



# GRINDCAP MEDICATION DISPOSAL SYSTEM

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## Abstract

Frequently, patients will be prescribed more opioids than they need, and this presents a problem because they are lacking a reasonable way to legally dispose of these medications. This project was started in order to address the current need for a personalized at-home medication disposal system, which will aid in slowing the rising opioid abuse problem in America. The proposed system would be easy to use and small enough to fit in an average household without issue. The system would also have to be effective at making the active ingredient of the prescription drug inert and inaccessible. Our design team has worked to create a design that increases convenience and improves environmental friendliness of disposal. Our design consists of a modified pill bottle that contains a grinder in the cap to disperse the medication tablets. The pill bottle also comes with pre-packaged inactivation agents that are easily added to these tablets. These two aspects are expected to be easy enough for the patient, while also reducing risk of these pills being abused and improperly disposed. Through absorbance and dissolution testing, we were able to formulate a method of use for our personalized medication system that is both safe and easy.

## Background and Motivation

- 4,397 heroin deaths in 2011, a 44% increase from 2010 [1]
- 16,917 deaths caused by prescription drug overdoses in 2011, a 2% increase from 2010 [1]
- Hydrocodone/Acetaminophen and Oxycodone HCL make up 28% of controlled substances prescribed in 2014 [2]
- Currently people deal with unused medication by throwing it away, flushing it down the toilet, or neglecting it entirely.
- No official protocols in the U.S. for opioid disposal [3].
- FDA suggests mixing with cat litter or coffee grounds and then throwing out.
- Current Methods:
  - Medical Drop boxes
  - Meds-away
  - Cactus Smart Sink



Figure 1: Medical Drop Box  
Source: City of Racine home page



Figure 2: Cactus Smart Sink  
Source: Apothecary Products



Figure 3: Meds-away medication disposal system  
Source: Apothecary Products

## Design Specifications

### Size

- Small enough to fit in medicine cabinet.
- Convenient for sale with medication from pharmacy.

### Use

- Minimize steps of operation (less than 10 steps).
- Ability to grind pill into pieces.
- Convenient.
- No harsh chemicals or dangerous components.
- Limit environmental harm.

### Cost

- Production cost less than \$5.
- Testing cost less than \$10
- Mass producible.

### Functional Specifications

- Render hydrocodone and oxycodone inert.
- Able to fit oxycodone (D = 6.46mm, H = 3.69mm) and hydrocodone (15mm x 7mm x 5mm) tablets inside.

## Final Design

### Materials

- Grinder plastic: Natural Polylactic Acid Filament
- Polyethylene Glycol (PEG) 300: Laxative to discourage ingestion and limit absorption of drug by body.
- Sodium bentonite: Medication absorbing agent that inactivates active ingredients and deters ingestion.

### Method of Use

1. Grind pills one at a time into bottle.
2. Add 0.5 mL water per pill.
3. Shake vigorously for 1 minute.
4. Let sit for 15 minutes.
5. Add one 27g sodium bentonite packet (per 30 pills).
6. Add one 15 mL PEG packet (per 30 pills).
7. Dispose of bottle in trash.

