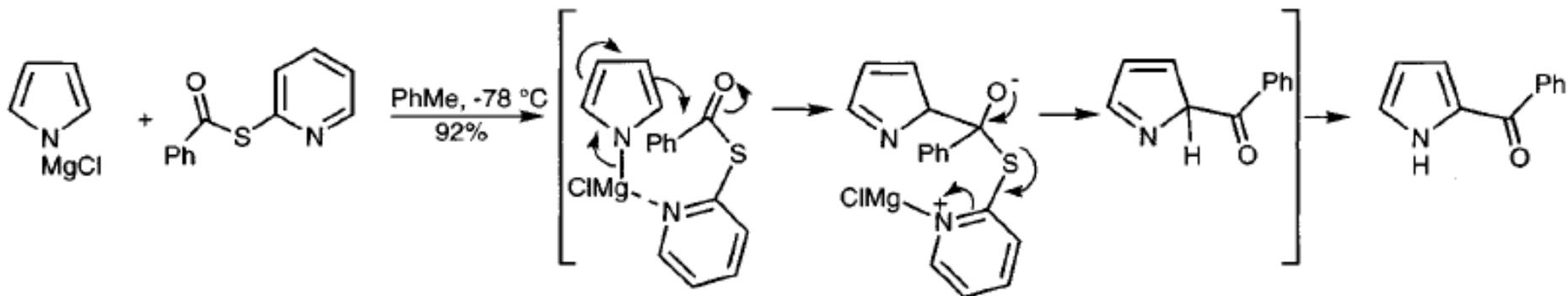
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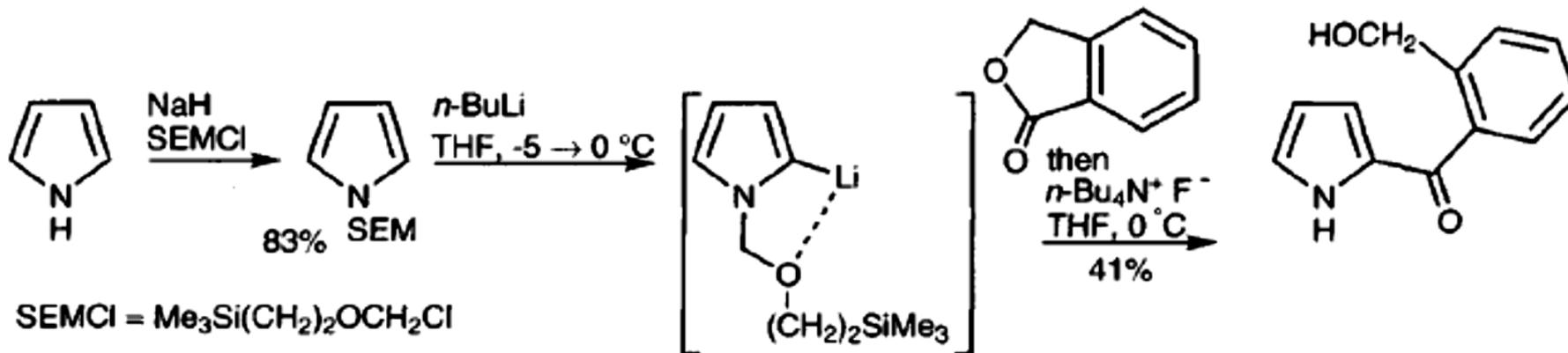
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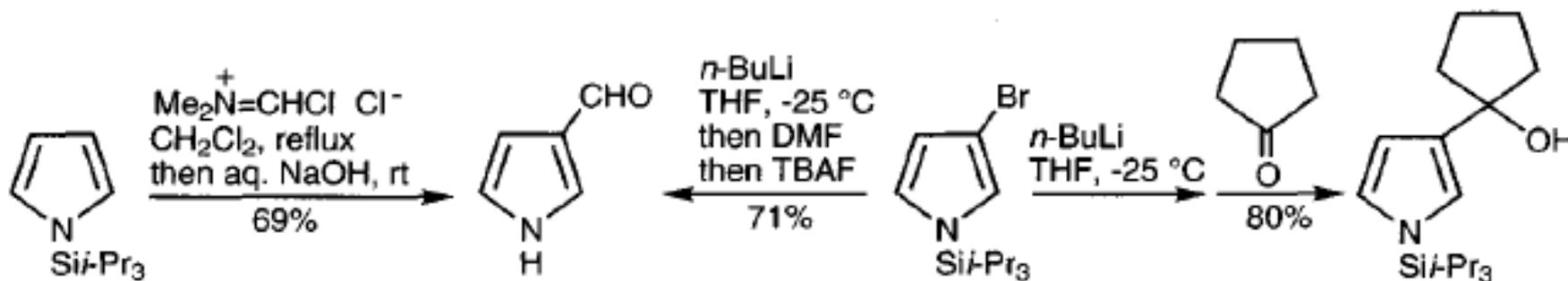
LiTMP = tetrametilpiperiruro de litio



