# The world's nitrogen fixation, explained

September 23 2015

Credit: NASA

Yale University scientists may have cracked a part of the chemical code for one of the most basic, yet mysterious, processes in the natural world—nature's ability to transform nitrogen from the air into usable nitrogen compounds.

The process is called nitrogen fixation, and it occurs in microorganisms on the roots of plants. This is how nature makes its own fertilizers to feed plants, which feed us.

The enzyme responsible for natural nitrogen fixation is called nitrogenase. Yale chemistry professor Patrick Holland and his team

designed a new chemical compound with key properties that help to explain nitrogenase. The findings are described in the Sept. 23 online edition of the journal *Nature*.

"Nitrogenase reacts with nitrogen at a cluster of iron and sulfur atoms, which is strange because other iron-sulfur compounds typically don't react with nitrogen, either in other enzymes or in the thousands of known iron-sulfur compounds synthesized by chemists," Holland said.

Keeping that in mind, Holland and his team designed a new compound with two distinct properties found in nitrogenase: large shielding groups of atoms that prevented undesired reactions, and a weak iron-sulfur bond that could break easily upon the addition of electrons. The design proved successful because the compound binds nitrogen from the atmosphere, just as nitrogenase does.

With this insight into how nature fixes nitrogen, Holland and his colleagues hope to design synthetic catalysts that turn nitrogen into ammonia, the main fertilizer produced in the natural system. "Natural systems are much friendlier than the current industrial process for making ammonia, which uses very high temperature and pressure," Holland said.

By making ammonia synthesis easier, it could be possible to make fertilizers on-site at farms, reducing transportation and production costs. "This work shows that carefully designed chemical compounds can help us figure out how natural systems use plentiful raw materials like the nitrogen in our atmosphere," Holland said.

**More information:** Binding of dinitrogen to an iron-sulfur-carbon site, DOI: 10.1038/nature15246

Provided by Yale University