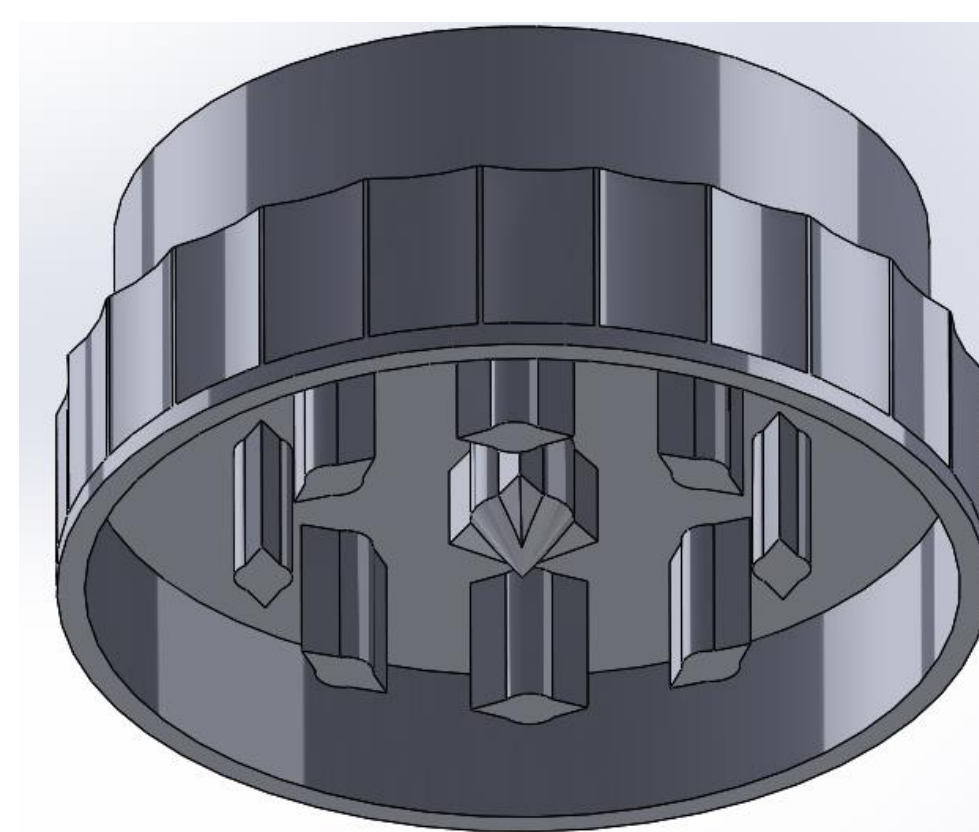


Figure 4: Top cap solidworks model

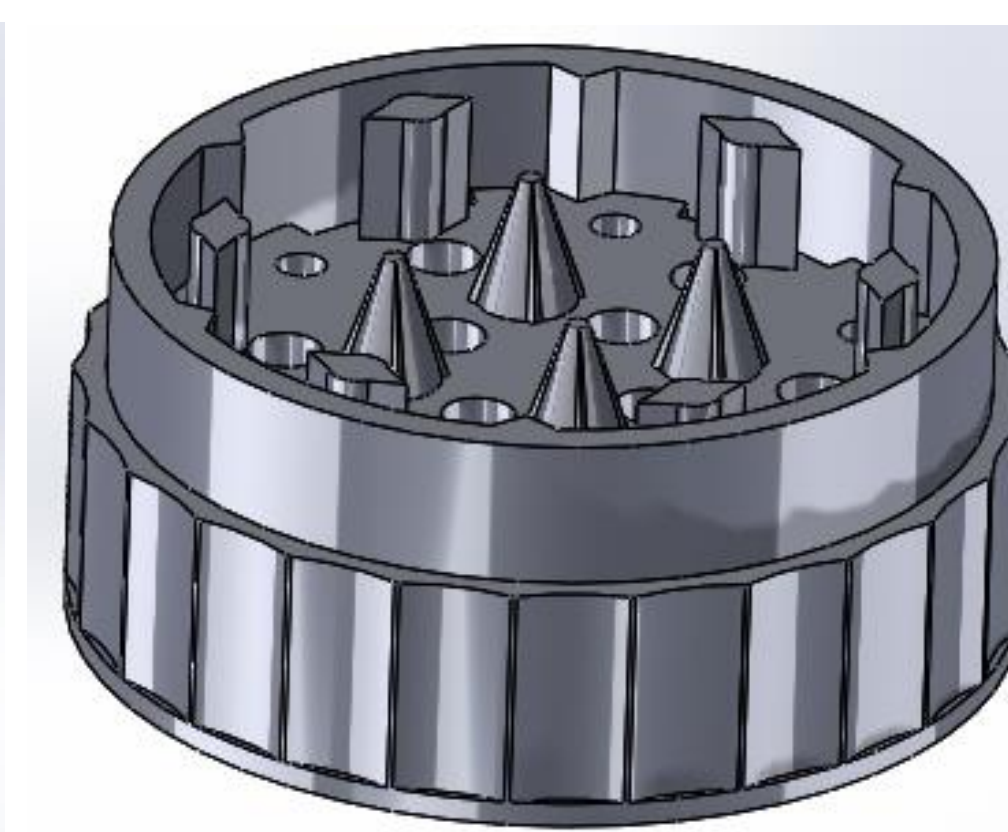


Figure 5: Bottom cap solidworks model

### Features

- Two-Part Grinder Attachment
- Top Portion:
  - Large "crusher" spike in center
  - Diamond-shaped slicing spikes
- Bottom Portion
  - Four cone-shaped "crusher" spikes, aligned for easy tablet placement.
  - Diamond-shaped slicing spikes
  - 3 mm diameter pores
  - Child-locked protrusions
- One 15mL PEG and 27g sodium bentonite packet per prescription.
- Total cost this semester: \$0
- Estimated cost of production: \$1.50/unit

### Dimensions (mm)

- Cap outer diameter: 37.67
- Cap inner diameter: 35.40
- Top cap height: 16.50
- Top cap grinder spike length: 6.00
- Top cap lid volume capacity: 5.5mL
- Bottom cap height: 10.10
- Bottom cap pore diameter: 3.00
- Bottom cap spike length: 5.50
- Distance between bottom cap crusher spikes: 7.50
- Total Cap height: 26.50

