

A Kinetic Study of the Glaser-Hay Coupling

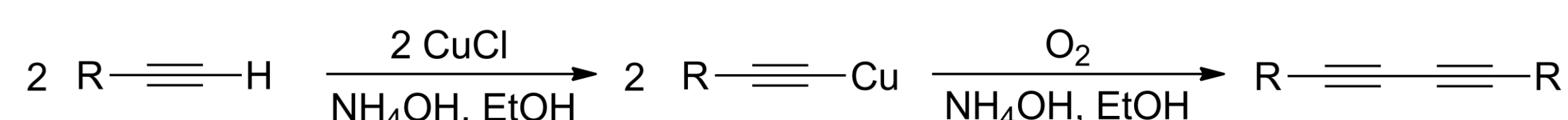
Mie Højer Vilhelmsen and Mogens Brøndsted Nielsen

Department of Chemistry, University of Copenhagen. E-mail: mhv@kiku.dk

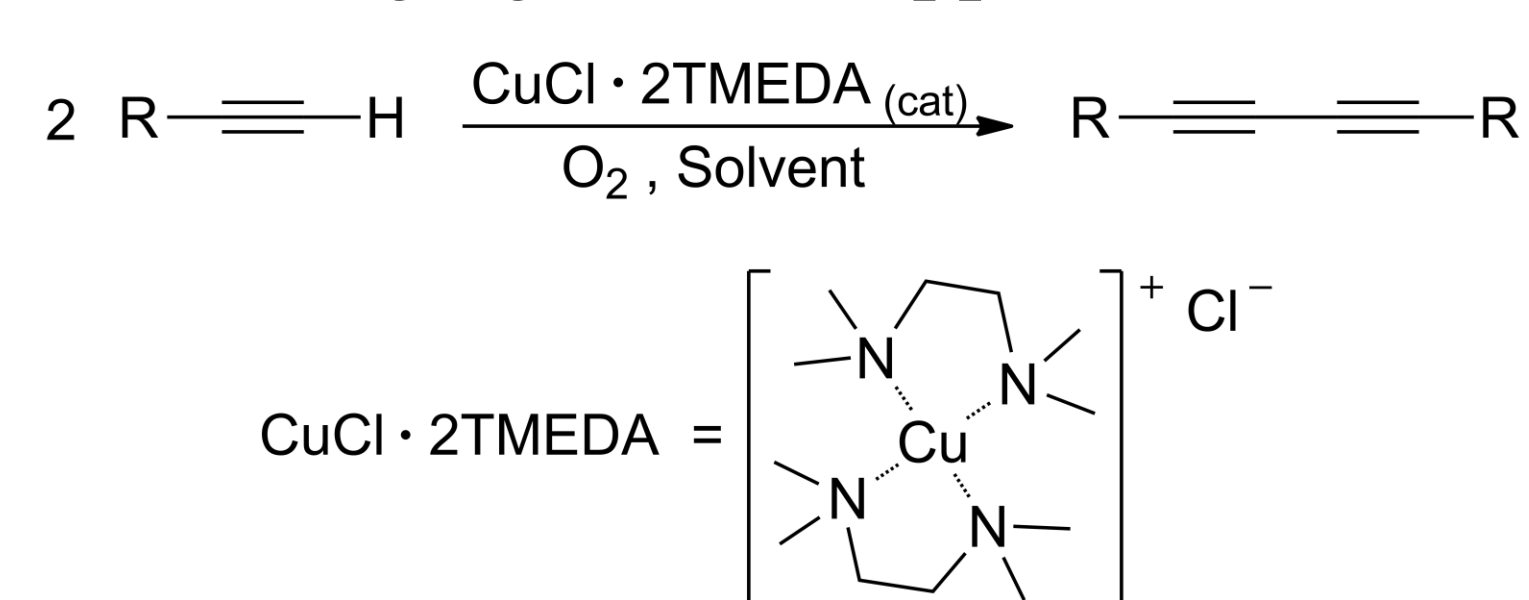
Past:

The Glaser-Hay coupling:

The copper mediated coupling of terminal alkynes was first discovered in 1869 by Carl Glaser:



The coupling was modified in 1962 by Allan S. Hay who used TMEDA as solubilizing ligand for copper:



Ref.: C. Glaser, *Ber. Dtsch. Chem. Ges.*, **1869**, 2, 422–424.
A.S. Hay, *J. Org. Chem.*, **1962**, 27, 3320–3321.