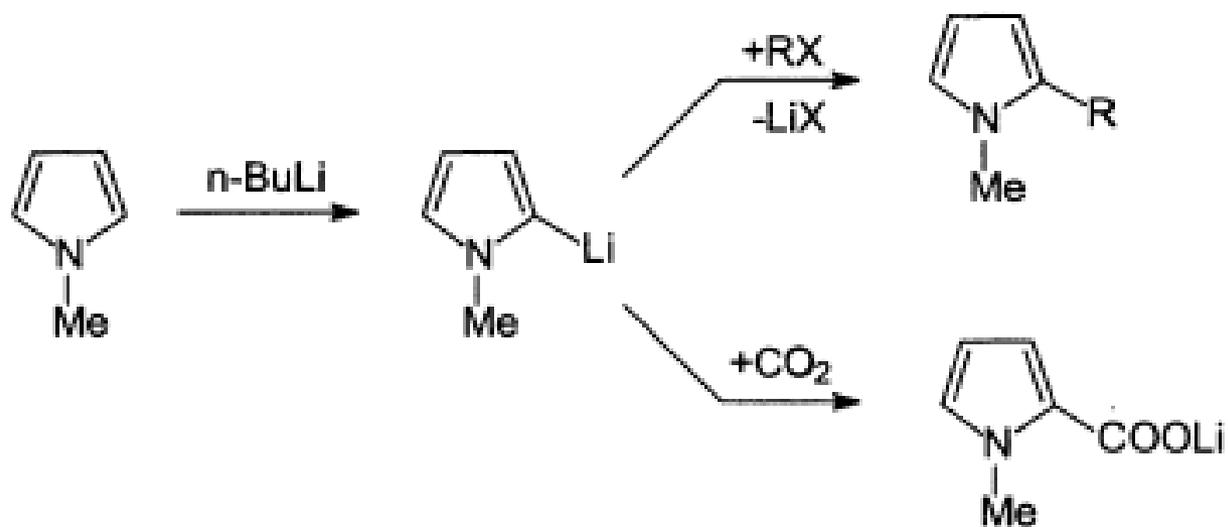
# REACCIONES CON BASES FUERTES. FORMACIÓN DE CARBANIONES



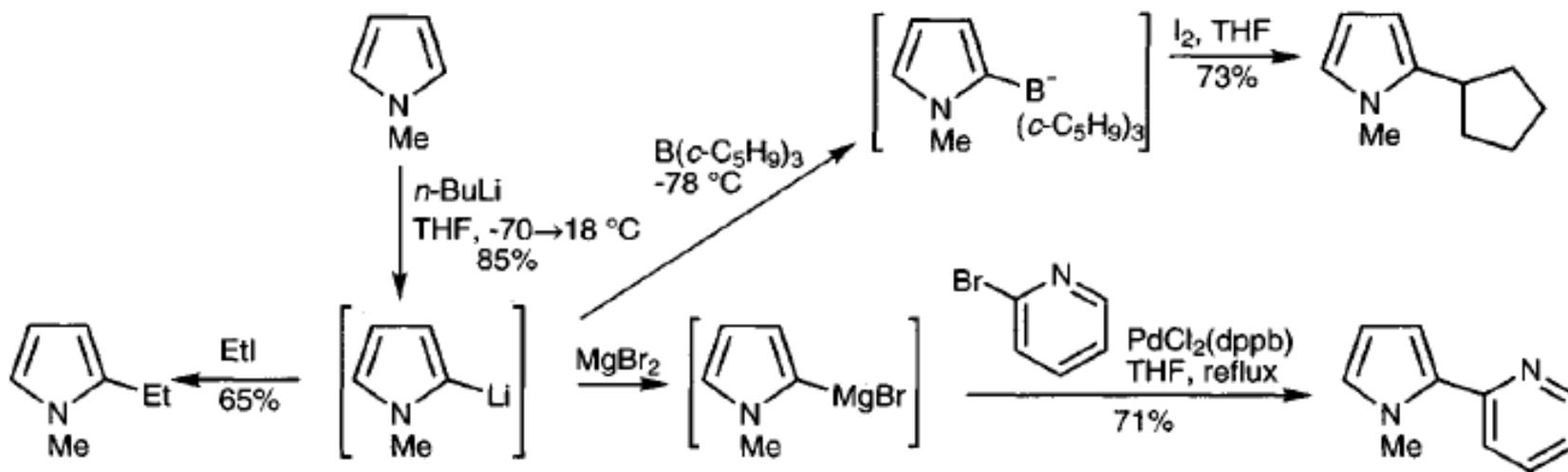
## COLORUO DE 2-(TRIMETILSILIL)-ETOXIMETILO



# REACCIONES CON BASES FUERTES. FORMACIÓN DE CARBANIONES

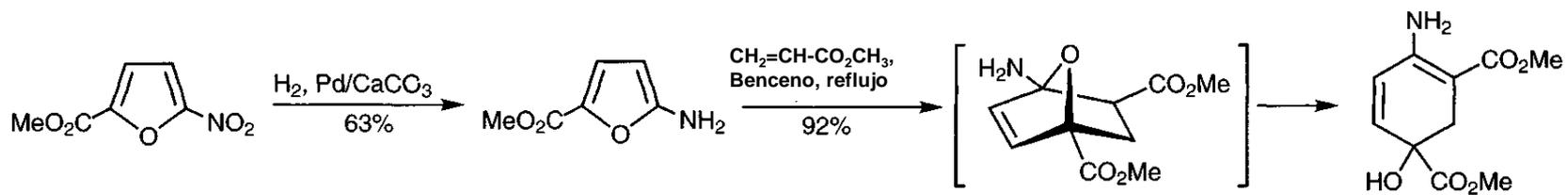
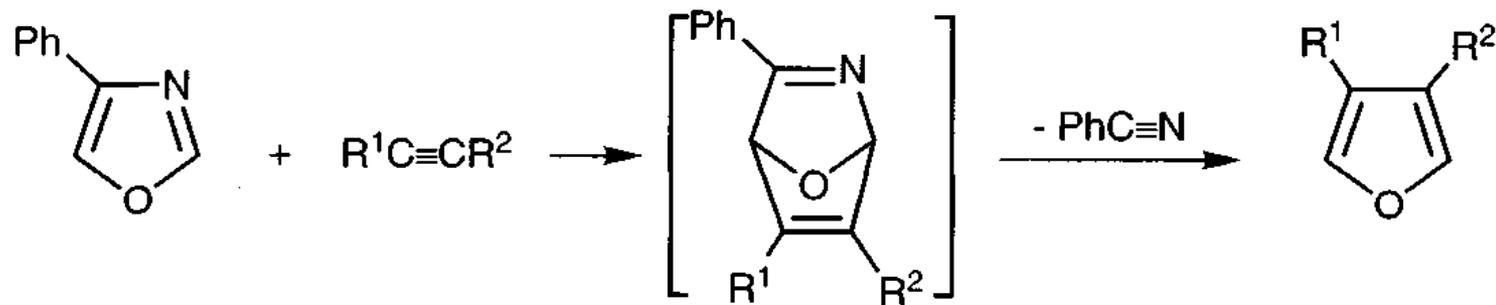


