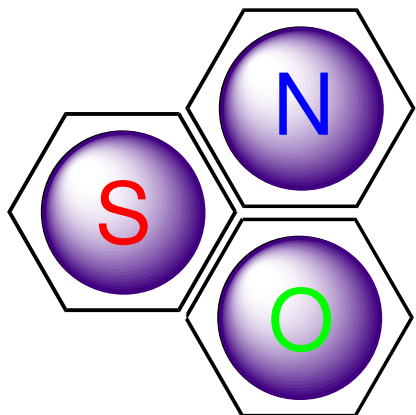


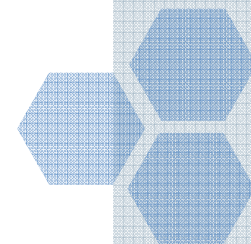


# Heterocyclic Chemistry



Five Membered  
Heterocycles:  
Furan and Thiophene

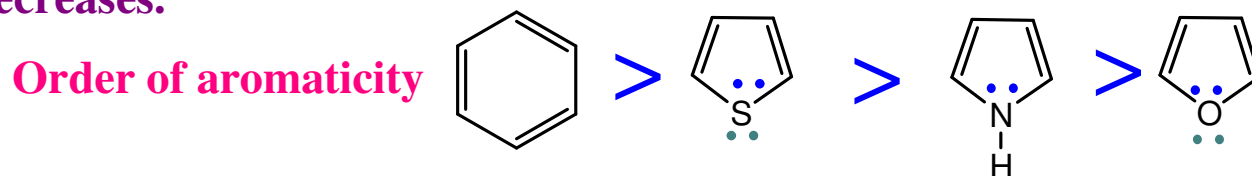
**SAYANWITA PANJA**  
**DEPT. OF CHEMISTRY**  
**SHAHID MATANGINI HAZRA GOVT. GENERAL DEGREE**  
**COLLEGE FOR WOMEN**





## Introduction

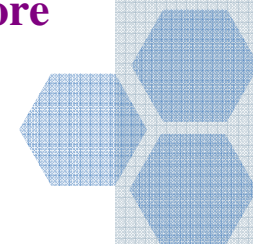
Furan is not very aromatic therefore if there is a possibility of forming stable bonds such as C-O bonds by addition, this may be preferred to substitution i.e. tendency to give addition products rather than substitution products increases as aromaticity decreases.



In comparison to benzene the order of reactivity in electrophilic substitution is as follows: **Pyrrole > Furan > Thiophene > Benzene**

