

Using Electrochemistry to Probe Hydrothermal Organic Transformations on Magnetite

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The interaction of organic compounds with mineral surfaces may be key to understanding the abundance of different organic reaction paths available in hydrothermal systems, sedimentary basins, meteorite parent bodies and beyond. The interface between organic compounds and mineral surfaces could result in the availability of reaction pathways otherwise unavailable without the presence of minerals.

Previous work has demonstrated that phenylacetic acid ($C_6H_5CH_2COOH$; PAA) in the presence of magnetite (Fe_3O_4) or hematite (Fe_2O_3) results in the formation of several different organic product pathways at hydrothermal conditions (300°C, 100 MPa) [1]. The formation of benzoic acid (C_6H_5COOH ; BA) was observed during these hydrothermal experiments. It was proposed that the reaction path to form BA from PAA was a stepwise oxidation through the reaction intermediates of benzyl alcohol ($C_6H_5CH_2OH$) and benzaldehyde (C_6H_5CHO) by the loss of electrons to redox active metal cation in solution or within a mineral [1,2]. It is proposed that magnetite may serve as an electron conductor during hydrothermal reactions, perhaps storing electrons from the organic compounds temporarily until another species in solution can be reduced. The exact mechanism is unknown and the extent to which magnetite and hematite differ as potential electron acceptors during organic reactions is unclear.

Propanol ($CH_3(CH_2)_2OH$) and propanal (CH_3CH_2CHO) were chosen as analogs to benzyl alcohol and benzaldehyde. Propanol and propanal are soluble at room temperature in water and have been used previously to investigate the formation of acetic acid from oil field brines [3]. The results of preliminary experiments to probe the effectiveness of magnetite in an electrochemical oxidation to propanoic acid (C_3H_7COOH) at (20°C, pH 7) will be discussed as a tool for understanding hydrothermal reaction mechanisms and the role that electrons play in those organic transformations.

[1] Johnson KN (2017) *PhD Dissertation, Arizona State University* [2] Yang Z (2015) *J. Org. Chem* [3] McCollom TM and Seewald JS (2003) *GCA*