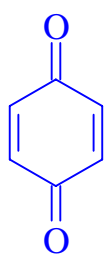
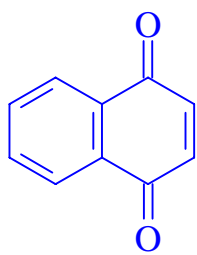


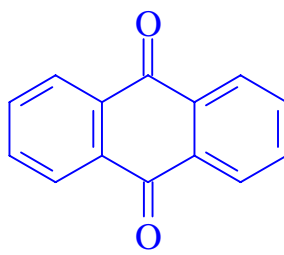
## Anthrachinon



p-Benzochinon

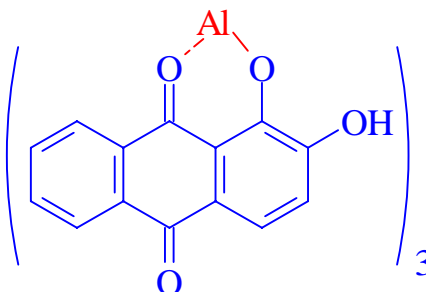
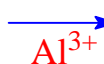
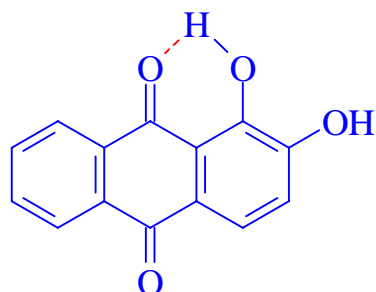
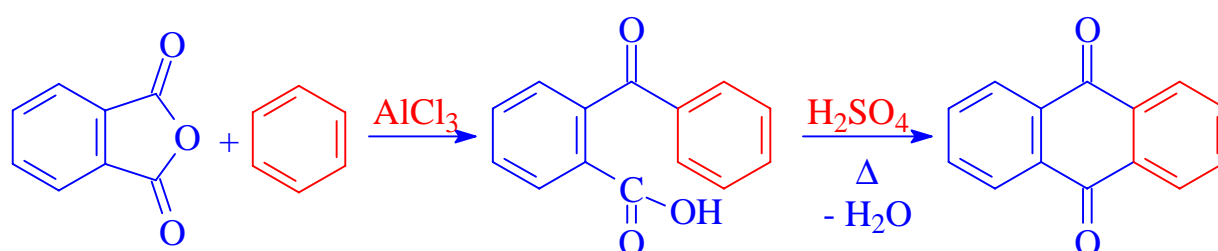