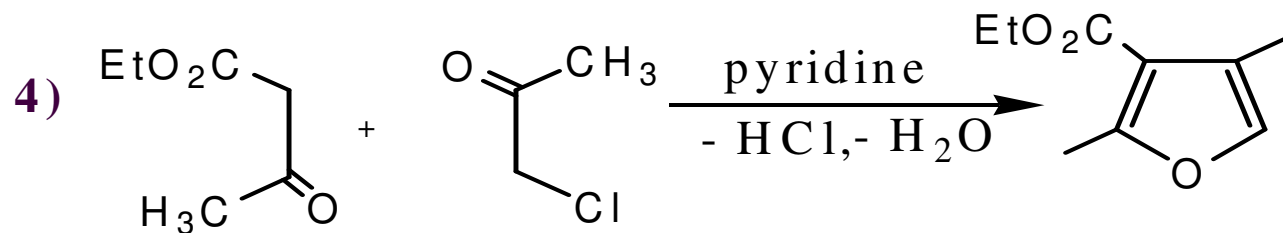
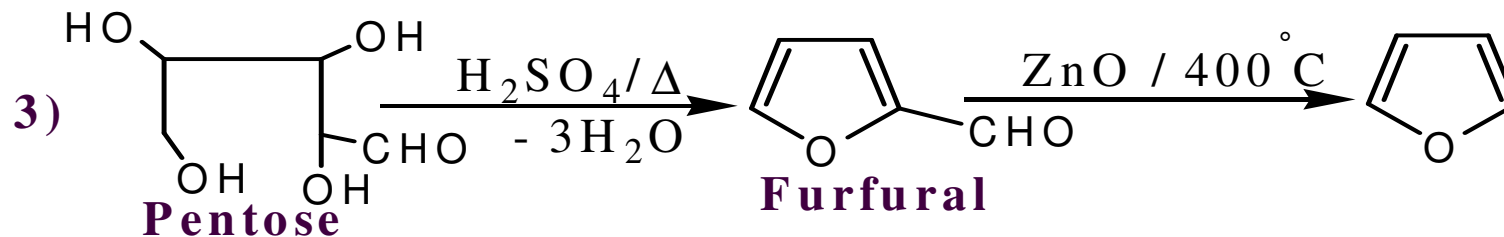
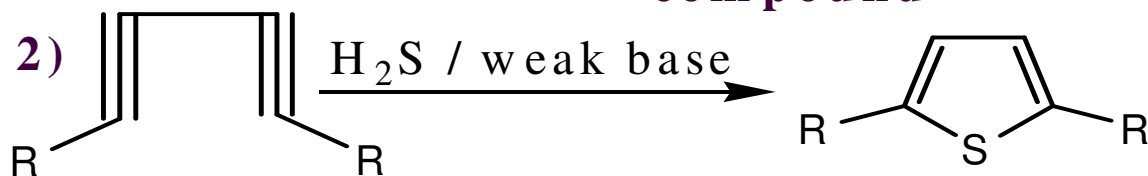
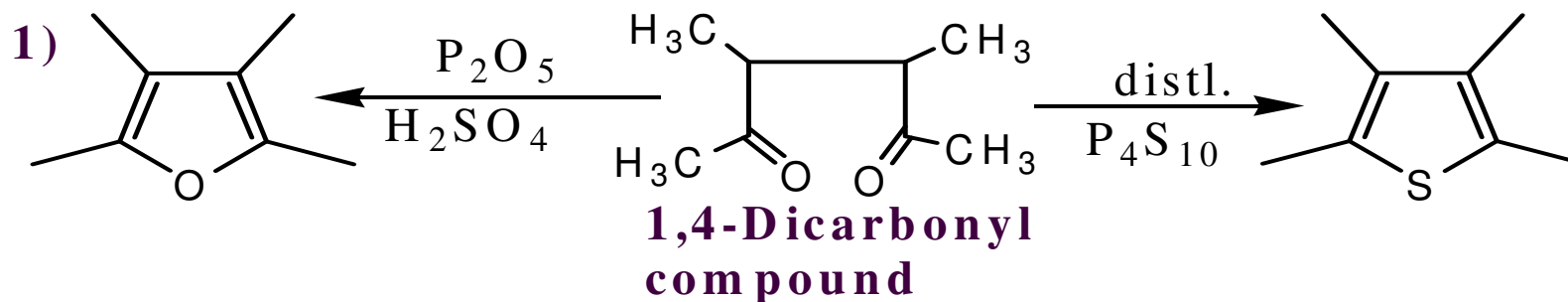
**Electrophilic substitution** on furan requires very mild **non acidic conditions** (acids may induce polymerization or ring opening), however, for thiophene the acidity is less critical since it is stable to aqueous mineral acids but not to 100 % strong acids or Lewis acids such as  $\text{AlCl}_3$ .

**Regioselectivity:** The **2 & 5 ( $\alpha$ )** positions are more reactive than **3 & 4 ( $\beta$ )** positions. As in pyrrole the intermediate results from electrophilic attack at C2 can be stabilized by three resonance structures while the intermediate results from the attack C3 is only stabilized by two resonance structures. Thus the former is more preferred.

