MELISSA
MICRO-ECOLOGICAL LIFE SUPPORT SYSTEM ALTERNATIVE

2022 MELISSA CONFERENCE
8-9-10 NOVEMBER 2022

CREATING A CIRCULAR FUTURE

Electrochemical Stabilization and Resource Recovery from Source-separated Urine

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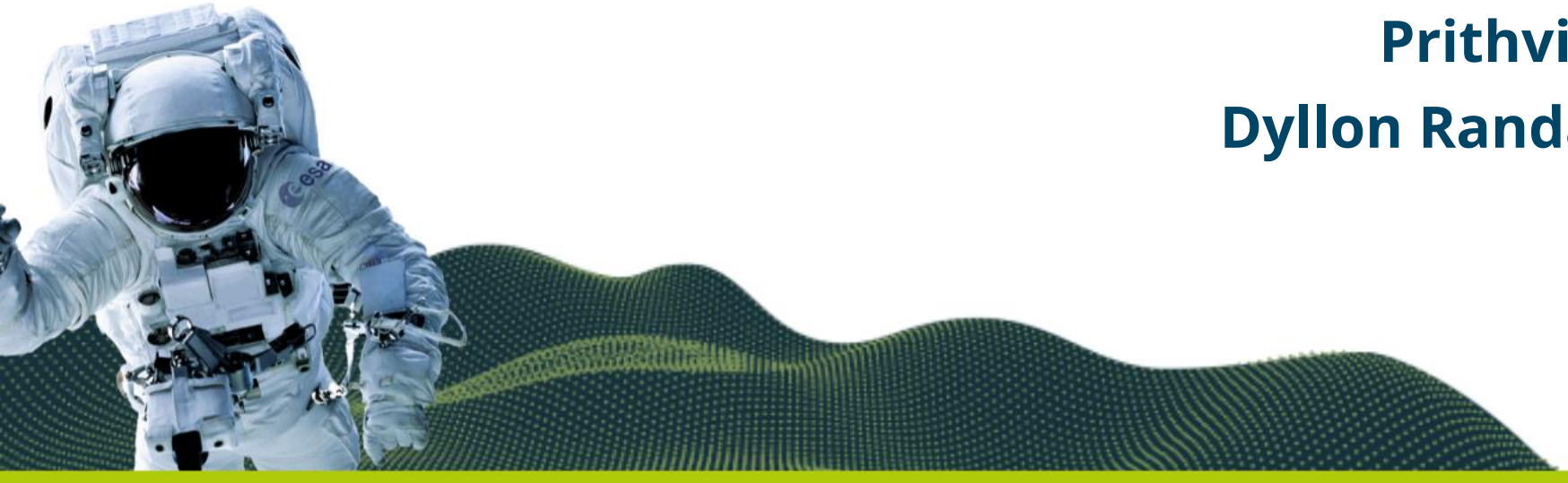

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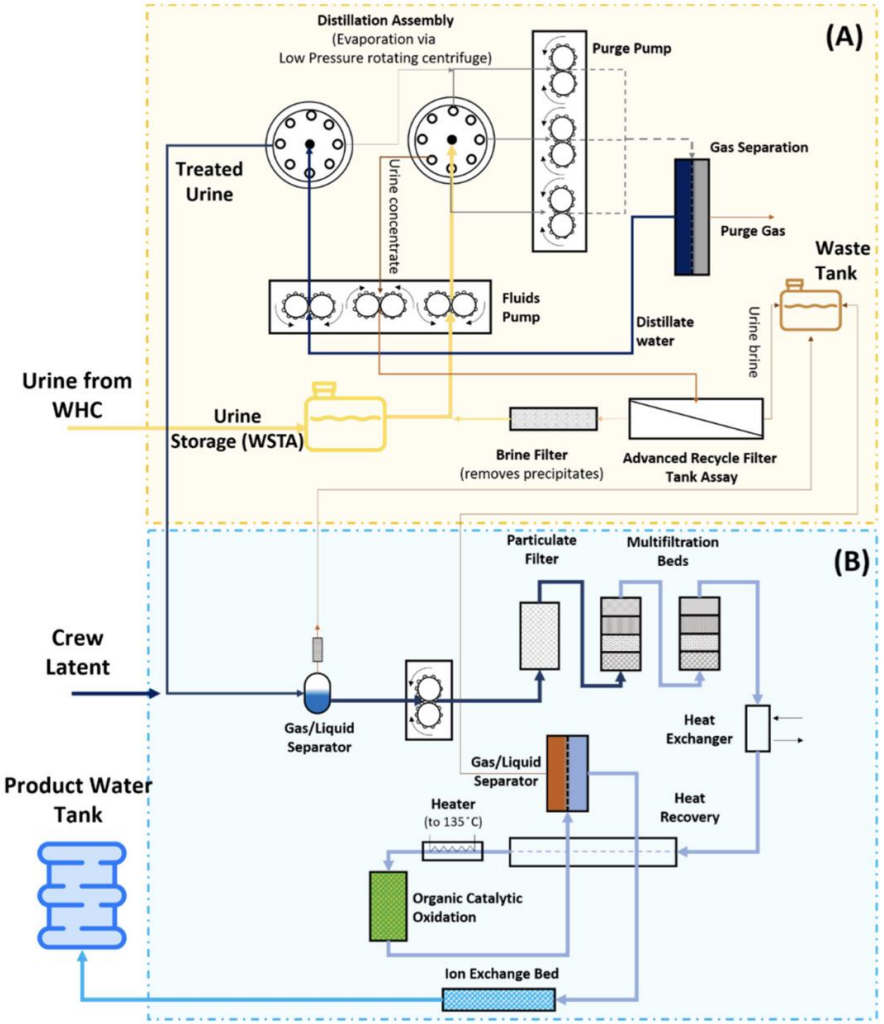
Prithvi Simha
SLU

