I. Introduction

Background
- Dialysis is a system designed to remove impurities from blood through filtration
- Peritoneal dialysis pumps dialysate into the peritoneal cavity and utilizes the peritoneum membrane as a natural membrane to achieve this filtration
- Patients who receive peritoneal dialysis are prone to infection and discomfort as the dialysate must be replaced 3-5 times a day to ensure continuous removal of waste

Objectives
- This research will develop a secondary membrane designed to remove 20 grams of urea from the dialysate per day
- The secondary filtration will decrease the need to change the dialysate more than once a day thereby decreasing the risk of infection for patients

II. Methods

Phase 1:
- Obtain information on different membranes (surface area, material, pore size, charge, selectivity, etc.)
- Research different enzymes that will cause urea to breakdown in to ammonia and bicarbonate
- Research different sorbents
- Find the toxicity level to the human body of all materials

Phase 2:
- Identify which membrane, enzyme, sorbent, and other materials will be used for the mathematical model
- Mathematics:
  - Ratio of enzyme and sorbent
  - Volume of byproducts produced during breakdown
  - Diffusion across the membrane
  - Needed pore size, charge, and surface area to diffuse 20 g per day in a 2 L bioreactor
  - Thickness of the enzyme and sorbent layers on the permeate side of the membrane
  - Rate of product adsorption to sorbent surface

Phase 3:
- Develop a mathematical model to describe the transfer of urea to its final form of adsorbed ammonia
- Plot urea removal rate in each membrane, enzyme, and sorbent component using the differing variables

III. Results

<table>
<thead>
<tr>
<th>Material</th>
<th>Pros</th>
<th>Cons</th>
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<tbody>
<tr>
<td>Filtration Membrane</td>
<td></td>
<td></td>
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<tr>
<td>Polyvinylpyrrolidone (hemodialysis)</td>
<td>Used as urea filtration method</td>
<td>No ion exclusion</td>
</tr>
<tr>
<td>Reverse Osmosis (RO) Membrane</td>
<td>Ion and size exclusion</td>
<td>Limited pore size</td>
</tr>
<tr>
<td>Polysulfone</td>
<td>Very stable</td>
<td>No ion exclusion</td>
</tr>
</tbody>
</table>

Enzyme Immobilization

- Modified polysulfone: Increased stability, Use of harsh chemicals
- Hydrogel: Increased enzyme active site access, Increased Km by a magnitude of 10
- Polysulfone: Can physically immobilize enzyme, Decreases enzyme reaction

Sorbent System

- Zirconium phosphate: Tightly binds NH3, Limited capacity
- Zirconium phosphate with activated charcoal: Absorbs organic metabolites, Another component added to system

IV. Discussion

- The urea diffusion through the RO membrane indicates that this membrane is capable of filtering the 20 g of urea at a fast diffusion rate (Fig. 2).
- The breakdown of urea into ammonia and bicarbonate through the enzyme polysulfone layer is the rate limiting step due to the enzyme reaction being slower than the diffusion rate of urea through the RO membrane (Fig. 3).

V. Conclusions

- Based on the mathematical model, an RO membrane paired with physically immobilized urease and zirconium phosphate are capable of creating a portable peritoneal dialysis system able to remove 20 g of urea in 24 hr

VI. Future Work

- Tune mathematical model
- Develop prototype to verify values determined by mathematical model

VII. References