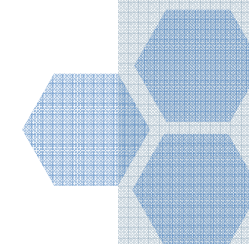




# Synthesis of Furan and Thiophene



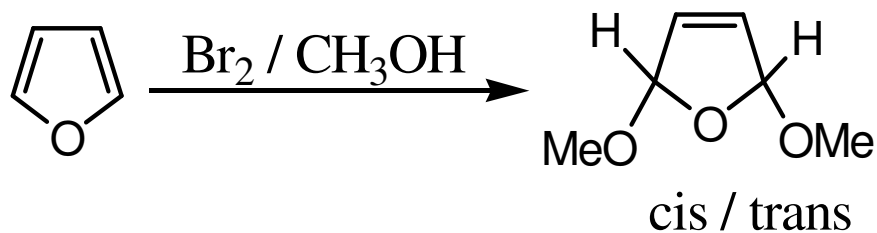
**Feist-Benary Furan Synthesis**





# 1 - Addition Reactions

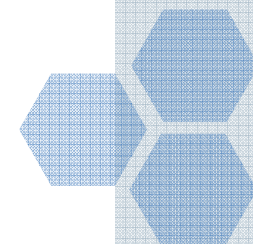
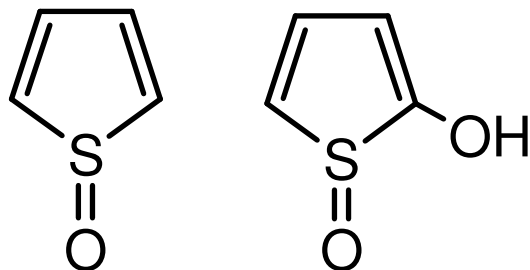
## a) Oxidation



2,5-Dihydro-2,5-dimethoxyfuran

❖ This reaction involves electrophilic addition of bromine in presence of methanol at 2 & 5 positions which is characteristic of 1,3-dienes followed by substitution by methanol.

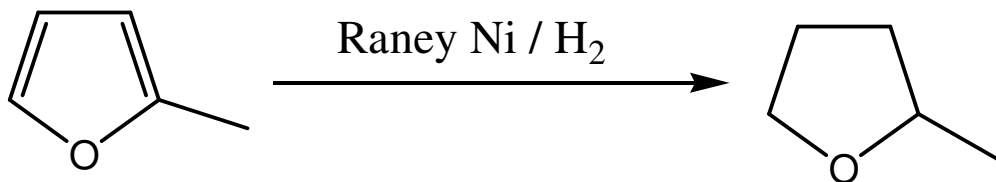
❖ Thiophene is oxidized by peracids to Thiophene-1-oxide and 2-hydroxythiophene oxide.





# 1 - Addition Reactions

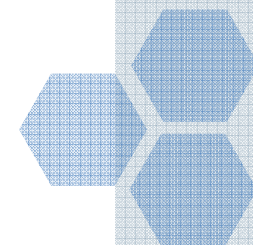
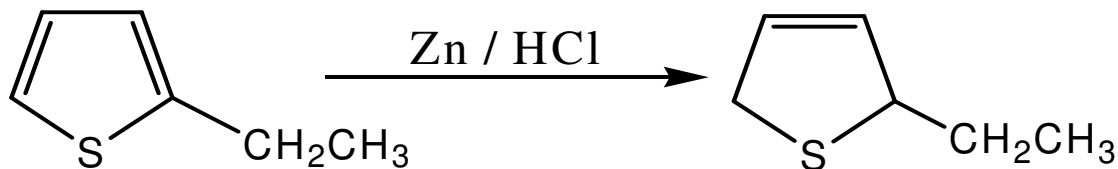
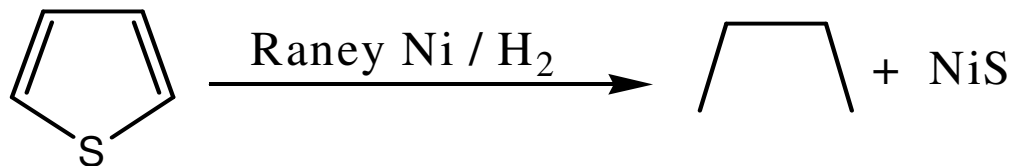
## b) Reduction



2-Methyltetrahydrofuran

❖ On the other hand **thiophene can not be reduced** under the same conditions due to sulfur poison the catalyst and **desulphurization** occurs with ring opening.

❖ However, partial reduction can take place by metals in acidic medium.





