Researchers use new technique to quantify the electrostatic contribution to the transition state of enzymatic reactions

December 19 2014, by Bob Yirka

(Phys.org)—A team of researchers working at Stanford University has used a new technique to help further understand the electrostatic contribution to the transition state of enzymatic reactions. They have outlined their research in a paper they have had published in the journal *Science*. Peter Hildebrandt with Technische Universität Berlin offers a Perspectives piece on the work done by the team in the same journal issue.

Scientists have been able to watch how electricity impacts the initial reaction state of enzymatic reactions for quite some time—in so doing they've learned a lot about the binding and crystallization that occurs between enzymes and the substrate involved. But what happens after that? Since there has been little hard evidence, chemical researchers have had to rely on theories that have been developed over the years. In this new effort, the research team has used a new technique that exploits the vibrational Stark effect (VSE) which comes from the perturbation of molecular vibrational energy levels present in an electric field, called, quite naturally, vibrational Stark effect spectroscopy. Doing so as part of analyzing the electrostatic impact on the enzyme ketosteroid isomerase which, the researchers note, exerts a very large electric field onto the Carbon-Oxygen chemical bond, showed a rearrangement in charge as part of the step that determined its rate. That allowed the team to measure frequency changes of the vibrations that were produced by the chemical bonds inside the molecule while the vibrations responded to an electric field.

In analyzing what was seen, the researchers were able to note that the enzyme was able to direct the electric field to the precise location where it was bound to a substrate molecule, which wound up influencing the efficiency of the reaction overall—or put another, that the electric field actually accelerated the reaction. This observation could, Hildebrandt notes, likely apply to other catalytic reactions as well, such as with other protein reactions, most specifically, those that occur in membranes, which he notes are naturally impacted by electric fields.

The researchers point out that they were able to quantify the fraction of the catalytic effect that was electrostatic in origin and suggest that what they've learned could be applied by molecular designers looking to generate enzymes with better catalytic efficiency.

More information: Extreme electric fields power catalysis in the active site of ketosteroid isomerase, *Science* 19 December 2014: Vol. 346 no. 6216 pp. 1510-1514. DOI: 10.1126/science.1259802

ABSTRACT
Enzymes use protein architecture to impose specific electrostatic fields onto their bound substrates, but the magnitude and catalytic effect of these electric fields have proven difficult to quantify with standard experimental approaches. Using vibrational Stark effect spectroscopy, we found that the active site of the enzyme ketosteroid isomerase (KSI) exerts an extremely large electric field onto the C=O chemical bond that undergoes a charge rearrangement in KSI's rate-determining step. Moreover, we found that the magnitude of the electric field exerted by the active site strongly correlates with the enzyme's catalytic rate enhancement, enabling us to quantify the fraction of the catalytic effect that is electrostatic in origin. The measurements described here may help explain the role of electrostatics in many other enzymes and

biomolecular systems.

Citation: Researchers use new technique to quantify the electrostatic contribution to the transition state of enzymatic reactions (2014, December 19) retrieved 2 May 2024 from https://phys.org/news/2014-12-technique-quantify-electrostatic-contribution-transition.html