1,4-Naphthochinon

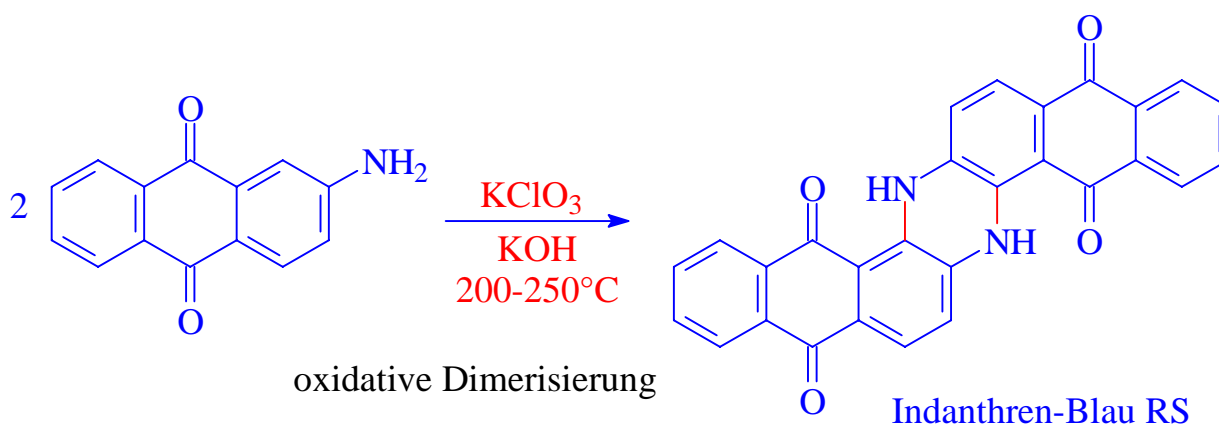


Anthrachinon

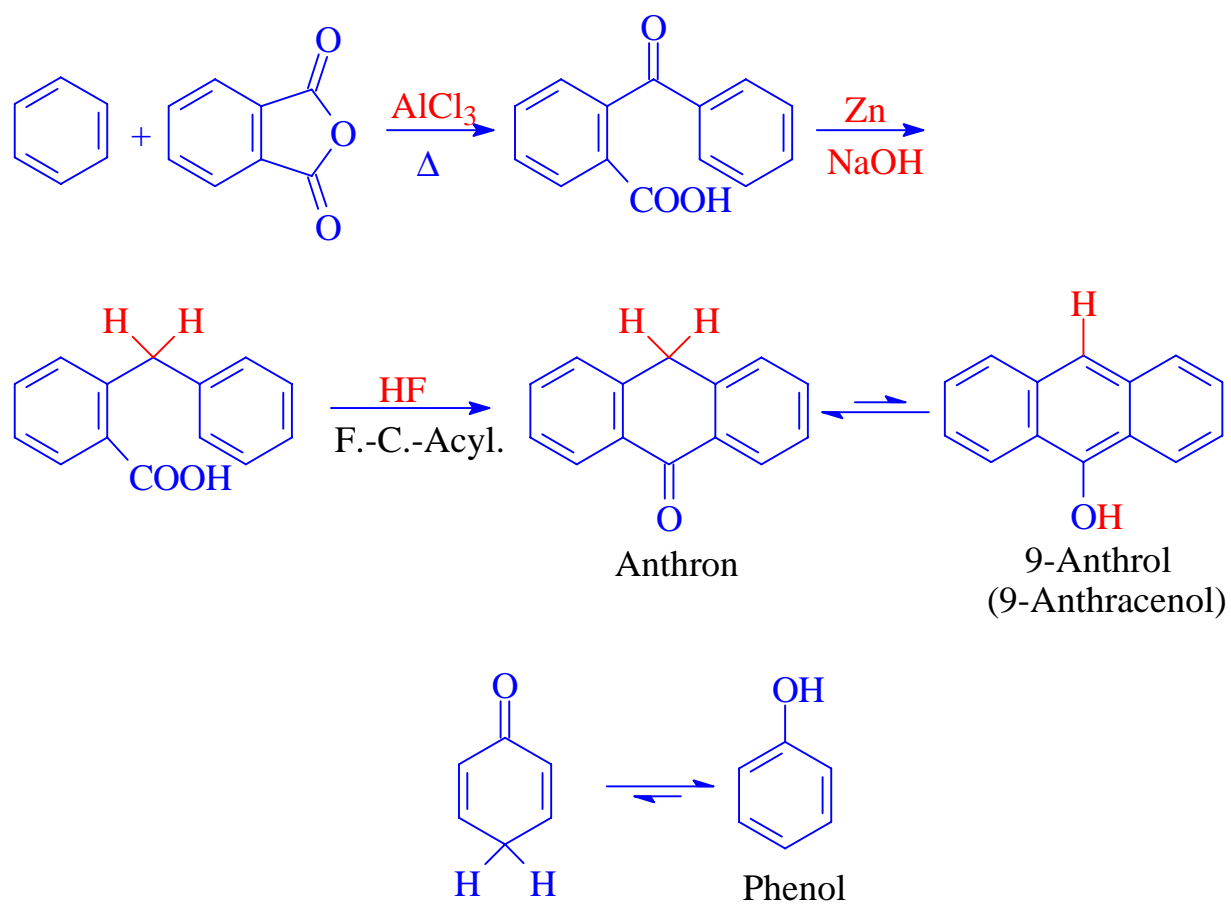
alle  
gelb



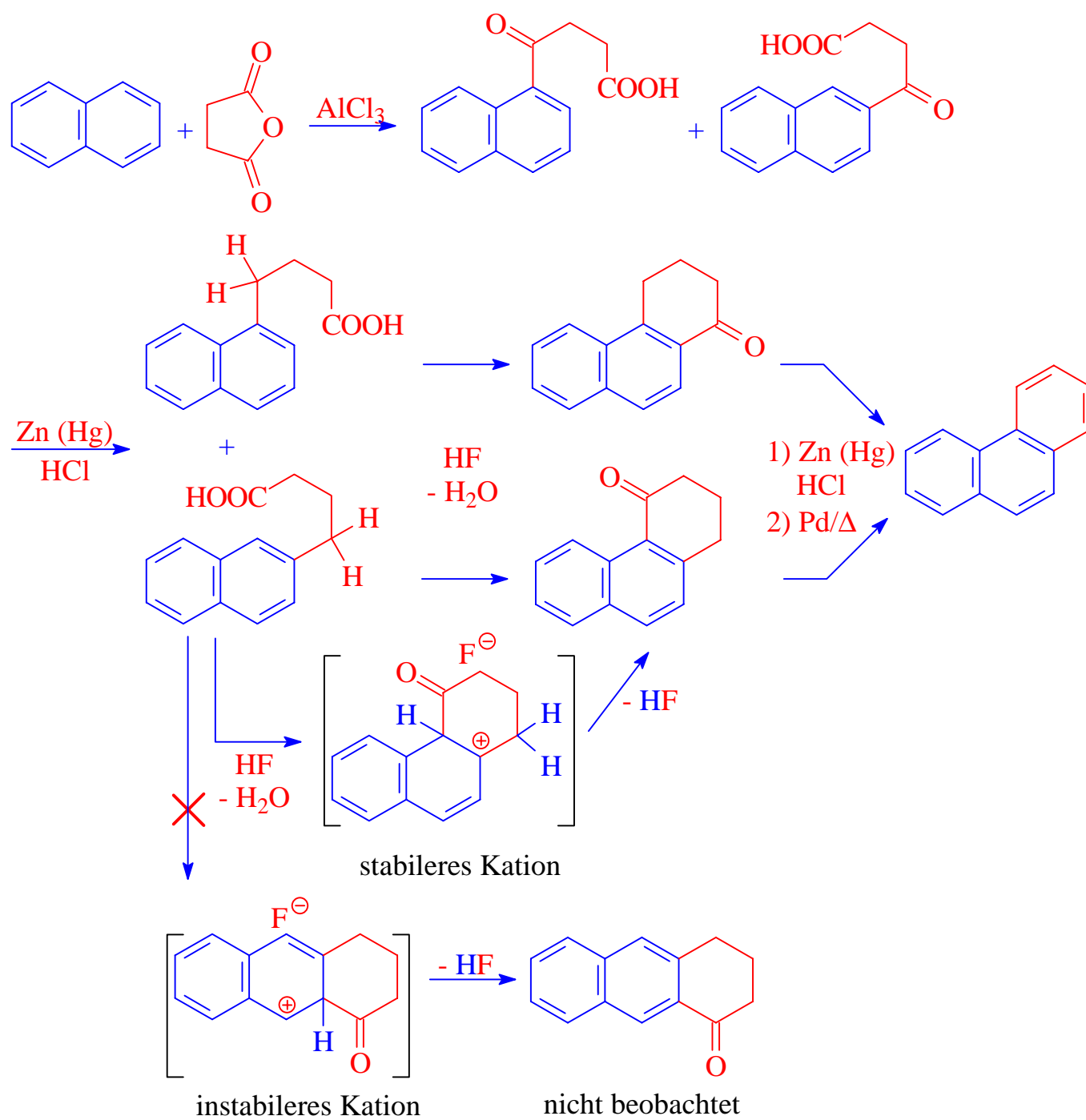
Chelat-Komplex,  
besonders gut haftbar  
auf Fasern.



## Synthese von Anthron



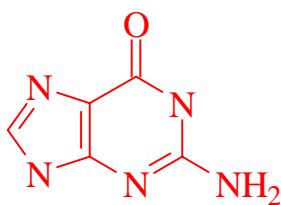
# Synthese von Phenanthren



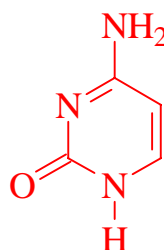
# Basen, die in der DNA (Desoxyribonucleic Acid – Desoxyribonucleinsäure) vorkommen



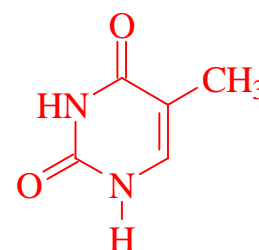
Adenin (A)



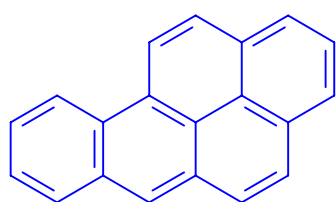
Guanin (G)



Cytosin (C)

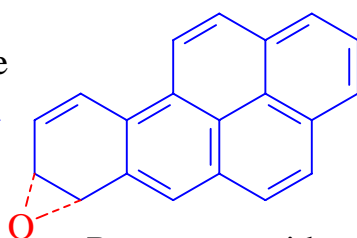


Thymin (T)



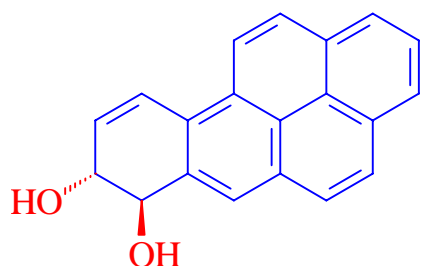
Benzpyren

enzymische Oxidation



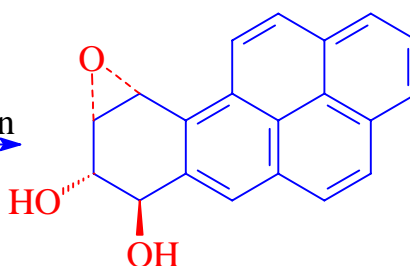
Benzpyrenoxid, ein Arenoxid

H<sub>2</sub>O  
enzymische Hydrolyse

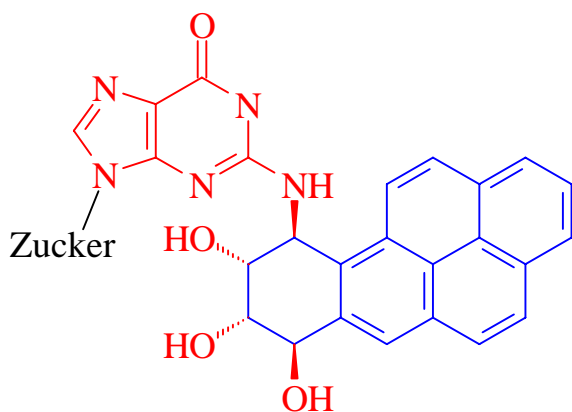


trans-Diol

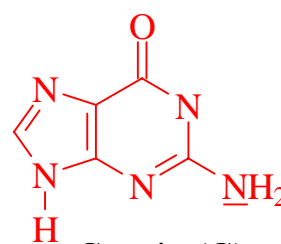
Oxidation



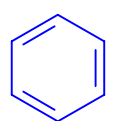
nucleophile Addition an den Epoxidring



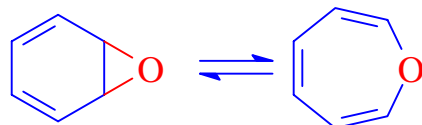
Zucker



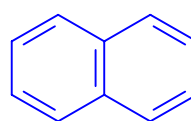
Guanin (G)



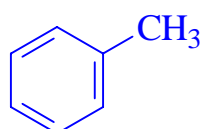
Benzoloxid



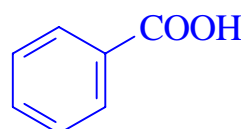
Oxepin



Naphthalinoxid



Oxid.



