COLLEGE OF SCIENCE
THE UNIVERSITY OF ALABAMA IN HUNTSVILLE

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Self-Assembled PEGylated Poly(amino acid)s – A Vehicle for Nanoparticles

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Purpose

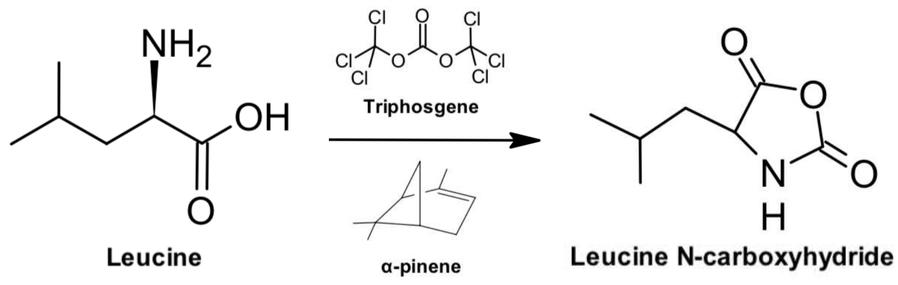
Nanoparticles have become more relevant in the biomedical community due to their potential for cell imaging, drug delivery, and diagnostics. Polymeric structures that are non-toxic, biocompatible and able to self-assemble are well suited to encapsulate these nanoparticles to locally concentrate them and prevent them from deterioration in aqueous environment.

Goal To synthesize various block copolymers and analyze their amphiphilic properties to find polymers suitable for nanoparticle encapsulation

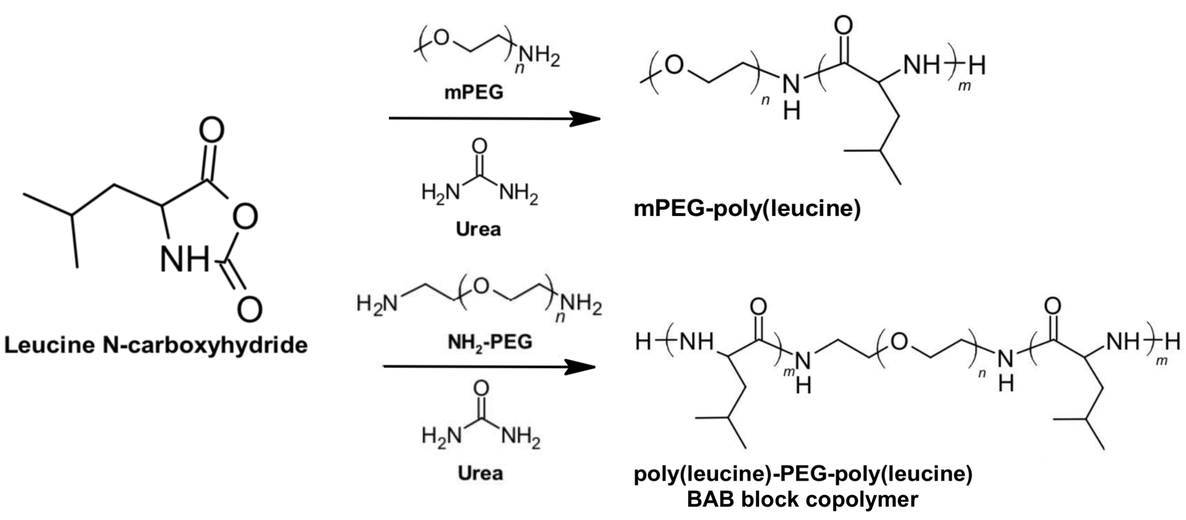
Methodology

NCA Synthesis → Polymerization → Assembly → Encapsulation

NCA Synthesis



Polymerization



Assembly & Encapsulation

To assemble block copolymers, 2 mg of block copolymer was first dissolved in 0.75 mL tetrahydrofuran (THF) and vortexed for 5 seconds. This polymer solution was filtered through at 0.2 µm filter. The filtered solution was added to 100 µL of nanoparticles (re-dissolved in THF previously). This new solution was added dropwise to 2 mL of of deionized (DI) water under vigorous stirring. The THF was then allowed to evaporate overnight under a vigorous vortex.

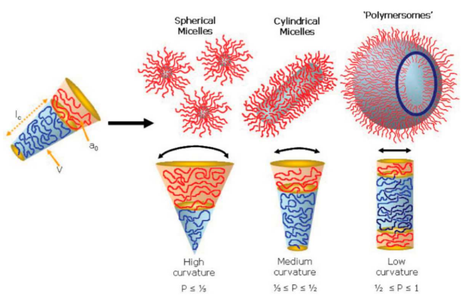


Fig 1: Different shapes block-copolymers will form depending on hydrophilic to hydrophobic chain ratio (1)

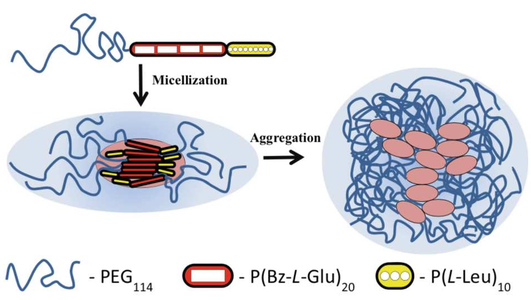


Fig 2: Hypothesized structure of aggregated micelles that assembled block co-polymers form within solution (2)

