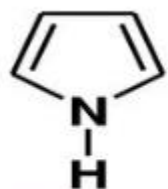
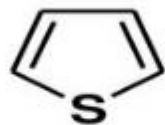


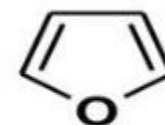
Five-Membered Heterocycles Containing Single Hetero Atom



Pyrrole

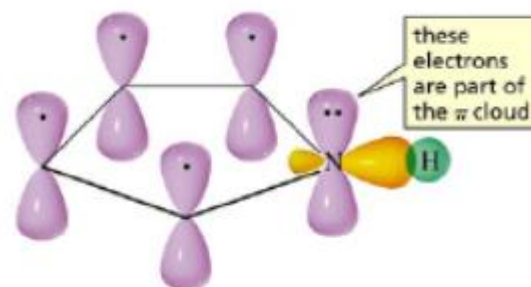


Thiophene

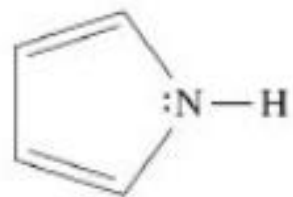


Furan

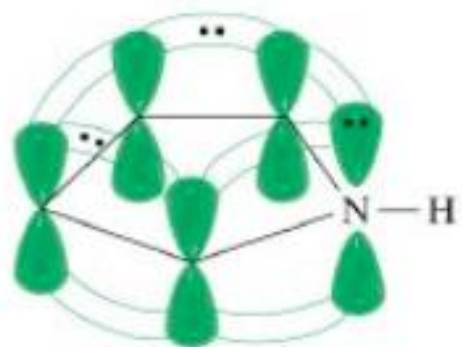
Aromaticity



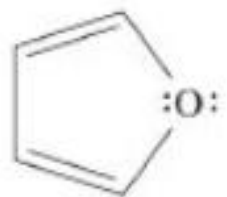
orbital structure of pyrrole



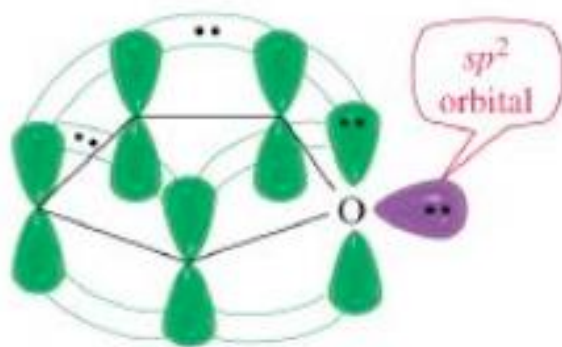
pyrrole



six pi electrons



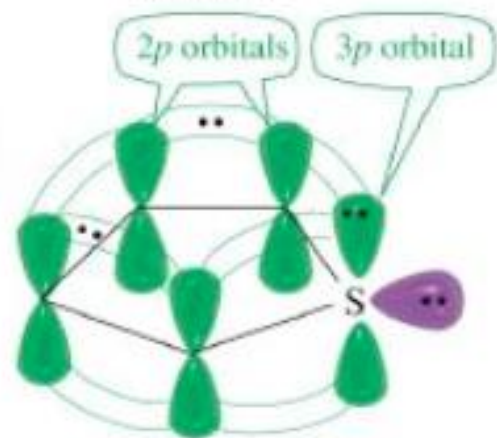
furan



six pi electrons