## Nicht-aromatische Heterocyklen

### Cyclische Ether

### Cyclische Thioether

### Cyclische Amine



Oxivan (Ethylenoxid)



Thiiran (Ethylensulfid)



Aziridin (Ethylenimin)



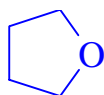
Oxetan



Thiethan



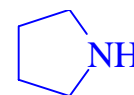
Azetidin



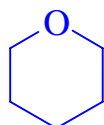
Tetrahydrofuran



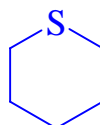
Tetrahydrothiophen



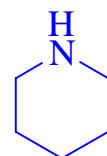
Pyrrolidin



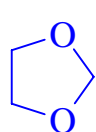
Tetrahydropyran



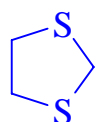
Tetrahydrothiopyran



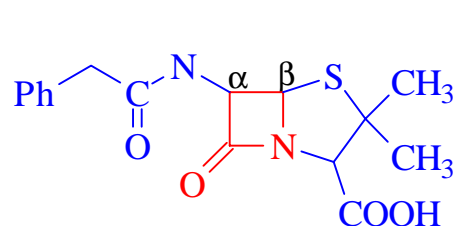
Piperidin



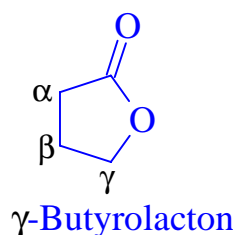
1,3-Dioxalan (Acetal aus  $\text{HOCH}_2\text{CH}_2\text{OH} + \text{H}_2\text{C=O}$ )



1,3-Dithian (Thioacetal aus  $\text{HSCH}_2\text{CH}_2\text{SH} + \text{H}_2\text{C=O}$ )



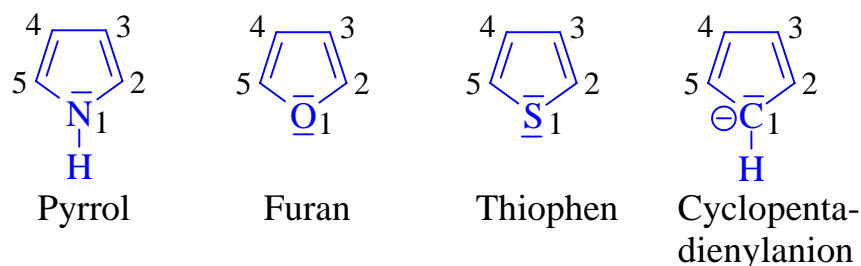
Penicillin G  
β-Lactamring



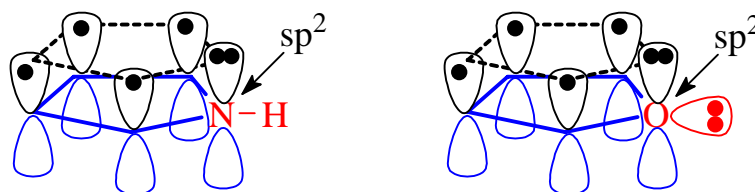
γ-Butyrolacton

## Fünfgliedrige Ringe

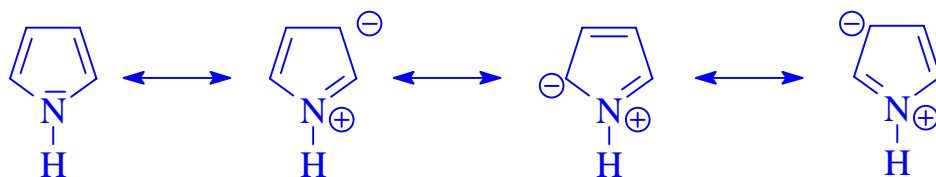
### Aromatische 5-Ring-Heterocyclen:



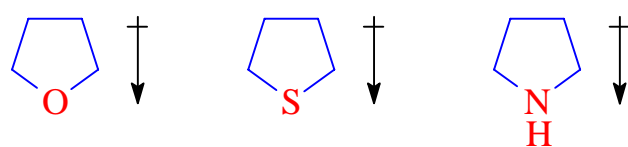
### MO-Bild



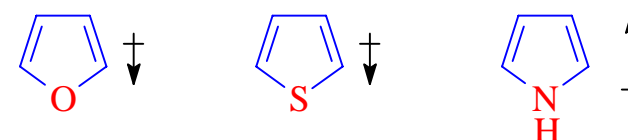
### Resonanzstrukturen



### Dipolmomente



1.73 D      1.90 D      1.58 D



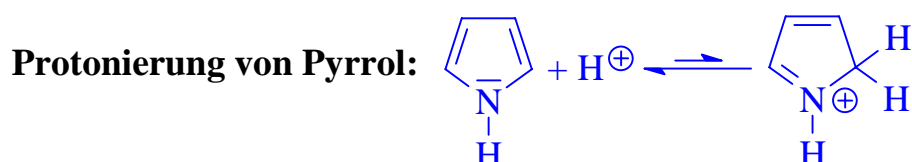
0.70 D      0.51 D      1.81 D

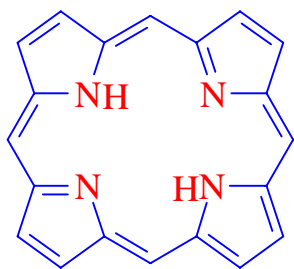
Basizitätskonstante  $K_B = \frac{[B^+ \cdot H] [OH^-]}{[B]}$

$10^{-4}$  [M]

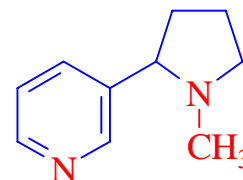
$2.5 \times 10^{-14}$  [M]

Resonanzenergie: R.E.  $\approx$  22-28 kcal/mol





**Porphin**  
(Grundkörper  
sonst Porphyrine)



Nicotin

Chlorophyll (grünes Pflanzenpigment)

Hämoglobin (Sauerstoff-Transport im Blut) (Folie 378)

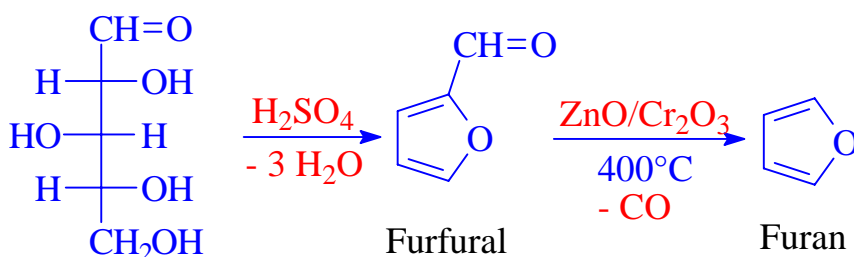
(Alkaloid des Tabaks)

Alkaloid  $\Rightarrow$  alkaliähnliche  
also basische Eigenschaften

Porphyrin-Derivate:

