Investigation of the Swelling and Shrinkage Behaviors of Alginate Capsules

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Abstract
The treatment of many diseases relies on alginate microcapsules for their ability to immune-isolate cells from the surrounding environment. Spherical alginate microcapsules are prepared by the gelation of alginate solution in CaCl₂ or BaCl₂ solution, which may include other additives such as Pluronic F68, a non-ionic surfactant. Investigation of the swelling and shrinkage behaviors of the microcapsules in various solutions is important for understanding transport mechanisms (i.e. nutrient and protein diffusion) within the capsule. To accomplish this objective, the change in the diameter of capsules made with five different concentrations of surfactant was monitored. Correlations between microscopy and Beckman Coulter Counter measurements were made to determine and optimize the procedure for measuring capsule diameter using the Coulter Counter. From the calculations of the swelling ratio, it was found that the microcapsules formed using the CaCl₂ solution swelled more than those made with the BaCl₂ solution. On average, the BaCl₂ capsules had 8.8% less water-uptake capacity than the CaCl₂ capsules. For all gelation methods, the surfactant-containing capsules had lower water-uptake capacity than those made without surfactant. These results aid determining which formulations to use when making capsules based on the desired cellular environment.

Interdisciplinary Connection: Treatment of Type 1 Diabetes
- T1D is characterized by an autoimmune attack of β-cells in the pancreas, which produce insulin
- Cause of the attack is still unknown
- Insulin regulates glucose levels in the blood signaling other cells to break-down starch or store glucose for later use
- Loss of its secretion causes hyperglycemia
- The current treatments include daily injection of insulin or the use of an insulin pump. Our solution is to immunoscaffold β-cells in alginate microcapsules for transplant into T1D patients.

Gelation of Alginate Capsules
Alginate mixture contains:
- 1% w/v alginate
- Glucose
- HEPES buffer
- F68 (concentration varied)

- Egg-box Structure
Alginate structure once extruded into CaCl₂ or BaCl₂ solution, with the middle element being either Ca²⁺ or Ba²⁺ ions.

Sizing steps:
- Images of capsules are taken using a inverted light microscope
- Threshold Set
- Using Image J, a threshold is set so that the capsules edge is continuous
- Using Image J’s particle analysis tool, an ellipse fit to the image and a diameter is calculated
- For >100 images per batch, an average is determined

Results

Capsules with F68
- y = 3.302x + 3.14 x = 0.0191
- y = 0.33x + 253.05
- y = 0.39x + 252.28

Capsules with 1% F68

Capsules with 5% F68

Swelling Ratios

- Figure 2 shows the result of plotting the size values calculated from the microscopic images versus the ones given by the coulter counter
- The three graphs represent the three concentrations of Pluronic F68 used
- In Figure 3, capsules in CaCl₂ had greater swelling ratios than the BaCl₂ capsules.
- Swelling ratios decrease as the F68 concentration increases

Conclusions
- In general, capsules size given by the coulter counter were smaller than the ones calculated from the microscopic images
- From Figure 2, I concluded that capsules gelled in CaCl₂ solutions have greater water-uptake capacity than the ones formed in BaCl₂ solutions
- As the concentration of Pluronic F68 increased, the ability of capsules to swell decreased
- F68 decreases capsules water-uptake capacity
- This was confirmed with the coulter counter as well
- These results will help determining which solution should be used to make capsules, depending on the type of cellular environment desired

Methods and Materials
- Beckman Coulter Counter
- Use CaCl₂ electrolyte to run CaCl₂ capsules
- Best results were obtained using a concentration of capsules inside electrolyte between 5 – 20%
- Samples were run for 30 seconds

Acknowledgments
- Roberts Research Group
- College of Engineering
- National Science Foundation (Award Number 0850424)

This work is supported in part by the National Science Foundation under NSF award number 0850424, James M. Smith, '67, and the Dean’s Fund for Undergraduate Research in Engineering established in honor of Joseph I. and Barbara H. Goldstein.

Any opinions, findings, conclusions, or recommendations expressed in this material are those of the authors and do not necessarily reflect those of the National Science Foundation.