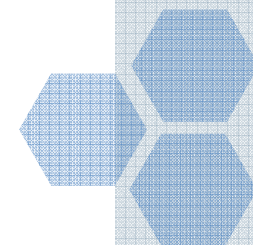
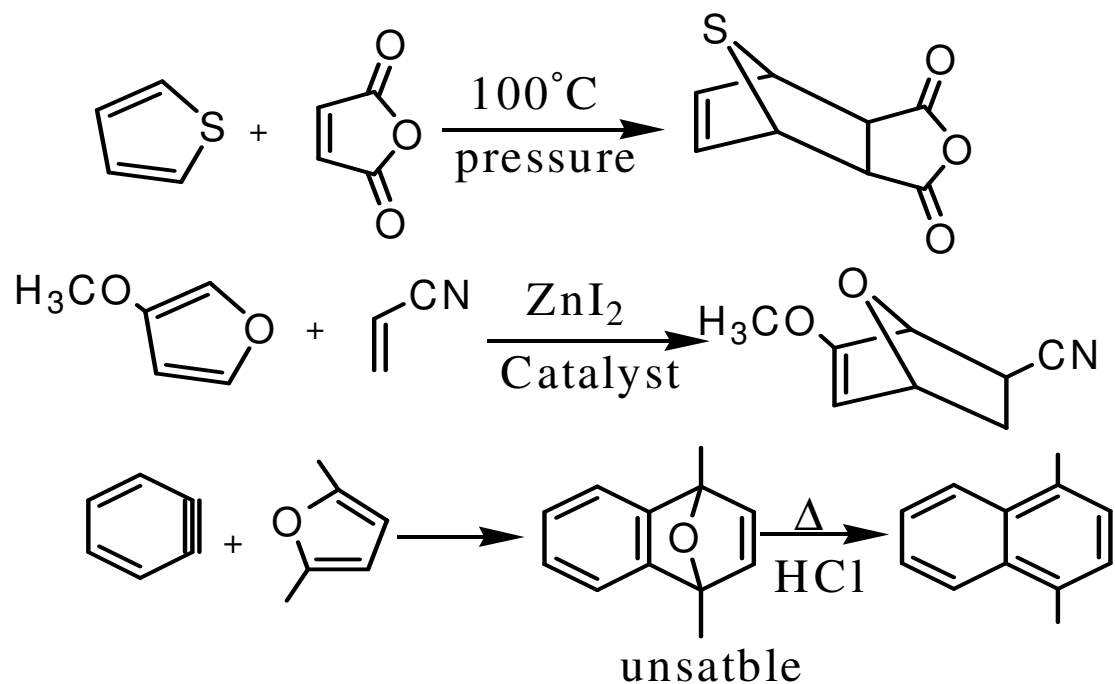
# 1 - Addition Reactions

## c) Diels- Alder Reaction:

❖ Reaction of thiophene with maleic anhydride requires more drastic conditions than in case of furan and pyrrole (high pressure and temperature), this is because it is the most aromatic thus it is the least reactive as a diene.

❖ The order of reactivity in D.A reaction is as follows:

Furan > N-alkyl pyrrole > Pyrrole > Thiophene.

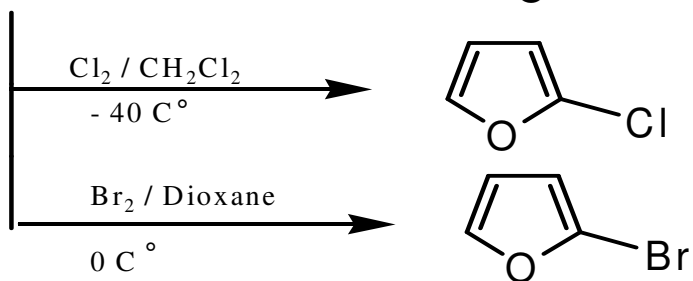
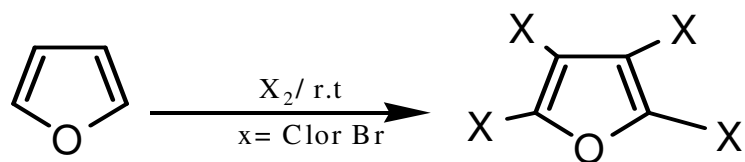
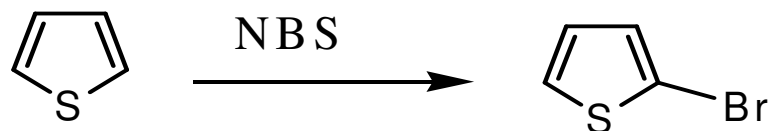