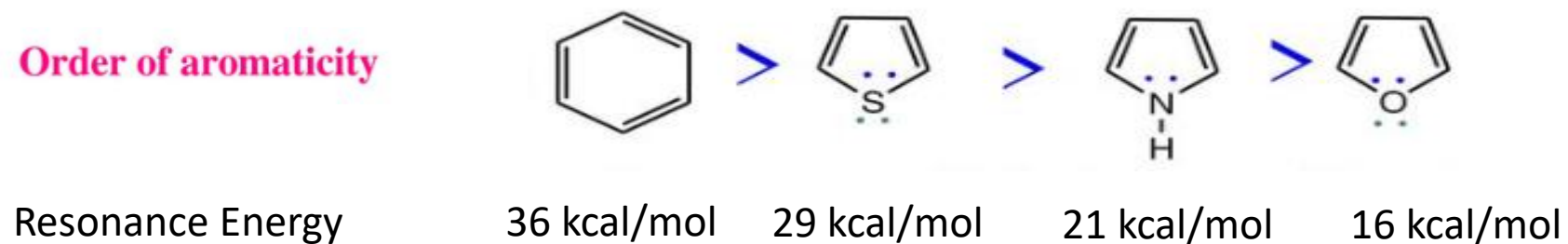


thiophene



six pi electrons

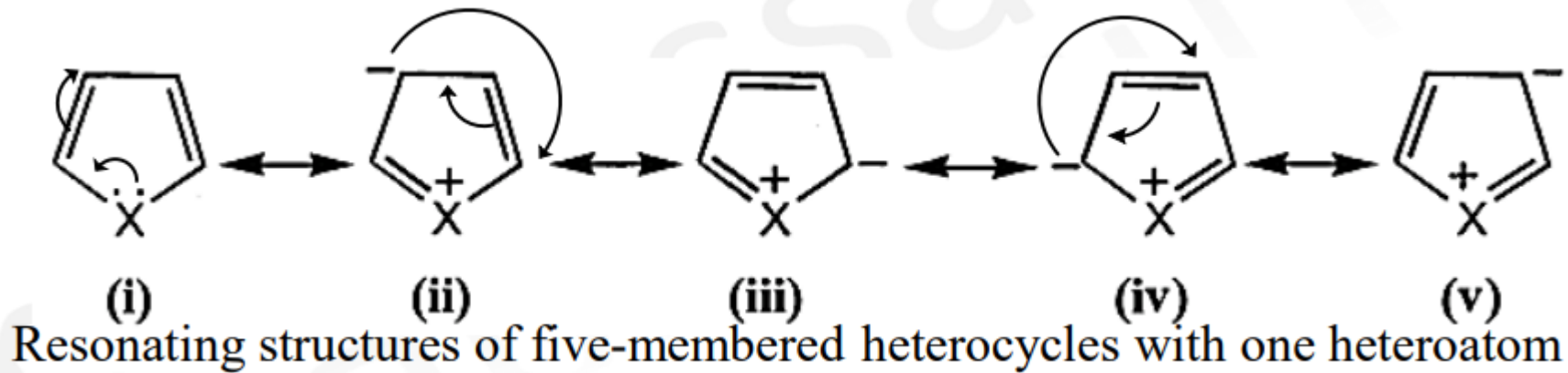
Order of aromaticity



The aromaticity order in these heterocycles depends on the electronegativity of the heteroatom : $O > N > S$ and, therefore, the aromaticity follows the order as

Thiophene > Pyrrole > Furan

Resonance Stabilization:



X = O, NH or S

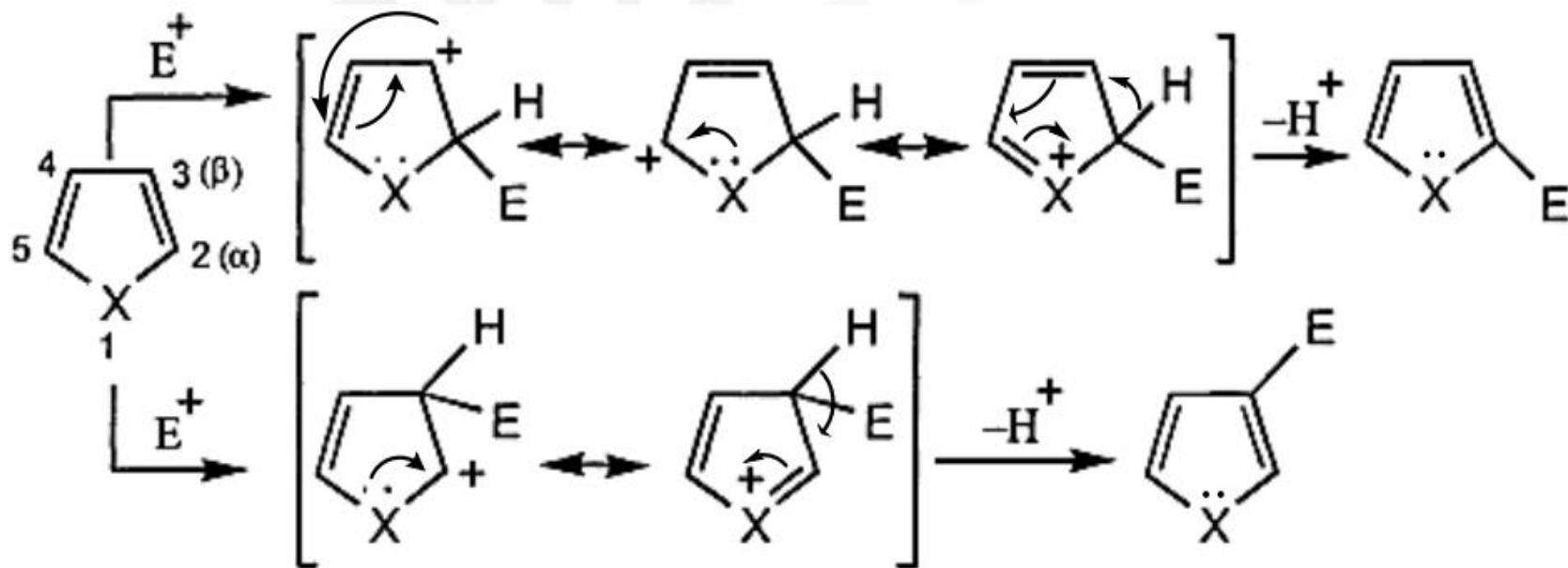
Note-Two uncharged resonance structures can be written for benzene, whereas only one structure without involving charge separation is possible for these heterocycles