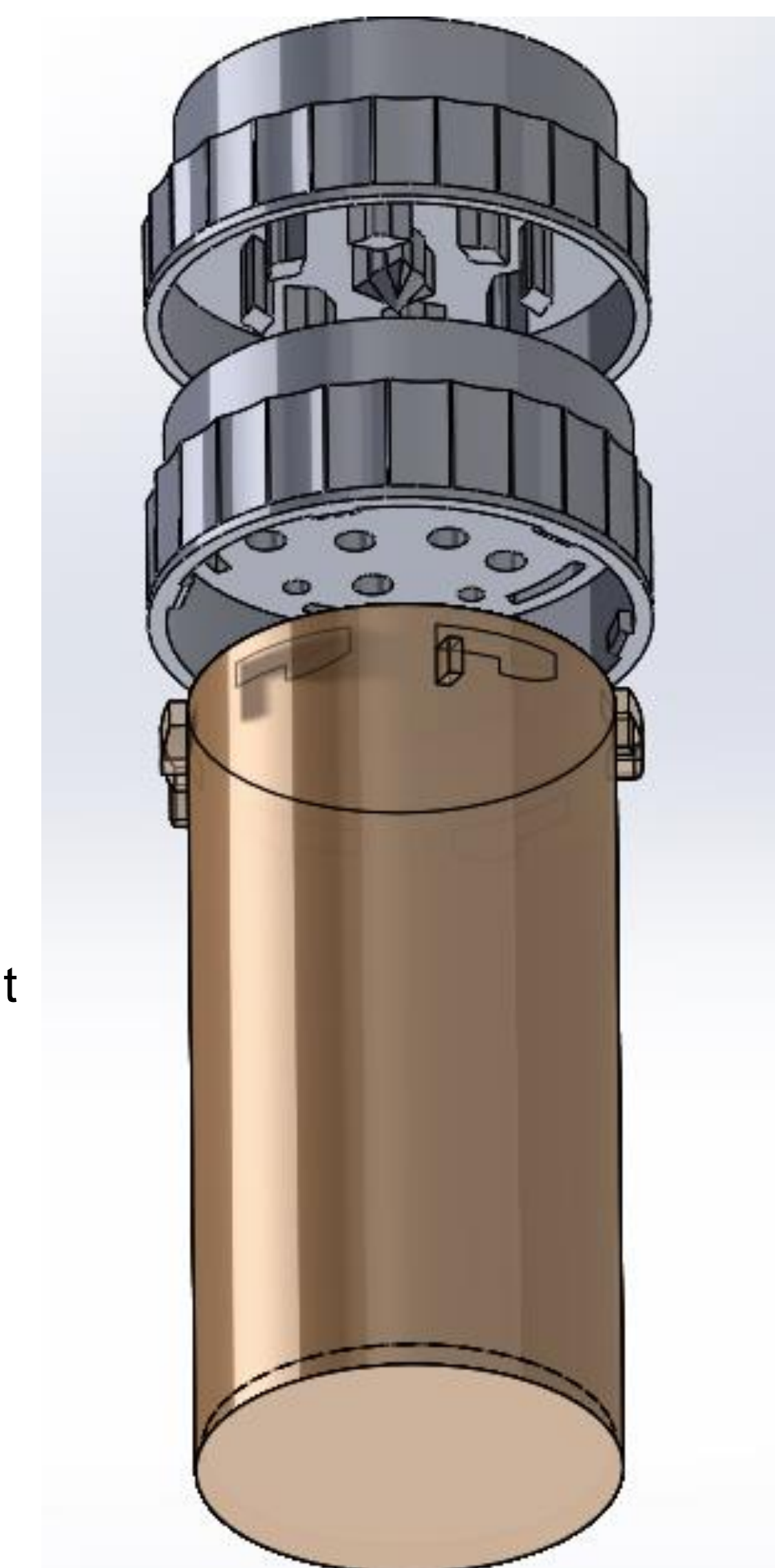


Figure 6: Expanded view of cap attachment to standard prescription pill bottle

## Testing

### Goals

- Determine recommended product use instructions based on optimal drug dissolution.
- Determine optimal amounts of PEG and sodium bentonite to use per pill.

### Absorbance Testing

- PEG per pill: 1mL PEG per pill.
- PEG in sodium bentonite: 1.1077 mL/g.
- Sodium Bentonite per pill = .903g (~27g/30 pills).

### Dissolution and HPLC: Oxycodone and Hydrocodone

- Tested differences between H<sub>2</sub>O vs. PEG, and agitation methods.
- Took samples at 15, 30, 45, 60, 90 and 120 minute time intervals for all samples.
- Oxycodone results were inconclusive, only Hydrocodone results are shown.

### Pill Dissolution (Whole)

- Untampered pill placed in 50mL of solvent.
- Used 50mL PEG, 50mL H<sub>2</sub>O, 50/50 mixture.
- Dissolution over time measured using HPLC.
- Results:
  - H<sub>2</sub>O high % dissolution by 45 minutes.
  - PEG and 50/50 constant low % dissolution.

### Rotator vs. Stir Bar vs. Shake (Crushed)

- Crushed pill placed in pill bottle, PEG or H<sub>2</sub>O added.
- Different methods of agitation were used for 1 min.
- Solution left to stand and dissolution over time measured with HPLC.
- Results:
  - Shaken H<sub>2</sub>O reached 90% dissolution after 15 min.
  - Stirred H<sub>2</sub>O and tilted PEG constant at ~75%.