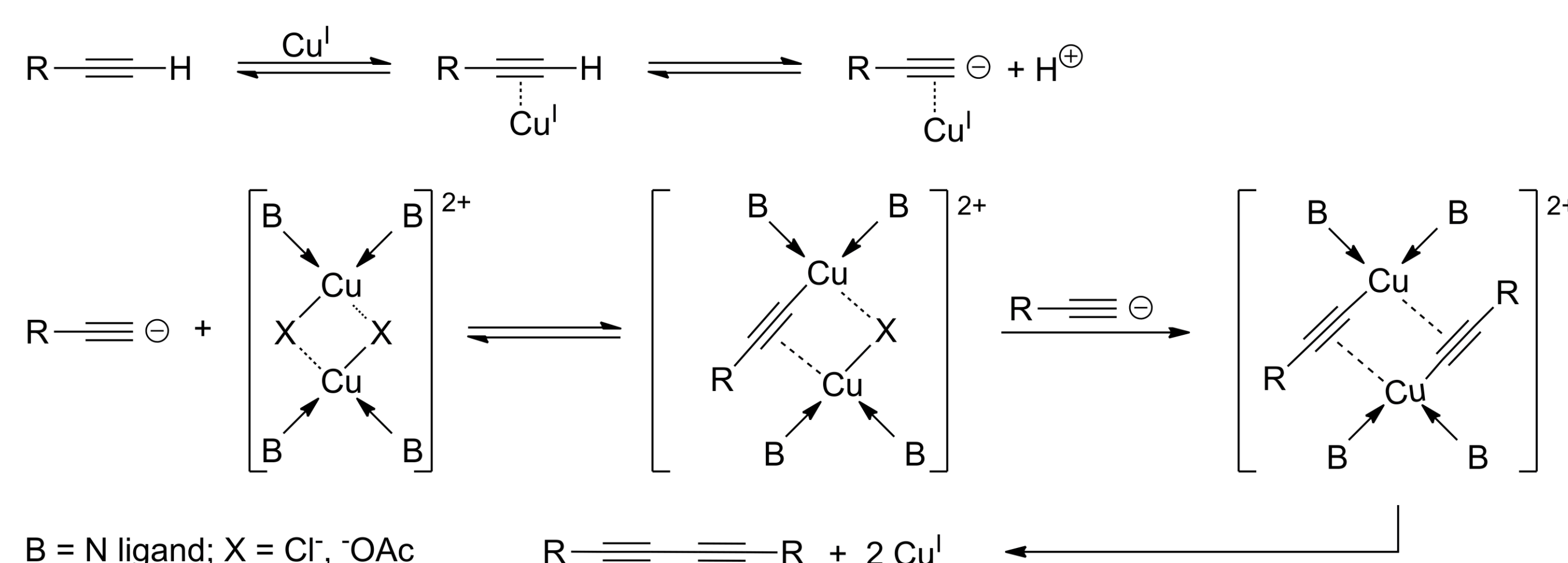
Motivation:

Through more than 70 years the Glaser-Hay reaction has been studied mechanistically. The proposals have ranged from pure radical processes to mechanisms like the one proposed by Bohlmann *et al.* However, there are two drawbacks of the studies:

- ❖ None of them are directly comparable as they employ different reaction conditions and measuring methods.
- ❖ None of them are performed on the Glaser-Hay reaction itself, e.g. excess of copper salts are added and/or the reaction is done under N₂.

The Bohlmann mechanism:

Of the many proposed mechanisms, the most widely accepted was published in 1964 by Bohlmann *et al.* They suggested a dinuclear copper(II) acetylide complex which collapses to the product:



Ref.: F. Bohlmann *et al.*, *Chem. Ber.*, **1964**, 97, 794–800.

