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Characterization of Sulfur in Biochar

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Introduction

The potential of renewable transportation fuel derived from biomass feedstock has been widely recognized due to its carbon-neutral characteristics, abundance, and projected economic competitiveness. A notable limitation affecting the economic feasibility of thermochemically produced biofuels is the production of unwanted byproducts, including organic tar and inorganic constituents (such as sulfur, chlorine, and alkali metals). The concentrations of such byproducts depend on variables such as feedstock, temperature, and process conditions (gasification versus pyrolysis). This study focuses on understanding sulfur contaminants by studying the content and speciation of inorganic sulfur in biochar. Elucidating the molecular transformation of sulfur during the conversion process will support the purposeful development of strategies to reduce the amount of undesirable sulfur in thermochemically derived biofuels.

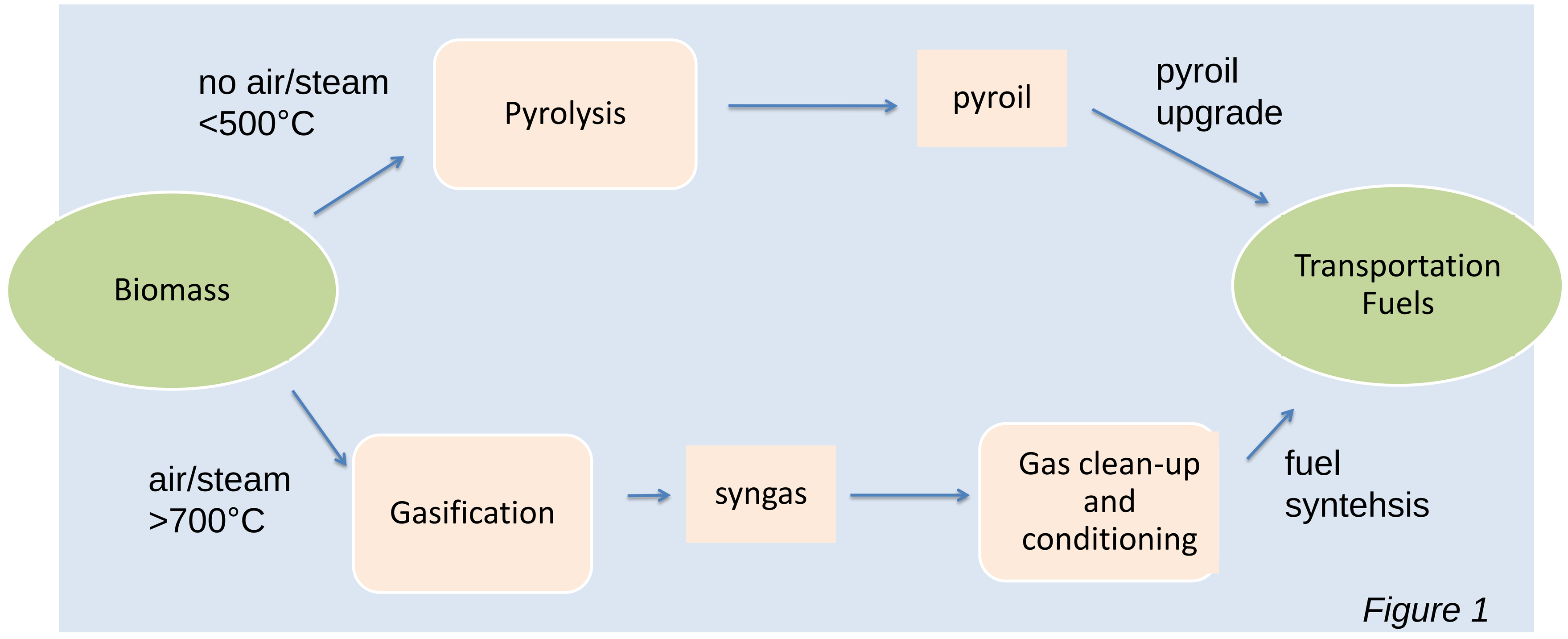


Figure 1: Gasification and pyrolysis are two thermochemical processes used to make biofuels from biomass.