Dyllon Randall
UCT

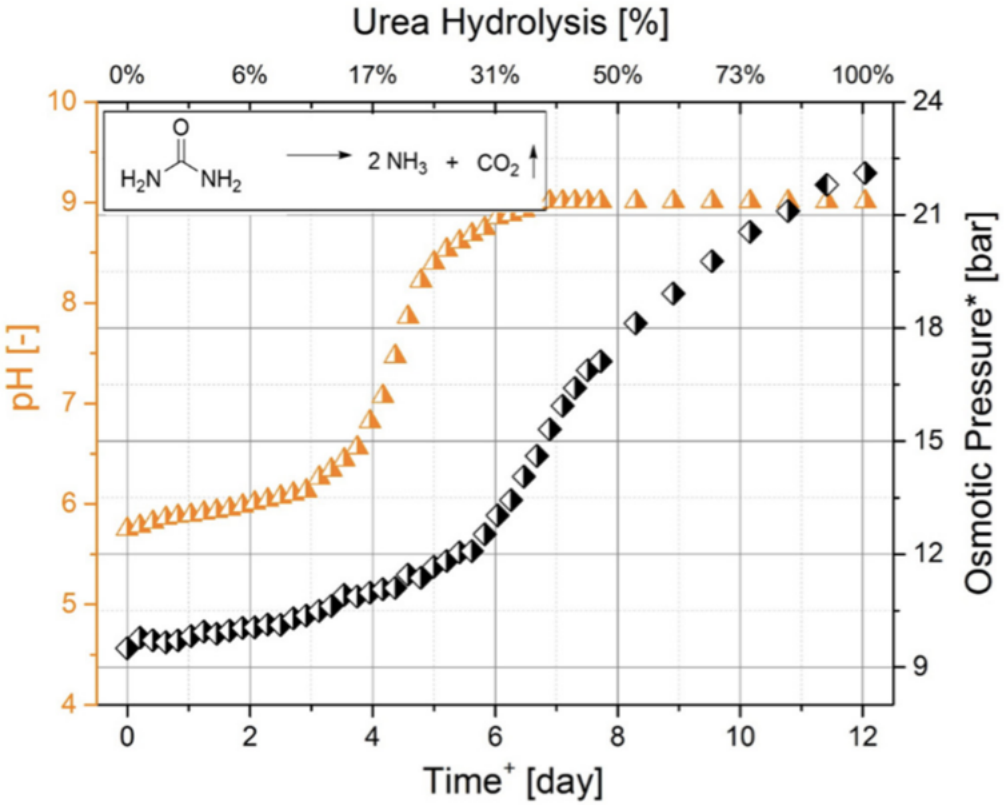
Urine Processing in Space

- The goal for urine processing in space is to maximize recovery of water
- New technologies could allow recovering phosphorus (P) and nitrogen (N)
- Shown here is the current Urine Processing Assembly (UPA) at the International Space Station (ISS)
- Our interest is in including electrification in urine processing, as opposed to chemical addition to minimize payloads

