UNIVERSITY of WISCONSIN UWMILWAUKEE Water Technology Accelerator

NOVEL POROUS MATERIAL FOR THE REMOVAL OF LEAD FROM WATER

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INTRODUCTION

Heavy metal contamination, including lead (Pb), is a well-known and documented issue for waste and drinking water. Despite the numerous health hazards associated with lead, many cities in the US and around the world still use lead pipes in their water infrastructure. External pollution also contributes to such lead contamination of water supplies. According to the World Health Organization, no known level of lead exposure is safe for humans, and lead poisoning is considered irreversible. Lead is known to affect the bones, blood, and organs such as the kidneys, liver, and brain. Children are particularly sensitive to the effects of lead poisoning.

An experimental method of removing lead from a water supply is using functionalized natural porous material. Functionalizing greatly increases a material's capacity for adsorption of lead. Lead has such a high affinity to this adsorbent that the release is undetectable, a very useful property should the material ever be used on a large-scale operation. The purpose of this research will be to understand how varying the frequency in the fabrication process affects the lead adsorption capacity and percent removal properties of the material.

OBJECTIVES

The quality control data will be compared to historical data from this project. The goal is to find the fabrication method that produces the best properties in percent removal and adsorption capacity.

The plan for this research will be to examine how altering frequency used in the fabrication of the functionalized porous material affects the material's adsorption capacity and percent removal properties of lead in water. The experimental materials will have all other parameters kept the same.

HYPOTHESES

As multiple factors were changed between the fabrications of Material Batch 1 and 2, one cannot conclusively state which factor(s) influenced the material's adsorption capacity properties, or how.

The current hypothesis is, allowing the fabrication to heat up significantly is the biggest influence in the change in adsorption capacity between Batch 1 and 2. Historical data supports this theory, by listing a maximum fabrication temperature of 80 Celsius.

Another hypothesis is that the setup of the sonic probe influenced the change in adsorption capacity. The change in setup involved irradiation over a greater surface area of containment.

No hypothesis can be made on how sonic irradiation frequency will affect the material's lead adsorption capacity or percent removal properties. SEM images will be needed to make such a hypothesis.

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METHODOLOGY

For fabrication, natural porous material, sorted by size, was cleaned by sonication and microwaving. A stoichiometric ratio of porous material and chemicals were placed in a glass beaker. Material Batch 1 was irradiated directly with a 20kHz sonic probe, and the reactants were kept cool, below 40 Celsius. Material Batch 2 was irradiated indirectly, through a water bath with the same probe, reactant ratios were modified, and the reaction allowed to heat up to 55-60 Celsius.

Quality control experiments for Batch 1, 2, and the referenced historical data were conducted with the same method. 0.2 grams of functionalized material was added to 200mL of lead solution from concentrations of 10 to 1000ppm. Initial samples of lead solution were collected. Lead solutions were modified to a pH of 5. The experiment was left on a shaker at 200 rpm for 24 hours at room temperature and final samples were collected. Both batches were tested for residual lead content using ICP-MS. Adsorption capacity and percent removed were calculated.