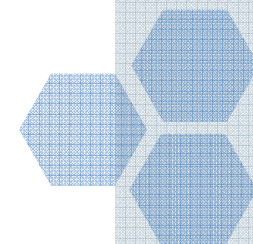
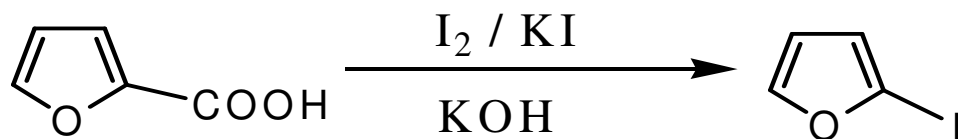


# Electrophilic Aromatic substitution Reactions

## 3) Halogenation



## Indirect insertion of iodine in furan ring

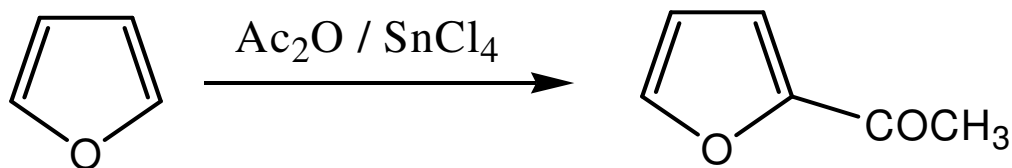
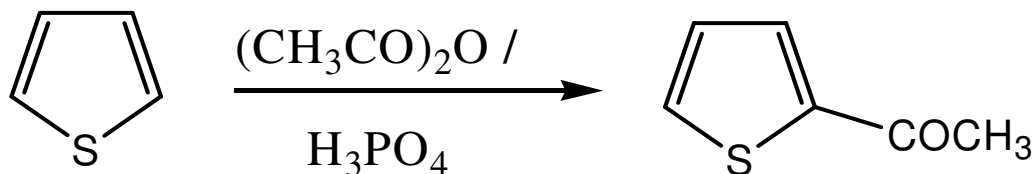






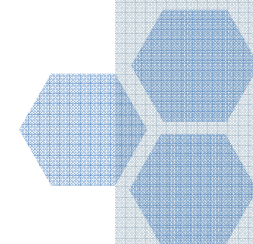
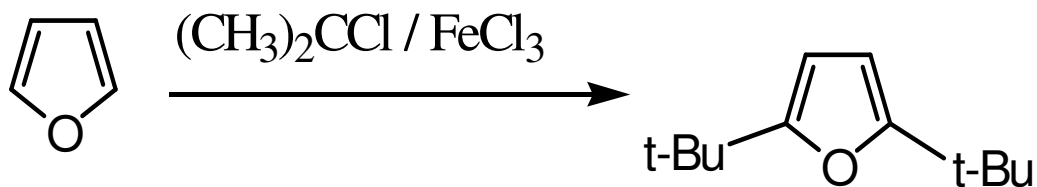
# Electrophilic Aromatic substitution Reactions

## 4) Acylation



## 5) Alkylation

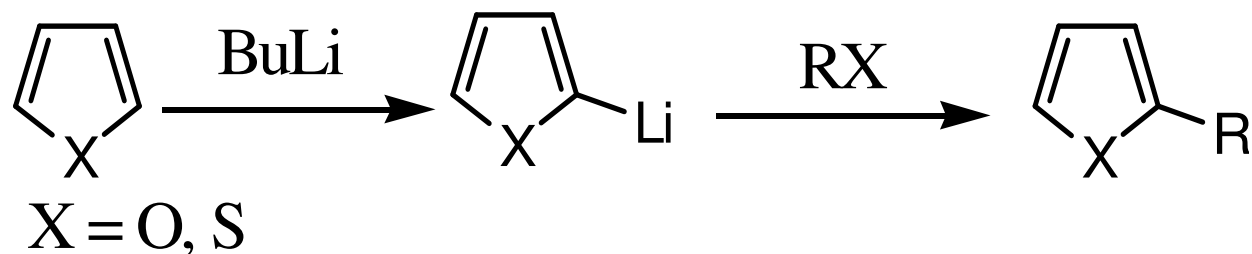
It is very low yielding reaction due to formation of polyalkylated products or polymers.