Evidences-

1. Bonds of these compounds are intermediate in length between the normal single and double bonds for C-C, C-N, C-S and C-O bonds
2. The dipole moment of tetrahydrofuran is 1.73 D, due to the greater electronegativity of oxygen than carbon. The dipole moment of furan is smaller than THF (0.70 D) and in opposite direction due to electron pair delocalization into the ring. Pyrrole and thiophene can be explained in a similar manner



General mechanism of electrophilic substitution in the five-membered heterocycles



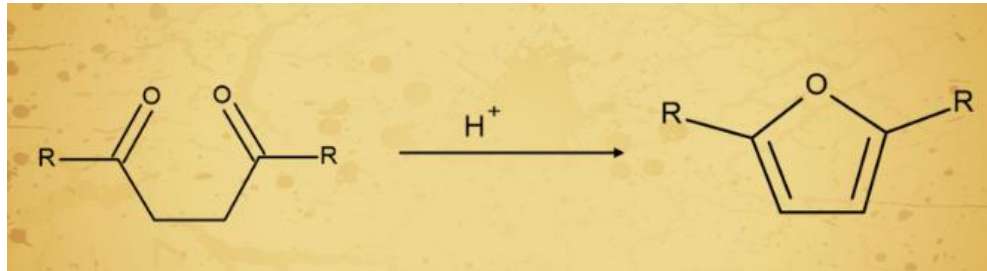
A look at the above resonance forms makes it clear that attack at **position 2** will be preferred due to extra stabilization caused by the contribution of an additional structure.

