## Objectives

- Perform the reaction of 3,4-dichloro-1-nitrobenzene with sodium methoxide
- Identify the product of 3,4-dichloro-1-nitrobenzene and sodium methoxide

## Background

### Nucleophilic Aromatic Substitution

Aromatic compounds are often thought of as being too stable to react, but aromatic rings can undergo substitution reactions. The most common aromatic reaction is the electrophilic aromatic substitution, in which electrons from the ring attack an electrophile, creating a new substituent. However, nucleophilic substitution is also possible for aromatic compounds under the right conditions.

### Overall Mechanism of the Reaction

The general reaction of nucleophilic aromatic substitution involves the replacement of a leaving group with a nucleophile, as shown in Figure 1. The nucleophile attacks at the carbon with the leaving group and leads to a carbanion intermediate. Therefore, the reaction requires a strong nucleophile and a good leaving group on the ring. The aromatic ring is then reestablished as the electrons rearrange and kick off the leaving group.

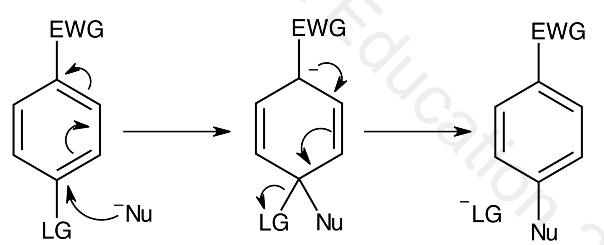


Figure 1 General mechanism of nucleophilic aromatic substitution including a nucleophile (Nu) attacking a ring with a leaving group (LG) and electron withdrawing group (EWG) attached

### Impact of the Substituents on the Ring

There are two important substituents on the aromatic ring for the reaction to succeed. First, there needs to be a substituent on the ring that can act as a leaving group. Halides are commonly used for this purpose. In addition to being good leaving groups, they also increase reactivity between the aromatic ring and the nucleophile by making the attached carbon have more of a partial positive charge. For a successful substitution, there needs to be a good leaving group in the position where the nucleophile will end up.

The other important substituent on the ring is at least one strong electron withdrawing group, such as a nitro group. The electron withdrawing ability helps stabilize the carbanion intermediate of the reaction. Thus, increasing the number of electron withdrawing groups generally increases the rate of reaction. However, some substituent positions have greater impact. Electron withdrawing groups in the ortho or para positions compared to the leaving group have the greatest increased reactivity because of the electrical distribution throughout the mechanism. Therefore, careful placement and selection of the substituents can have a large effect on the reactivity of the aromatic ring toward the desired substitution.

## Materials

- 3,4-dichloro-1-nitrobenzene
- Methanol
- 25% sodium methoxide in methanol
- Dichloromethane
- Anhydrous magnesium sulfate
- Microscale glassware kit
- Boiling chips
- Melting point apparatus

***Safety goggles are required!***

***All work should be performed in the fume hood.***

*3,4-dichloronitrobenzene is a toxic irritant. Sodium methoxide is flammable and corrosive. Methanol is flammable and toxic. Dichloromethane is a toxic irritant. Magnesium sulfate is an irritant.*



## Procedure

### Nucleophilic Aromatic Substitution

1. Place 0.075 g of 3,4-dichloro-1-nitrobenzene in a 5 mL round bottom flask.
2. Add 2.4 mL of methanol, 2.4 mL of 25 % sodium methoxide in methanol, and a couple of boiling chips to the flask.
3. Assemble the reflux apparatus using an elastomeric connector to attach the distillation column to the top of the tube. Wrap the top of the distillation column with a wet paper towel to aid in condensation.
4. Heat the reaction mixture to a boil to start the reflux. Do not allow the methanol to escape out of the top of the reflux apparatus.
5. Reflux for 60 minutes.
6. Pour 4 mL of distilled water into a 15 mL centrifuge tube.
7. Pour the reaction mixture into the water in the centrifuge tube to precipitate the product.
8. Add 2 mL of dichloromethane to the centrifuge tube, and mix well to dissolve the product in the dichloromethane.
9. Remove the dichloromethane layer and place in a clean centrifuge tube.
10. Set the water layer to one side for later disposal.
11. Wash the dichloromethane layer with 2 mL of distilled water. Remove the water layer and add to the previous water layer.
12. Add up to 0.05 g of anhydrous magnesium sulfate to dry the dichloromethane. Allow the magnesium sulfate to be in the dichloromethane for five minutes.
13. Transfer the dichloromethane solution to a 5 mL vial, leaving the magnesium sulfate in the tube.
14. In a fume hood, evaporate the dichloromethane from your product. Use your hands to warm the vial to speed evaporation.

15. Measure the mass of the product.
16. Measure the melting point of the product.
17. Discard the water layer in the **halogenated** organic waste. Discard the product by dissolving in a small amount in dichloromethane and discard in the **halogenated** waste. Clean and wash all work areas and glassware.

## Pre-Lab Questions

Prepare for lab by completing and understanding the answers to these questions. Refer to the Background or another resource, such as your textbook, if necessary.

1. What precautions should one use when working with sodium methoxide?

2. Calculate the theoretical yield for the product from 0.075 g of 3,4-dichloro-1-nitrobenzene. Show all calculations.

3. Explain how mixture melting points can be used to distinguish between two compounds with similar melting points.

4. Predict the reactivity of chlorobenzene with sodium methoxide compared to the reactivity of 3,4-dichloro-1-nitrobenzene. Explain.

# Nucleophilic Aromatic Substitution Report Sheet

Name ______________________ Section ______________________

Date ______________________ Instructor ______________________

## Nucleophilic Aromatic Substitution

Amount of reactant used (grams) ____________________________

Amount of reactant used (moles) ____________________________

*Space for calculations:*

Product obtained (grams) ____________________________

Product obtained (moles) ____________________________

*Space for calculations:*

Product theoretical yield ____________________________

*Space for calculations:*

Product percent yield ____________________________

*Space for calculations:*

Write the equation for the reaction.

## Post-lab Questions

1. What is the melting point range of your product?

2. Does the melting point indicate that your product is relatively pure? Explain.