### Results

#### % Hydrocodone Dissolved in Variable Solvent

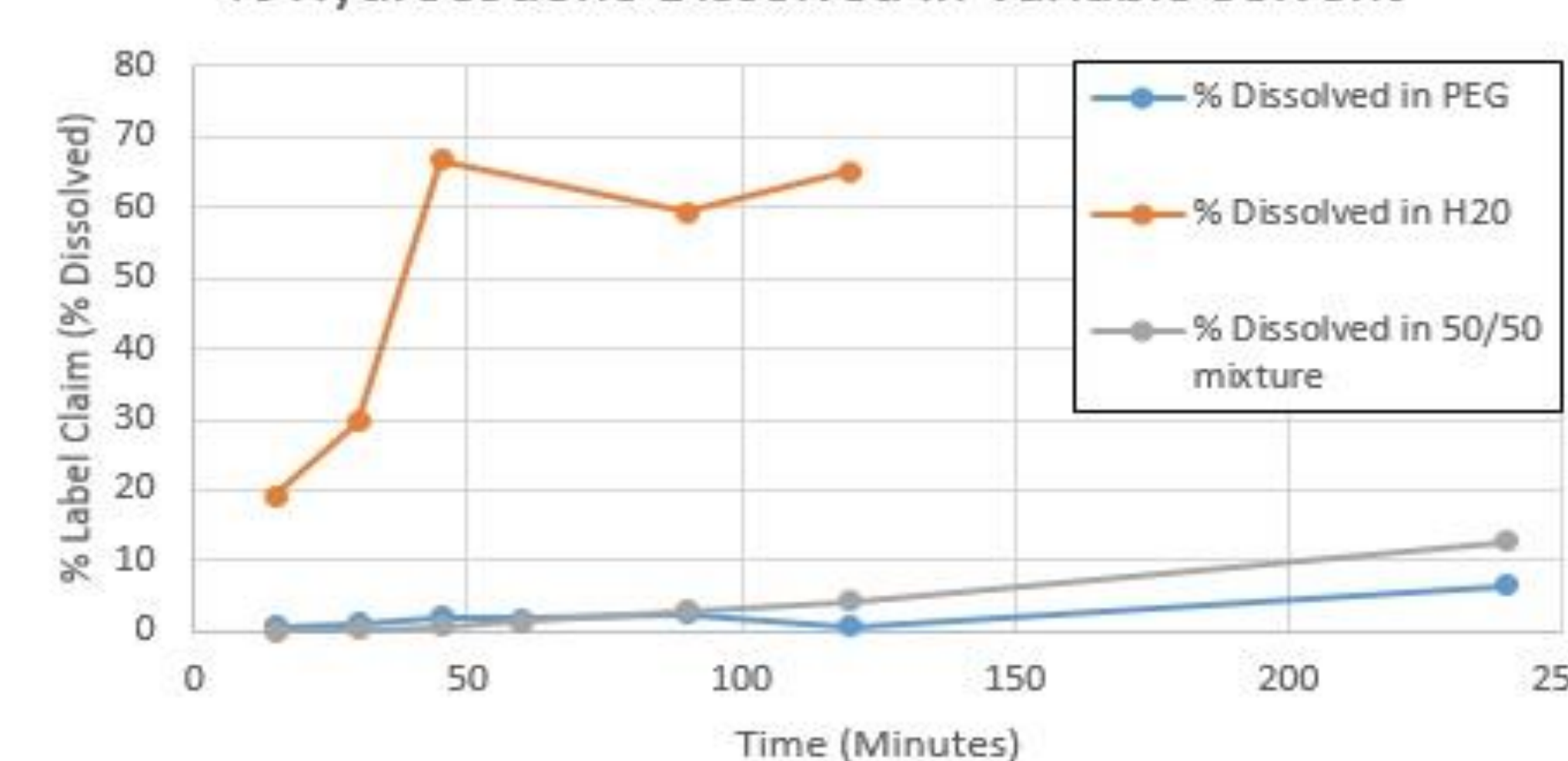


Figure 7: Whole pill dissolution testing with PEG, H<sub>2</sub>O, and a 50/50 mixture as solvents.

