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# Probing Organic Transformations on Mineral Surfaces Through Electrochemical and Hydrothermal Experiments

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## Abstract

Before life, organic compounds existed in geologic environments in the presence of different varieties of minerals. By performing simplified experiments, I can determine the role of minerals in abiotic organic reactions and the mechanisms by which those reactions take place. These reactions contain only one organic compound as the starting material and one pure mineral phase so that detailed kinetic studies can be performed. My previous work has been performed at hydrothermal conditions. I am continuing hydrothermal experiments, but also adding the additional tool of electrochemistry to pursue organic redox reactions in an environment where the electron flow can be more easily controlled. This work has application to hydrothermal systems, sedimentary basins, meteorite parent bodies and other pre-biotic geologic environments.

Previous work has demonstrated that phenylacetic acid (C<sub>6</sub>H<sub>5</sub>CH<sub>2</sub>COOH; PAA) in the presence of magnetite (Fe<sub>3</sub>O<sub>4</sub>) or hematite (Fe<sub>2</sub>O<sub>3</sub>) results in the formation of several different organic product pathways at hydrothermal conditions (300°C, 100 MPa) [1]. The formation of benzoic acid (C<sub>6</sub>H<sub>5</sub>COOH; 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<sub>6</sub>H<sub>5</sub>CH<sub>2</sub>OH) and benzaldehyde (C<sub>6</sub>H<sub>5</sub>CHO) by the loss of electrons to redox active metal cations in solution or at the surface of 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<sub>3</sub>(CH<sub>2</sub>)<sub>2</sub>OH) and propanal (CH<sub>3</sub>CH<sub>2</sub>CHO) 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<sub>3</sub>H<sub>5</sub>COOH) at (20°C, pH 7 and pH 13) will be discussed as a tool for understanding hydrothermal reaction mechanisms and the role that electrons play in those organic transformations.

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

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