

Fish Bones: From Trash to Treasure!

Isolation of Hydroxyapatite from Atlantic Salmon Waste using an Enzyme Cocktail

Sarah Boudreau,^a Sabahudin Hrapovic,^b Yali Liu,^b Alfred C. W. Leung,^b Edmond Lam,^b Fabrice Berru e,^b and Francesca M. Kerton^a

Background

Fish production is increasing exponentially! Large amounts of by-products are being disposed using unsustainable practices.



Landfills:

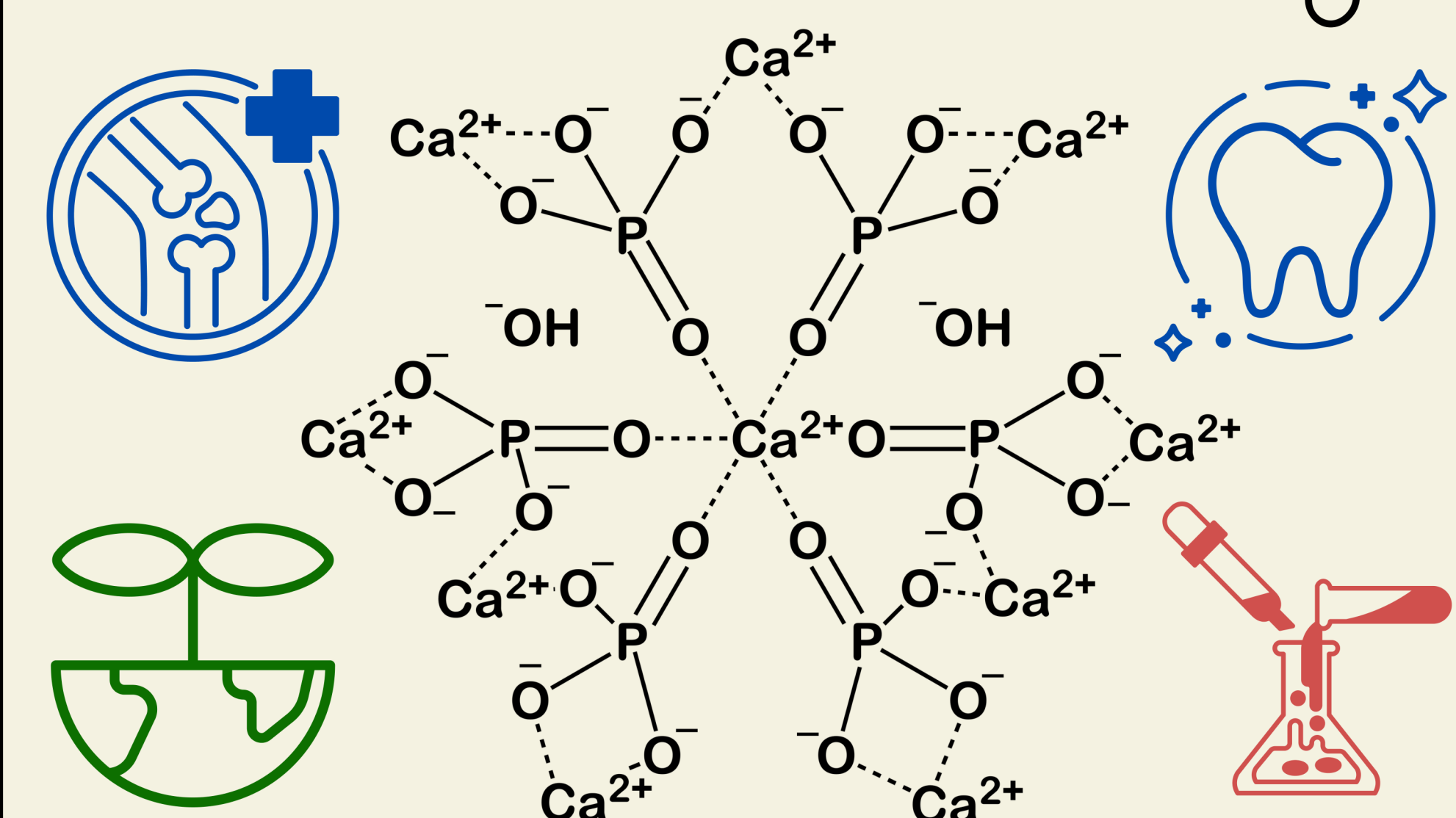
- CO₂, CH₄
- Groundwater contamination

Ocean disposal:

- Acidification
- Eutrophication

What is HAP?

Makes up 60% of bones!



HAP has been widely used in biomedicine and dentistry,¹ but it has also been explored for remediation² and catalysis.³

Current processes

Calcination

Requires extremely high temperatures (1200 °C) for several hours.⁴

Alkaline treatment

Relies on large volumes of concentrated strong base (50% NaOH).⁴

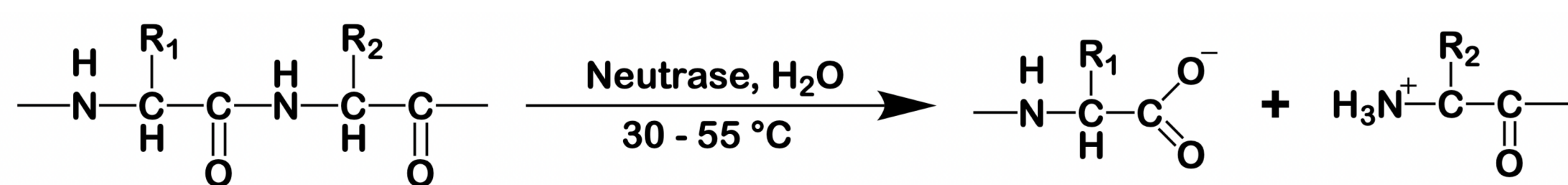
Unsustainable & industrially inapplicable!



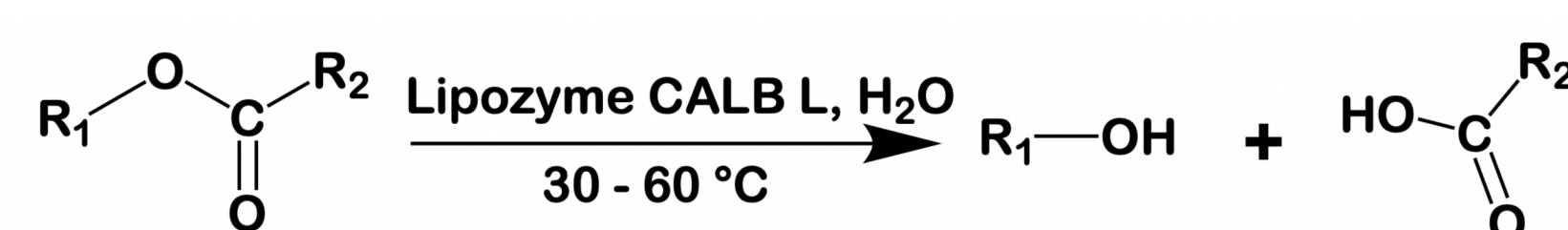
Enzyme optimization

Enzymes

Neutrane: zinc metalloendoprotease that hydrolyzes proteins



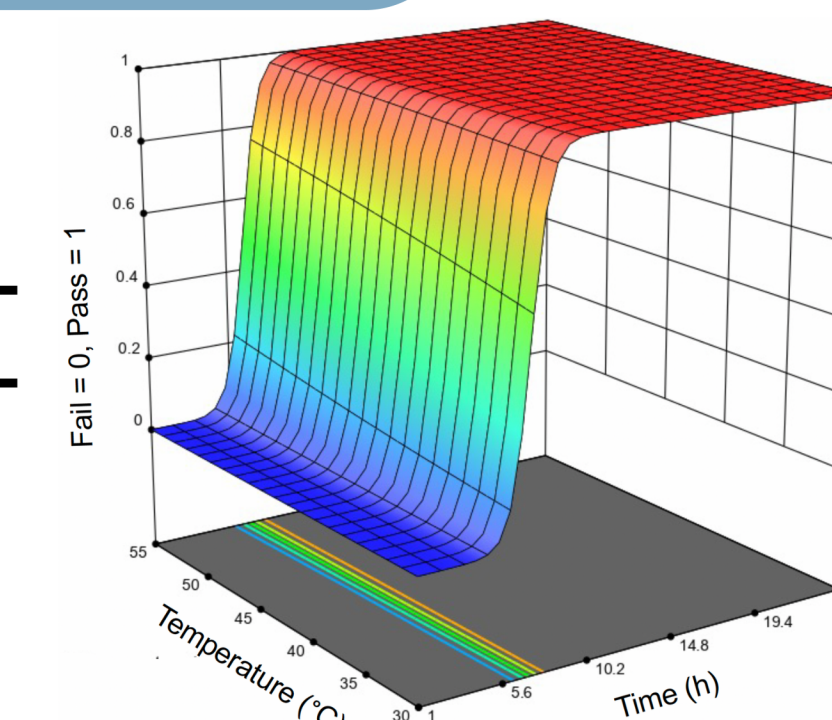
Lipozyme CALB L: lipase with specificity towards alcohols and esters



Design of Experiment

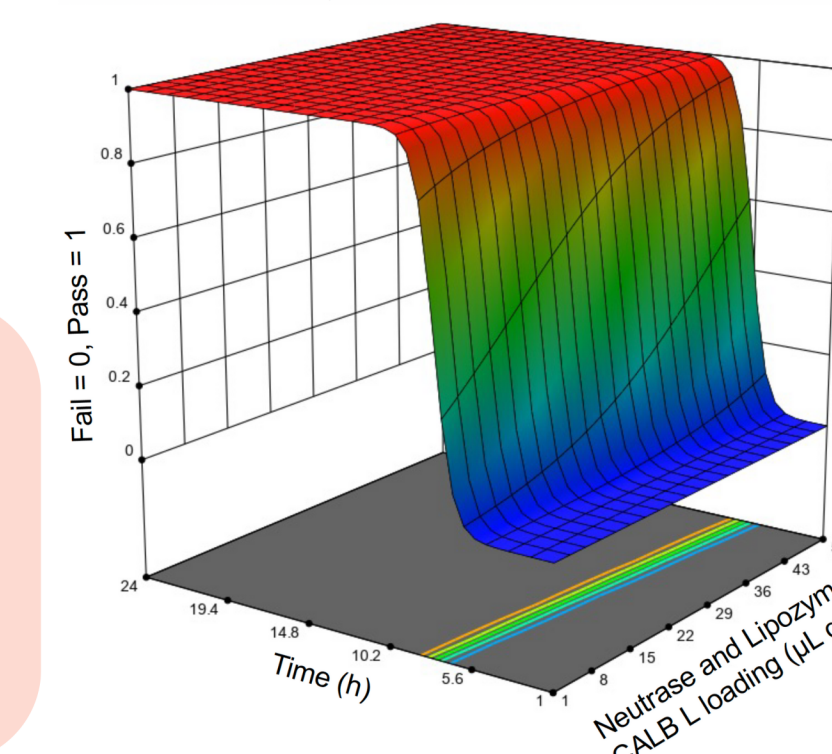
2⁴ factorial design

Parameter	High	Low
Neutrane loading	1.0 µL/g	25 µL/g
Lipozyme CALB L loading	0.5 µL/g	25 µL/g
Time	1 h	24 h
Temperature	30 °C	55 °C



Optimized conditions

15 µL/g Neutrane
7.5 µL/g Lipozyme CALB L
6 h, 40 °C



Wasted fish bones are an excellent feedstock for hydroxyapatite (HAP)!



- ✓ Principles of Green Chemistry
- ✓ Sustainable
- ✓ Designed for industrial application

Check out our manuscript!



Life Cycle Analysis

Simplified gate-to-gate LCA⁵

Method	ISF	IGW	INHNT	INIGT	PER
1 (our work)	0	321	0	2	NO
2	0	425	0	2	NO
3	1	552	6	51,560	MOD
4	49	597	6	440,770	MOD
5	0	328	<1	339,089	NO

ISF = smog formation potential
IGW = global warming potential
INHNT = human inhalation potential
INIGT = human ingestion potential
PER = persistence potential

Our process is currently the greenest!