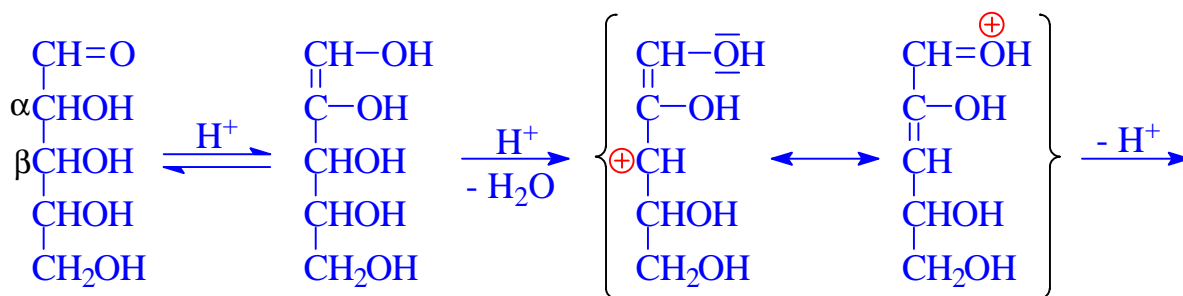
### Synthese von Furan, Thiophen und Pyrrol

#### 1) Furan

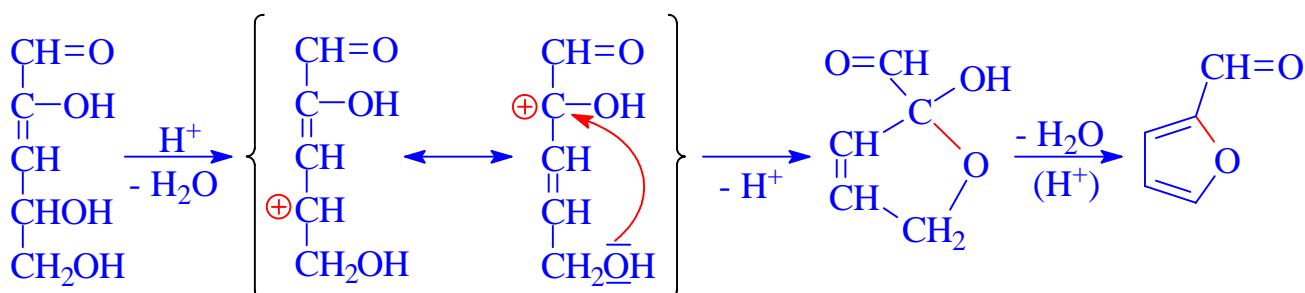


Pentose  
(z.B. aus Kleie)

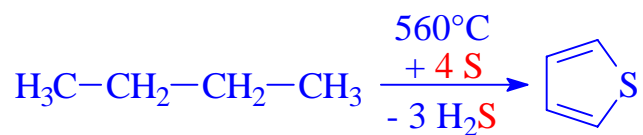
#### Mechanismus



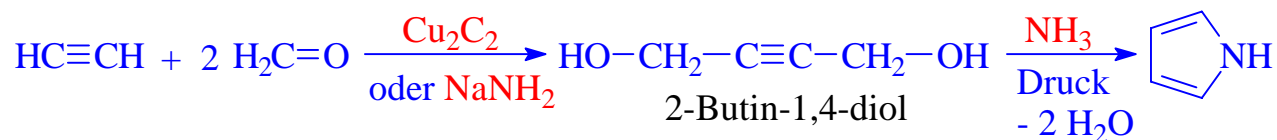
Keto-Enol-Tautomerie



## 2) Thiophen

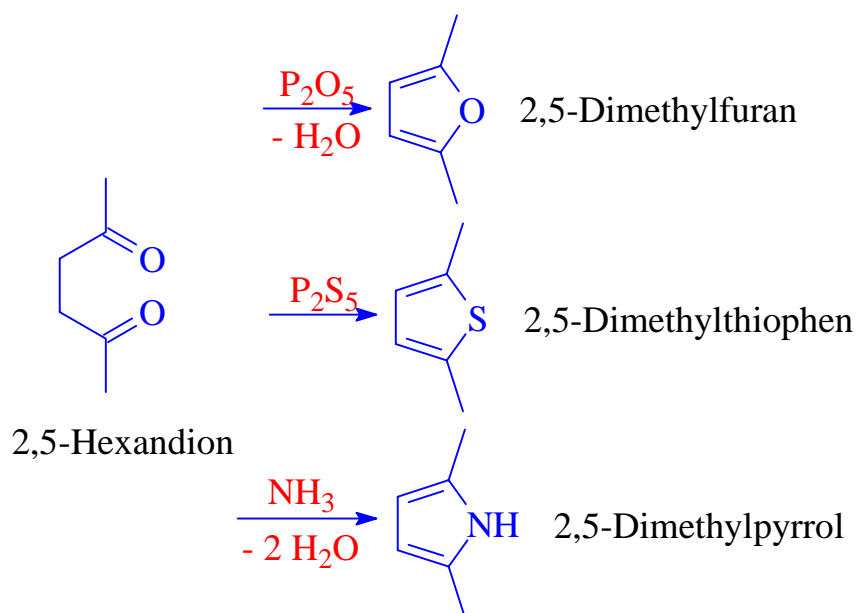


## 3) Pyrrol



(technische Synthese)

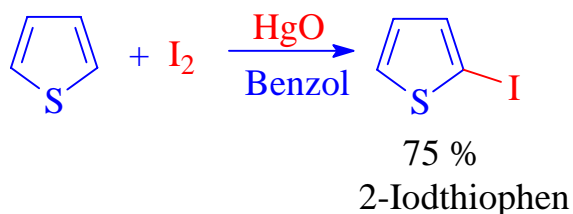
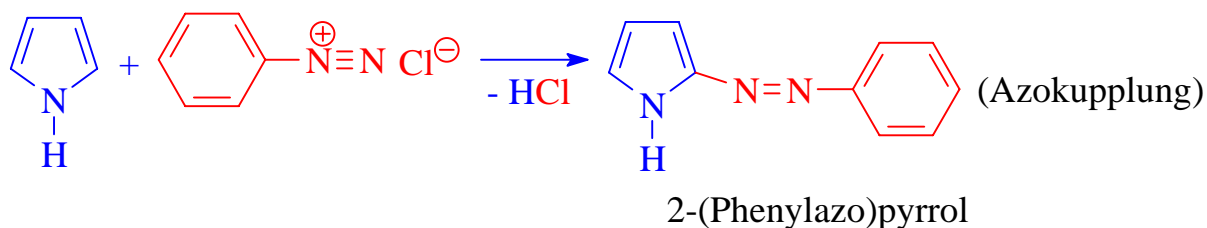
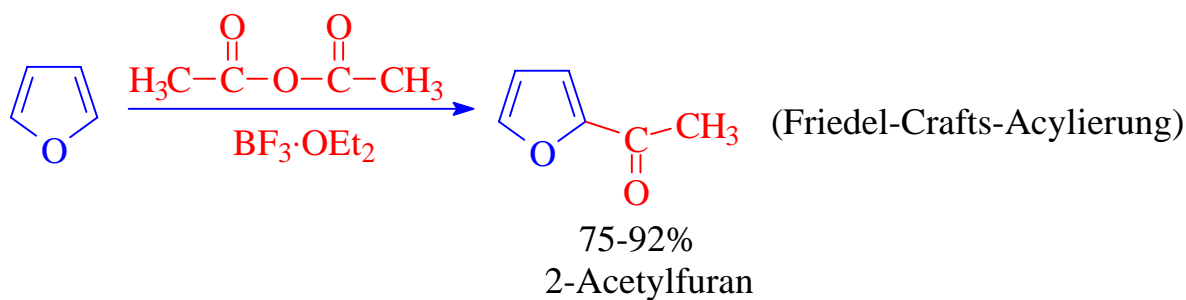
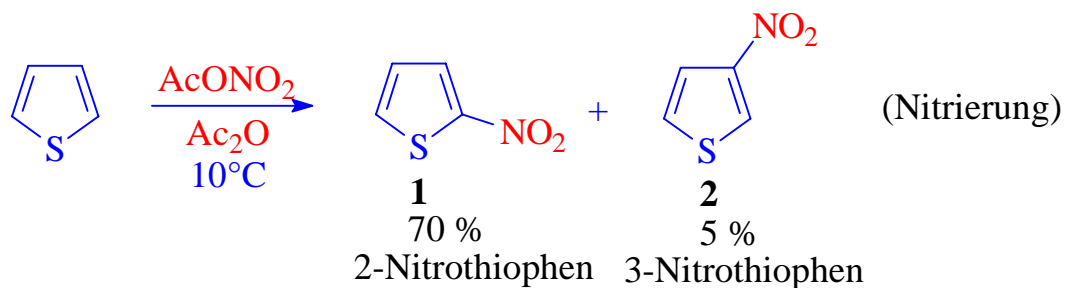
## Substituierte Furane, Thiophene und Pyrrole aus 1,4-Diketone