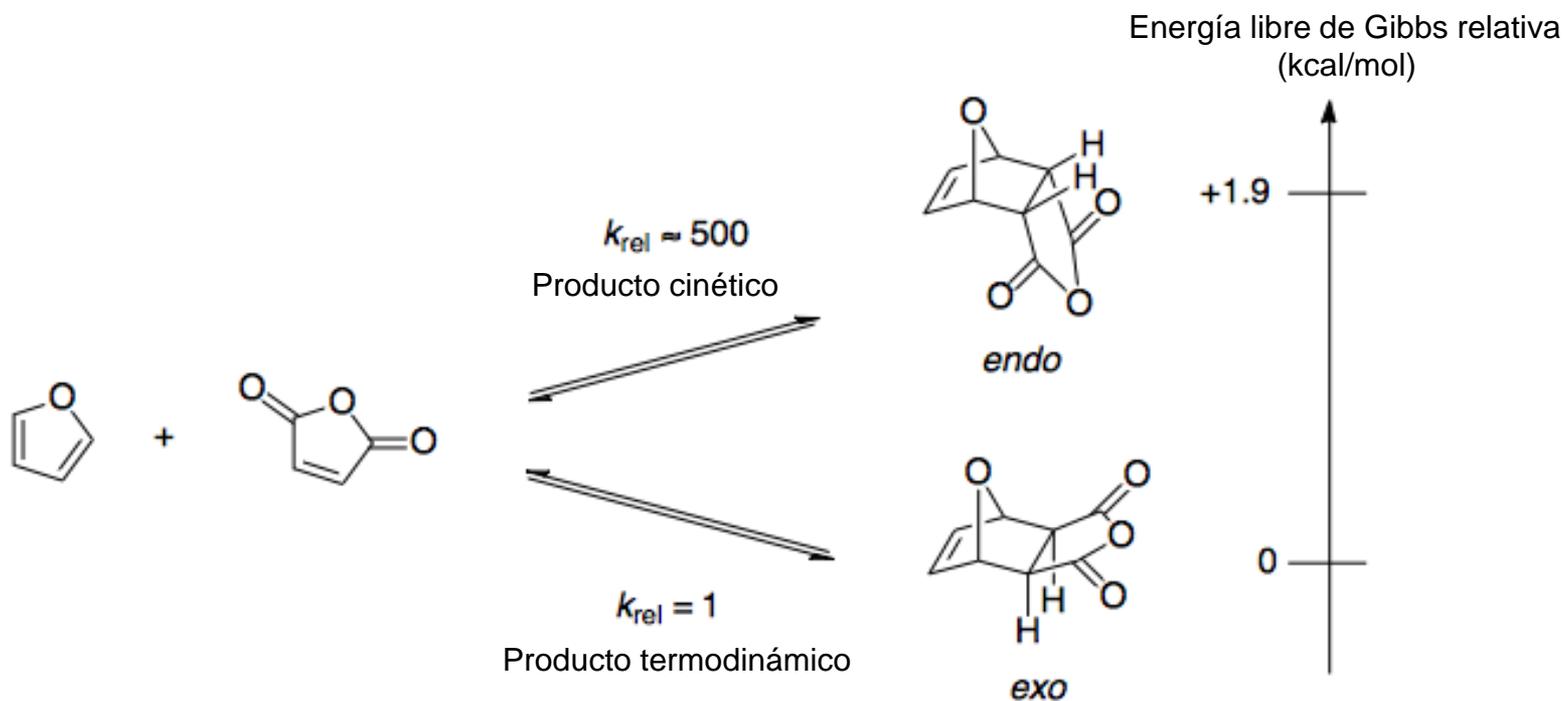
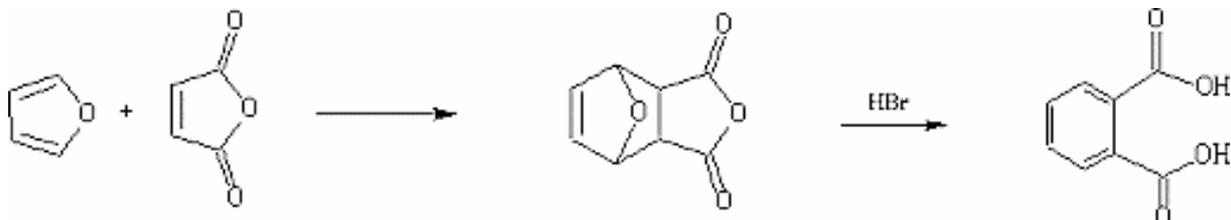
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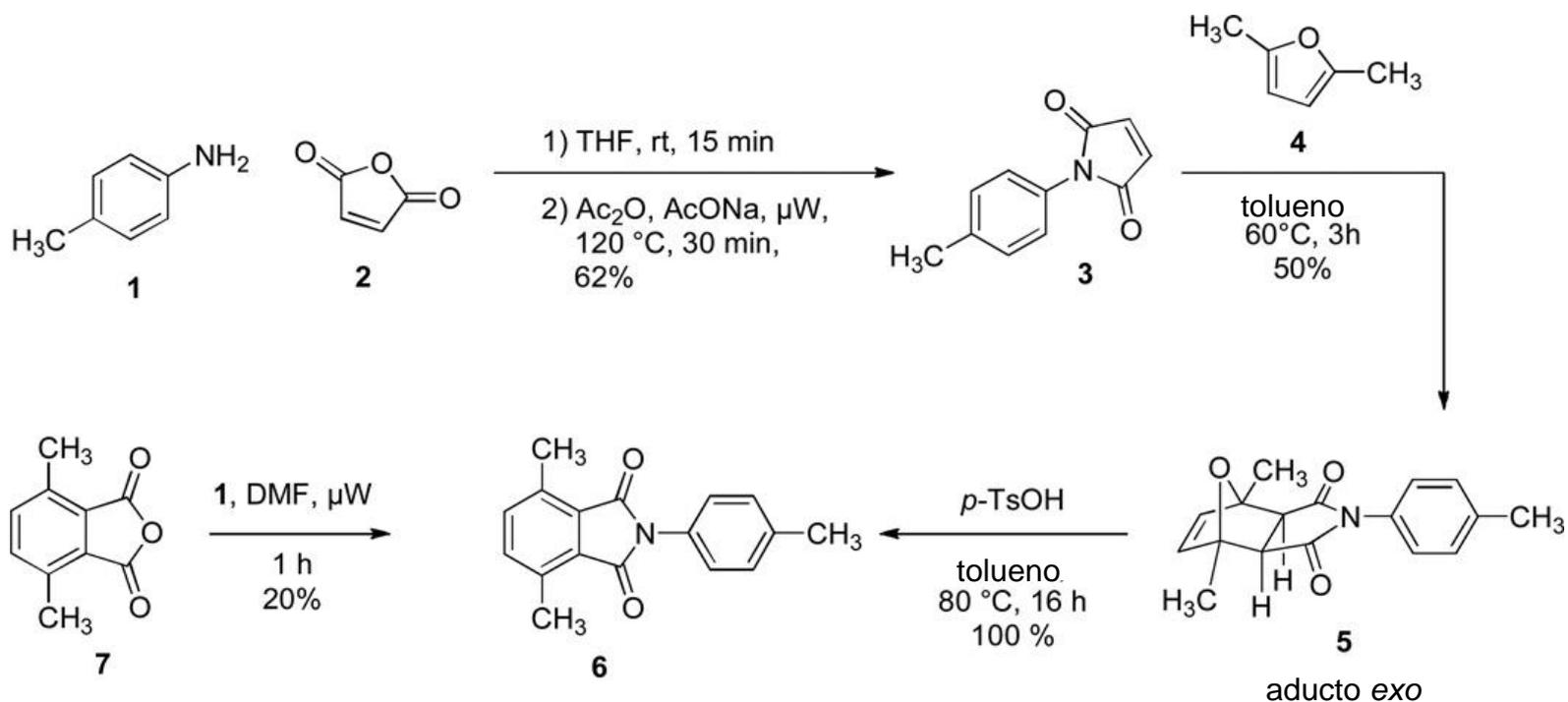
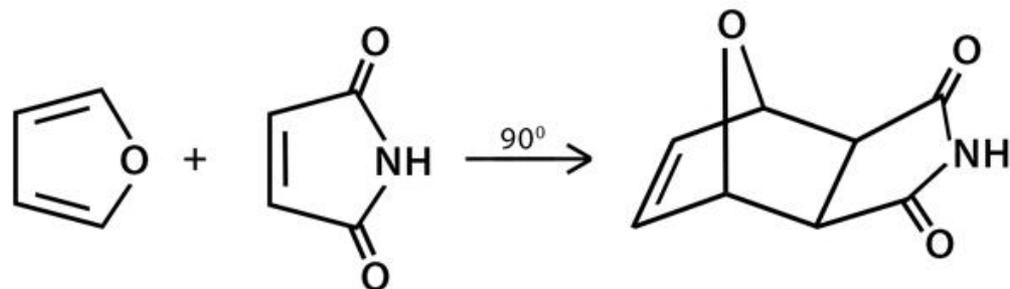