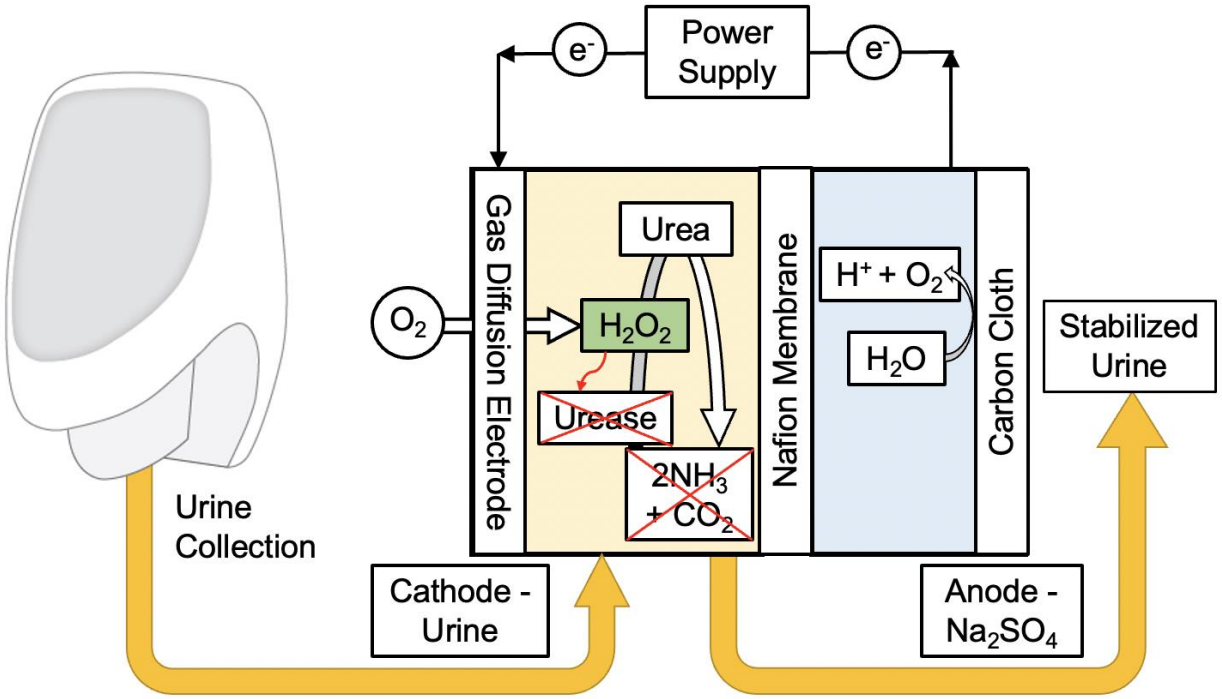


Problem of Urea Hydrolysis

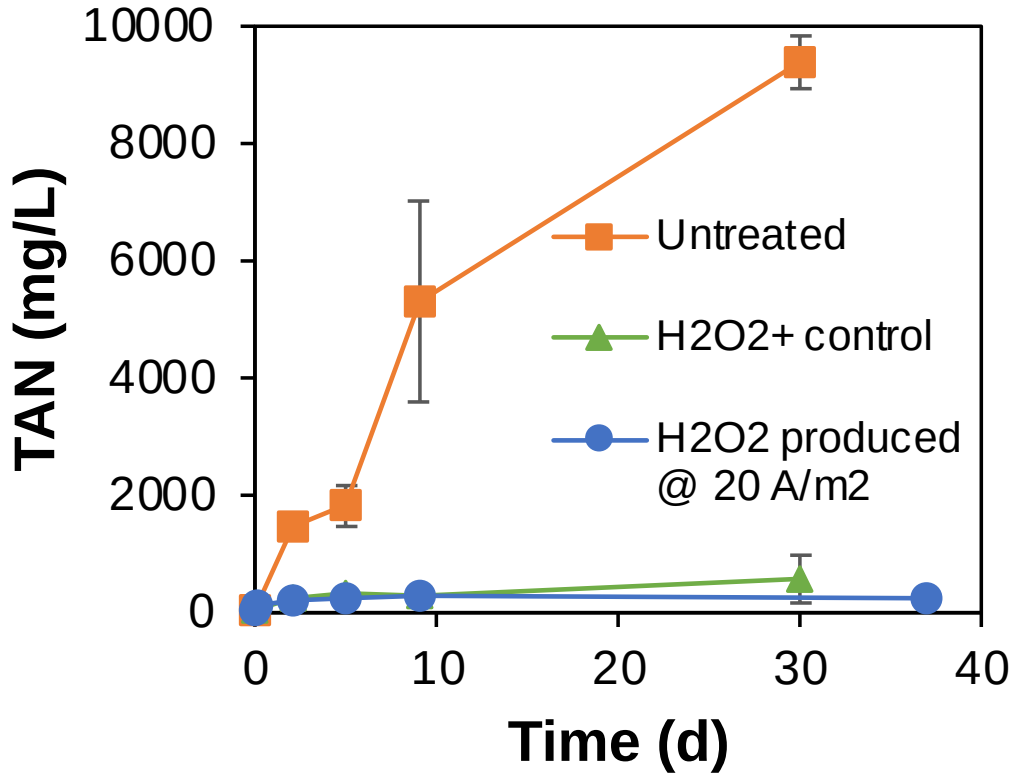
- Urea hydrolysis is catalyzed by the urea enzyme produced by many ubiquitous bacteria
- Current approach at the ISS is to add chromium trioxide + sulfuric acid to stabilize urine upon collection
- Could we replace toxic chemicals with other approaches?