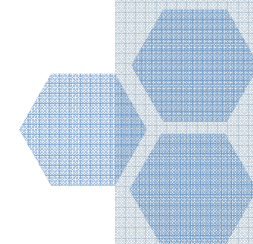
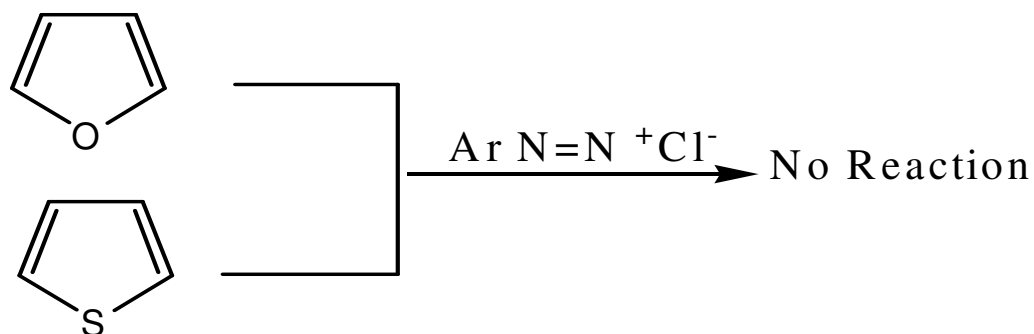
## Electrophilic Aromatic substitution Reactions

### 4) Lithiation



### 5) Diazocoupling:

Furan and thiophene can not couple with diazonium salts which shows that they are less reactive than pyrrole.





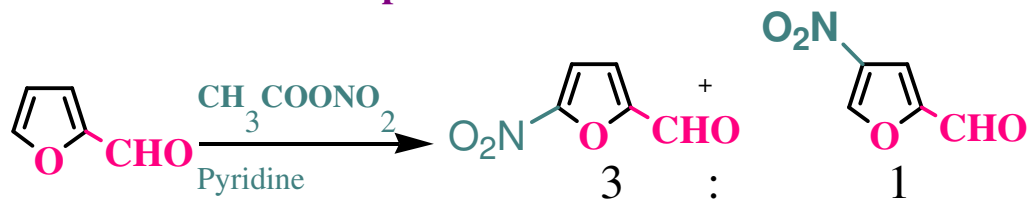
## Second Electrophilic Substitution in Furan and Thiophene

a) Monosubstituted furan & thiophene with electron withdrawing groups such as COOH, CHO, CN, COR, SO<sub>3</sub>H are less reactive than unsubstituted compounds

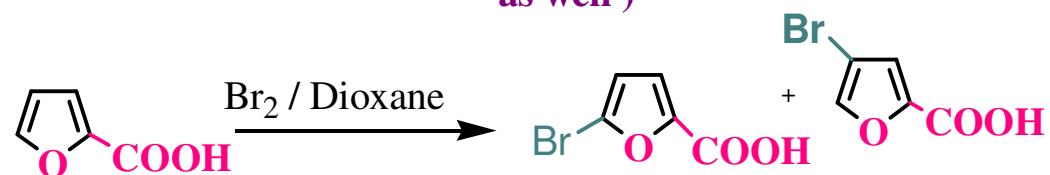
i) EWG at position 2



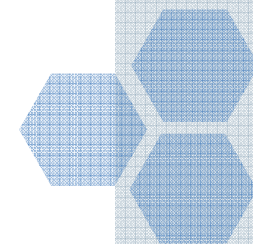
Less reactive than thiophene



Less reactive than furan (incoming E<sup>+</sup> is directed to position 5 mainly and to position 4 as well)