# Reacción de Diels-Alder





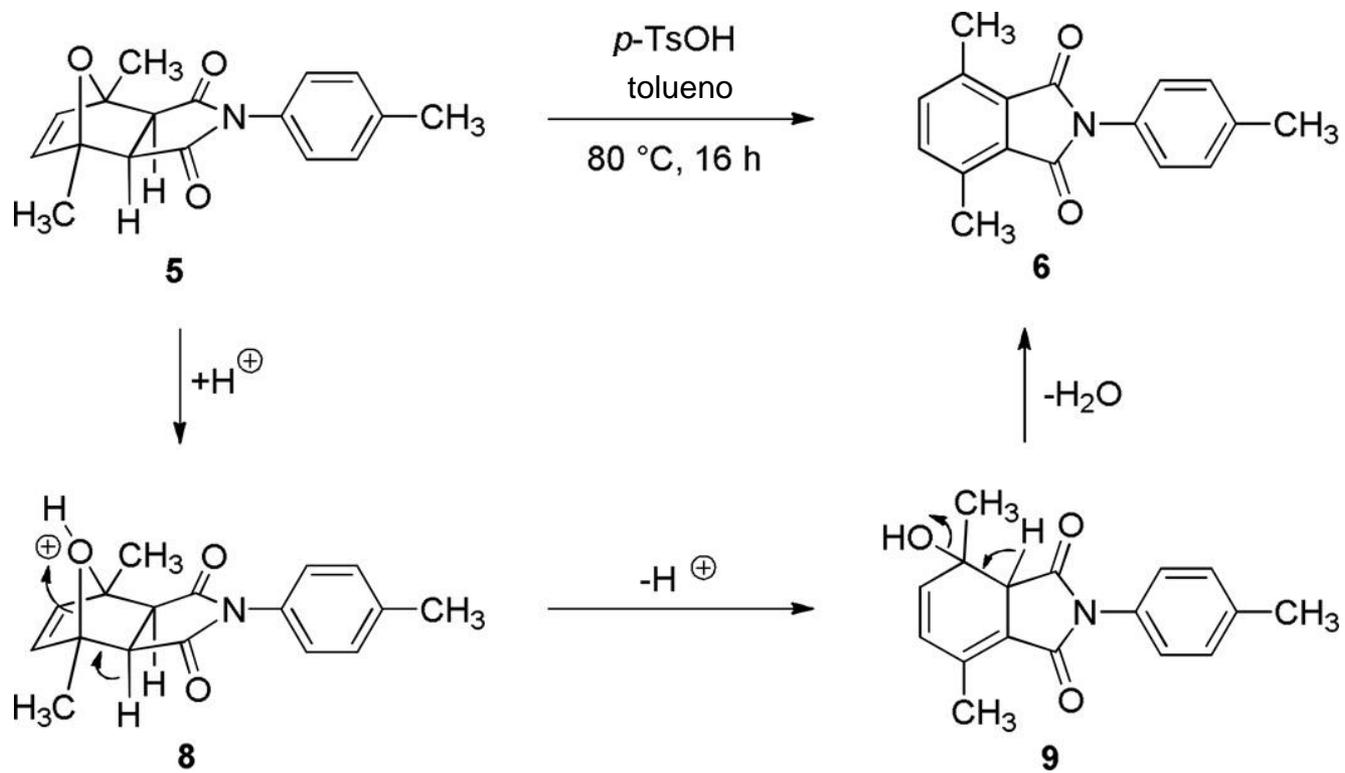


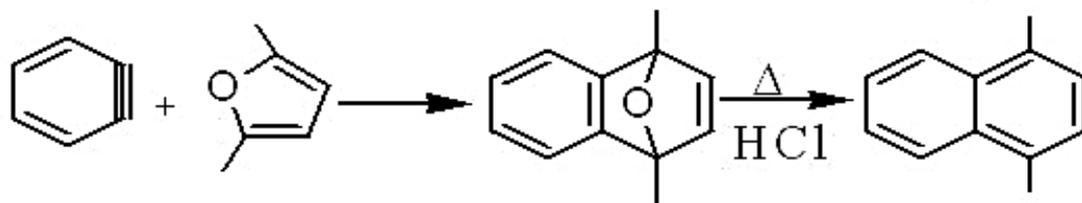
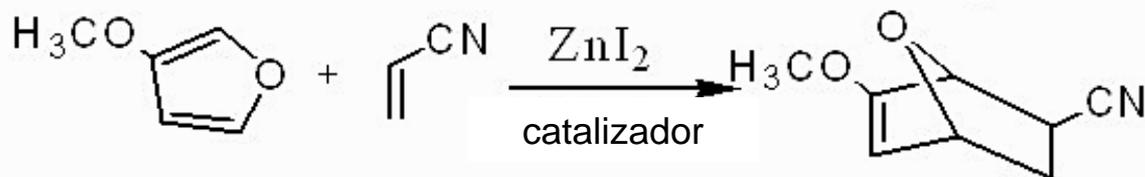
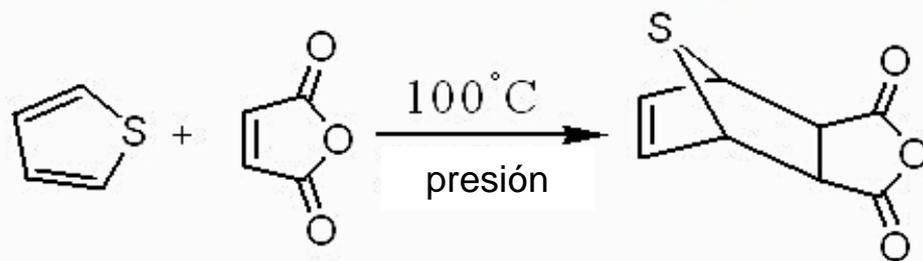


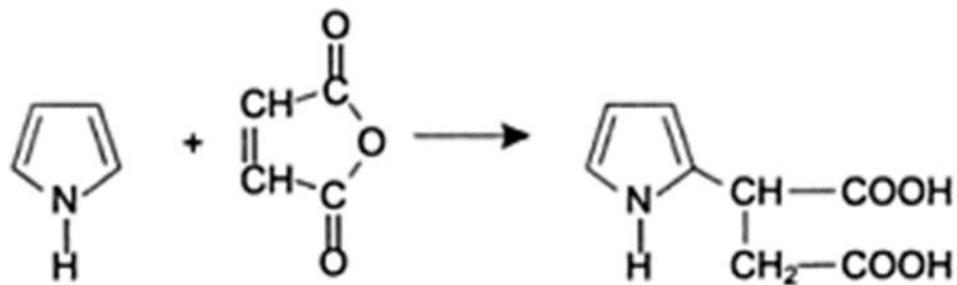
Xiaoyuan Ding, Son T. Nguyen, John D. Williams, Norton P. Peet  
 Diels-Alder reactions of five-membered heterocycles containing one heteroatom

*Tetrahedron Lett.* **2014**, *17*; 55(51): 7002–7006.  
 doi: [10.1016/j.tetlet.2014.10.114](https://doi.org/10.1016/j.tetlet.2014.10.114)

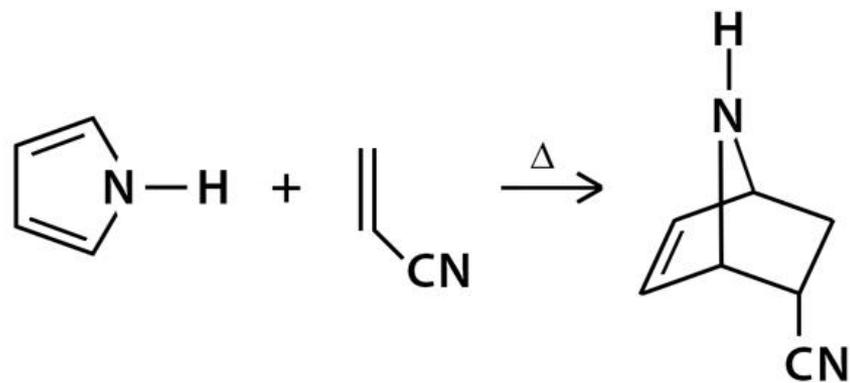


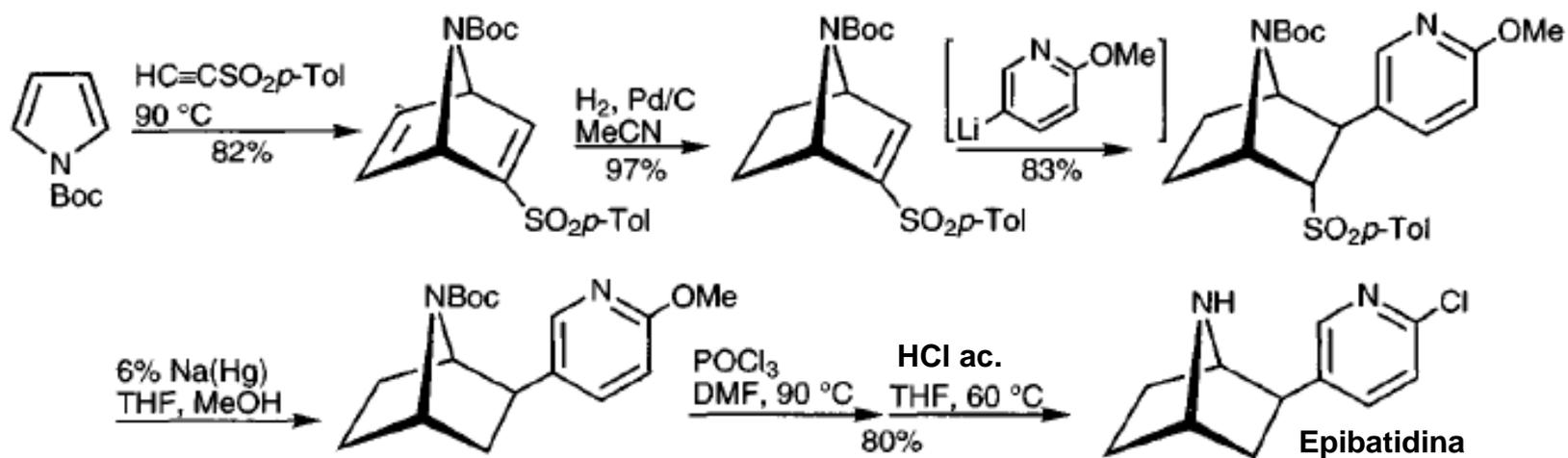
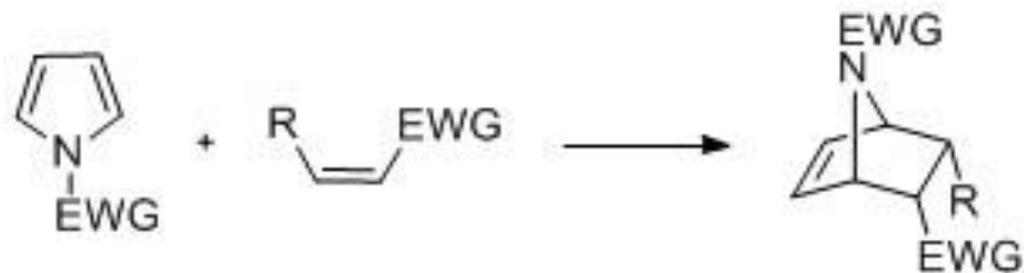


