Synthesis of Polypeptides Using Difunctional Initiators

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Introduction

Goal of Research:
Synthesis of polypeptides using difunctional initiators.

What is an initiator?
It is a molecule which combines with a monomer to activate polymerization.

\[ I^* + M \rightarrow I\sim M^* \quad (\text{initiation}) \]
Introduction

Focus Questions

- First step: How effective are certain initiators in activating *living polymerization*?
- Next step: Are the initiators *difunctional*?

\[
M + *I* + M \rightarrow *M\sim I\sim M* \quad \text{(initiation)}
\]

\[
M + *M\sim I\sim M* + M \rightarrow *M\sim M\sim I\sim M\sim M* \quad \text{(propagation)}
\]
Methods

Experimental Objectives:

- Test and analyze effectiveness of initiators.
- Introduce “weak link” to prove difunctionality of initiators (future)

Materials:

- 3 sample initiators
- Monomer (Glu-NCA)
- Solvents (THF, DMF, ethyl ether)
Polymerization of Glu-NCA

\[ M + I^* + M \rightarrow ^*M\sim I\sim M^* \] (initiation)

**Init.**
- 48 hrs
- room temp
- THF

**Init =**

**X:**
- Init 1 = [Structure A]
- Init 2 = [Structure B]
- Init 3 = [Structure C]
- Init 4 = [Structure D]

**depe** = 1,2-bis(diethylphosphino) ethane
**R’** = -CH₂CH(CH₃)₂
**R** = -CH₂CH₂CO₂CH₂C₆H₅
Methods
Experimental procedure

• Prepare reactants, THF solvent, and utensils.

• Polymerize Glu-NCA with initiator in drybox (oxygen & water-free). Stir 48 hours.

• Precipitate polymer in ethyl ether.

• Measure $M_n$ & $M_w/M_n$ using GPC.

(Repeat, varying initiator concentration.)
Synthesis of Polypeptide

Procedure:
1. In drybox, dissolve Glu-NCA in THF. Put into reaction flask. Add initiator. Remove flask from drybox.

2. Stir at 25°C for 48 hrs under hood.

3. Precipitate in ethyl ether and dry polymer.

4. Analyze polymer using GPC.
1. Polypeptide is dissolved in DMF, filtered, and injected onto the columns.

2. Large molecules move faster than smaller ones on the columns.

3. Polymer solution moves from columns to light scattering and RI detectors. Large molecules arrive and are detected by laser first, then smaller ones.

4. Detector sends data to computer program, which plots curve and prints report.
## Results

<table>
<thead>
<tr>
<th>Initiator 1 (mmol)</th>
<th>$M_n$ (GPC)</th>
<th>PDI ($M_w/M_n$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00365</td>
<td>317500</td>
<td>1.2</td>
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</table>

The line graph shows the relationship between initiator concentration and molecular weight ($M_n$) with the following equation:

$$y = -3E+06x + 109643$$

with a coefficient of determination ($R^2$) of 0.9293.

![Graph showing the relationship between initiator concentration and molecular weight](image)

The molecular structures of Initiator 1 and 2n are also depicted, along with a note indicating the reaction conditions: 48 hrs at room temperature in THF.
Results

$M_n$ vs Amount of Initiator

![Graph showing $M_n$ vs Amount of Initiator for different initiators. The graph illustrates the relationship between the molecular weight average ($M_n$, GPC) and the amount of initiator (mmol), with distinct markers and lines for Initiator 1, Initiator 2, Initiator 3, and their linear fits.]
Conclusions
Despite different core structures, all initiators effectively polymerized Glu-NCA.

Future work
Prove difunctionality of initiator:

If initiator is difunctional:  
by GPC \[ M'_n = \frac{1}{2} M_n \]
Potential application

• **Use difunctional initiators** to prepare ABA block copolymers.

  \[ A\sim A\sim B\sim B\sim I\sim B\sim B\sim A\sim A \]

• **Create polypeptides with predetermined properties and sizes.**
Personal Reflections

• Scientific research is an inquiry-based and data-driven process of discovery. The questions and answers are not provided beforehand.

• Scientists are persevering. Formal research is a long-term, sometimes tedious, carefully documented process.

• Formal research integrates other academic disciplines. i.e. statistics, technology, communication, & literacy.