ii) EWG at position 3

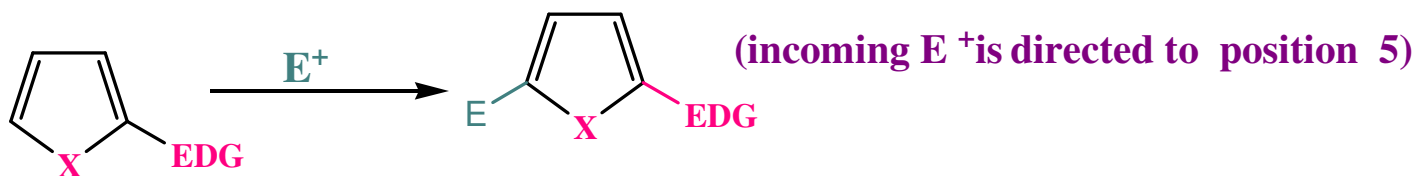




## Second Electrophilic Substitution in Furan and Thiophene

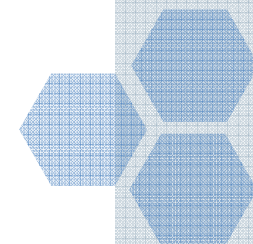
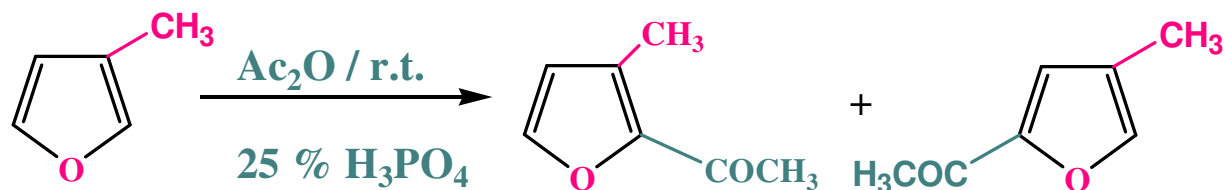
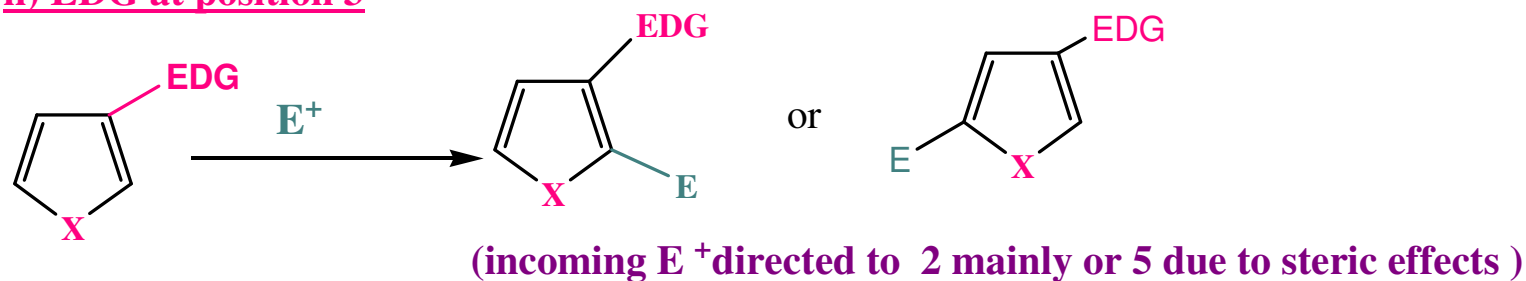
b) Monosubstituted furan & thiophene with electron donating group such as  $\text{CH}_3$ ,  $\text{OH}$ ,  $\text{NH}_2$ ,  $\text{OCH}_3$

i) EDG at position 2



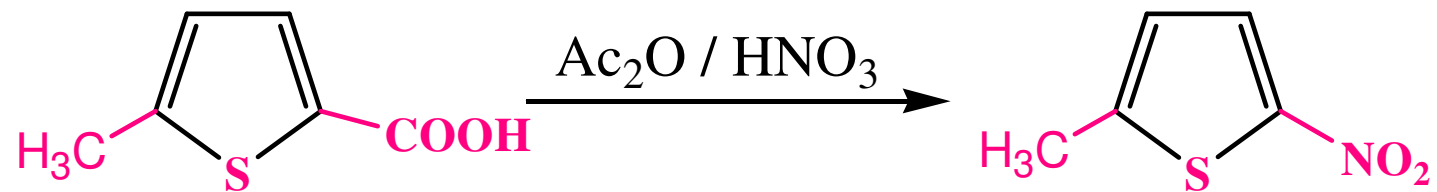
More reactive than unsubstituted compound

ii) EDG at position 3

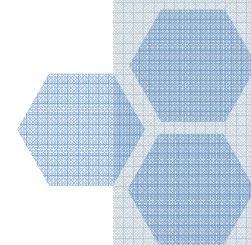




## Second Electrophilic Substitution in Furan and Thiophene



(Replacement of leaving group takes place)





THANK YOU