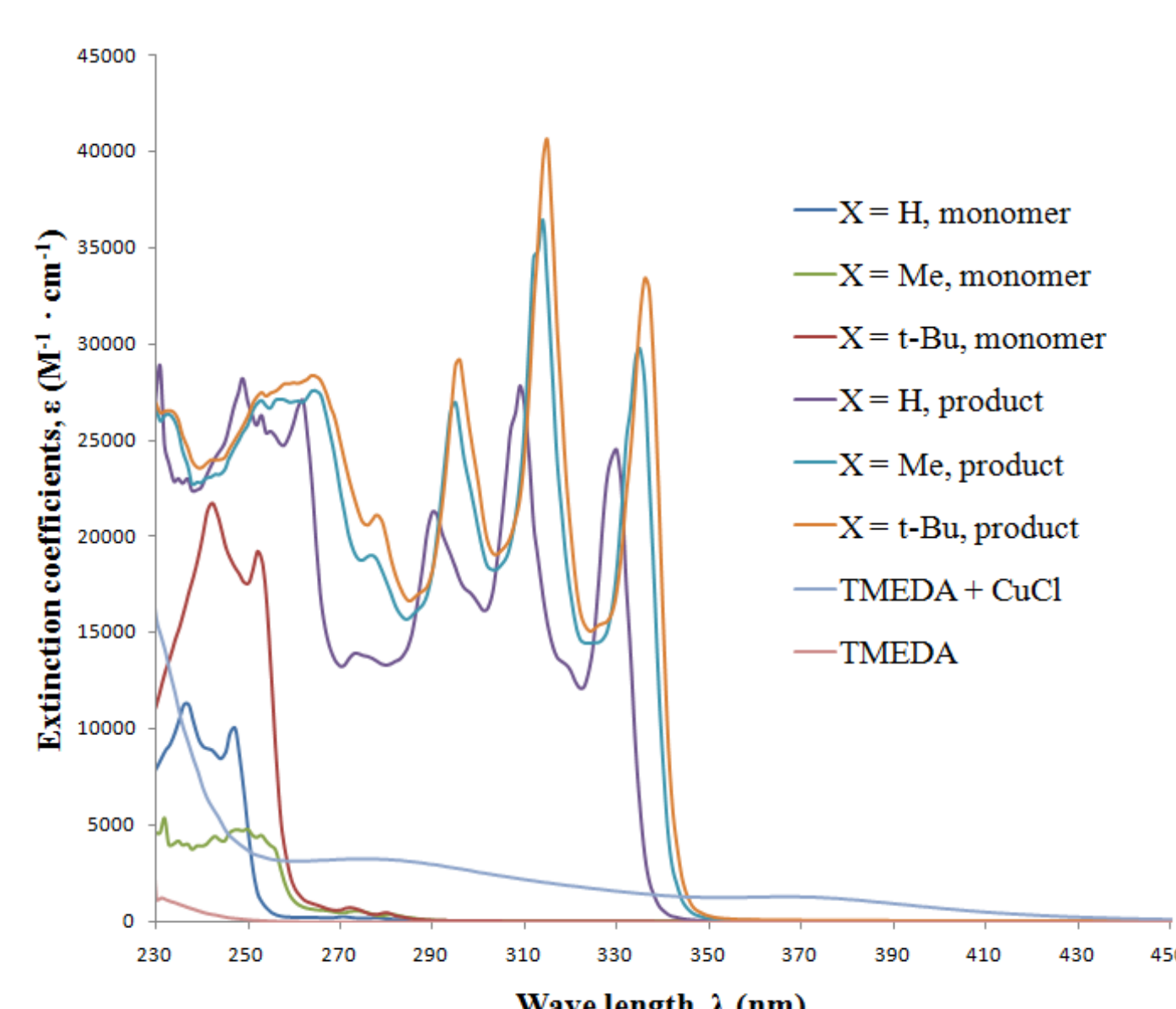
Present:

Method:

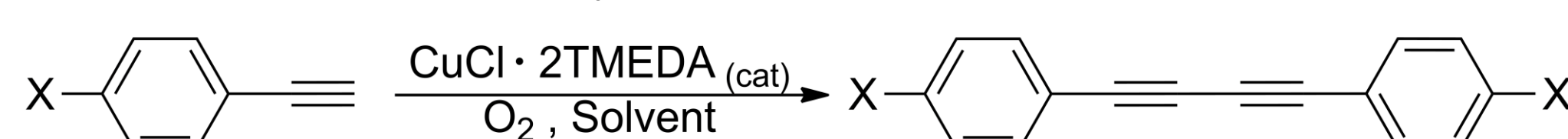
The kinetic studies are done on the Glaser-Hay reaction under the normally applied conditions, i.e., with a catalytic amount of CuCl with 2 eq. of TMEDA per mol Cu(I). The reaction is carried out at RT, with magnetic stirring, and exposure to air. The solvent used was either dichloromethane or 1,2-dichloroethane.

The kinetic measurements were done by UV-VIS absorption spectroscopy from 230 – 450 nm on a Varian Cary50 instrument. The measurements should give the reaction order of the acetylene and show the effect of substrate and ligand alterations.

