# Threonine: An Amino Acid Autonomous Molecular Assembly

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## Abstract

In our research we utilized scanning tunneling microscopy to study the molecular self-assembly of chiral amino acids, specifically Threonine, on metal surfaces. The study of molecular self-assembly is a key component to nature and a phenomena that is utilized by nanoscale research. Chiral molecular assemblies are of interest for drug development, catalysis, and sensing. Amino acids are chiral molecules that are the building block of proteins. One of the unsolved mysteries in science is in the synthesis of proteins. The goal of this study is to further our understanding of chiral molecular assembly on single crystal metal surfaces. In particular, we explored the hypothesis that racemic mixtures will lead to selective chiral assemblies. We utilized the scanning tunneling microscope to characterize these molecular assemblies at the atomic-scale. This project combines fundamental elements of physics, chemistry, and biology.

## Introduction

- This research utilized scanning tunneling microscopy (STM) to study the molecular self-assembly of a chiral amino acid on copper surfaces.
- The exploration of molecular self assembly can further understanding of a critical phenomena found throughout nature. There may be chiral selectivity occurring within these assemblies while studying them at the atomic level.
- Ultimately, this experiment will provide insight into why amino acids in living things utilize the “L” form of molecules, when the “D” form occurs in equal amounts.

## Methods

- Using the STM, illustrated in Figure 1(a), samples are prepared in an ultrahigh vacuum chamber. Samples were characterized with atomic-resolution utilizing the STM. Images and data samples were collected with a computer software.
- The Cu (111) surface was cleaned by sputter annealing.
- The molecules were dosed onto the copper surface using a molecular doser, illustrated in Figure 1(b). Following the dose, the samples were annealed at 450 K.
- While remaining in the Ultra High Vacuum, the sample was transfered to the STM to be imaged.
- Images were taken at 55 K.

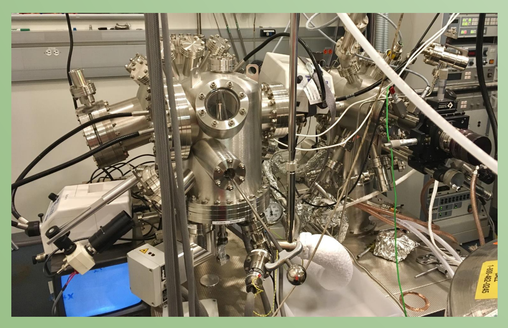


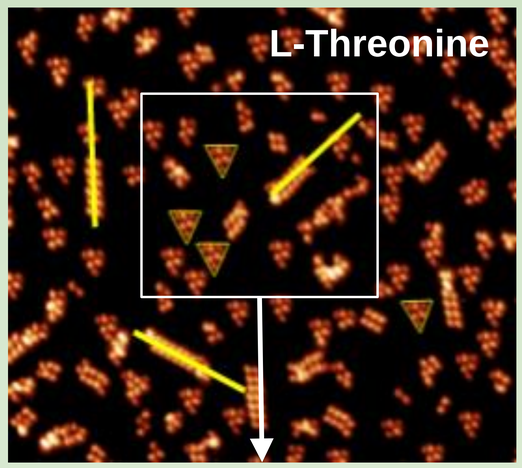
Figure 1a

Figure 1b

## Results

In both the L and D forms, two major assemblies were found: triangular and chain-like structures.

- L-Threonine orientations differ from D-Threonine, specifically in their angles.