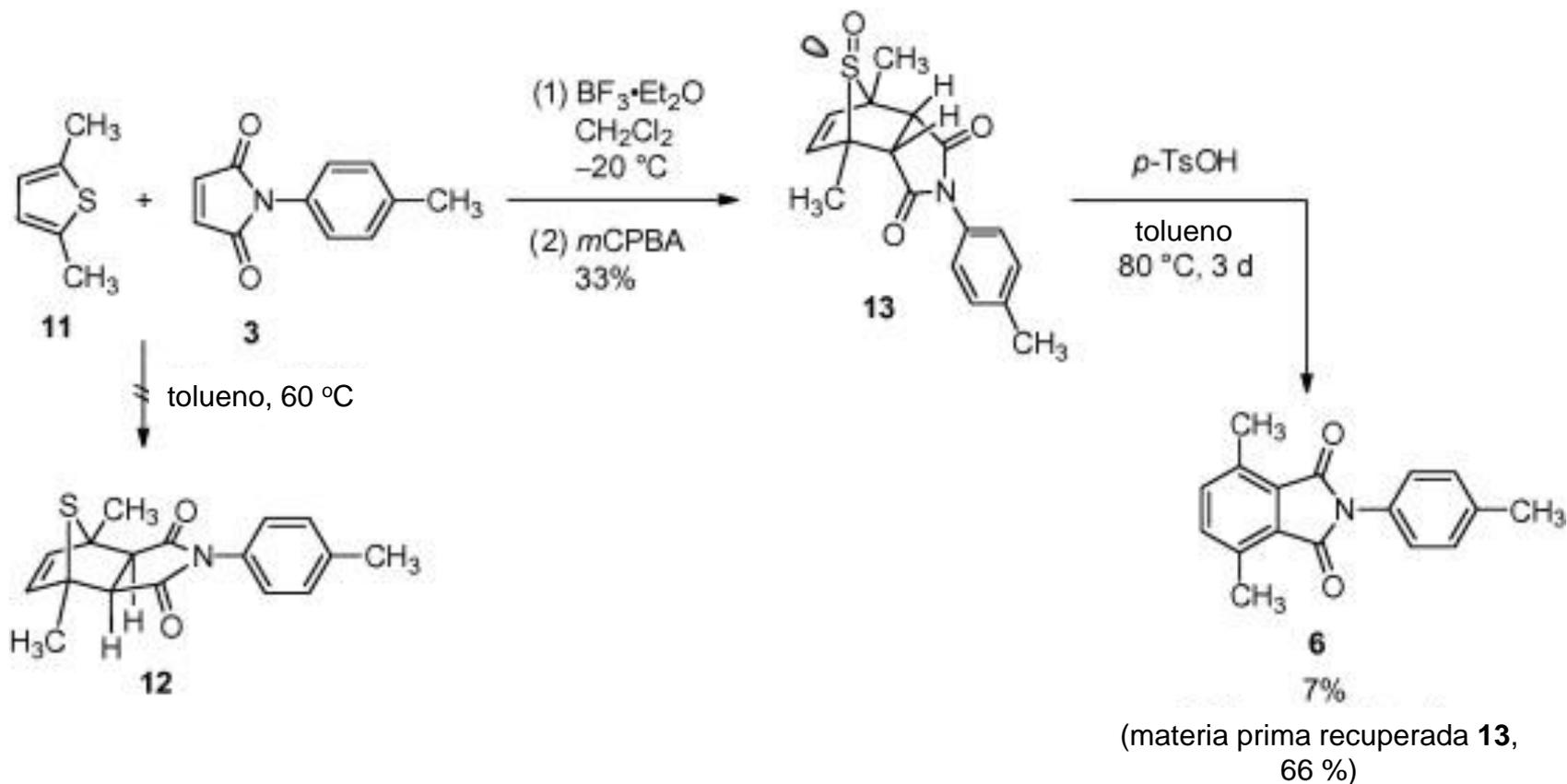




### Reacción de Diels-Alder con el pirrol

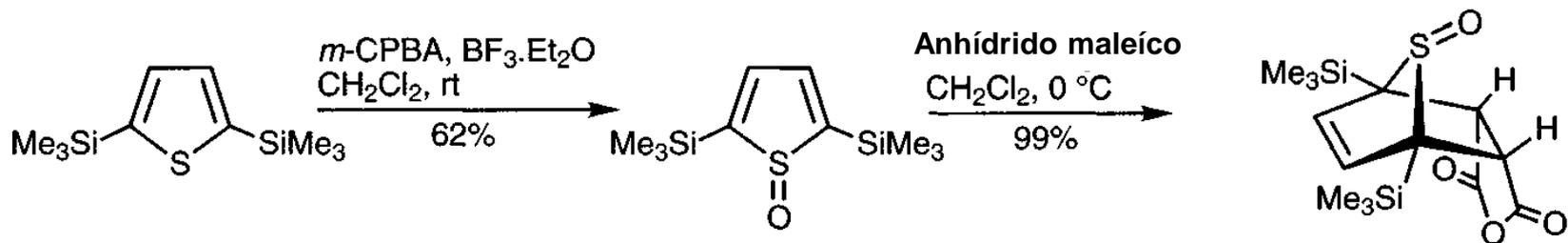
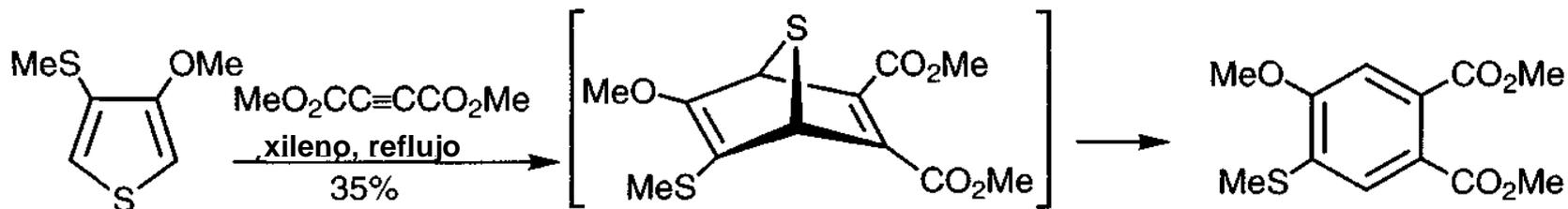
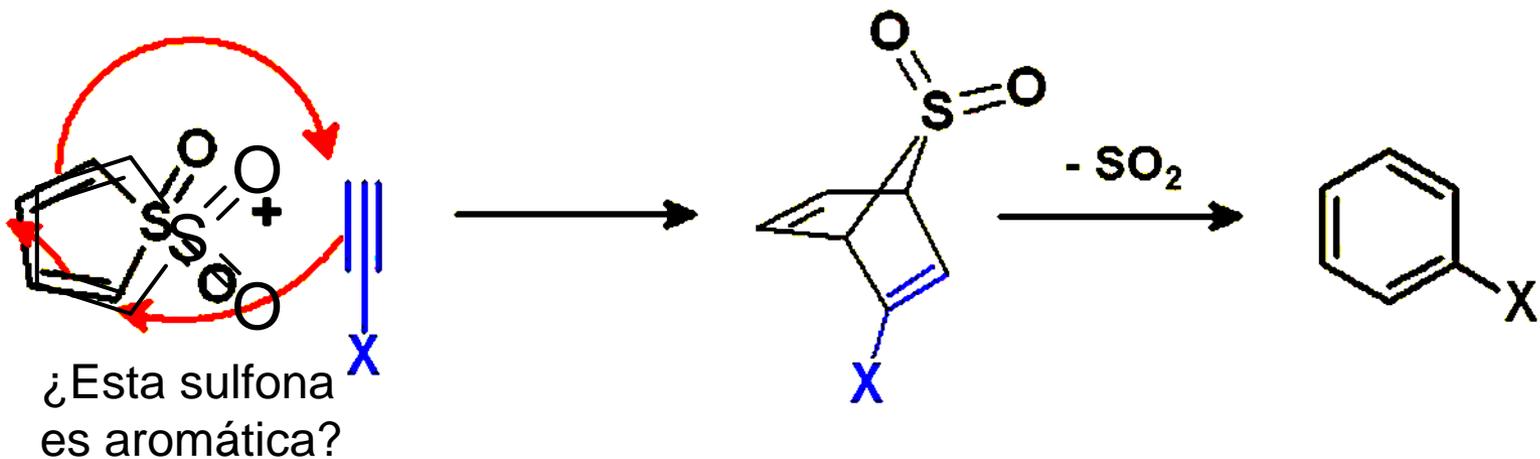