References

1) **Feng, H.; Lu, X.; Wang, W.; Kang, N.-G.; Mays, J.W. Block Copolymers: Synthesis, Self-Assembly, and Applications. Polymers 2017, 9, 494.**
2) **Ulkoski, David & Meister, Annette & Busse, Karsten & Kressler, Jörg & Scholz, Carmen. (2015). Synthesis and structure formation of block copolymers of poly(ethylene glycol) with homopolymers and copolymers of L-glutamic acid γ-benzyl ester and L-leucine in water. Colloid and Polymer Science. 293. 10.1007/s00396-015-3632-6.**

Results

- Nuclear Magnetic Resonance **(NMR)** spectroscopy was used to confirm the successful synthesis of various block-copolymers (**Fig. 3**)
- Dynamic Light Scattering **(DLS)** was used to analyze particle size (**Fig. 4**).

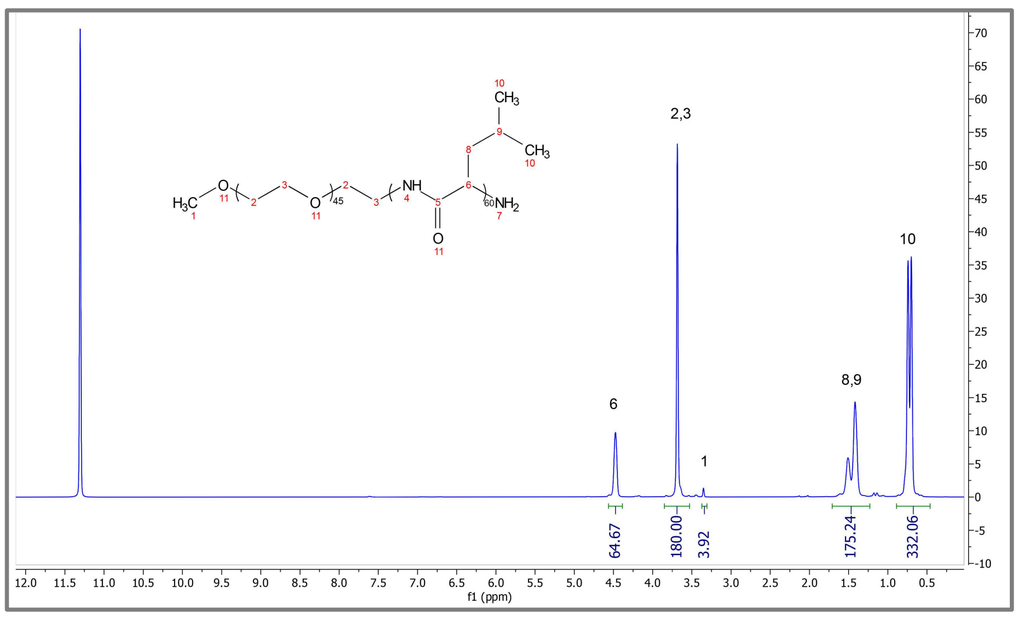


Fig 3: H-NMR Spectrum for $mPEG_{45}$–$p(Leu)_{53}$

Polymer	1:10 dilution diameter (nm)	1:100 dilution diameter (nm)	Conditions
mPEG45-pLeu6	663.220	---	No filtration & under 50°C bath
mPEG45-pLeu20	560.320	---	No filtration & under 50°C bath
mPEG45-pLeu53	368.120	---	No filtration & under 50°C bath
mPEG22-pLeu10	3065.000	---	No filtration & under 50°C bath
HO-PEG77-pLeu15	23.216	---	No filtration & under 50°C bath
HO-PEG114-pLeu15	54.464	---	0.2 µm filtration & under 50°C bath
mPEG113-pLeu22	20.036	---	0.2 µm filtration & under 50°C bath
mPEG113-pLeu22	378.24	---	0.2 µm filtration, 200 µL chloroform, 50°C water bath
mPEG113-pLeu22	156.94	157.52	0.2 µm filtration, 30 nm particles in THF, no heat

Fig 4: DLS for several block copolymers

Fig 5: Vials of mPEG113-pLeu22 after assembly & encapsulation for the original sample, 1:10 dilution, then 1:100 dilution from left to right

Conclusions

- DLS results (ref. **Fig. 4**) indicate longer hydrophobic chains (within the same series—polymers that have the same hydrophilic chain length) create smaller particles after assembly & analysis.
- BAB block co-polymers were found to be difficult to dissolve in THF.
- Nanoparticles received were dissolved in chloroform, which is not miscible in the water used during assembly. To solve this, chloroform was first evaporated then re-dissolved in THF.
- Increasing the hydrophobic chain length of the polyleucine relative to the PEG chain resulted in a decrease in particle size.
- Synthesis & assembly of $mPEG_{22}$-$pLeu_{10}$ created a surfactant

Future Directions

- Nanoparticles were successfully encapsulated within self-assembled polymeric nanostructures
  - Analysis of several other amphiphilic polymers is currently in progress
  - The encapsulation procedure is being refined to create even smaller virus-sized particles

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