Materials and Methods

Six samples of biochar were obtained from a variety of thermochemical processes.

ID	Feedstock	Temperature(°C)	Method
1	oak	800	gasification
2	oak	600	pyrolysis
3	oak	500	pyrolysis
4	corn stover	850	gasification
5	corn stover	500	pyrolysis
6	corn stover	500	pyrolysis

Table 1: Six samples of biochar used Samples were chosen to represent three of the factors known to influence sulfur content: feedstock, temperature, and conversion method.

Sulfur TruSpec Add-On Module was used to determine sulfur content of each biochar sample by combusting the sample to a gas and measuring the amount of sulfur dioxide gas present. This concentration is reported as the percentage of sulfur present. Samples were imaged and analyzed with Scanning Electron Microscopy-Energy Dispersive Spectroscopy (SEM-EDS). EDS spectrums (Figure 2) were acquired and used for x-ray mapping of sulfur and other elements present such as C, O, Mg, Al, Si, Ca, K, and Cl.

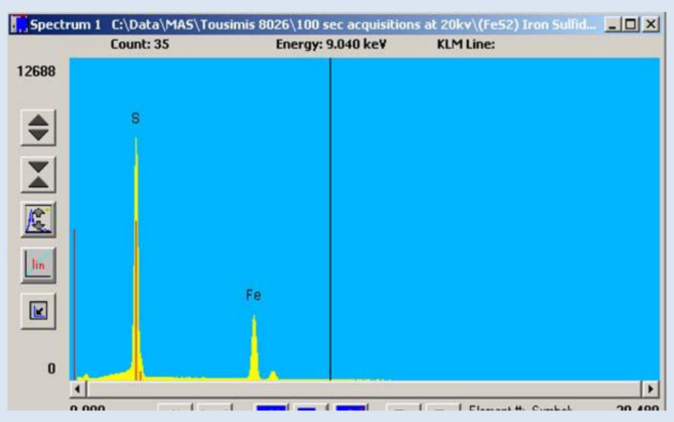


Figure 2: Sample EDS spectrums

Results – Sulfur Analysis

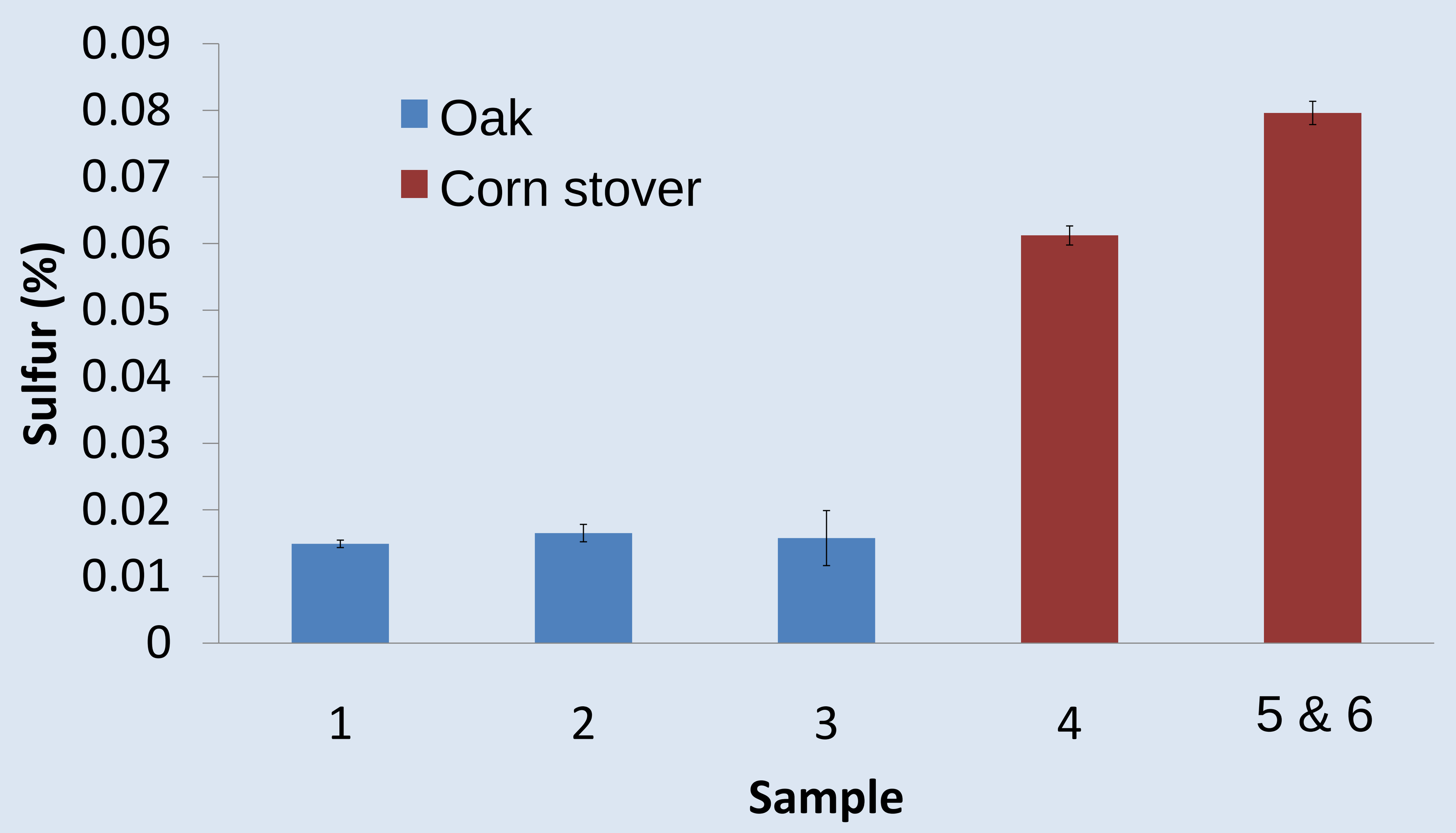
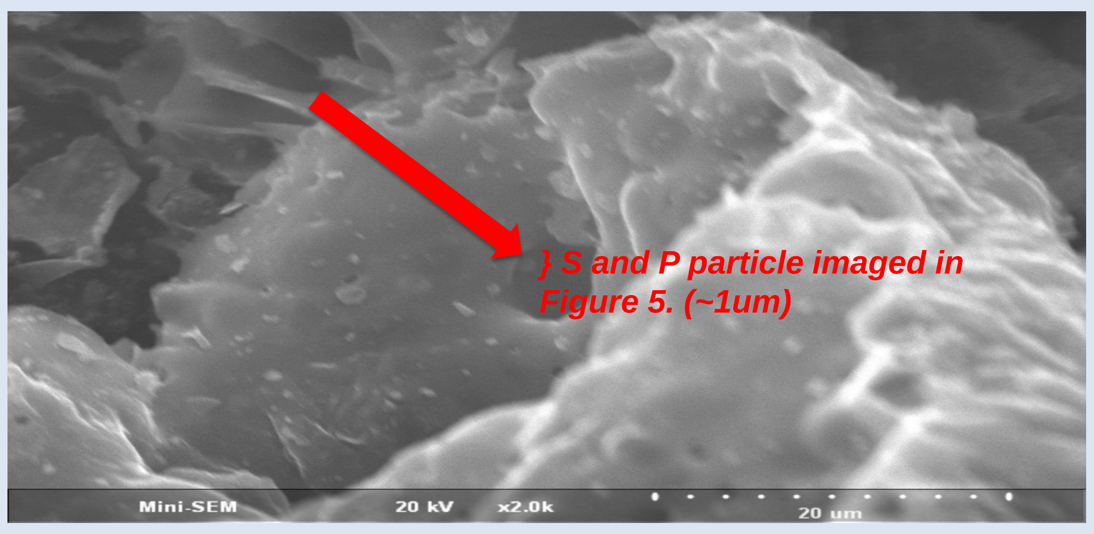
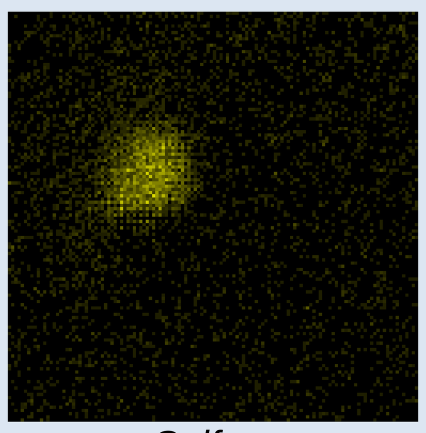


Figure 3. Percent sulfur found in biochar from different feedstocks, corn stover and oak, See Table 1 for addition details about each sample.