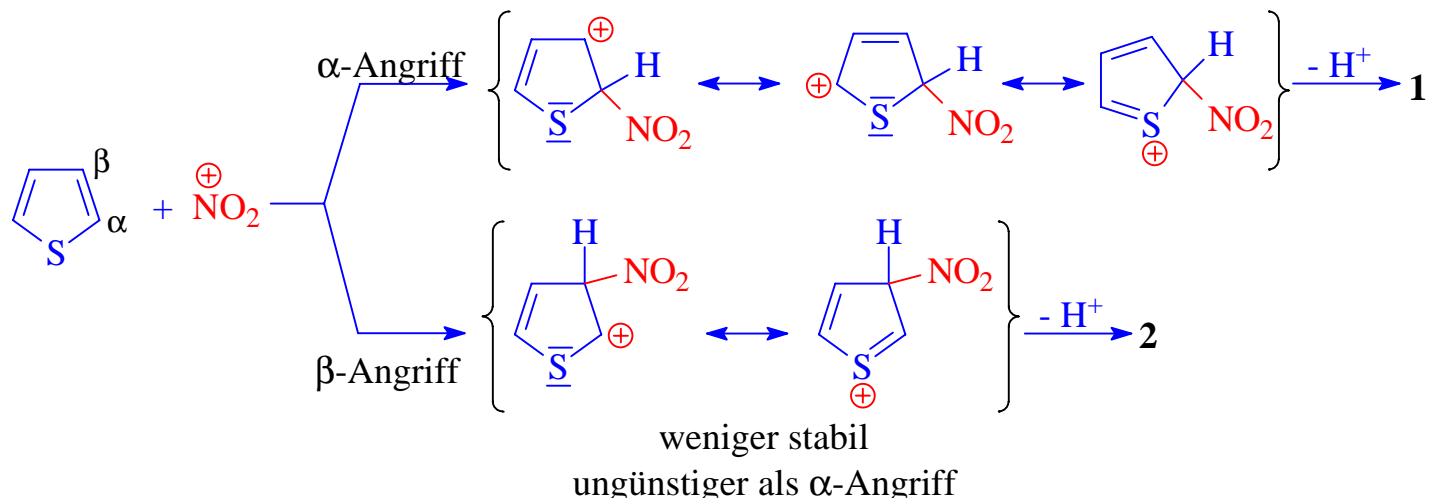
## Reaktionen

### 1) Elektrophile aromatische Substitution

Reaktivität: Pyrrol > Furan > Thiophen >> Benzol

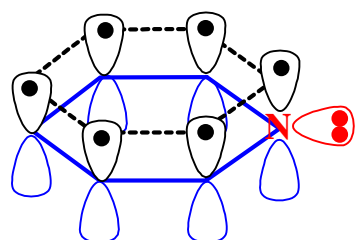


### Orientierung bei der Substitution

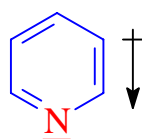




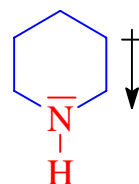
## Sechsgliedrige Ringe (Sechring-Heteroaromaten)



### Dipolmoment

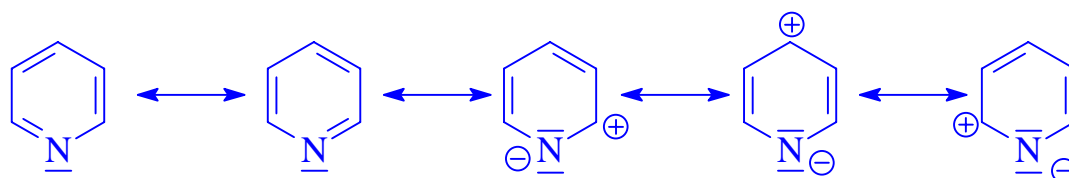


2.26 D

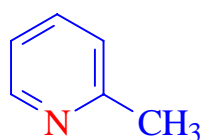


1.17 D

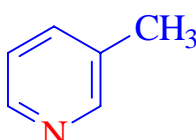
### Kekule-Strukturen



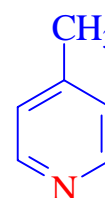
### Pyridin-Derivate



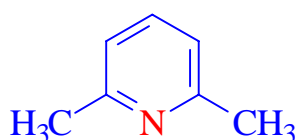
2-Methylpyridin

 $\alpha$ -Picolin

3-Methylpyridin

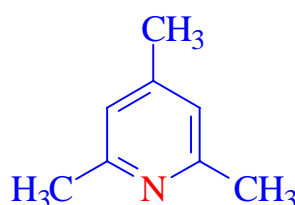
 $\beta$ -Picolin

4-Methylpyridin

 $\gamma$ -Picolin

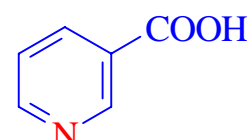
2,6-Dimethylpyridin

2,6-Lutidin



2,4,6-Trimethylpyridin

(Collidin)

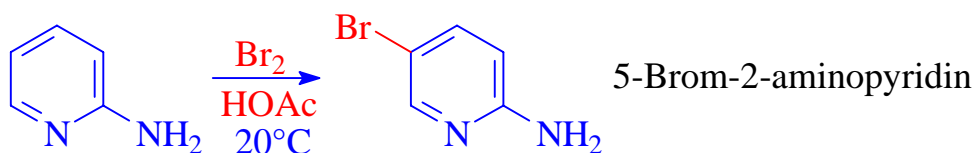
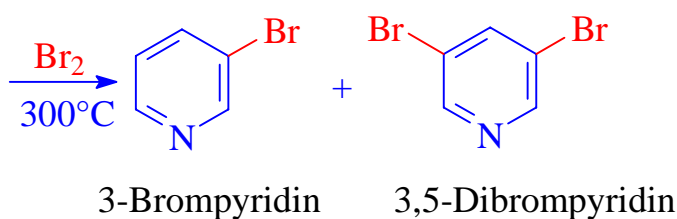
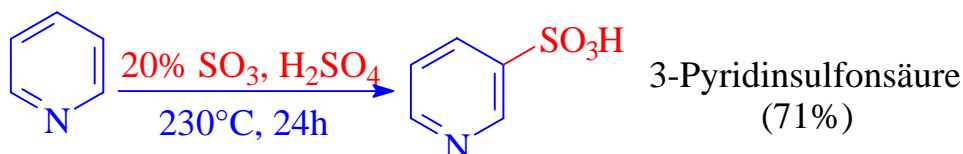
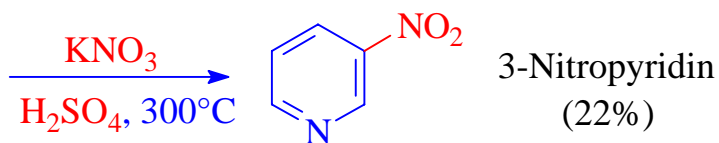


Nicotinsäure

(3-Pyridincarbonsäure)