Diels–Alder Reaction of Thiophene: Dramatic Effects  
 of High-Pressure/Solvent-Free Conditions<sup>‡</sup>  
 Koji Kumamoto, Isao Fukada, Hiyoshizo Kotsuki  
 30 March 2004  
<https://doi.org/10.1002/anie.200353487>

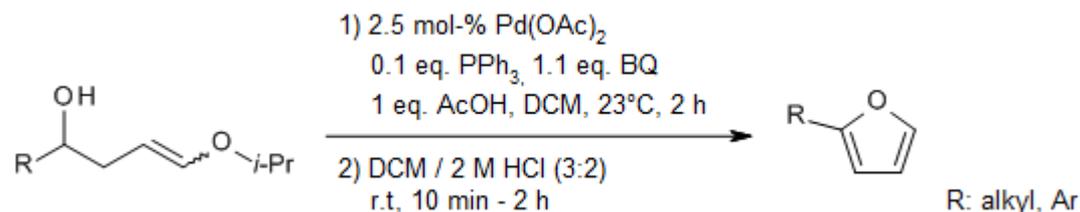
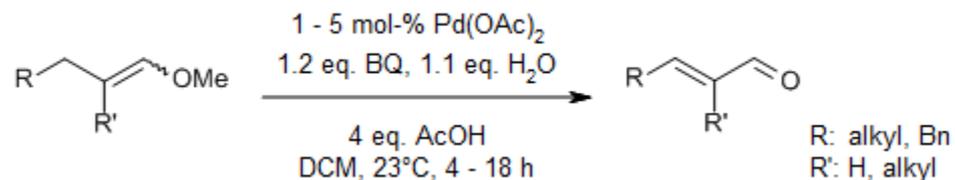




## SEMINARIO 1

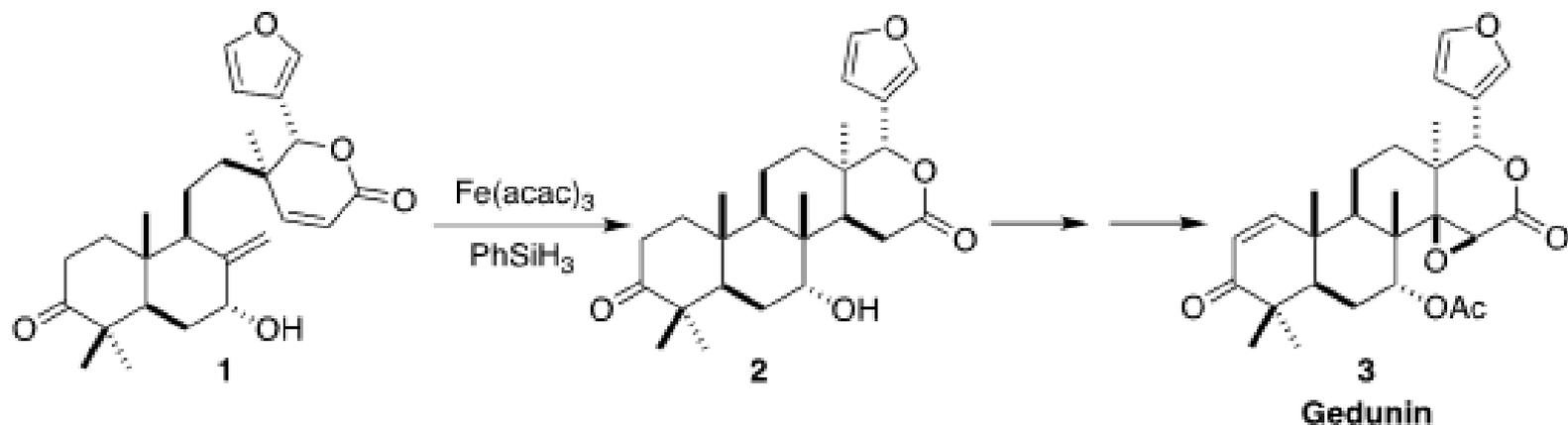
A mild oxidation of alkyl enol ethers to enals employs low loadings of a palladium catalyst and tolerates a diverse array of functional groups, while allowing the formation of di-, tri-, and tetrasubstituted olefins. The application of this methodology to intramolecular reactions of alkyl enol ethers containing pendant alcohols provides furan and 2,5-dihydrofuran products.

M. G. Lauer, W. H. Henderson, A. Awad, J. P. Sambuli, *Org. Lett.*, 2012, 14, 6000-6003.



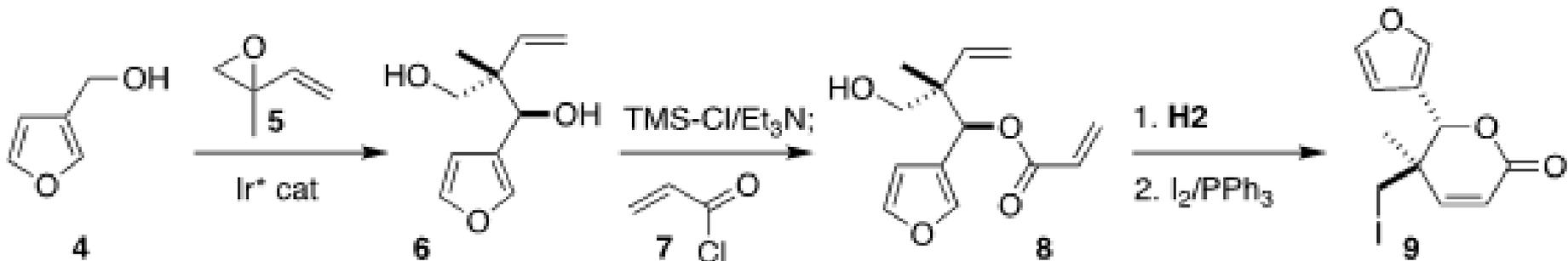
## SEMINARIO 2

Gedunin (3), isolated from the Indian neem tree *Azadirachta indica*, modulates the activity of Hsp90. En route to 3, Hans Renata of Rice University devised the diastereoselective H-atom transfer cyclization of 1 to 2 (J. Am. Chem. Soc. 2022, 144, 19238. DOI: 10.1021/jacs.2c09048).



