Chem 4524 Organic Chemistry II Alfred State College

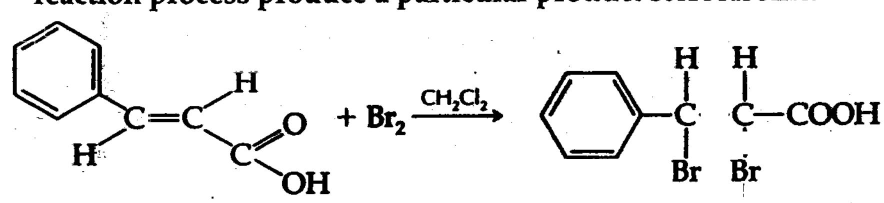
Laboratory #2

Addition of Br_2 to trans-cinnamic acid:

Example of mechanistic reasoning with stereochemistry

The Stereochemistry of Bromine Addition to *trans*-Cinnamic Acid

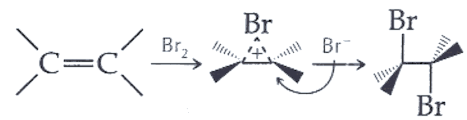
Discover how the geometry of an alkene and a stereoselective reaction process produce a particular product stereoisomer.



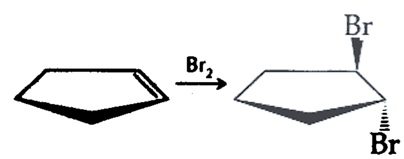
trans-Cinnamic acid
(*E*-isomer)
MW 148
mp 133°C

2,3-Dibromo-3-phenylpropanoic acid
MW 308
Which racemic mixture is formed?
enantiomers (2*S*,3*S*) and (2*R*,3*R*)
mp 93.5–95°C
enantiomers (2*S*,3*R*) and (2*R*,3*S*)
mp 202–204°C

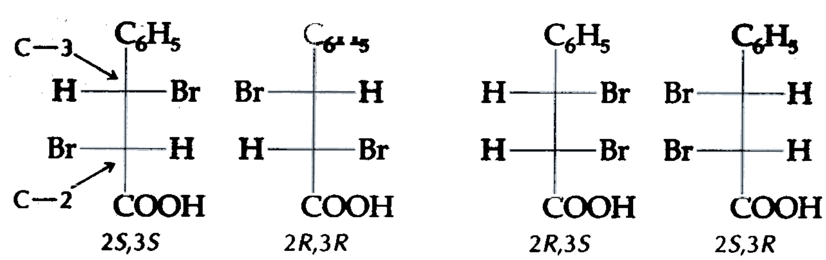
The addition of molecular bromine to the double bond of an alkene is a reaction whose stereochemical and mechanistic details are well established. Diatomic molecular bromine acts as source of electrophilic bromine, and the addition of the electrophilic Br^+ species to the π-system of the double bond produces a bridged bromonium ion. This bridged ion is in turn nucleophilically captured by bromide ion to produce dibromide in an *anti* fashion:



Support for an *anti* process comes from the fact that bromine adds to cyclopentene to form the *trans*-dibromide:



The addition of bromine to *trans*-cinnamic acid gives a dibromide with two stereocenters (chiral centers) of different types. Thus, there are four stereoisomers possible and these are shown here in their Fischer projections:



Enantiomeric pair (threo diastereomer)

Another enantiomeric pair (erythro diastereomer)

2,3-Dibromo-3-phenylpropanoic acids

In this experiment, you will determine the melting point of the dibromide product and use this result to draw a conclusion as to which enantiomeric pair has formed. You can then use the stereochemistry of the products to deduce the mechanism of the bromination reaction by which these products were formed.

Macroscale Procedure

Techniques Reflux: Technique 3.3
Mixed Solvent Recrystallization: Technique 5.2a

SAFETY INFORMATION

Dichloromethane is toxic, an irritant, absorbed through the skin, and harmful if swallowed or inhaled. Use it in a hood and wash your hands thoroughly after handling it.

Bromine is very corrosive and causes serious burns. Its vapors are toxic and irritating to the eyes, mucous membranes, and respiratory tract. A solution of bromine also emits bromine vapor and should be used only in a well-ventilated hood. Wear gloves impermeable to Br_2 while measuring and transferring the Br_2 solution.

***trans*-Cinnamic acid is a mild irritant. Avoid skin contact and wash your hands after handling it.**

Place 0.60 g of *trans*-cinnamic acid in a 25-mL round-bottomed flask. Add 3.5 mL of dichloromethane and 2.0 mL of 10% bromine in dichloromethane solution. Put a boiling stone in the flask and attach the water-cooled condenser [see Technique 3.3]. Clamp the flask in a beaker of water whose temperature is 45–50°C. Reflux the reaction mixture *gently* for 30 min. The product will begin to precipitate as the reaction proceeds. If the bromine color disappears during the reflux period, add 10% bromine in dichloromethane solution dropwise through the top of the condenser until a light orange color persists.

Cool the reaction flask to room temperature, then cool it further in an ice-water bath for 10 min, to ensure complete crystallization of the product. Collect the crude product by vacuum filtration in a Buchner funnel. Wash the crystals three times with 2.0-mL portions of cold dichloromethane by disconnecting the vacuum, pouring the solvent over the crystals, and then restarting the vacuum.

Transfer the crystals to a 50-mL Erlenmeyer flask and add 2.0 mL of ethanol. Heat until boiling on a steam bath or hot plate. If the crystals do not all dissolve, continue adding ethanol in

0.5-mL increments, boiling briefly after each addition, until the crystals do dissolve. Add a volume of water equal to the total amount of ethanol used and warm the mixture until any crystals that formed when the water was added have dissolved. Cool the flask to room temperature before placing it in an ice-water bath. Recover the crystals by vacuum filtration. Allow the crystals to dry overnight before determining the melting point and mass. Calculate the percent yield.

From the melting point of your product, decide whether the addition of bromine followed a *syn* or *anti* mechanism (or both). Propose a mechanism that explains your results.

Cleanup: Pour the filtrates from the reaction mixture and from the recrystallization in the container for halogenated waste.

Microscale Procedure

Techniques

- Microscale Reflux: Technique 3.3
- Mixed Solvent Recrystallization: Technique 5.2a
- Microscale Filtration: Technique 5.5, Figure 5.7

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Bromine is very corrosive and causes serious burns. Its vapors are toxic and irritating to the eyes, mucous membranes, and respiratory tract. A solution of bromine also emits bromine vapor and should be used only in a well-ventilated hood. Wear gloves impermeable to Br_2 while measuring and transferring the Br_2 solution.

trans-Cinnamic acid is a mild irritant. Avoid skin contact and wash your hands after handling it.

Place 100 mg of *trans*-cinnamic acid in a 3-mL reaction vial. Add 0.7 mL of dichloromethane and 0.35 mL of 10% bromine in dichloromethane solution. Put a boiling stone in the vial and fit it