Electrochemically synthesized H_2O_2 for Urine Stabilization

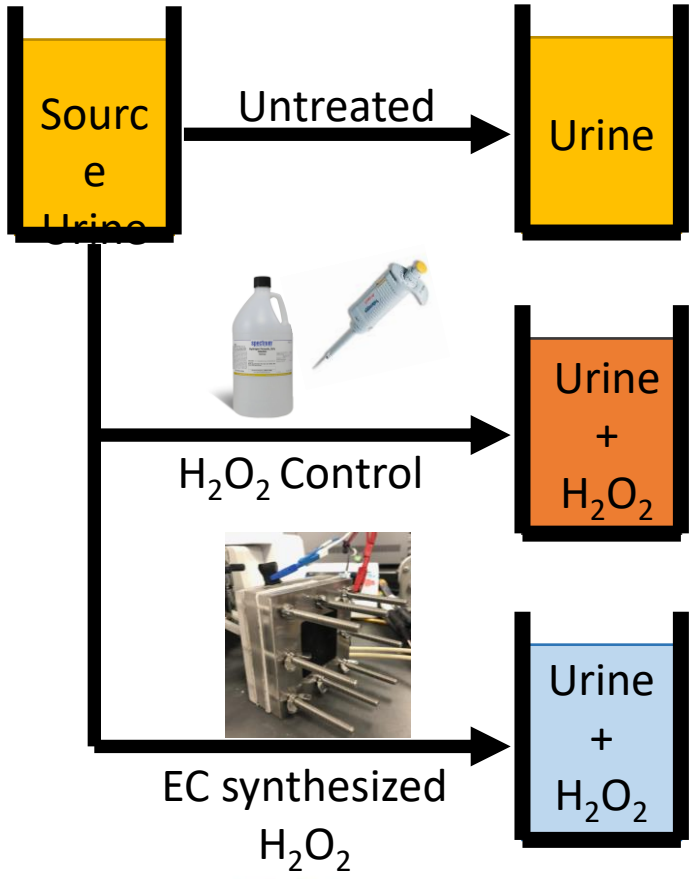


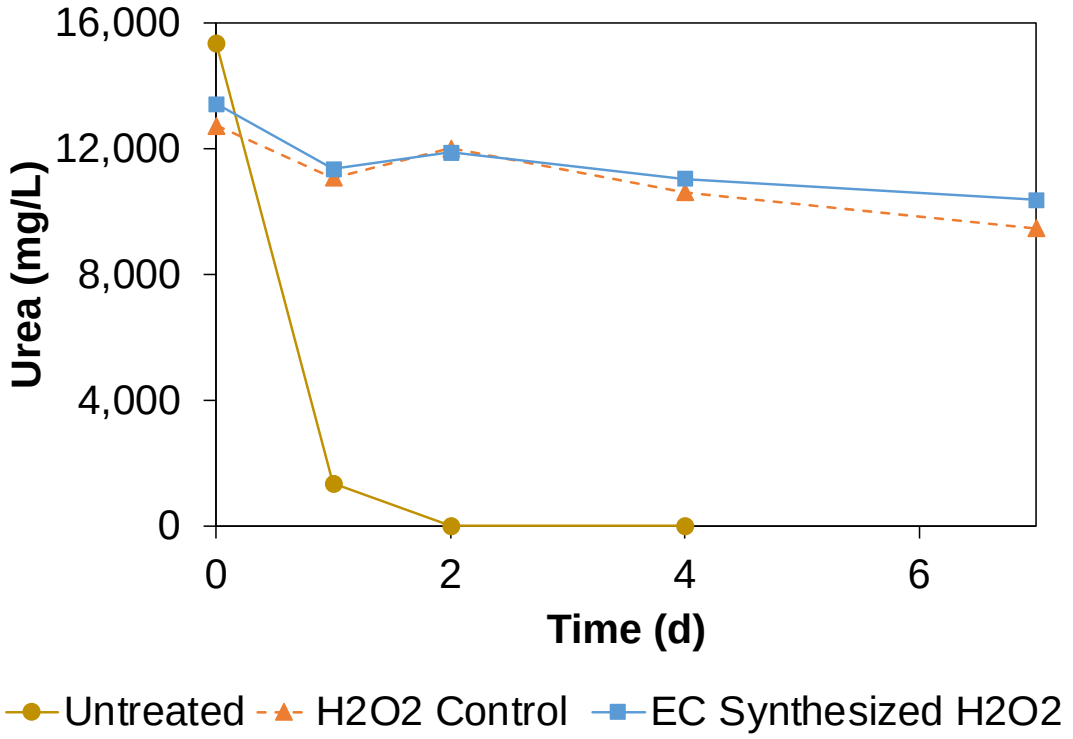
Arve and Popat, ACS ES&T Engineering, 2021