#### % Hydrocodone Dissolved with Variable Agitation Methods

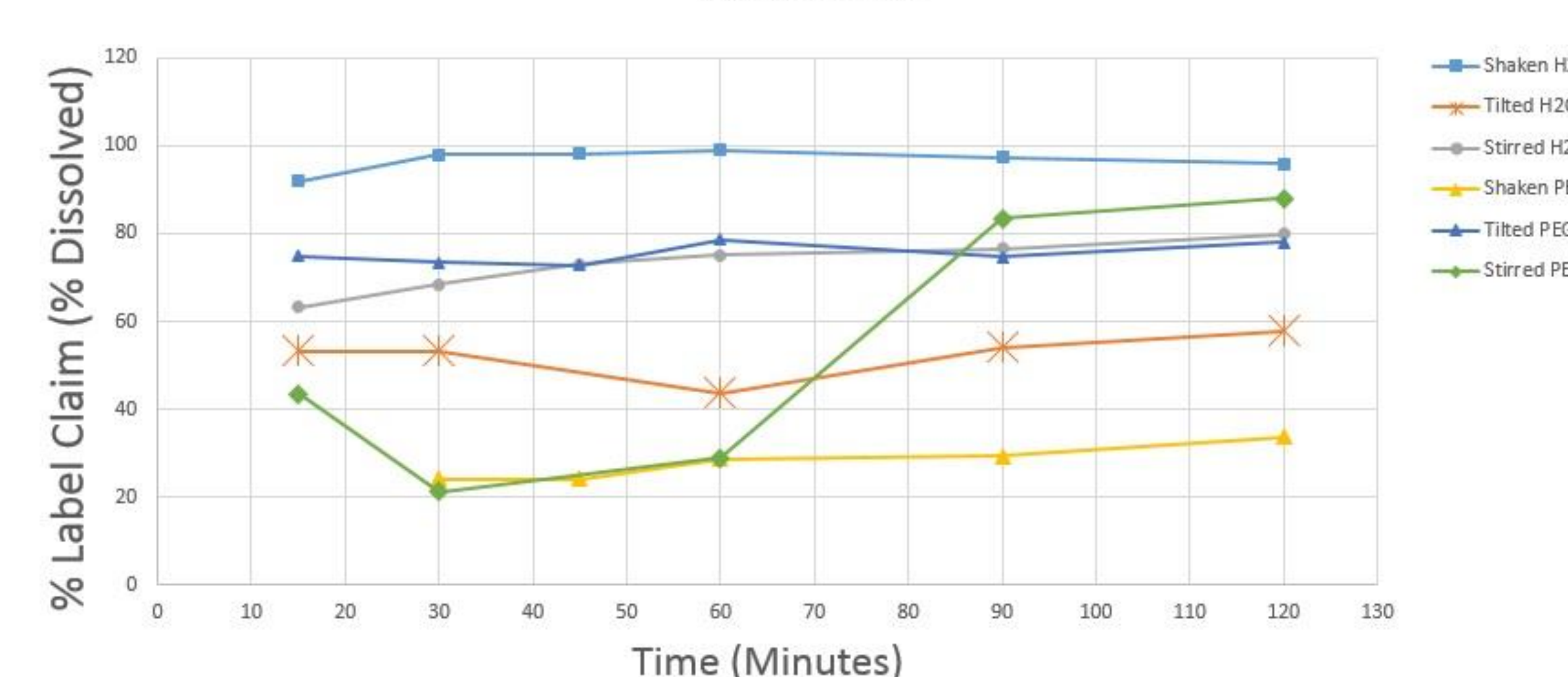


Figure 8: Crushed pill dissolution tests with three agitation methods, tested in both PEG and H<sub>2</sub>O solvent.

## Discussion

**GrindCap is designed to be inexpensive, easy to use, versatile, and compatible with the current method of drug distribution.**

### Cost

- The estimated cost per unit of \$1.50 is reasonable for pharmacies buy into this design for controlled substance prescriptions

### Ease of Use

- Small size with limited pieces.
- Eliminates need to leave home or buy extra material.
- Easy 7 step disposal process.
- Grinding achieved by simply pressing down and rotating top

### Versatility

- Can be modified to include inactivation agents specific to other drugs as needed.

### Compatibility

- This design is an add-on that allows the patient to use the same pill bottle that is used for distribution as a vessel for safe disposal.
- Cap could be put on any standard pill bottle.
- Bentonite clay and PEG packets could be included with prescription.

## Future Work

### Dissolution rates of other considered medications:

More dissolution and HPLC testing, conclusive results for Oxycodone.

### Ergonomics:

Easy grip cap, more effective grinder design and materials.

### Different neutralizing/binding agent

Experiment with substitutes for PEG and sodium bentonite.

### Retail/Packaging:

Design packets for PEG and sodium bentonite, figure out retail price and packaging.

### Environmental Toxicity Testing

Test the effect of our method of disposal on landfills

### Human Ingestion Testing

Using metabolic analog or animal testing, observe the effects of ingesting our mixture.

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## References

- [1] J. Fauber. (2014). Overdose deaths from opioids, heroin on the rise. Milwaukee Wisconsin Journal Sentinel. Available: <http://www.jsonline.com/watchdog/reports/overdose-deaths-from-oxycodone-heroin-on-the-rise-b99302962z1-265452991.html>
- [2] Bullard-Cawthorne, L., Ndiaye, M. "Snapshot of Opioid Problem in Wisconsin and Dane County 2015." Public Health: Madison & Dane County.
- [3] M. E. Herring, S. K. Shah, S. K. Shah, and A. K. Gupta. (2014). Current Regulations and Modest Proposals Regarding Disposal of Unused Opioids and Other Controlled Substances. Available: <http://www.jaoa.osteopathic.org.ezproxy.library.wisc.edu/content/108/7/338.full>