Absorption spectra:

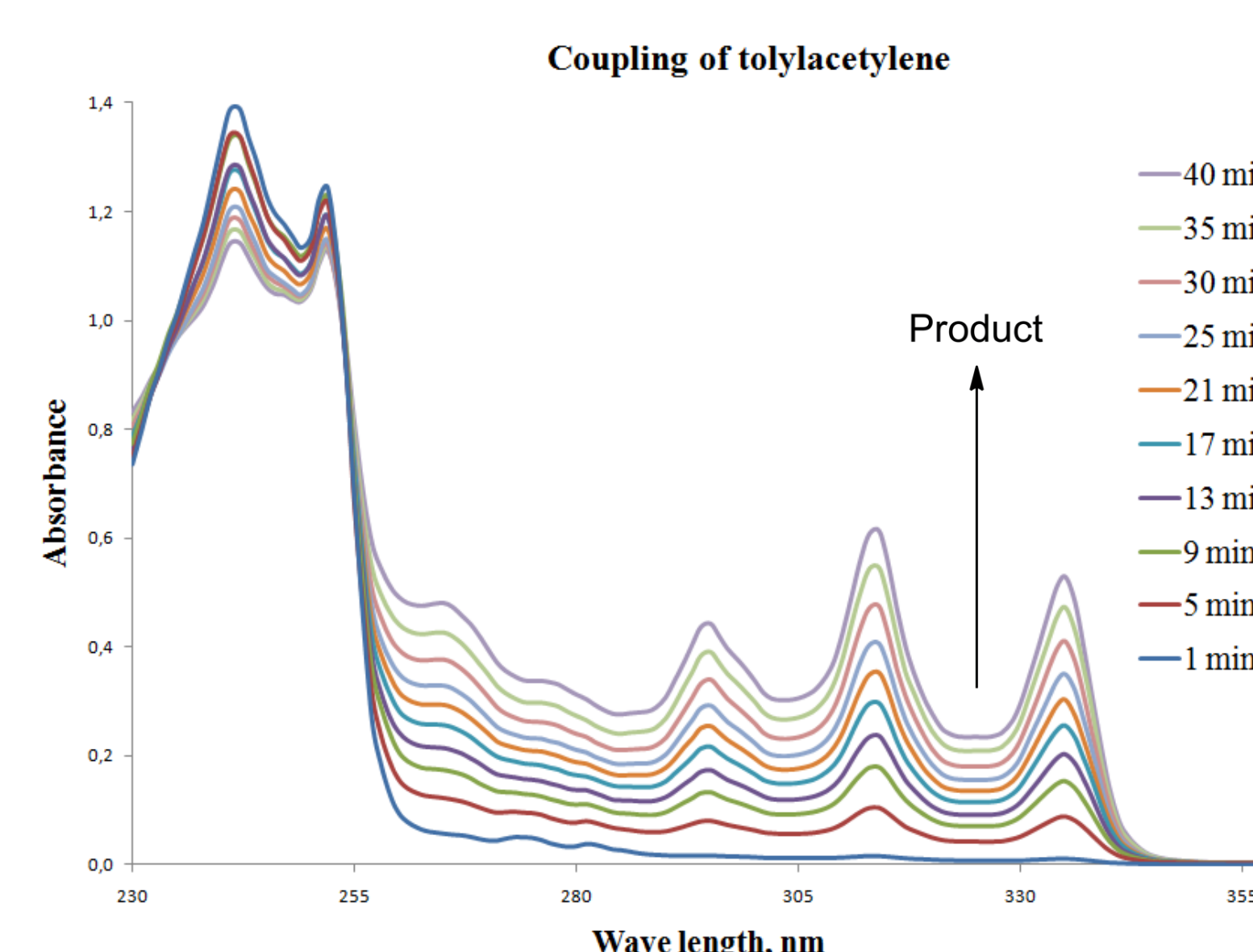


The reaction to be studied by UV-VIS (X = H, Me, ^tBu):



Kinetics:

Measurements have been done for the coupling of phenylacetylene, *p*-tolylacetylene and *p*-*tert*-butylphenylacetylene. Here is shown the data for the coupling of *p*-tolylacetylene.