Proof-of-concept with synthetic urine

Electrochemically synthesized H_2O_2 for Urine Stabilization

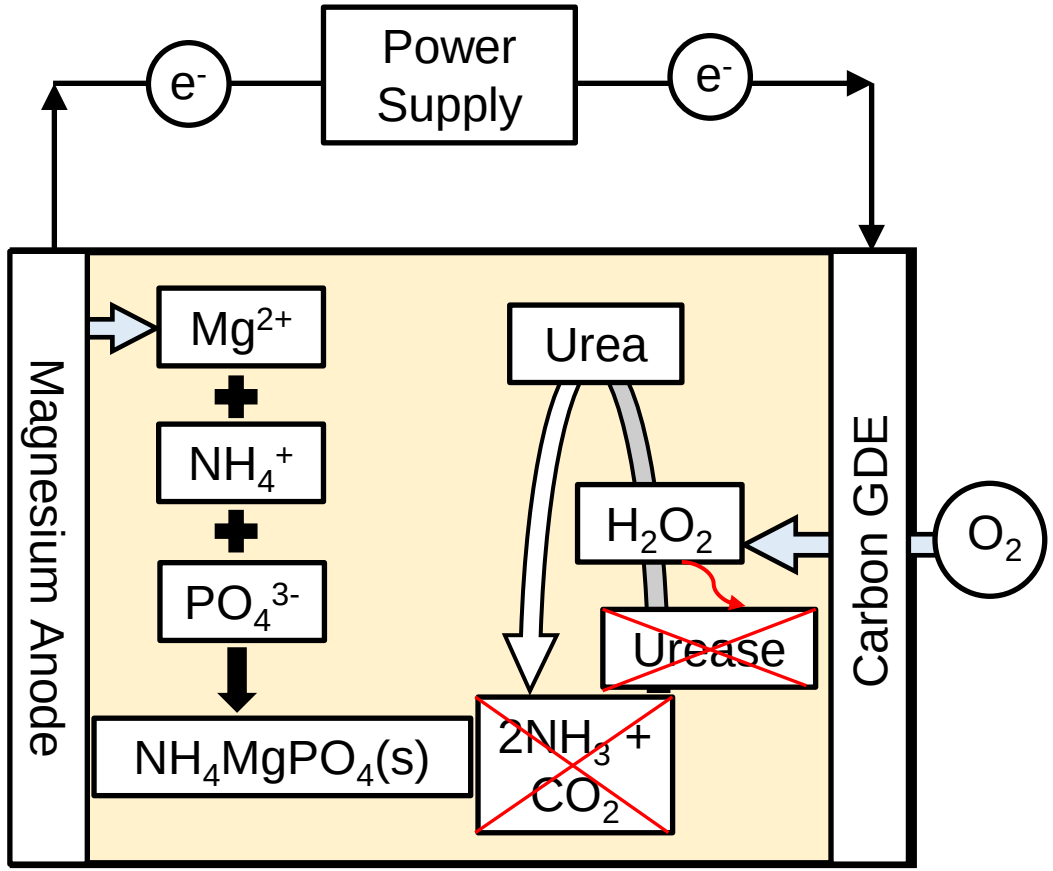




Proof-of-concept with real urine

Arve et al., in preparation

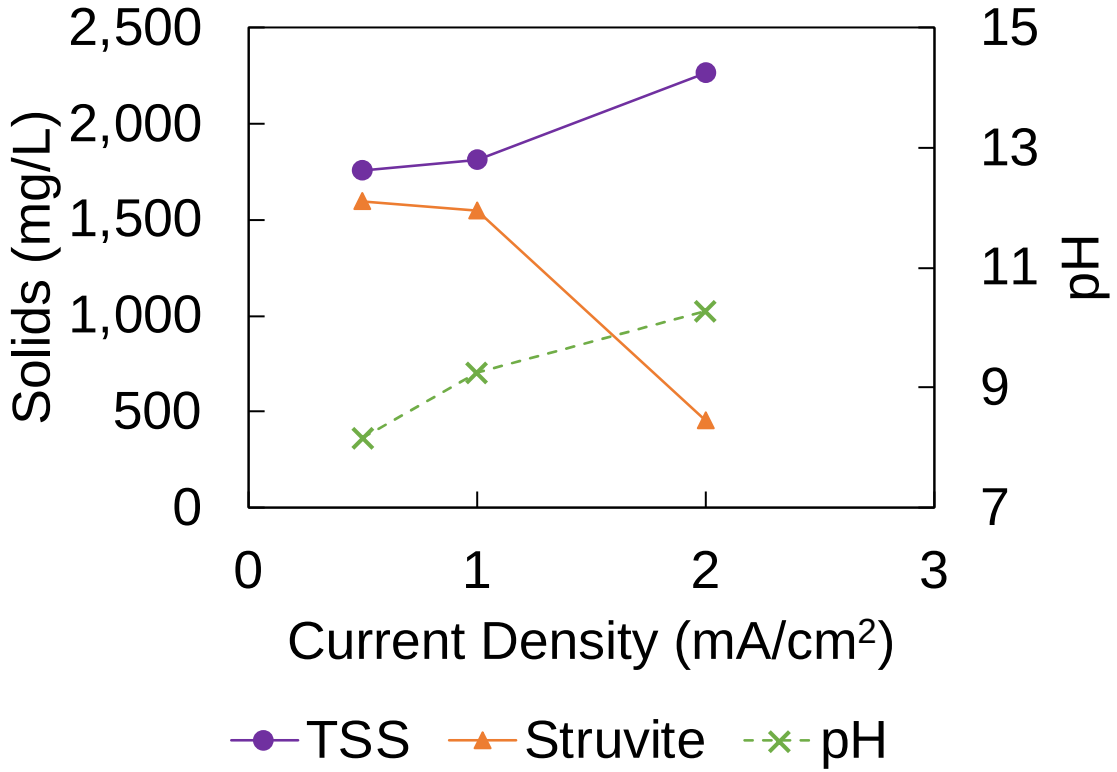
Adding More Functions to Electrochemical Stabilization of Urine