# Reaktionen des Pyridins

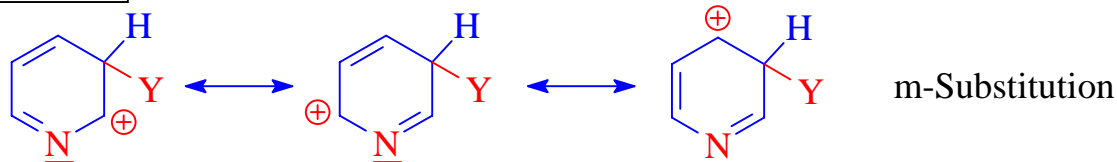
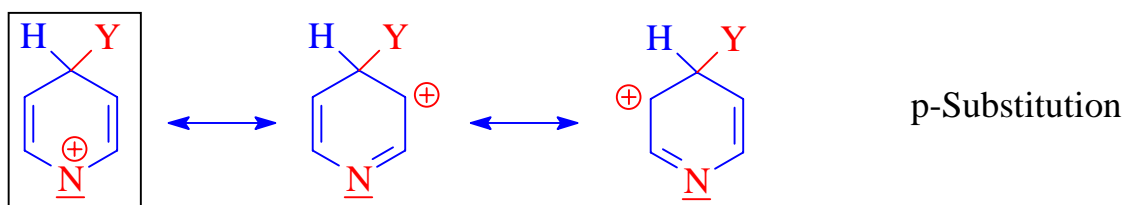
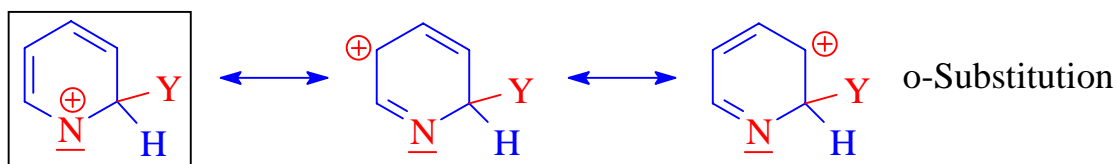
## 1) Elektrophile Substitution



2-Aminopyridin

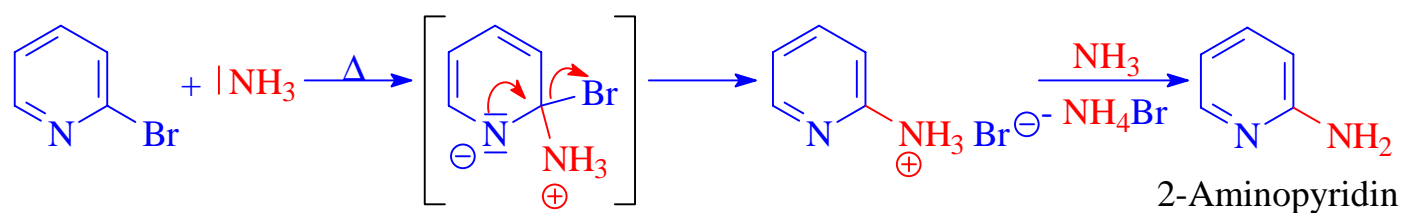
## Erklärung der Orientierung des Substituenten in die m- bzw. 3-Position

Elektronensextett und positive Ladung am N-Atom  $\Rightarrow$  besonders ungünstig

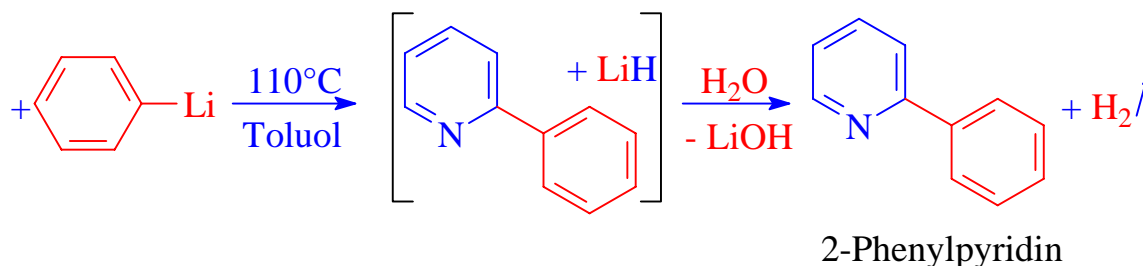
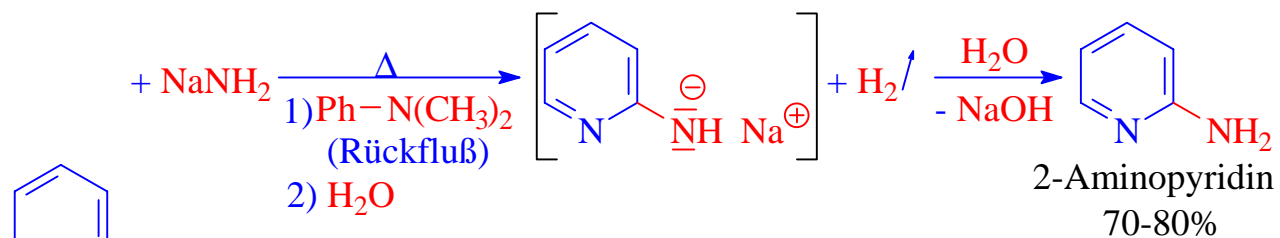


## 2) Nucleophile Substitution

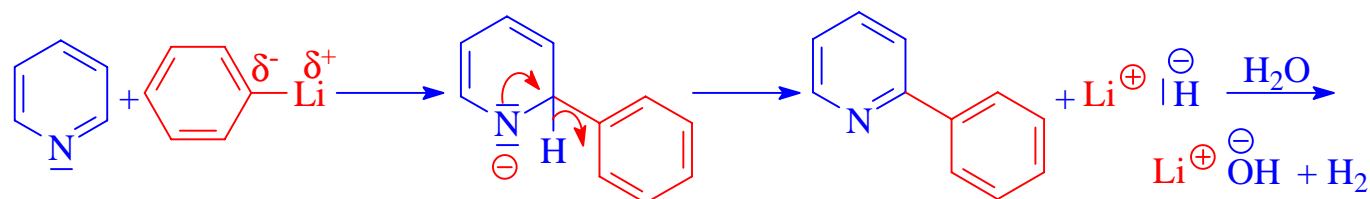
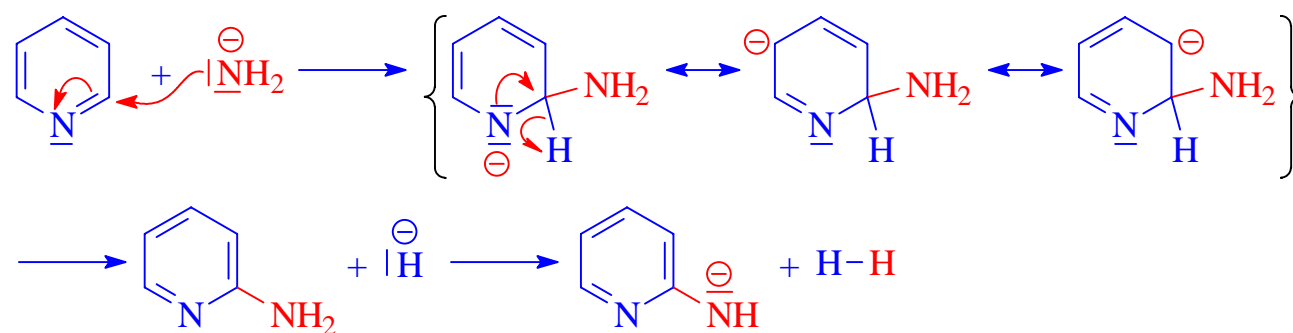
a)