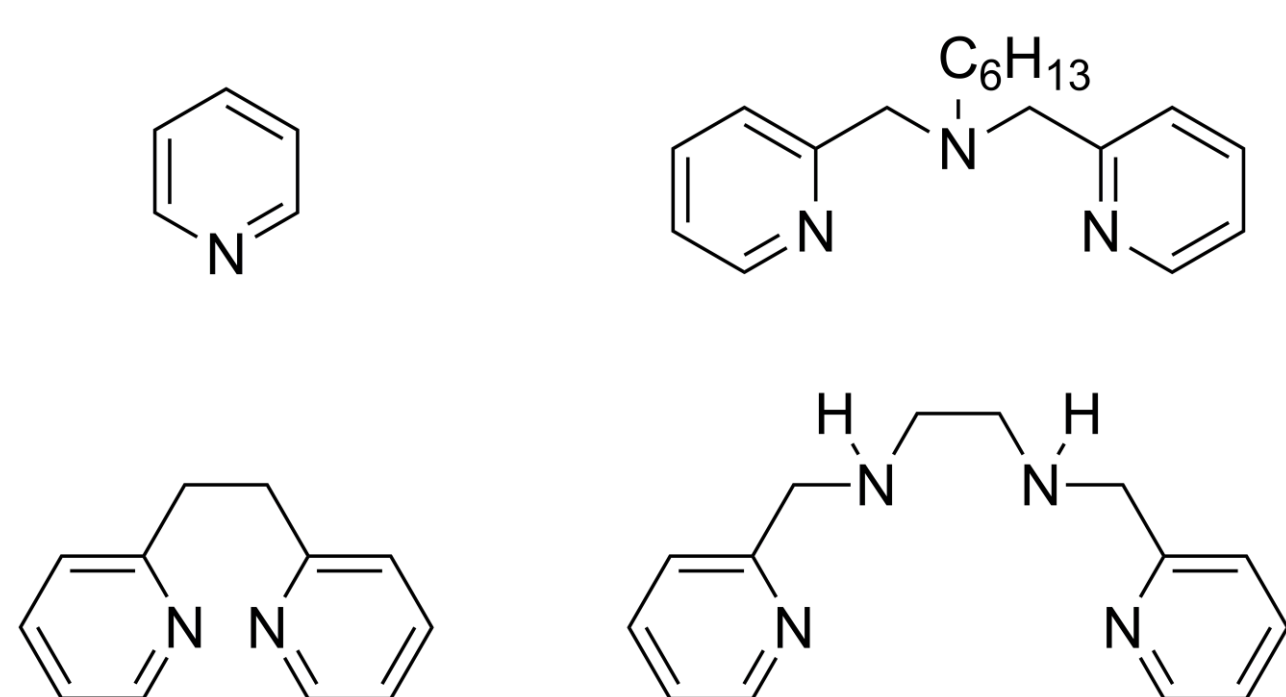


Preliminary findings suggest that the reactions is of 1st order with respect to the acetylene and furthermore that the reactions progress faster in dichloromethane as compared to 1,2-dichloroethane.

Future:

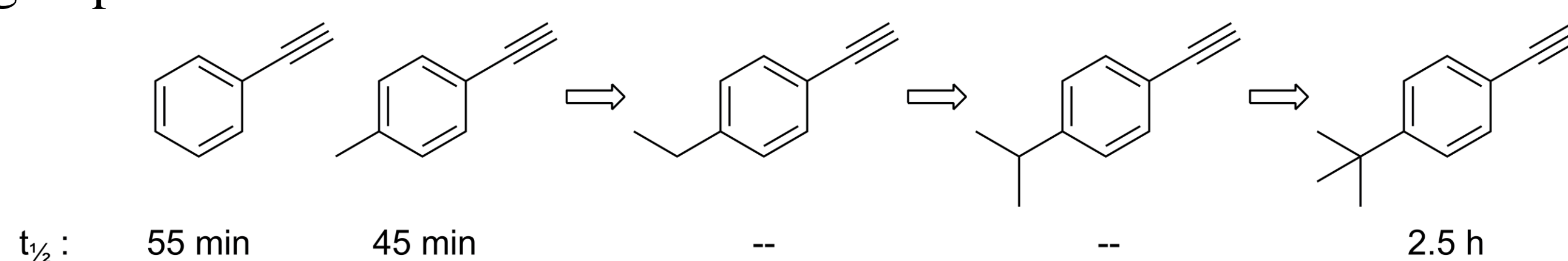
Alternative ligands:

The effect of the ligand on the coupling reaction will be examined through the use of a series of four ligands pyridine and ligands which exhibit polydentate binding character:



Steric effects:

Quantitative results from the kinetic studies show that the substitution of the hydrogens on the methyl group of tolylacetylene slows down the reaction considerably. Therefore, the effect of the hydrogen substitution will be examined by stepwise addition of a methyl group:



Electron donating/accepting substituents:

Furthermore the effect of the electronic character of the *para*-substituent on the benzene ring will be examined. This will be done through the following series:

