Surface Modification of Coal and its Application to Mitigate Ammonia Loss from Livestock Manure

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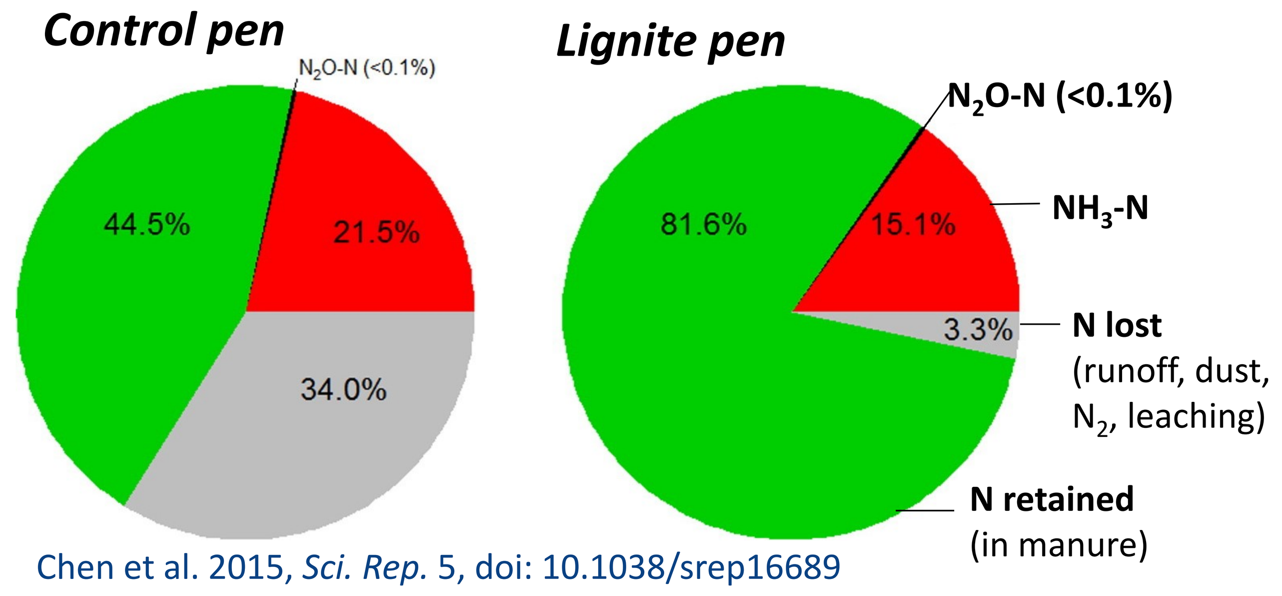
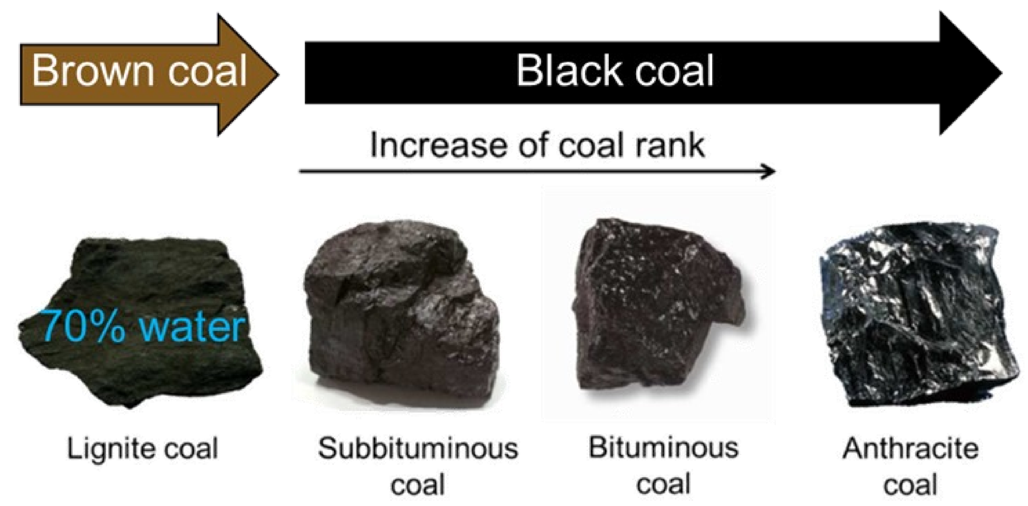
Introduction

- Intensive livestock production systems are hotspots for ammonia (NH_3) loss to the environment.
- Application of lignite (i.e., brown coal) to outdoor cattle pens reduced NH_3 emissions by 30 – 66% in cattle feedlots.



Chen et al. 2015, *Sci. Rep.* 5, doi: 10.1038/srep16689
Sun et al., 2016, *Sci. Total Environ.* 565, doi: 10.1016/j.scitotenv.2016.04.156

- However, the high water content of lignite can lead to prohibitive costs on long distance transport.
- We dewater lignite and modify black coal and coal washery tailings to work like lignite to reduce NH_3 loss.

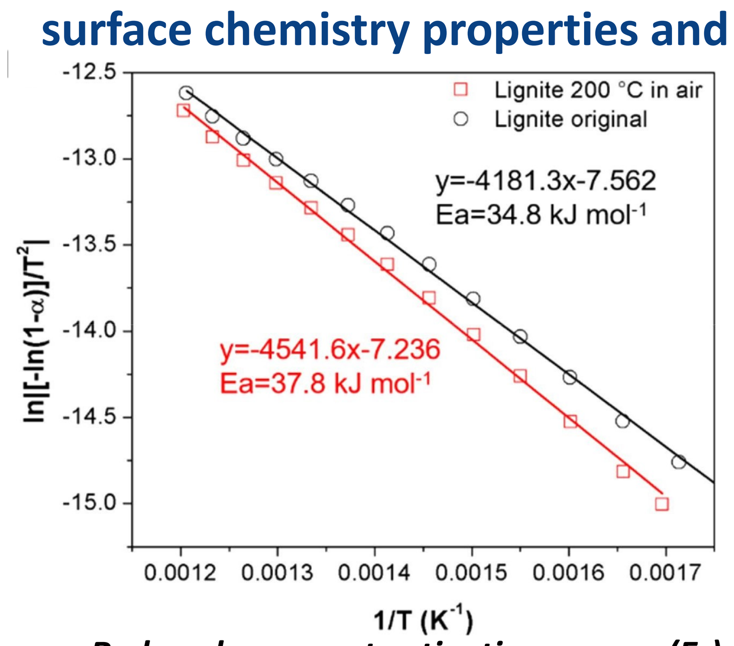


Objectives

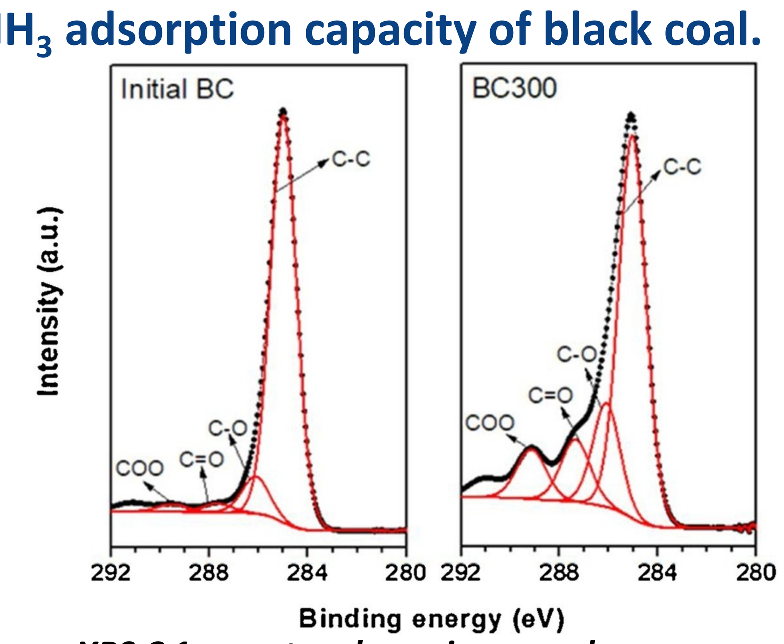
- Investigate the feasibility of using a thermal air oxidation method to dewater lignite and surface modify black coal and coal tailings to enhance NH_3 adsorption.
- Evaluate the potential ability of modified coal materials to reduce NH_3 loss from livestock manure and the underlying mechanisms.
- Explore the NH_3 adsorption mechanisms on modified coal materials and the reaction kinetics of acidic group formation during thermal oxidation.

Results

- Thermal air oxidation reduced the water content of lignite and would not increase the spontaneous combustion risk. Thermal air oxidation increased the surface chemistry properties and NH_3 adsorption capacity of black coal.

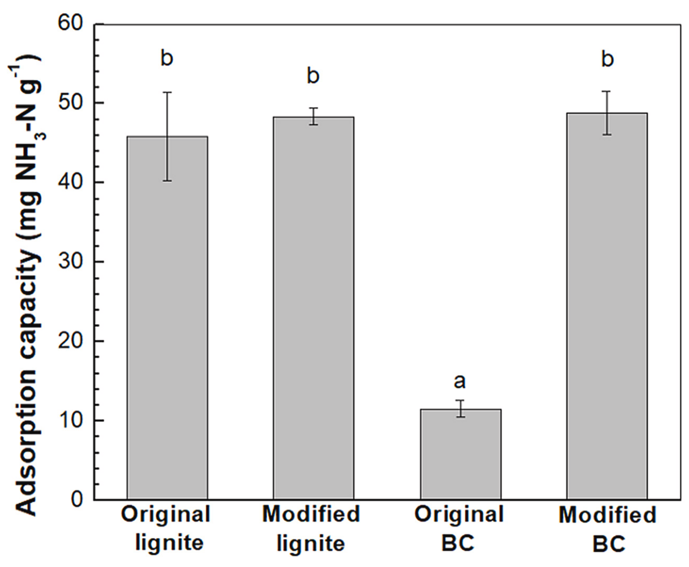


Reduced apparent activation energy (E_a) of combustion for dewatered lignite

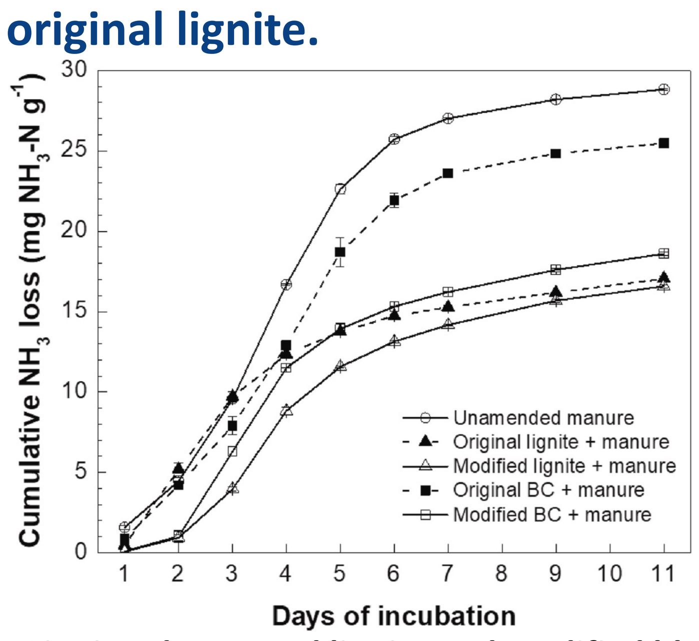


XPS C 1s spectra shows increased oxygen-containing functional groups on modified black coal

- Dewatered lignite and modified black coal reduced cattle manure NH_3 volatilization to a similar extent as the original lignite.

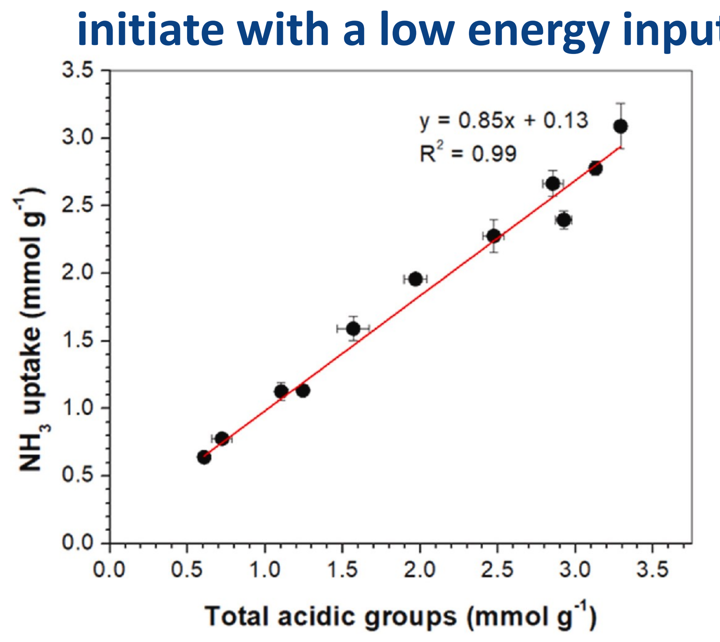


NH_3 adsorption capacity of lignite, dewater lignite, black coal and modified black coal