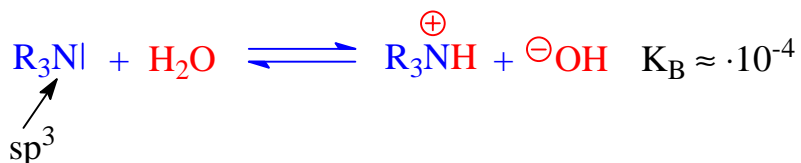
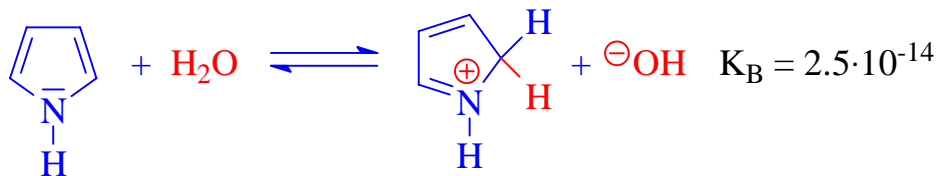
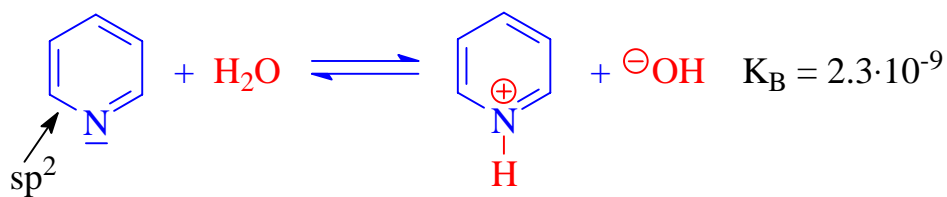
## b) Tschitschibabin-Reaktion und Ziegler-Reaktion



## Mechanismus

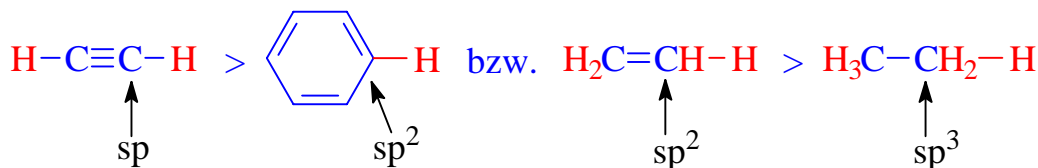


### 3) Basizität



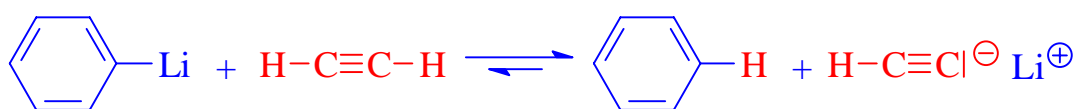
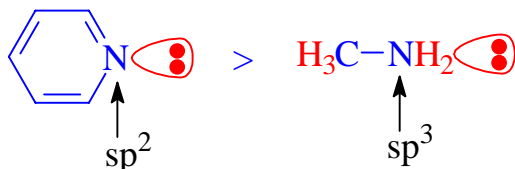
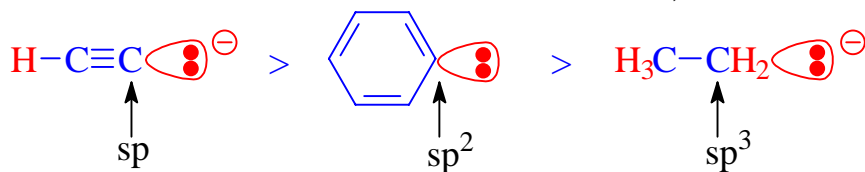
### Relative Azidität

—————> abnehmende Azidität



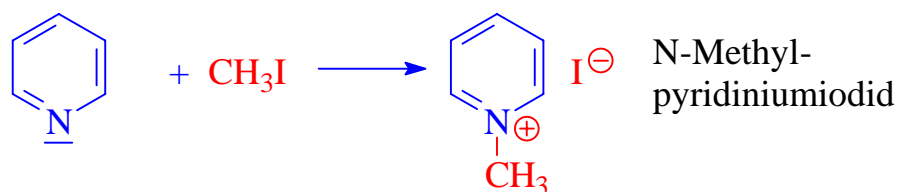
### Stabilität der Anionen

—————> abnehmende Anionenstabilität, zunehmende Basizität

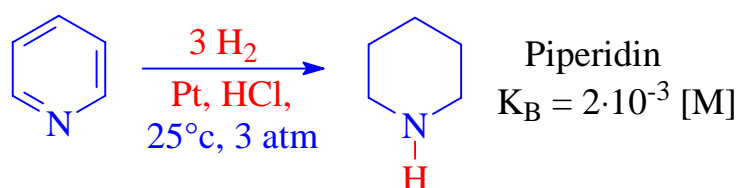


stärkere Base      stärkere Säure

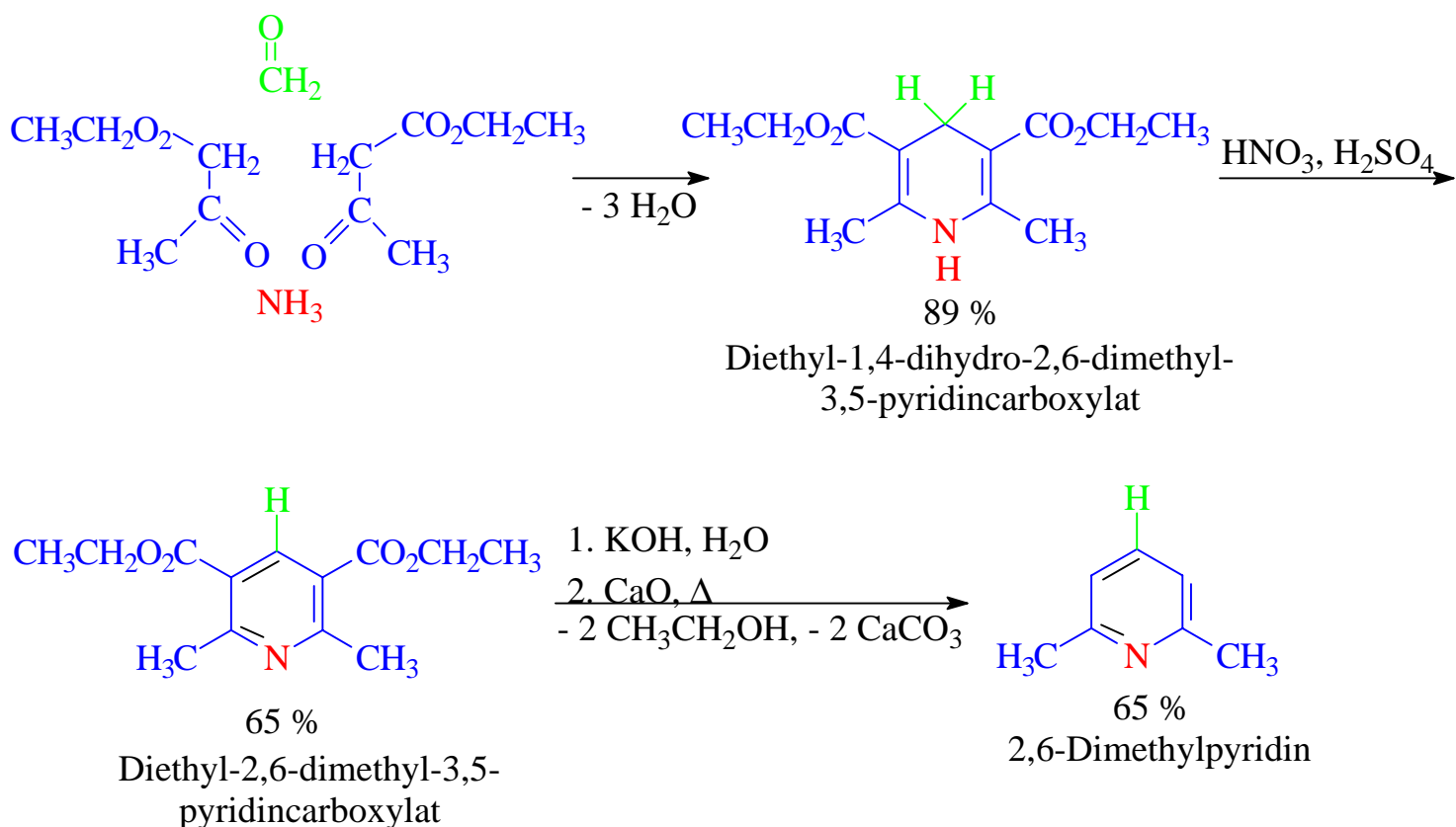
#### 4) Alkylierung von Pyridin (S<sub>N</sub>2-Reaktion)

