Preparation of N-Ethyl Saccharin

- An example of an $S_N2$ reaction
- Sodium saccharin is made from base-catalyzed deprotonation of saccharin

\[
\begin{align*}
\text{saccharin} & \xrightarrow{\text{NaOH}} \text{sodium saccharin} \\
\text{resonance contributors} & + H-O-H
\end{align*}
\]

• Reaction Scheme (put in notebook and lab report)
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• This is an example of a nucleophilic substitution reaction of the second order (S_N2)
• Solvent is Dimethylformamide (DMF)
• Reaction rate dependent on both the concentration of the nucleophile and the substrate.

\[
\text{rate} = \frac{d [\text{CH}_3\text{CH}_2\text{I}]}{dt} = k [\text{CH}_3\text{CH}_2\text{I}] [\text{Na saccharin}]
\]

k = experimental rate constant
• Dependent upon temperature and solvent

\[\text{H}_3\text{C} \backslash \text{N} \equiv \text{C} \backslash \text{H}\]
\[\text{N,N-Dimethylformamide (DMF)}\]
\[\text{polar, aprotic solvent}\]
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- **Mechanism**

  ![Chemical diagram showing the reaction mechanism](image)

- On the substrate molecule in the transition state, the 2 carbons and 2 hydrogens are planar. This plane is perpendicular to the line (180° angle) through nitrogen, carbon, and iodine.

- **Alternative representation**

  ![Alternative chemical diagram showing the reaction mechanism](image)
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Factors that Favor $S_{N2}$ Reactions

1) Methyl or primary halides as substrates
   a) With secondary halides, steric hindrance can be a problem
   b) Tertiary halides are too bulky, they never undergo $S_{N2}$ reaction
      i) They give elimination products, alkenes

2) Moderate Temperatures
   a) At high temperatures, elimination could be a competing reaction
   b) Not enough energy at low temperatures

3) Aprotic Solvents - do not have H attached to an electronegative element (N, O, F)
   In protic solvents, e.g. ethanol (CH$_3$CH$_2$OH), solvation occurs.

Solvation causes a nucleophile weakening effect therefore marked (large) decrease in the reaction rate
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- Procedure “Catalyst” (pg. 97-102)
  - Bring goggles, labcoat, lab notebook
  - Write reaction scheme at top of notebook page along with physical constants of chemicals used
  - Same procedure: Place DMF (5 mL) in flask and add ethyl iodide (1 mL) in hood
  - Add sodium saccharin
  - Mixture needs to be warmed for 20 min (hot plate setting 1)
  - Continue procedures as described in text
  - Ethyl iodide and their graduate cylinders must be kept in the hoods!
  - Do not inhale the vapors. Keep everything under the hood!
  - Slowly pour the reaction mixture into cold water
  - Collect the product by vacuum filtration, dry, weigh
  - Determine the melting point and percent yield