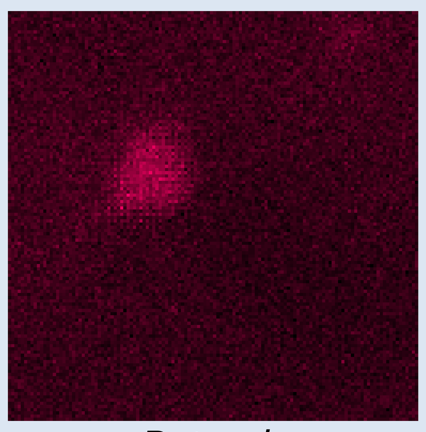
Results - SEM-EDS Nanoanalysis

Figure 4: SEM image of biochar particle from corn stover pyrolysis (sample 5) at 2000x. Arrow denotes the particle with high concentrations of sulfur and potassium, shown below in Figure 5.

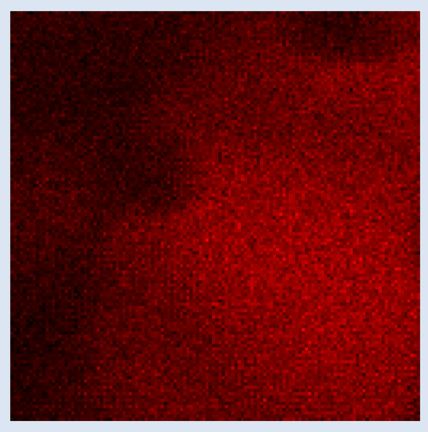




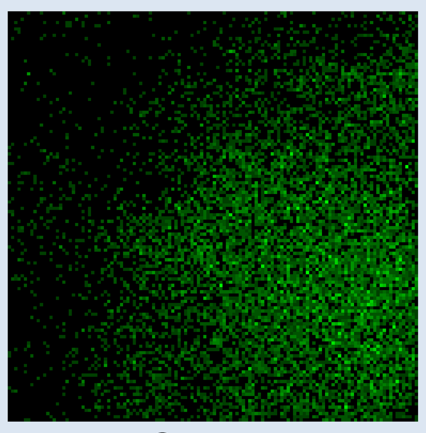
Sulfur



Potassium



Carbon



Oxygen

Figure 5: EDS nanoanalysis x-ray maps of a sampling of elements at 15000x. Elemental maps for S and K reveal a distinct particulate region, ~1um in size, which corresponds to the region referred to in Figure 4. Carbon and oxygen are more uniformly dispersed throughout biochar and appear to be sparse, even nonexistent where sulfur and potassium are present.

Conclusion

•Percent sulfur found in biochar from corn stover is greater than that found in oak.

•Inorganic sulfur appears to associate with potassium in biochar from corn stover pyrolysis.

Future Work

•Continue biochar characterization in greater detail, considering additional inorganic contaminants.
•Apply knowledge of biochar constituents to the overarching goal of developing informed strategies for reducing the amount of unwanted inorganic contaminants in biofuels.

Acknowledgements

This project was completed with the support of the National Bioenergy Center at the National Renewable Energy Laboratory, the National Science Foundation, the Department of Energy's Office of Science, and Cal Poly Science Teacher and Researcher (STAR) Internship Program. Special thanks to Calvin Feik, Jessica Olstad, and Steven Phillips for their assistance in sample and data collection. Additional thanks to Linda Lung, Jennifer Coughlin, and Doug Duncan for supporting my development as a teacher-researcher. Above all, I would like to thank my mentor, Singfoong Cheah, for her assistance and support, and showing me the value of curiosity and perseverance in science.

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