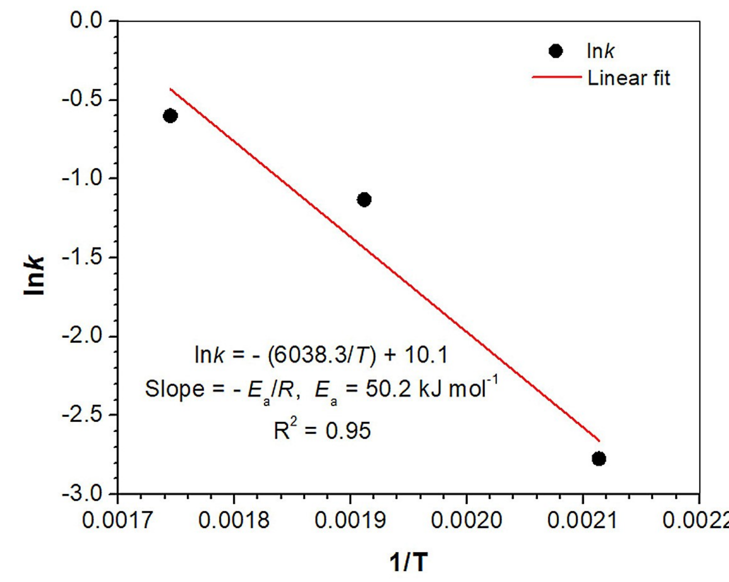


Lignite, dewatered lignite and modified black coal reduced NH_3 volatilization from manure

- Acidic surface functional groups from thermal oxidation played a crucial role in NH_3 adsorption on modified coal tailings.
- The relatively low activation energy of acidic group formation implies that the thermal air oxidation method is an effective approach to oxidize carbon surfaces for the generation of acidic functional groups and this reaction can initiate with a low energy input.

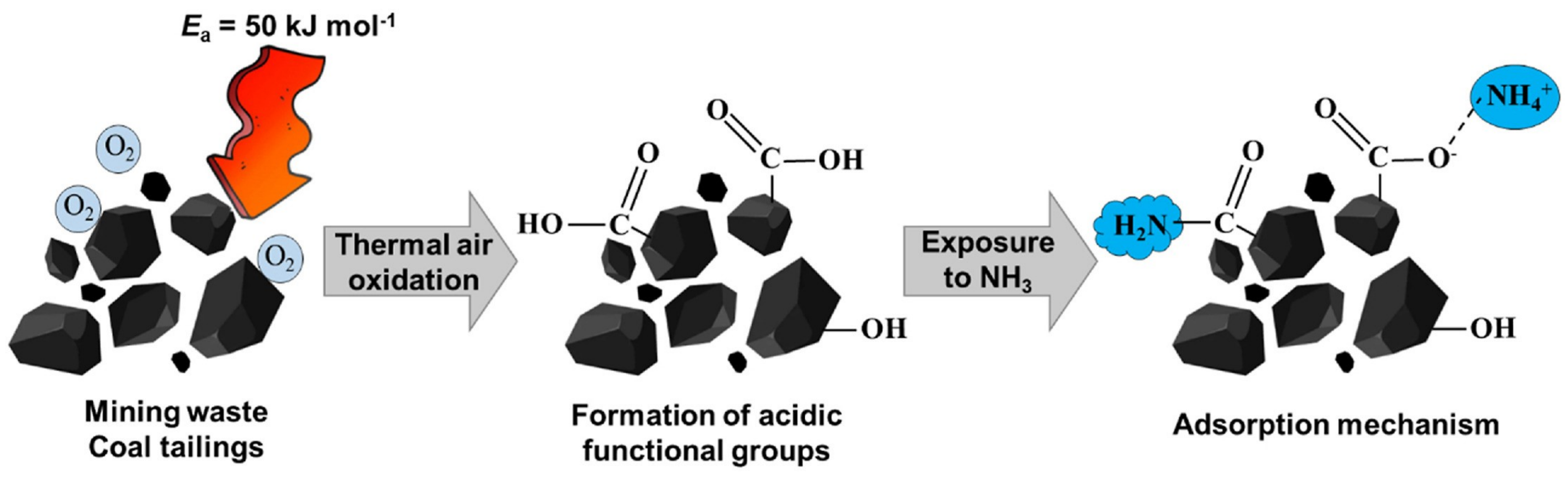


Linear relationship between NH_3 adsorption capacity and concentration of acidic surface functional groups



A relatively low activation energy (E_a) for acidic group formation on coal tailings

- NH_3 adsorption mechanisms on modified coal tailings.



Conclusions

- The research has demonstrated that thermal air oxidation is a simple and effective surface oxidative modification method to dewater lignite and increase the NH_3 adsorption capacity of black coal and coal tailings. The acidic surface functional groups from oxidation played a crucial role in the adsorption process.
- The addition of modified lignite and black coal in cattle manure can reduce NH_3 volatilization to a similar extent as the raw lignite and enhance N retention in manure.
- These findings suggest that modified coal materials are promising alternatives to lignite as additives to animal beddings where lignite is not available and offer potential for mitigation of NH_3 loss in livestock farms, improvement of N retention in manure and development of a circular nutrient economy.

References

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