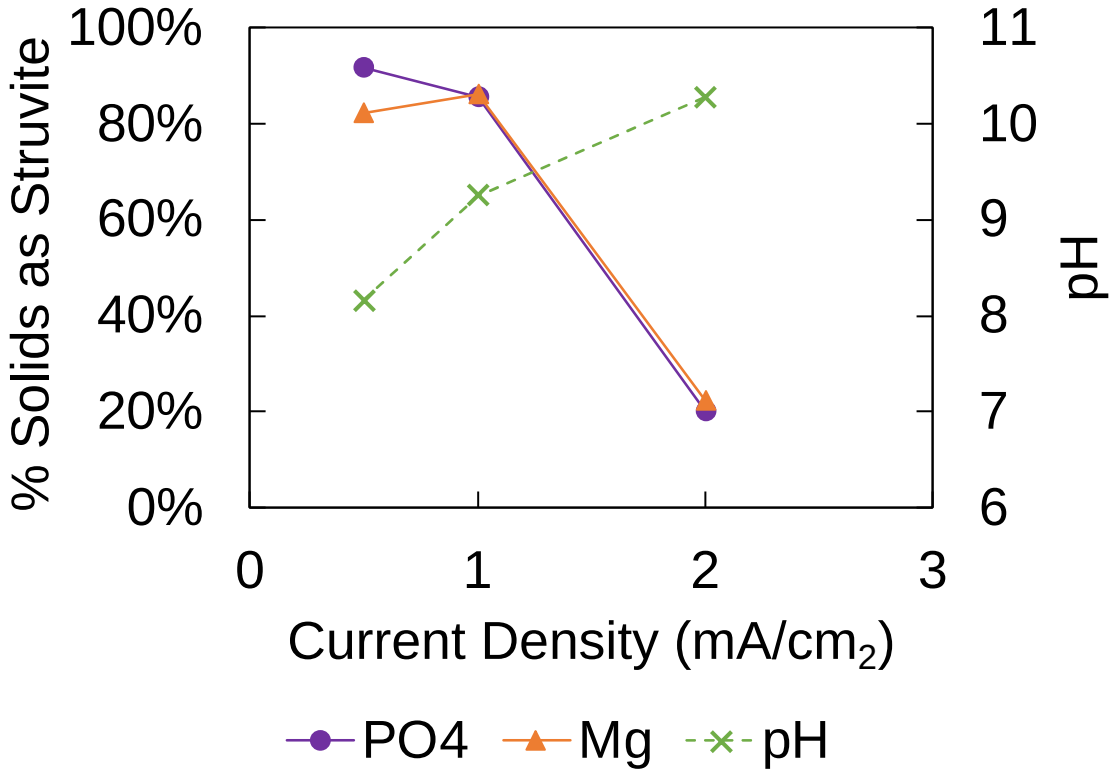


- Replace carbon-based anode with magnesium anodes that produce magnesium ions in urine
- Remove ion exchange membrane
- Leads to precipitation of phosphate, preferably as struvite
- Questions:
  - Can we avoid chlorine production?
  - How does current density regulate pH and thus form of phosphate salts?