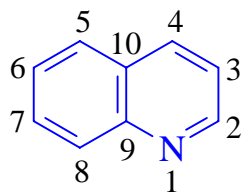


#### 5) Reduktion



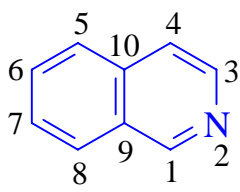
#### Hantzsch-Synthese von 2,6-Dimethylpyridin





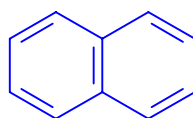
Chinolin

$$K_B = 3 \cdot 10^{-10} \text{ [M]}$$

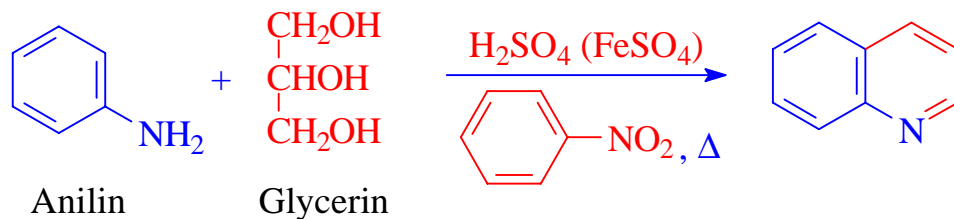


Isochinolin

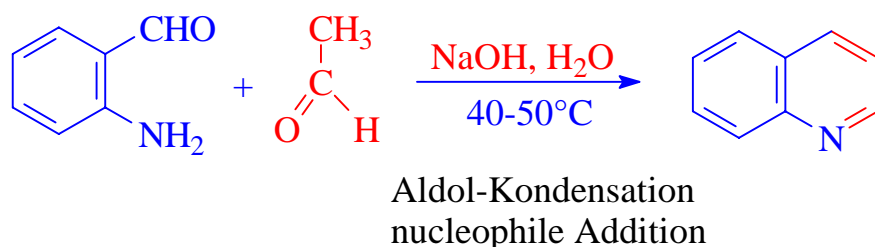
$$K_B = 1.1 \cdot 10^{-9} \text{ [M]}$$



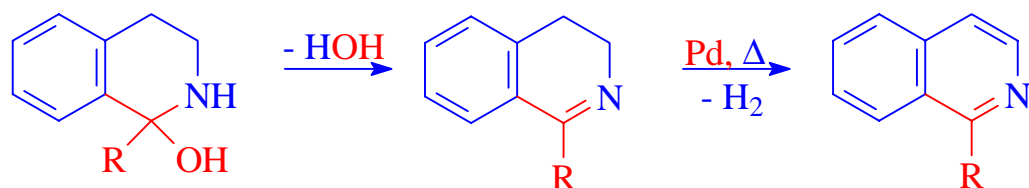
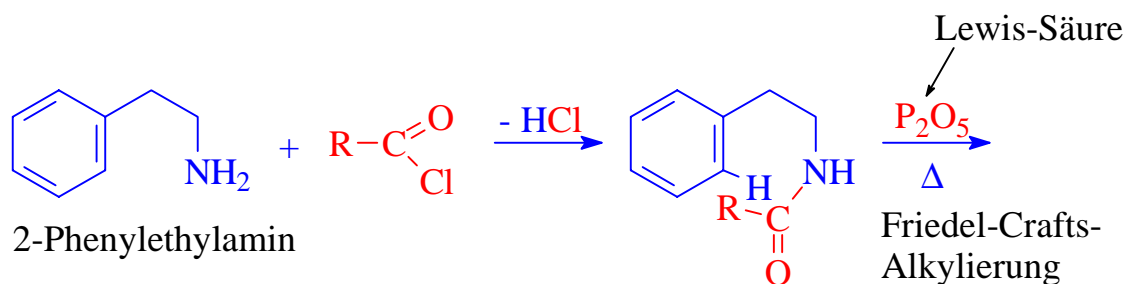
### a) Skraup-Synthese von Chinolin



### b) Friedländer-Synthese

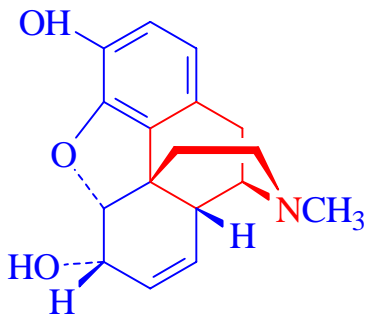


### c) Bischler-Napieralski-Synthese von Isochinolin-Derivaten

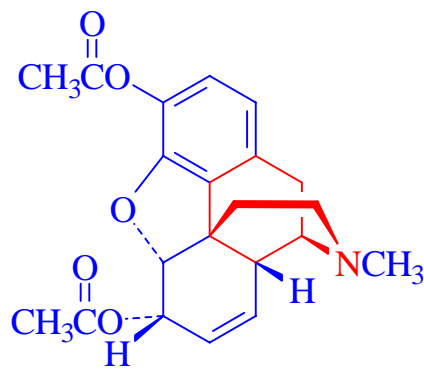


R = CH<sub>3</sub> : 1-Methylisochinolin

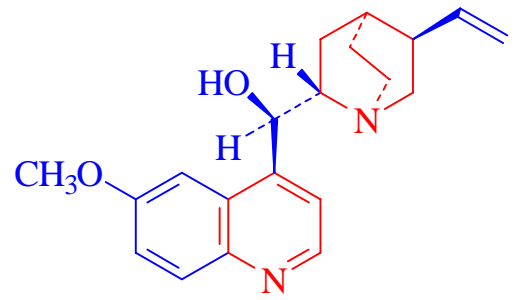
# Alkaloide: Physiologisch wirksame Heterocyclen der Natur



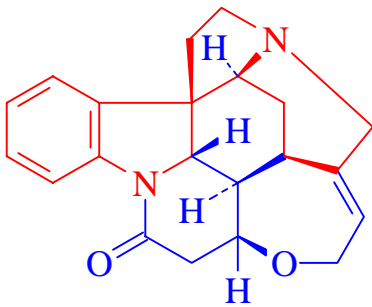
**Morphin**



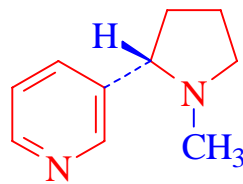
**Heroin**



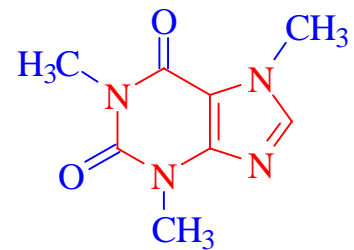
**Chinin**



**Strychnin**



**Nicotin**



**Coffein**