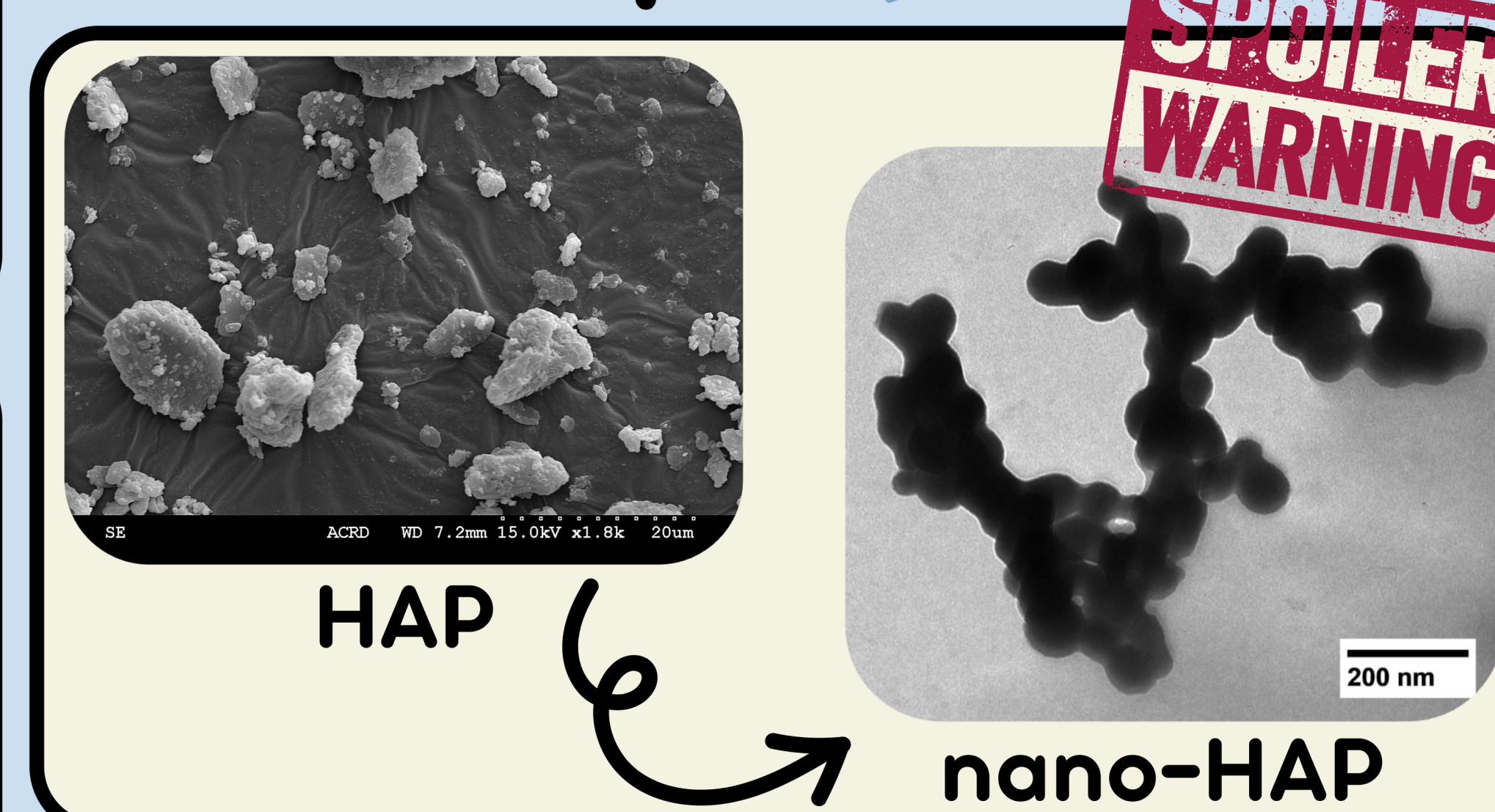
Scaling up

15 frames treated simultaneously



Isolated 150 g HAP!

Next steps



Acknowledgements

- Memorial University of Newfoundland^a
- National Research Council Canada (Ocean Program)^b
- Ocean Frontier Institute (OGEN)
- Natural Sciences and Engineering Research Council of Canada

References:

1. S. M. George et al., ACS Biomater. Sci. Eng., 2022, 20162.
2. A. I. Adeogun et al., ACS Omega, 2018, 1991.
3. R. More and P. More, Bull. Mater. Sci., 2022, 111.
4. K. L. Hernandez-Ruiz et al., Sustain. Chem. Pharm., 2022, 101109.
5. S. Mercer et al., J. Chem. Educ., 2012, 215-220.