Furan

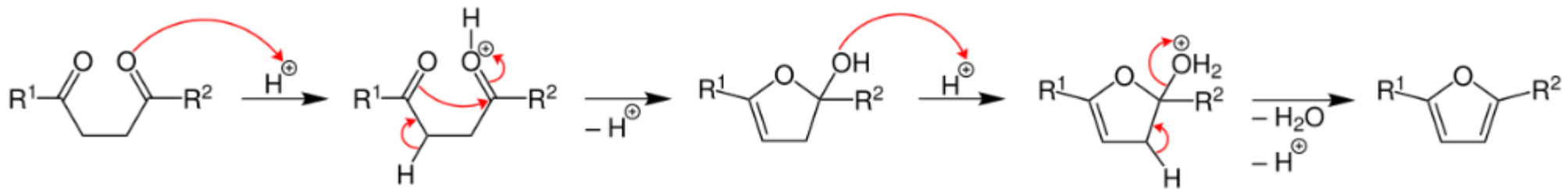
Preparation

1. Paal-Knorr Furan Synthesis

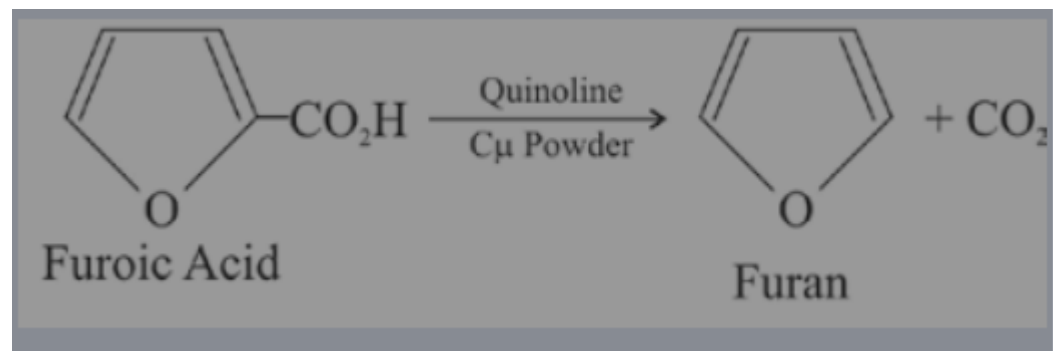
The acid-catalyzed cyclization of 1,4-dicarbonyl compounds known as the **Paal-Knorr synthesis**