Arve et al., in preparation

Controlled Struvite Precipitation in Electrochemical Urine Stabilization Tests

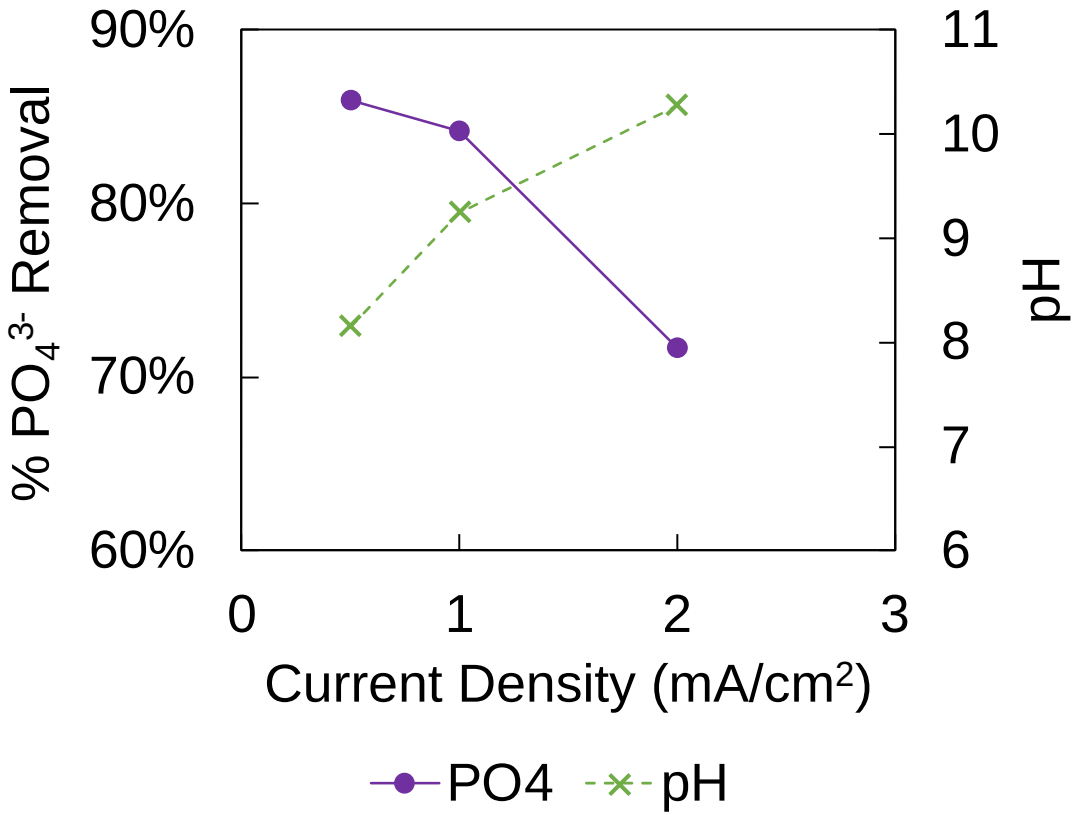




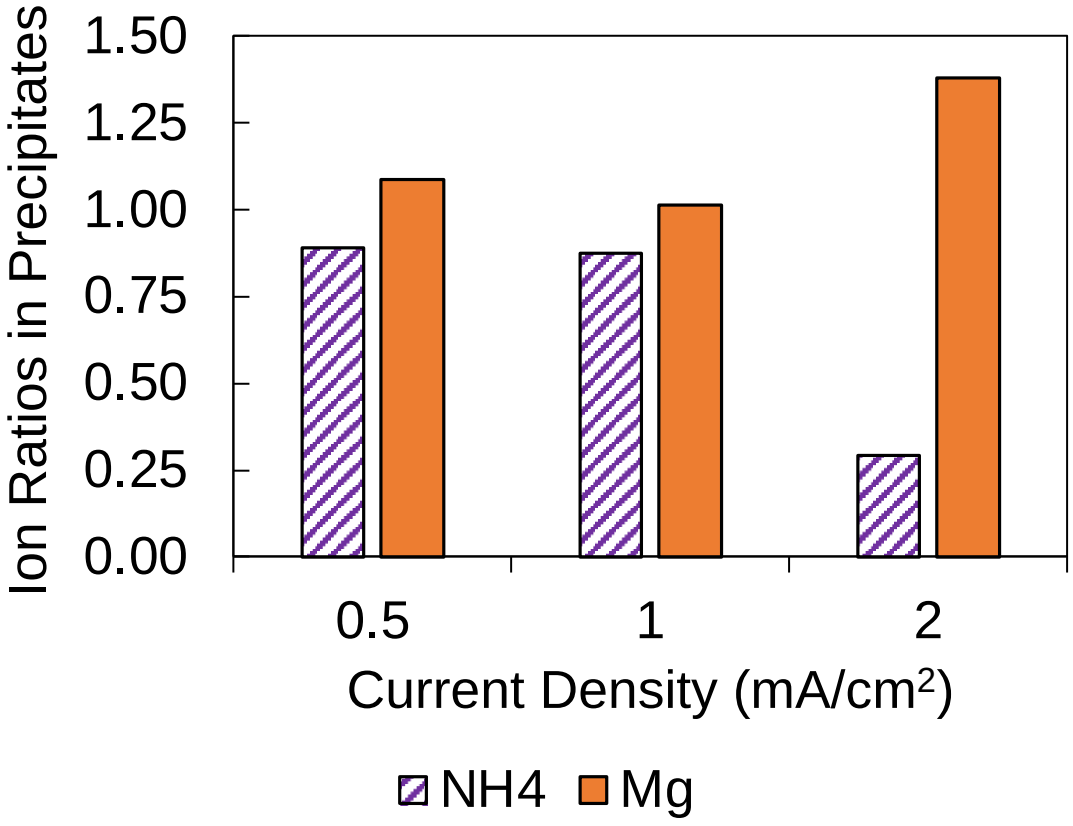
Arve et al., in preparation

Lower struvite recovery at higher current densities, linked to a high pH achieved at higher current densities

Controlled Struvite Precipitation in Electrochemical Urine Stabilization Tests



Arve et al., in preparation



Phosphate removal not affected by current density, suggesting precipitation at calcium and magnesium phosphates at higher pHs

Take-home Messages

1. Electrochemical stabilization of real urine can be achieved with in situ electrochemical peroxide production

2. Using magnesium anodes in electrochemical urine stabilization leads to the dissolution of Mg for struvite precipitation and avoidance of Cl_2 production

3. Struvite precipitation is affected by current density, which affects the urine pH in the electrochemical cell – pHs >10 leads to phosphate recovery as calcium and/or magnesium phosphates

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THANK YOU.

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