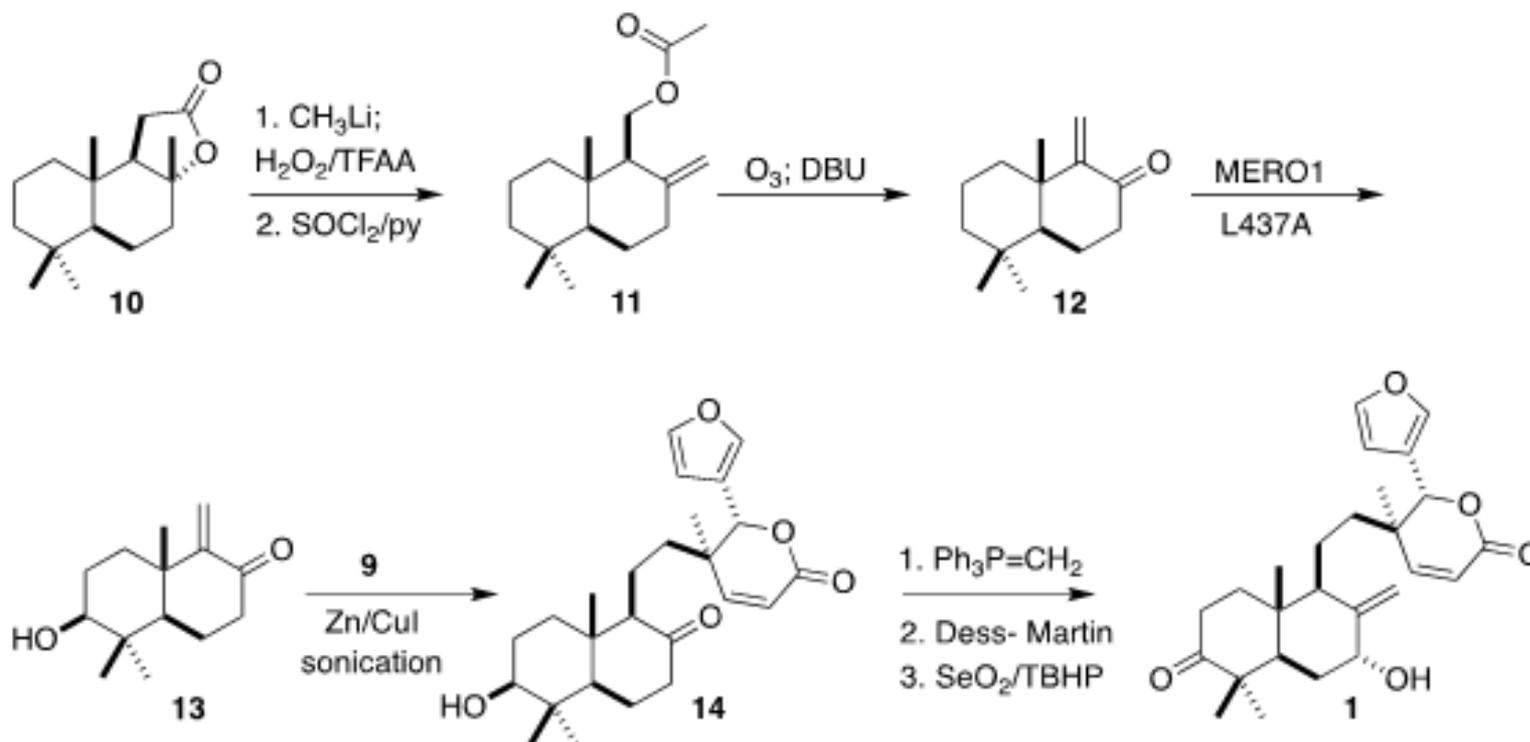
## SEMINARIO 3

The convergent assembly of the triene 1 began with furfuryl alcohol 4 and racemic isoprene monoepoxide 5. Following the Krische protocol, coupling of the two led to the diol 6 with high diastereo- and enantioselectivity. The derived monoacrylate 8 was cyclized, then carried on to the iodide 9.



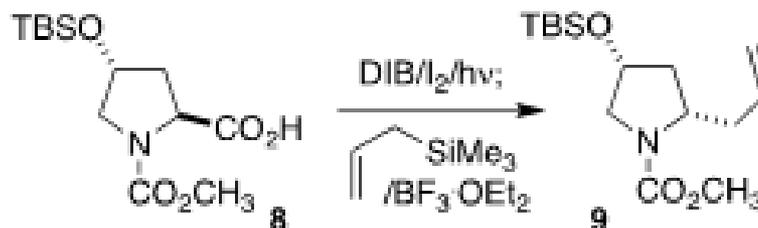
## SEMINARIO 4

The inertness of the A ring of sclareolide 10 allowed ready conversion, via methyl ketone formation, Baeyer-Villiger oxidation and dehydration, to the alkene 11. Ozonolysis followed by  $\beta$ -elimination delivered the enone 12, that was oxidized by a cytochrome P450 variant to install the equatorial secondary hydroxyl on the A ring. Reductive conjugate addition of 9 to 13 gave the ketone 14, that was carried on to 1.



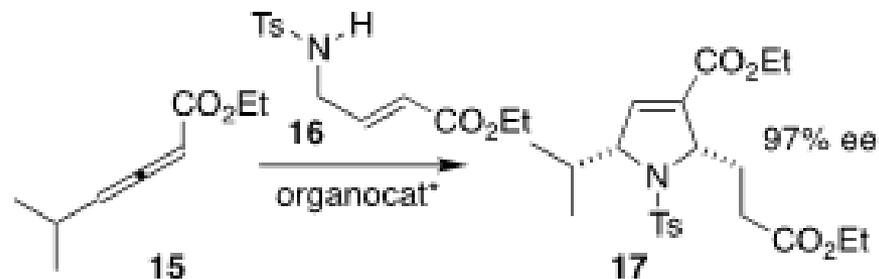
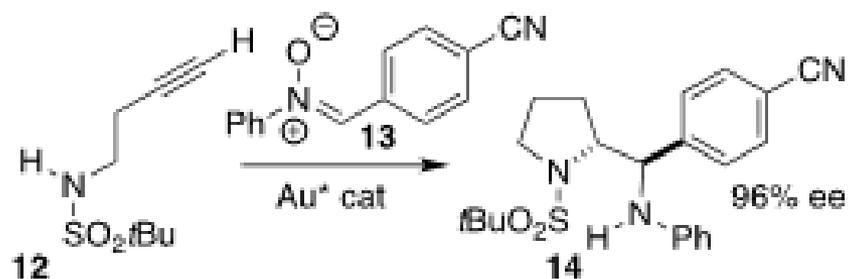
## SEMINARIO 5

Dacil Hernández and Alicia Boto of the Instituto de Productos Naturales y Agrobiología del CSIC oxidized the proline derivative **8**, then coupled the intermediate with allyl trimethylsilane to give the pyrrolidine **9** (J. Org. Chem. 2021, 86, 2796. DOI: 10.1021/acs.joc.0c02751).