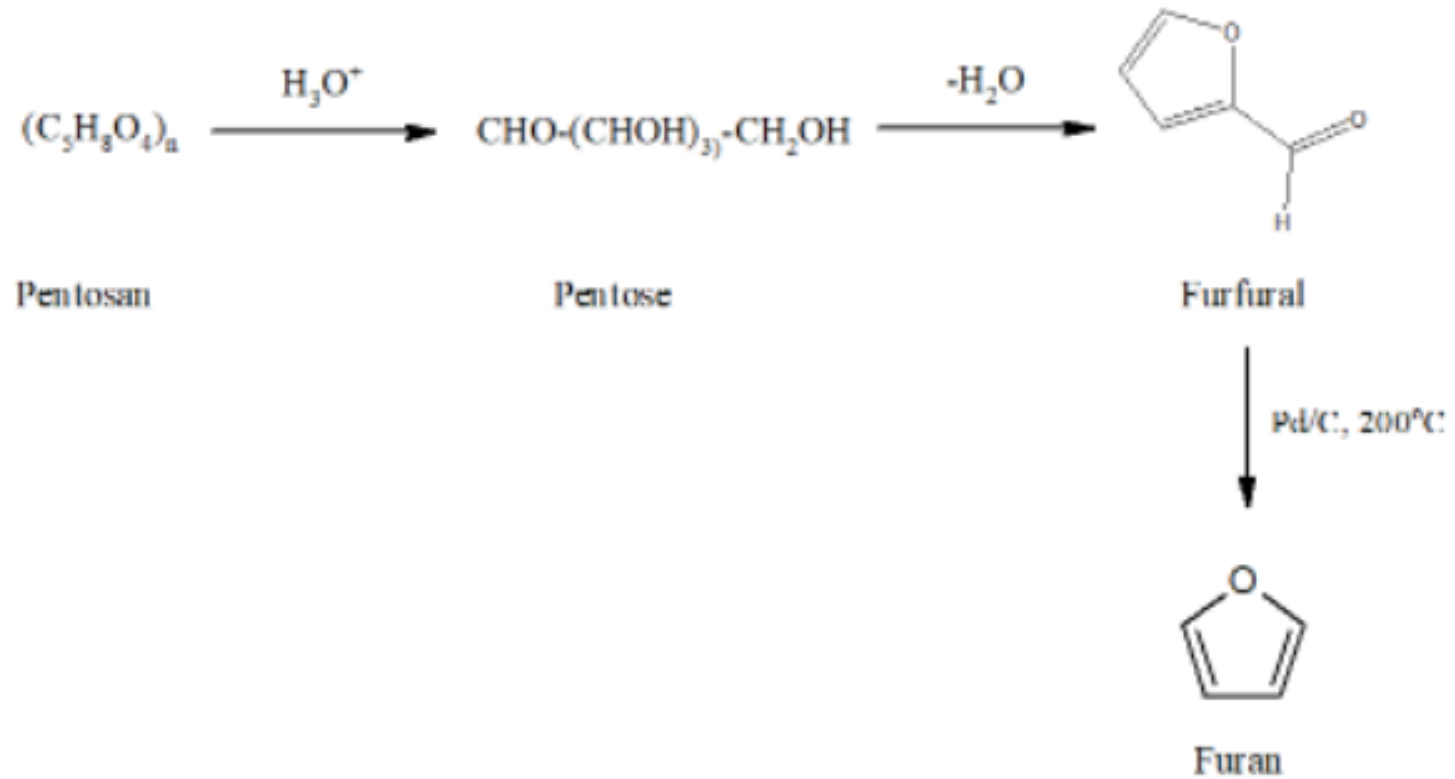
Mechanism

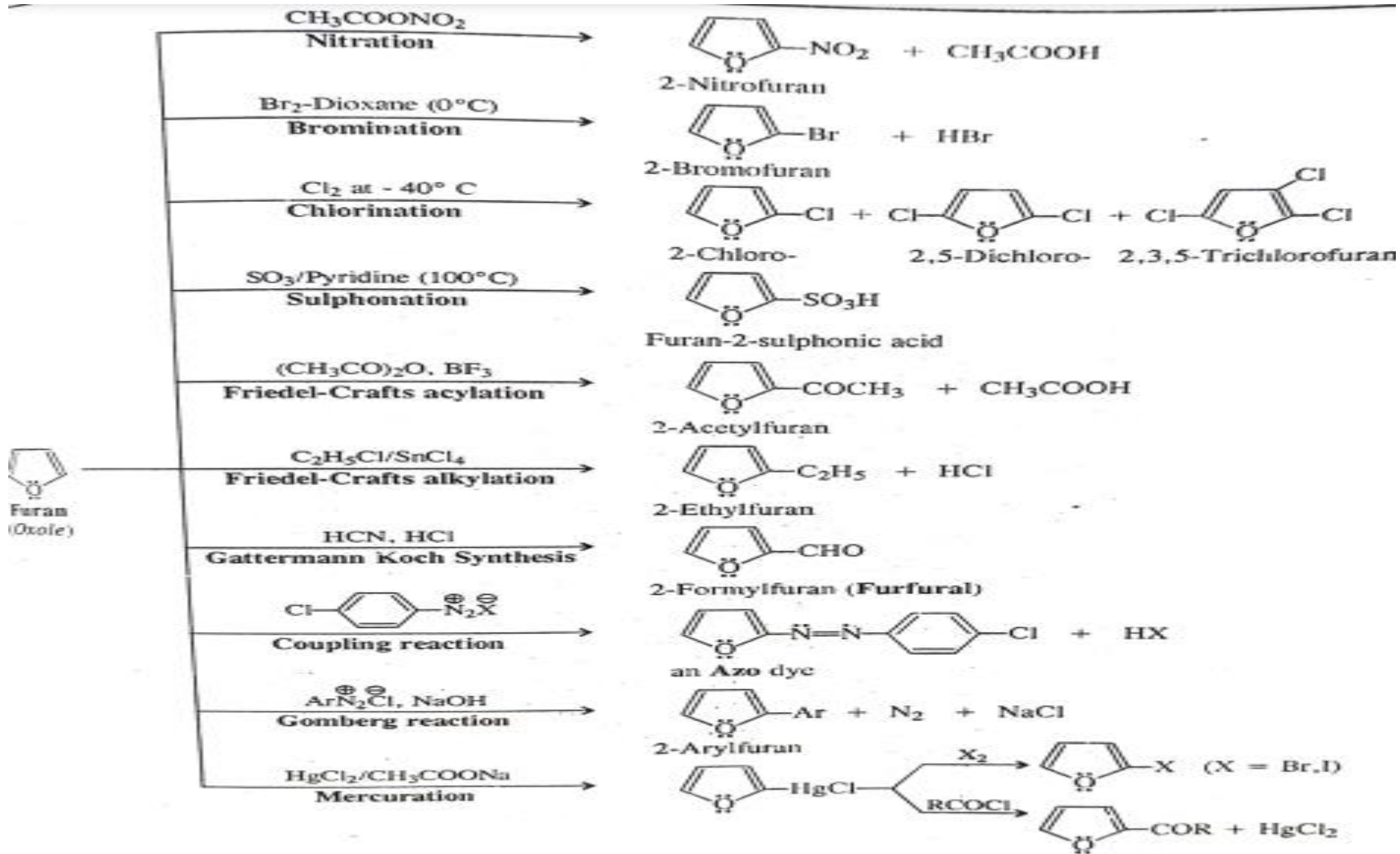


2. By the decarboxylation of furoic acid



3. Commercially it is prepared from agricultural waste (rice-bran and oat-hulls) containing pentosans





Electrophilic substitution reaction of Furan