FIGURES

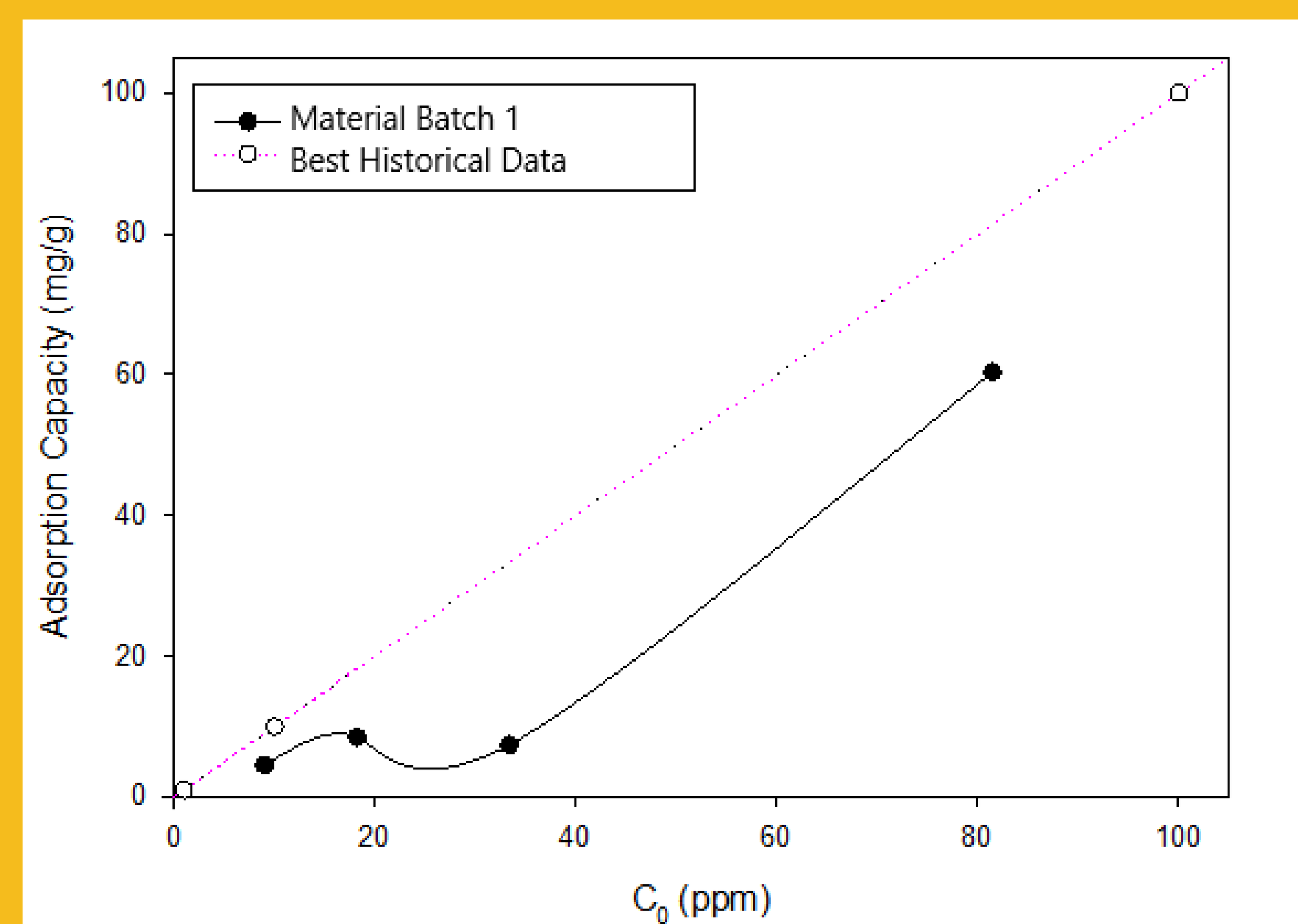

Figure 1: Batch 1 adsorption capacity compared to best historical data

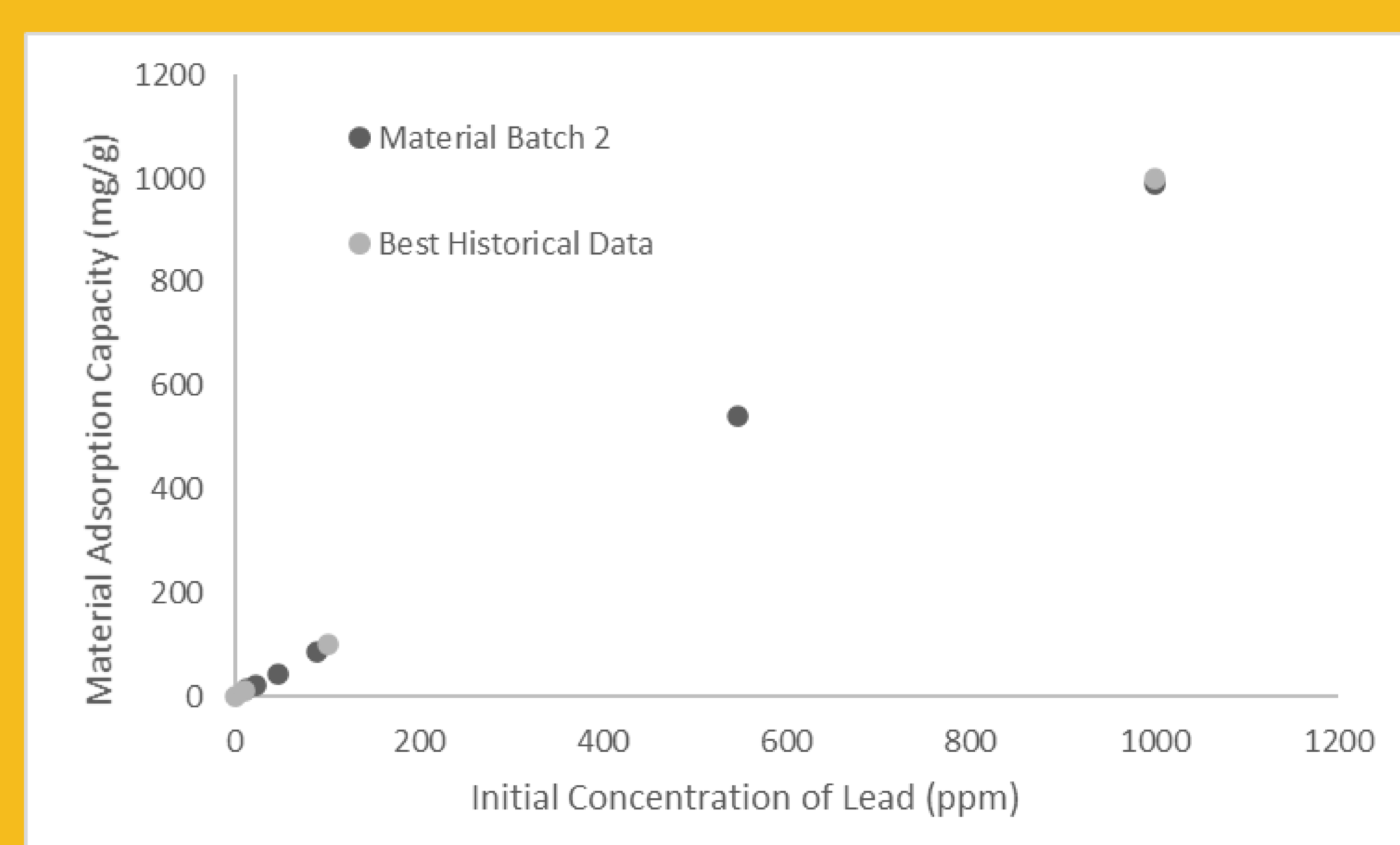

Figure 2: Batch 2 adsorption capacity compared to best historical data

RESULTS

Batch 1 displayed a much lower adsorption capacity for lead at all initial concentrations tested compared to the best historical data on this material. This led to a radical change in the fabrication process, to create Batch 2.

When tested, Batch 2 produced results extremely close to the best historical data for adsorption capacity, The heating ramp rate was logged during the successful fabrication of Batch 2 described in Figure 2. Future replications of Batch 2 will aim to follow the same heating ramp rate.

The highest adsorption capacity observed from historical data is 999.49 mg/g. The highest adsorption capacity of Material Batch 2 observed was approx. 991.29 mg/g.

CONCLUSION

Material Batch 1 performed worse than the best historical data regarding adsorption capacity of lead.

After modifying the fabrication process to make Material Batch 2, and performing quality control testing, the data shows Material Batch 2's adsorption capacity properties are nearly identical to that of the best historical material.

Batch 2 of functionalized porous material is very effective at removing lead from water.

FUTURE WORK

This future experiment set will fabricate functionalized porous material at 20, 37, and 80 kHz. The heating ramp rate will be monitored, and the temperature allowed to rise as high as safely possible. The same mass of reactants and fabrication time will be maintained across the board. SEM photos will be taken of each material batch. BET analysis may also be done to calculate surface area and pore size. The material will be quality control tested using the same method described in Methodology.

The next step in research with this material will focus on regeneration study so the adsorbent may be reused.

Research may also be done on how to scale up fabrication without losing the materials' lead adsorbing properties.

A third direction for research may be to find a more efficient process or use of chemicals for fabrication.

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