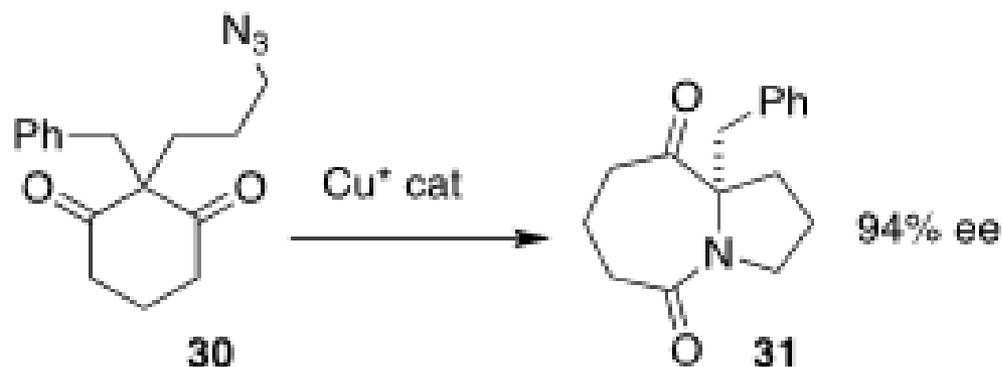
## SEMINARIO 6

Xinfang Xu of Sun Yat-sen University achieved high diastereoselectivity and enantioselectivity in the gold-catalyzed coupling of the alkyne **12** with the nitrene **13**, to give **14** (Chem. Commun. 2021, 57, 12171. DOI: 10.1039/D1CC04830A). Liezhong Chen of the Zhejiang Academy of Agricultural Sciences and Hongchao Guo of China Agricultural University used a tricyclic amino phosphine to catalyze the addition of the amine **16** to the allene **15**, leading to the dihydropyrrole **17** (Org. Lett. 2021, 23, 9173. DOI: 10.1021/acs.orglett.1c03483).



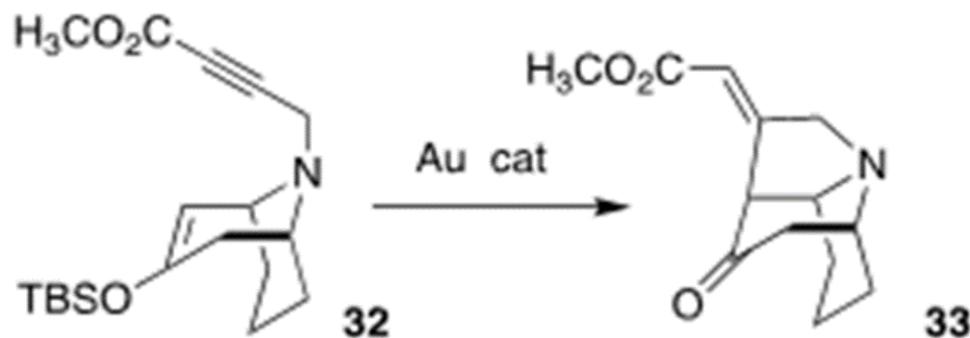
## SEMINARIO 7

Fu-Min Zhang and Yong-Qiang Tu of Lanzhou University used a Cu catalyst to effect the enantioselective ring expansion of the prochiral diketone **30** to the lactam **31** (*Angew. Chem. Int. Ed.* 2021, 60, 22688. DOI: 10.1002/anie.202107909).



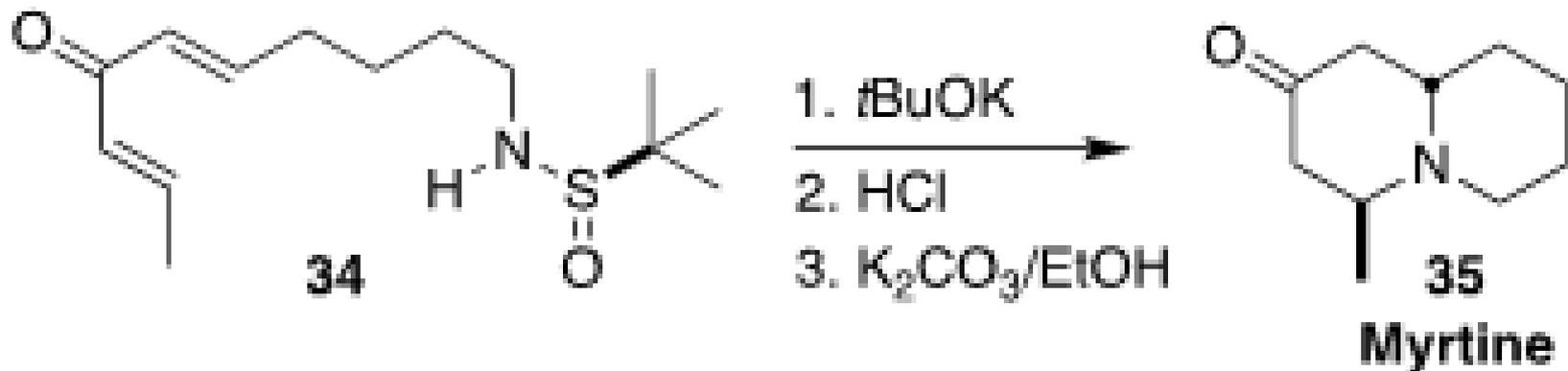
## SEMINARIO 8

Hiroyuki Nakamura of the Tokyo Institute of Technology showed that a gold catalyst efficiently cyclized the alkyne **32** to the tricyclic amine **33** (*Chem. Eur. J.* 2021, 27, 11888. DOI: 10.1002/chem.202101440).



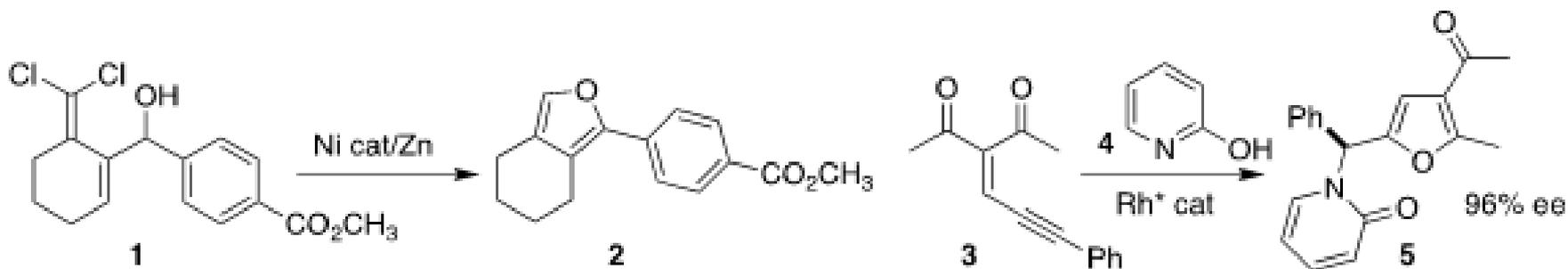
## SEMINARIO 9

The alkaloid myrtine (35) was isolated from the European bilberry, *Vaccinium myrtillus*. Carlos del Pozo of the University of Valencia developed a simple route to 35, based on the diastereoselective double cyclization of the dienone 34 (*Org. Biomol. Chem.* **2021**, *19*, 8740. DOI: 10.1039/D1OB01488A).



## SEMINARIO 10

Christopher Uyeda of Purdue University reduced **1** to the intermediate vinylidene (also termed "alkylidene") carbene, that cyclized to the furan **2** (ACS Catal. 2021, 11, 193. DOI: 10.1021/acscatal.0c04713). Xinhao Zhang of Peking University Shenzhen Graduate School and Jiangtao Sun of Changzhou University assembled the furan **5** by coupling the 2-pyridone **4** with the enone **3** (Angew. Chem. Int. Ed. **2021**, 60, 16942. DOI: 10.1002/anie.202104708).



## SEMINARIO 11

Anton S. Makarov of Perm State University rearranged the furan **6** to the pyrrole **7** (Org. Chem. Front. 2021, 8, 6553. DOI: 10.1039/D1QO01281A). B. V. Subba Reddy of CSIR-Indian Institute of Chemical Technology prepared the pyrrole **10** by combining the sugar-derived aldehyde **8** with N-methyl glycine (**9**) (*Tetrahedron* **2021**, 97, 132389. DOI: 10.1016/j.tet.2021.132389).

