

## Organic Chemistry: Electrophilic Aromatic Substitution

### Topic: Nucleophilic Aromatic Substitution (NAS)

#### Given:

- Starting Material: 4-fluoroacetophenone (para-fluoroacetophenone)
- Reagent: Dimethylamine (CH<sub>3</sub>)<sub>2</sub>NH
- Product: 4-acetyl-N,N-dimethylaniline

#### Introduction

This reaction is a typical example of a Nucleophilic Aromatic Substitution (NAS), where a nucleophile (dimethylamine) replaces a leaving group (fluoride) on an aromatic ring. NAS typically involves two key steps: 1) Addition of the nucleophile, and 2) Elimination of the leaving group.

#### Step-by-Step Mechanism

##### Step 1: Formation of the Meisenheimer Complex (Addition Step)

###### Reactants:

4-fluoroacetophenone, dimethylamine

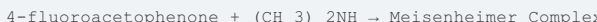
###### Reaction:

The nucleophile, (CH<sub>3</sub>)<sub>2</sub>NH, attacks the carbon atom bonded to the leaving group (fluoride).

###### Intermediate:

Formation of a Meisenheimer complex, where the aromatic ring is temporarily converted into a non-aromatic intermediate.

The nucleophile attacks the carbon atom bonded to the electronegative fluorine, which is the leaving group. This forms a tetrahedral intermediate known as the Meisenheimer complex.



##### Step 2: Elimination of the Leaving Group (Fluoride ion)

###### Intermediate to Product Transformation:

The intermediate loses the fluoride ion, regenerating the aromaticity of the ring.

###### Final Product:

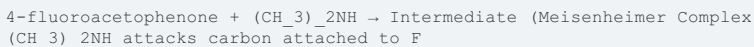
4-acetyl-N,N-dimethylaniline

Restoring the aromaticity is a thermodynamically favorable step. The elimination of the fluoride ion completes the substitution process.



#### Detailed Mechanism with Structures

##### Addition Step:



The fluoro group is substituted by the dimethylamino group forming a Meisenheimer complex.

### Elimination Step:

Meisenheimer Complex  $\rightarrow$  4-acetyl-N,N-dimethylaniline + F<sup>-</sup>  
Loss of fluoride ion, restoring aromaticity

### Supporting Statements

- The electron-withdrawing group (COCH<sub>3</sub>) activates the ring towards nucleophilic attack by polarizing the  $\pi$ -electrons.
- Fluoride, being a good leaving group, facilitates the substitution.
- The intermediate Meisenheimer complex is a stabilized transition state that ensures the reaction proceeds efficiently.

### Final Solution

The provided mechanism shows how 4-fluoroacetophenone reacts with dimethylamine in a nucleophilic aromatic substitution reaction to produce 4-acetyl-N,N-dimethylaniline. The key steps include the formation of a Meisenheimer complex and the elimination of the fluoride ion.