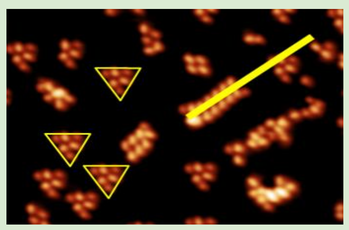



Figure 2a

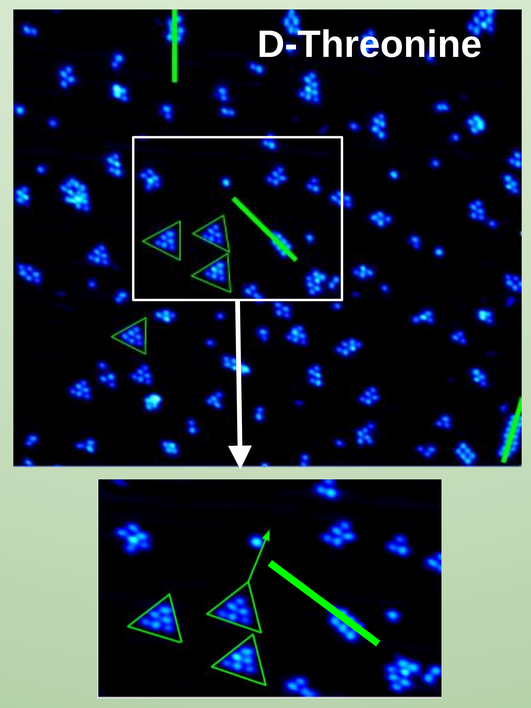



Figure 2b

## Results (*cont.*)

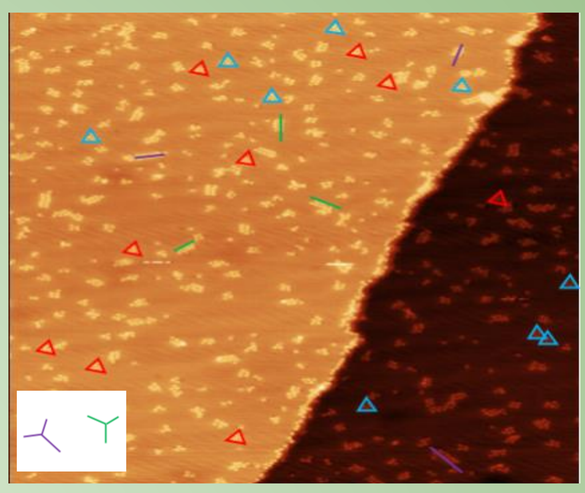


Figure 3

- Figure 3 shows a scanning of DL-Threonine, a mixture of 50% D-Threonine and 50% L-Threonine.
- Two distinct orientations of D and L structures are still present.

## Conclusion

- The L-Threonine tended to self assemble with other L-Threonine molecules while D-Threonine tended to self assemble with other D-Threonine molecules.
- There were two structures observed; both L-Threonine and D-Threonine formed triangle structures as well as chain structures. The chains and triangles differ in orientation between the two chiralities.
- Both L- and D- Threonine can each exist in two stereoisomers, which may explain the assembly of two distinct structures within each form (L- and D-). (Figure 4)
- The self-assembled structures and orientation of L-Threonine and D-Threonine may provide information on how stereoisomers interact; this could impact how amino acids are incorporated into proteins, potentially impacting protein structure and therefore function.

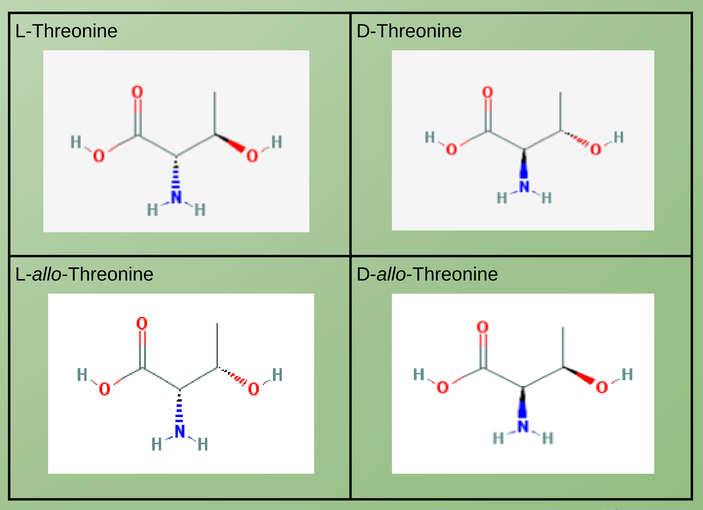



Figure 4

Literature Cited

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